FITTER

NSQF LEVEL - 4

2nd Year

TRADE THEORY

SECTOR : CAPITAL GOODS & MANUFACTURING

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : **Capital Goods & Manufacturing**

Duration : **2 Years**

Trade : **Fitter - Trade Theory - 2nd Year - NSQF Level - 4 (Revised 2022)**

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Post Box No.3142
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INDIA
Email: chennai-nimi@nic.in
Website: www.nimi.gov.in

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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 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 Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Fitter - Trade Theory - 2nd Year - NSQF Level - 4 (Revised 2022) in CG & M Sector** under **Annual Pattern.** The NSQF Level - 4 (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 - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

Atul Kumar Tiwari, *I.A.S*
Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

March 2023
New Delhi - 110 001

PREFACE

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

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

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and 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**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Theory)** for the trade of **Fitter 2nd Year - NSQF Level - 4 (Revised 2022)** under the **CG & M** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Shri. P.K. Radha Krishnan	-	Senior Instructor Govt ITI, Kerala.
Shri. T. Gopalan	-	Assistant Training officer Govt ITI, Ambattur, Chennai.
Shri. U. Abdul Kadar	-	Junior Training officer Govt ITI, Guindy, Chennai.
Shri. S. Suresh	-	Junior Training Officer Govt ITI, Karaikudi.
Shri. S. Suresh	-	Junior Training Officer Govt ITI, Vadakarai.
Shri. A. Vijayaraghavan	-	Assistant Director of Training (Retd.), ATI, Chennai.
Shri. M. Sampath	-	Training Officer (Retd.), CTI, Chennai.

NIMI COORDINATORS

Shri. Nirmalya Nath	-	Deputy Director, NIMI, Chennai - 32.
Shri. V. Gopala Krishnan	-	Manager NIMI, Chennai - 32.

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

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

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

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the two years course of the **Fitter** in **Capital Goods & Manufacturing** trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF Level - 4 (Revised 2022)

This manual is divided into Eight modules. The Eight modules are given below

Module 1	Assembly - 1
Module 2	Gauges
Module 3	Pipes and Pipe Fittings
Module 4	Drill jig
Module 5	Repairing Technique
Module 6	Hydraulics and Pneumatics
Module 7	Preventive Maintenance
Module 8	Erection and Testing

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 two years course of the **Fitter** in **Capital Goods & Manufacturing** Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade Theory. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the 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 at least 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.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

Sl.No.	Learning Outcome	Exercise No.
1	Make & assemble components of different mating surfaces as per required tolerance by different surface finishing operations using different fastening components, tools and check functionality. [Different Mating Surfaces – Dovetail fitting, Radius fitting, Combined fitting; Different surface finishing operations – Scraping, Lapping and Honing; Different fastening components – Dowel pins, screws, bolts, keys and cotters; Different fastening tools-hand operated & power tools, Required tolerance - ±0.02mm, angular tolerance ± 10 min.] **(Mapped NOS: CSC/N0304)**	2.1.115 - 2.1.138
2	Make different gauges by using standard tools & equipment and checks for specified accuracy. [Different Gauges – Snap gauge, Gap gauge; Specified Accuracy - ±0.02mm] **(Mapped NOS:CSC/N0304)**	2.2.139 - 2.2.148
3	Apply a range of skills to execute pipe joints, dismantle and assemble valves & fittings with pipes and test for leakages.[Range of skills – Cutting, Threading, Flaring, Bending and Joining] **(Mapped NOS:CSC/N0304)**	2.3.149 - 2.3.156
4	Make drill jig & produce components on drill machine by using jigs and check for correctness. **(Mapped NOS:CSC/N0304)**	2.4.157 - 2.4.158
5	Plan, dismantle, repair and assemble different damaged mechanical components used for power transmission & check functionality. [Different Damage Mechanical Components – Pulley, Gear, Keys, Jibs and Shafts.] **(Mapped NOS:CSC/N0304)**	2.5.159 - 2.5.170
6	Identify, dismantle, replace and assemble different pneumatics and hydraulics components. [Different components – Compressor, Pressure Gauge, Filter Regulator Lubricator, Valves and Actuators.]	2.6.171 - 2.6.176
7	Construct circuit of pneumatics and hydraulics observing standard operating procedure& safety aspect.	2.6.177 - 2.6.179
8	Identify, dismantle, replace and assemble different pneumatics and hydraulics components. [Different components – Compressor, Pressure Gauge, Filter Regulator Lubricator, Valves and Actuators.]	2.6.180 - 2.6.184
9	Construct circuit of pneumatics and hydraulics observing standard operating procedure& safety aspect.	2.6.185 - 2.6.186
10	Plan & perform basic day to day preventive maintenance, repairing and check functionality. [Simple Machines – Drill Machine, Power Saw and Lathe] **(Mapped NOS:CSC/N0304)**	2.7.187 - 2.7.192
11	Plan, erect simple machine and test machine tool accuracy. [Simple Machines – Drill Machine, Power Saw and Lathe]	2.7.193 - 2.8.196

SYLLABUS FOR FITTER

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 255Hrs; Professional Knowledge 70Hrs	Make & assemble components of different mating surfaces as per required tolerance by different surface finishing operations using different fastening components, tools and check functionality. [Different Mating Surfaces – Dovetail fitting, Radius fitting, Combined fitting; Different surface finishing operations – Scraping, Lapping and Honing; Different fastening components – Dowel pins, screws, bolts, keys and cotters; Different fastening tools-hand operated & power tools, Required tolerance - ±0.02mm, angular tolerance ± 10 min.] **(Mapped NOS: CSC/N0304)**	115. Make 'H' fitting. (13 hrs.) 116. Power tools: Practice operation of power tool for fastening. (5 hrs.) 117. Tightening of bolt/ screw with specified torque. (2 hrs.) 118. Selection of right tool as for Tightening or loosening of screw/bolt as per accessibility. (1 hr.)	Screws: material, designation, specifications, Property classes (e.g. 9.8 on screw head), Tools for tightening/ loosening of screw or bolts, Torque wrench, screw joint calculation uses. Power tools: its constructional features, uses & maintenance. (06 hrs.)
		119. Assembly sliding for using keys, dowel pin and screw, ± 0.02 mm accuracy on plain surface and testing of sliding fitting job. (13 hrs.) 120. File & fit angular mating surface within an accuracy of ± 0.02 mm & 10 minutes angular fitting. (12 hrs.)	Locking device: Nuts- types (lock nut castle nut, slotted nuts, swam nut, grooved nut) Description and use. Various types of keys, allowable clearances & tapers, types, uses of key pullers. (06 hrs.)
		121. Drill through and blind holes at an angle using swivel table of drilling machine. (09 hrs.) 122. Precision drilling, reaming and tapping and Test- Job. (12 hrs.)	Special files: types (pillar, Dread naught, Barrow, warding) description & their uses. (07 hrs.)
		123.Make Dovetailed fitting and radius fitting. (18hrs.)	Templates and Radius/fillet gauge, feeler gauge, hole gauge, and their uses, care and maintenance. (05 hrs.)
		124. File and fit, combined fit with straight, angular surface with ± 0.02 mm accuracy and check adherence to specification and quality standards using equipment like Vernier-calipers, micrometresetc.(18 hrs.)	Slip gauge: Necessity of using, classification & accuracy, set of blocks (English and Metric). Details of slip gauge. Metric sets 46: 103: 112. Wringing and building up of slip gauge and care and maintenance. (06 hrs.)
		125. Drilling and reaming, small dia. holes to accuracy & correct location for fitting. (4 hrs.) 126. Perform drilling using 'V' block and a clamp. (1 hrs.) 127. Make male and female fitting parts, drill and ream holes not less than 12.7 mm. (18 hrs.)	Application of slip gauges for measuring, Sine Bar-Principle, application & specification. Procedure to check adherence to specification and quality standards. (05 hrs.)
		128. Make Sliding Diamond fitting. (22 hrs.) 129. Lap flat surfaces using lapping plate. (5 hrs.)27. Filing flat, square, and parallel to an accuracy of 0.5mm. (07 hrs.)	Lapping: Application of lapping, material for lapping tools, lapping abrasives, charging of lapping tool. Surface finish importance, equipment for testing-terms relation to surface finish. Equipment for

			tasting surfaces quality – dimensional tolerances of surface finish. (06 hrs.)
		130. Prepare Stepped keyed fitting and test job. (16 hrs.) 131. Lapping holes and cylindrical surfaces. (5 hrs.)	Honing: Application of honing, material for honing, tools shapes, grades, honing abrasives. Frosting-its aim and the methods of performance. (05 hrs.)
		132. Dovetail and Dowel pin assembly. (16 hrs.) 133. Scrape cylindrical bore. (5 hrs.)	Metallurgical and metal working processes such as Heat treatment, various heat treatment methods - normalizing, annealing, hardening and tempering, purpose of each method, tempering colour chart. (06 hrs.)
		134. Scrapping cylindrical bore and to make a fit-(12 hrs.) 135. Scrapping cylindrical taper bore and check taper angle with sine bar. (08 hrs.)	Annealing and normalizing, Case hardening and carburising and its methods, process of carburising (solid, liquid and gas). (07 hrs.)
		136. Make a cotter jib assembly. (20 hrs.)	Tapers on keys and cotters permissible by various standards. (06 hrs.)
		137. Hand reams and fit taper pin. (12 hrs.) 138. Drilling and reaming holes in correct location, fitting dowel pins, stud, and bolts. (08 hrs.)	The various coatings used to protect metals, protection coat by heat and electrical deposit treatments. Treatments to provide a pleasing finish such as chromium silver plating, nickel plating and galvanizing. (05hrs.)
Professional Skill 113Hrs; Professional Knowledge 30Hrs	Make different gauges by using standard tools & equipment and checks for specified accuracy. [Different Gauges – Snap gauge, Gap gauge; Specified Accuracy - ± 0.02 mm] **(Mapped NOS:CSC/N0304)**	139. Making a snap gauge for checking a dia. of 10 ±	Gauges and types of gauge commonly used in gauging finished product-Method of selective assembly 'Go' system of gauges, hole plug basis of standardization. (06 hrs.)
		140. Scrape external angular mating surface and check angle with sine bar. (15 hrs.) 141. Scrape on internal surface and check. (10 hrs.)	Bearing-Introduction, classification (Journal and Thrust), Description of each, ball bearing: Single row, double row, description of each, and advantages of double row. (06 hrs.)
		142. Practice in dovetail fitting assembly and dowel pins and cap screws assembly. (16 hrs.) 143. Industrial visit. (5 hrs.)	Roller and needle bearings: Types of roller bearing. Description & use of each. Method of fitting ball and roller bearings (06 hrs.)
		144. Preparation of gap gauges. (12 hrs.) 145. Perform lapping of gauges (hand lapping only) (10 hrs.)	Bearing metals – types, composition and uses. Synthetic materials for bearing: The plastic laminate materials, their

			properties and uses in bearings such as phenolic, Teflon polyamide (nylon). (06hrs.)
		146. Preparation of drill gauges. (10 hrs.) 147. File and fit straight and angular surfaces internally. (13 hrs.) 148. Identify different ferrous metals by spark test (2 hrs.)	The importance of keeping the work free from rust and corrosion. (06 hrs.)
Professional Skill 62 Hrs.; Professional Knowledge 18Hrs	Apply a range of skills to execute pipe joints, dismantle and assemble valves & fittings with pipes and test for leakages.[Range of skills – Cutting, Threading, Flaring, Bending and Joining] **(Mapped NOS:CSC/N0304)**	149. Flaring of pipes and pipe joints. (02 hrs.) 150. Cutting & Threading of pipe length. (3 hrs.) 151. Fitting of pipes as per sketch observing conditions used for pipe work. (10 hrs.) 152. Bending of pipes- cold and hot. (06 hrs.)	Pipes and pipe fitting- commonly used pipes. Pipe schedule and standard sizes. Pipe bending methods. Use of bending fixture, pipe threads-Std. Pipe threads Die and Tap, pipe vices. (06 hrs.)
		153. Dismantling & assembling – globe valves, sluice valves, stop cocks, seat valves and non-return valve. (20 hrs.)	Use of tools such as pipe cutters, pipe wrenches, pipe dies, and tap, pipe bending machine etc. (06 hrs.)
		154. Fit & assemble pipes, valves and test for leakage & functionality of valves. (18 hrs.) 155. Visual inspection for visual defects e.g. dents, surface finish. (1 hr.) 156. Measuring, checking and recording in control chart. (2 hrs.)	Standard pipefitting- Methods of fitting or replacing the above fitting, repairs and erection on rainwater drainage pipes and household taps and pipe work. Inspection & Quality control -Basic SPC -Visual Inspection. (06 hrs.)
Professional Skill 24 Hrs.; Professional Knowledge 06 Hrs.	Make drill jig & produce components on drill machine by using jigs and check for correctness. **(Mapped NOS:CSC/N0304)**	157. Make a simple drilling jig. (20 hrs.) 158. Use simple jigs and fixtures for drilling. (04 hrs.)	Drilling jig-constructional features, types and uses. Fixtures-Constructional features, types and uses. (06 hrs.)
Professional Skill 152Hrs. Professional Knowledge 43 Hrs.	Plan, dismantle, repair and assemble different damaged mechanical components used for power transmission & check functionality. [Different Damage Mechanical Components – Pulley, Gear, Keys, Jibs and Shafts.] **(Mapped NOS:CSC/N0304)**	159. Marking out for angular outlines, filing and fitting the inserts into gaps. (06 hrs.) 160. Exercises on finished material such as aluminium/ brass/ copper / stainless steel, marking out, cutting to size, drilling, tapping etc. without damage to surface of finished articles. (09 hrs.)	Aluminum and its alloys. Uses, advantages and disadvantages, weight and strength as compared with steel. Non-ferrous metals such as brass, phosphor bronze, gunmetal, copper, aluminum etc. Their composition and purposes, where and why used, advantages for specific purposes, surface wearing properties of bronze and brass. (04 hrs.)

		161. Making an adjustable spanner: - Marking out as per Blueprint, drilling, cutting, straight and curve filing, threading, cutting slot and cutting internal threads with taps. (16 hrs.)	Power transmission elements. The object of belts, their sizes and specifications, materials of which the belts are made, selection of the type of belts with the consideration of weather, load and tension methods of joining leather belts. (04 hrs.)
		162. Dismantling and mounting of pulleys. (12 hrs.) 163. Making & replacing damaged keys. (12 hrs.) 164. Dismounting, repairing damaged gears and mounting and check for workability. (16 hrs.) 165. Repair & replacement of belts and check for workability. (12 hrs.)	Vee belts and their advantages and disadvantages, use of commercial belts, dressing and resin creep and slipping, calculation. Power transmissions- coupling types-flange coupling,-Hooks coupling-universal coupling and their different uses. Pulleys-types-solid, split and 'V' belt pulleys, standard calculation for determining size crowning of faces-loose and fast pulleys-jockey pulley. Types of drives-open and cross belt drives. The geometrical explanation of the belt drivers at an angle. Clutch: Type, positive clutch (straight tooth type, angular tooth type). Chains, wire ropes and clutches for power transmission. Their types and brief description. (15 hrs.)
		166. Making of template/gauge to check involute profile. (17 hrs.)	Power transmission –by gears, most common form spur gear, set names of some essential parts of the set-The pitch circles, Diametral pitch, velocity ratio of a gear set. (05 hrs.)
		167. Repair of broken gear tooth by stud and repair broker gear teeth by dovetail. (17 hrs.)	Helical gear, herring bone gears, bevel gearing, spiral bevel gearing, hypoid gearing, pinion and rack, worm gearing, velocity ratio of worm gearing. Repair of gear teeth by building up and dovetail method. (05 hrs.)
		168. Make hexagonal slide fitting. (16 hrs.) 169.Prepare different types of documentation as per industrial need by different methods of recording information. (04 hrs.)	Method or fixing geared wheels for various purpose drives. General cause of the wear and tear of the toothed wheels and their remedies, method of fitting spiral gears, helical gears, bevel gears, worm and worm wheels in relation to required drive. Care and maintenance of gears. (05 hrs.)

		170. Marking out on the round sections for geometrical shaped fittings such as spline with 3 or 4 teeth. Finishing and fitting to size, checking up the faces for universality. (15 hrs.)	Fluid power, Pneumatics, Hydraulics, and their comparison, Overview of a pneumatic system, Boyle's law. Overview of an industrial hydraulic system, Applications, Pascal's Law. (05 hrs.)
Professional Skill 21Hrs; Professional Knowledge 07Hrs	Identify, dismantle, replace and assemble different pneumatics and hydraulics components. [Different components – Compressor, Pressure Gauge, Filter Regulator Lubricator, Valves and Actuators.]	171. Identify pneumatic components – Compressor, pressure gauge, Filter-Regulator-Lubricator (FRL) unit, and Different types of valves and actuators. (2 hrs.) 172. Dismantle, replace, and assemble FRL unit. (5 hrs.) 173. Demonstrate knowledge of safety procedures in pneumatic systems and personal Protective Equipment (PPE). (2 hrs.) 174. Identify the parts of a pneumatic cylinder.(1 hrs.) 175. Dismantle and assemble a pneumatic cylinder.(6 hrs.) 176. Construct a circuit for the direction & speed control of a small-bore single-acting (s/a) pneumatic cylinder. (5 hrs.)	Compressed air generation and conditioning, Air compressors, Pressure regulation, Dryers, Air receiver, Conductors and fittings, FRL unit, Applications of pneumatics, Hazards & safety precautions in pneumatic systems. Pneumatic actuators:- Types, Basic operation, Force, Stroke length, Single-acting and double-acting cylinders. (07 hrs.)
Professional Skill 20Hrs; Professional Knowledge 07Hrs	Construct circuit of pneumatics and hydraulics observing standard operating procedure& safety aspect.	177. Construct a control circuit for the control of a d/a pneumatic cylinder with momentary input signals. (4 hrs.) 178. Construct a circuit for the direct & indirect control of a d/a pneumatic cylinder with a single & double solenoid valve. (08 hrs.) 179. Dismantling &assembling of solenoid valves. (08hrs.)	Pneumatic valves:- Classification, Symbols of pneumatic components, 3/2-way valves (NO & NC types) (manually-actuated & pneumatically-actuated) & 5/2-way valves, Check valves, Flow control valves, One-way flow control valve Pneumatic valves: Roller valve, Shuttle valve, Two-pressure valve Electro-pneumatics: Introduction, 3/2-way single solenoid valve, 5/2-way single solenoid valve, 5/2-way double solenoid valve, Control components -Pushbuttons (NO & NC type) and Electromagnetic relay unit, Logic controls. (07 hrs.)
Professional Skill 20Hrs; Professional Knowledge 07Hrs	Identify, dismantle, replace and assemble different pneumatics and hydraulics components. [Different components – Compressor, Pressure Gauge, Filter Regulator Lubricator, Valves and Actuators.]	180. Demonstrate knowledge of safety procedures in hydraulic systems (Demo by video) (04 hrs.) 181. Identify hydraulic components – Pumps, Reservoir, Fluids, Pressure relief valve (PRV), Filters, different types of valves, actuators, and hoses (04 hrs.) 182. Inspect fluid levels, service reservoirs, clean/replace filters (04 hrs.) 183. Inspect hose for twist, kinks, and minimum bend radius, Inspect hose/ tube fittings (04 hrs.)	- Symbols of hydraulic components, Hydraulic oils – function, properties, and types, Contamination in oils and its control - Hydraulic Filters – types, constructional features, and their typical installation locations, cavitation, Hazards & safety precautions in hydraulic systems - Hydraulic reservoir & accessories, Pumps, Classification – Gear/vane/ piston types, Pressure relief valves – Direct acting and pilot-operated types

		184. Identify internal parts of hydraulic cylinders, pumps/motors (04 hrs.)	- Pipes, tubing, Hoses and fittings – Constructional details, Minimum bend radius, routing tips for hoses. (07 hrs.)
Professional Skill 18 hrs.; Professional Knowledge 05Hrs	Construct circuit of pneumatics and hydraulics observing standard operating procedure& safety aspect.	185. Construct a circuit for the control of a s/a hydraulic cylinder using a 3/2-way valve (Weight loaded d/a cylinder may be used as a s/a cylinder), 4/2- & 4/3-way valves. (8 hrs.) 186. Maintenance, troubleshooting, and safety aspects of pneumatic and hydraulic systems (The practical for this component may demonstrated by video). (10 hrs.)	- Hydraulic cylinders –Types - Hydraulic motors –Types - Hydraulic valves: Classification, Directional Control valves – 2/2- and 3/2-way valves - Hydraulic valves: 4/2- and 4/3-way valves, Centre positions of 4/3-way valves - Hydraulic valves: Check pneumatic and hydraulic systems (The practical for this component may demonstrated by video). (10 hrs.) valves and Pilot-operated check valves, Load holding function - Flow control valves: Types, Speed control methods – meter-in and meter-out - Preventive maintenance & troubleshooting of pneumatic & hydraulic systems, System malfunctions due to contamination, leakage, friction, improper mountings, cavitation, and proper sampling of hydraulic oils. (05 hrs.)
Professional Skill 80Hrs; Professional Knowledge 23Hrs	Plan & perform basic day to day preventive maintenance, repairing and check functionality. [Simple Machines – Drill Machine, Power Saw and Lathe] **(Mapped NOS:CSC/N0304)**	187. Dismantle, overhauling & assemble cross-slide & hand-slide of lathe carriage. (20 hrs.)	Importance of Technical English terms used in industry –(in simple definition only)Technical forms, process charts, activity logs, in required formats of industry, estimation, cycle time, productivity reports, job cards. (05 hrs.)
		188. Simple repair of machinery: - Making of packing gaskets. (04 hrs.) 189. Check washers, gasket, clutch, keys, jibs, cotter, Circlip, etc. and replace/repair if needed. (04 hrs.) 190. Use hollow punches, extractor, drifts, various types of hammers and spanners, etc. for repair work. (16 hrs.) 191.Dismantling, assembling of different types of bearing and check for functionality. (20 hrs.) 192. Perform routine check of machine and do replenishas per requirement. (15 hrs.)	Method of lubrication-gravity feed, force (pressure) feed, splash lubrication. Cutting lubricants and coolants: Soluble off soaps, suds-paraffin, soda water, common lubricating oils and their commercial names, selection of lubricants. Washers-Types and calculation of washer sizes. The making of joints and fitting packing. (18 hrs.)

Professional Skill 75 Hrs; Professional Knowledge 16Hrs	Plan, erect simple machine and test machine tool accuracy. [Simple Machines – Drill Machine, Power Saw and Lathe]	193. Inspection of Machine tools such as alignment, levelling. (10 hrs.) 194. Accuracy testing of Machine tools such as geometrical parameters. (15 hrs.)	Lubrication and lubricants- purpose of using different types, description and uses of each type. Method of lubrication. A good lubricant, viscosity of the lubricant, Main property of lubricant. How a film of oil is formed in journal Bearings. (04 hrs.)
		195. Practicing, making various knots, correct loading of slings, correct and safe removal of parts. (5 hrs.) 196. Erect simple machines. (45 hrs.)	Foundation bolt: types (Lewis cotter bolt) description of each erection tools, pulley block, crowbar, spirit level, Plumb bob, wire rope, manila rope, wooden block. The use of lifting appliances, extractor presses and their use. Practical method of obtaining mechanical advantage. The slings and handling of heavy machinery, special precautions in the removal and replacement of heavy parts. (12 hrs.)

Scan the QR Code to view the video for these exercise

Module 1 - Ex.No. 2.1.115 to 2.1.138

Screw drivers

Ex.No.2.1.116-118

Locking devices - Nuts - Types

Ex.No.2.1.119

Template and gauges

Ex.No.2.1.123

Module 2

Ex.No. 2.2.139 to 2.2.148

Gauges

Ex.No.2.2.139

Module 3

Ex.No. 2.3.149 to 2.3.156

Pipes and pipe fittings

Ex.No.2.3.149-152

Module 6

Ex.No. 2.6.171 to 2.7.186

Non-return valve/check valve

Ex.No.2.6.178

Screws

Objectives: At the end of this lesson you shall be able to
- **state the results of poor selection of fasteners**
- **state the various types of fasteners in industrial use**
- **state the types of thread fasteners and their uses - machine bolts, machine screws, cap screws and set screws.**

In the industrial field much depends on the proper choice of fasteners to be used in each job.

- A poorly selected fasteners might greatly lead to unsafe condition.
- Increase the assembly cost.
- Products are inferior quality.

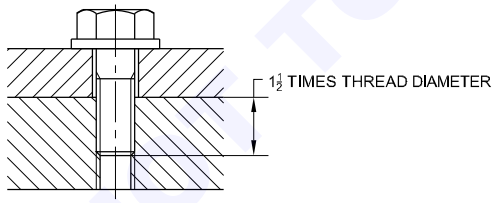
Various types of fasteners

- Threaded fasteners
- Rivets
- Pins
- Retaining ring or circlips
- Keys
- Staples
- Adhesives.

Threaded fasteners

Fasteners: Fasteners that fall into category utilise the wedging action of screw thread for clamping pressures. To achieve maximum strength, a threaded fasteners should screw into its mating part a distance equal to 1.5 times (minimum) the diameter of thread. (Fig 1)

Fig 1



Machine screws: Machine screws are used for general assembly work. (Fig 2) It is manufactured in both COARSE and FINE series, fitted with either a slotted or recessed head. (Fig 3)

Fig 2

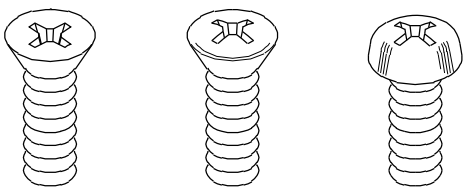
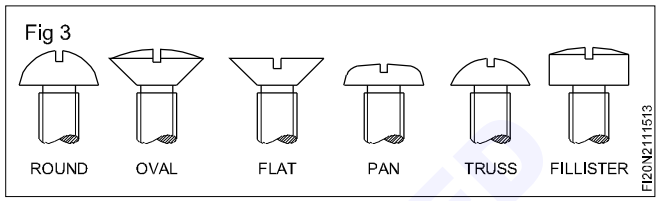


Fig 3



Sizes vary in diameter from 1.5 mm to 12 mm and in length 2 mm to 75 mm.

Machine bolts: Machine bolts (Fig 4) are manufactured with square and hexagonal heads. They are used where a close tolerance assembly is not required. Available in diameter 6 mm to 75 mm and in length 12 mm to 300 mm. Tightening the nut on machine bolt (Fig 5) produce clamping action.

Fig 4

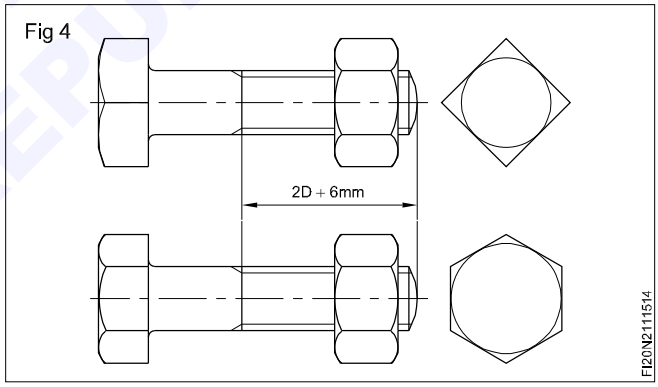
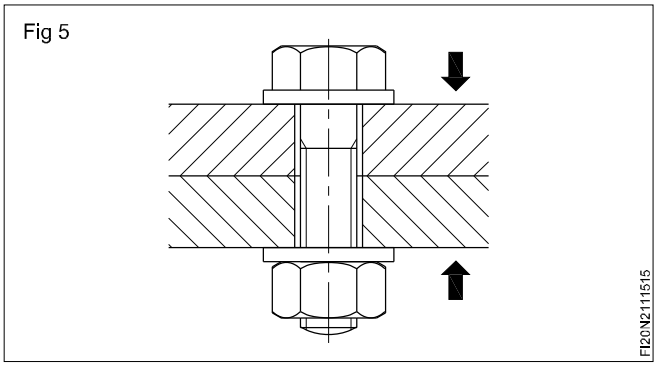


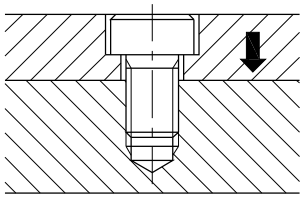
Fig 5



Cap screws: Cap screws are used when assembly requires a stronger, more precise and better appearing fastener. A cap screw is fitted through a clearance hole in one of the piece and screws into a threaded hole.

A clamping action is developed by tightening the cap screws. (Fig 6)

Fig 6



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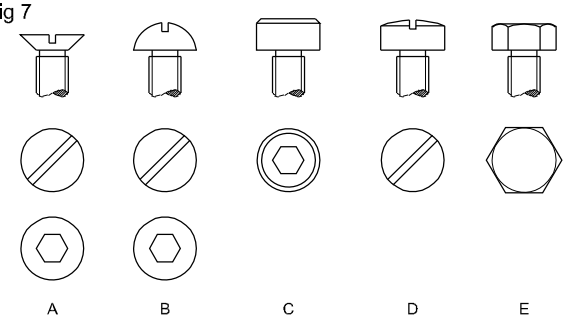
Cap screws are manufactured to closer tolerance than machine bolts and produced with semi-finished bearing surface. They stocked in aluminium, brass, bronze, mild steel, alloy steel (Heat treated), stainless steel and titanium and in coarse in fine and special thread series (Fig 7).

Fig 7



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Cap screws are available in diameter from 6 mm to 50 mm and in length from 10 mm to 200 mm. Nuts are not included with cap screws.

Set screws: Set screws are used to prevent pulleys from slipping on shafts, positioning and holding collars in place, on shafts and holding shafts in place in assemblies. (Fig 8)

Headless set screws have either a slotted or socket head and threaded entire length. Screw points are available in various styles and their recommended use. (Fig 9)

Fig 8

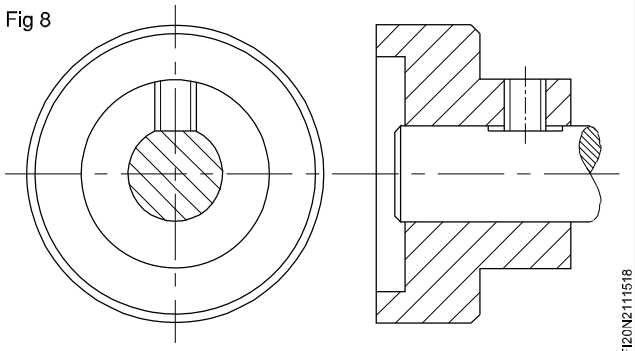

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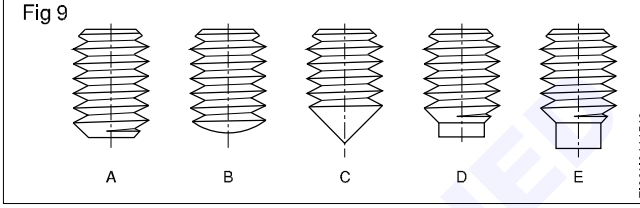
Fig 9



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Uses

A Flat point set screw is used on parts requiring frequent adjustment.

B Oval point set screw is used against a shaft that has been spotted to receive it.

C Cone point set screw is used for setting machine parts permanently on shaft and it is used as a pivot or hanger and for adjustment.

D The half dog point set screws is probably one of the most useful and it can be used as a dowel. A hole is drilled to receive the point.

E The full dog point set screw is suitable for use as a key that slides in a key way.

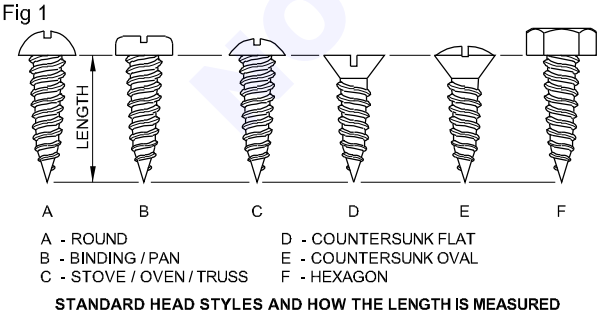
Types of screws

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

- **state the various types of fastening screws and their uses**

Self tapping screw: To eliminate the cost of tapping, a thread forming screw has been derived. These are designed to form a thread as they are driven. (Fig 1)

Fig 1



STANDARD HEAD STYLES AND HOW THE LENGTH IS MEASURED

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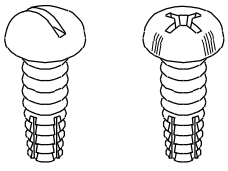
Thread cutting screws: Thread cutting screws which are hardened, actually cut rather than form threads.

Type F: Cuts a standard machine thread used in castings and forgings. (Fig 2)

Fig 2



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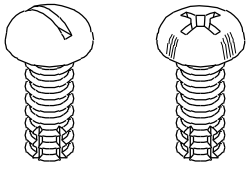
Type BF: This screw is recommended for die castings and plastics. (Fig 3)

Fig 3



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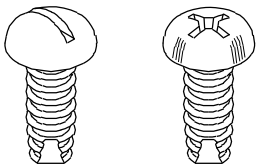
Type L: Widely used with plastics. (Fig 4)

Fig 4



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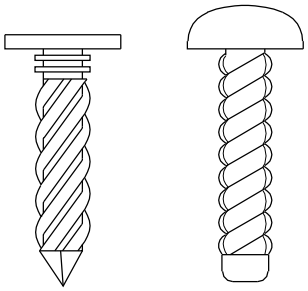
Driver screws: Driver screws are simply hammered into a drilled hole or punched hole of the proper size. They make a permanent joints. (Fig 5)

Fig 5



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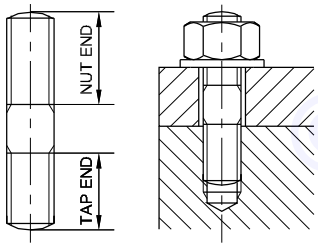
Stud bolts: Stud bolts are threaded on both ends. One threaded end is designated for semi-permanent installation in a tapped hole while the other end threaded for standard nut assembly to clamp the pieces together. (Fig 6)

Fig 6



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Non threaded fastening devices

Dowel pins: Dowel pins are made of heat treated alloy steel and are used in assemblies where a parts must be accurately positioned and held in absolute relation to one another. They assure perfect alignment and facilitate quicker disassembly of parts and reassembly in exact relationship.

Property classes (as per IS/ISO) IS: 1367

The symbol for the property classes of bolts, screws and studs consists of two numbers separated by a point. The first number, when multiplied by one hundred, indicates the nominal tensile strength in newtons per square millimeter. The second figure, multiplied by ten, states the ratio between the lower yield stress and the nominal tensile strength (yield stress ratio) as a percentage. The multiplication of these two figures will give one tenth of the yield stress in newtons per square millimeter.

Example of a screw in property class 5.8

Nominal tensile strength

5 x 100 = 500 N/mm^2 (MPa)

Yield stress ratio

8 x 10 = 80%

Yield stress

80% of 500 = 400 N/mm^2 (MPa)

The designation consists of two figures:

- The first figure indicates 1/100 of the nominal tensile strength in N/mm^2 and
- The second figure indicates 1/10 of the ratio, expressed as a percentage, between nominal yield stress and nominal tensil strength.

The multiplication of these two figures will give 1/10 of the nominal yield stress in N/mm^2.

Designation: Metric thread bolts, screws are identified by a letter M for the thread profile form. The letter M is followed by the value of nominal diameter expressed in millimeters and nominal length separated by the sign “x”. (Example: M 8 x 35)

Materials: The table below specifies steel for the different property class of bolts, screws and studs. The minimum tempering temperature is mandatory for property classes 8.8 to 12.9 in all cases.

Chemical composition

Property Class	Material and Treatment	Chemical composition limits %				Tempering Temperature RE° C Min
		C		P	S	
		min.	max.	max.	max	
4.6, 4.8, 5.8, 6.8*	Low or medium carbon steel	-	0.55	0.05	0.06	-
8.8	Medium carbon steel quenched, tempered	0.25	0.55	0.04	0.05	425
9.8	medium carbon steel quenched, tempered	0.25	0.55	0.04	0.05	425
10.9	Medium carbon steel additives e.g. boron, Mn, Cr or Alloy steel-quenched, tempered	0.20	0.55	0.04	0.05	425
12.9	Alloy steel-quenched, tempered	0.20	0.50	0.035	0.035	380

- Free cutting steel is allowed for these classes with the following maximum sulpher, phosphorus and lead content:

  S-0.34% P- 0.11% Lead - 0.35%

- Alloy steel shall contain one or more of chromium, nickel, molybedenum or vanadium
- For size M20 and larger a temperature of 425° C may be used.

Note:

Property class 9.8 applies only to sizes up to 16 mm thread diameter and is included for information only and manufacture of products with this property class is to be discouraged.

The minimum tempering temperatures listed in above listed in above table are mandatory for property classes 8.8 to 12.9 in all cases.

Mating screws and nuts

Property classes bolts, screws, studs	3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9	14.9
Property classes nuts	5					6	8	9	10	12	14

Nuts of a higher property class can normally to be used in the place of nuts of a lower property classes.

- Property classes 14.9 are not ISO or ANSI standard = quenched and tempered

Screw drivers

Objectives : At the end of this lesson you shall be able to
- **state different types of screw drivers and their uses**
- **specify a screw driver**
- **list the precautions to the observed while using screw driver.**

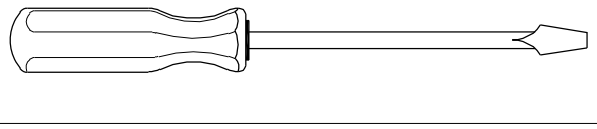
Screwdrivers are used to tighten or loosen screws and are available in various lengths.

Hand-held screwdrivers are of the following types.

Standard screwdriver (Light duty) (Fig 1)

It is of round shank/blade with metal, wood or moulded, insulated material handle.

Fig 1



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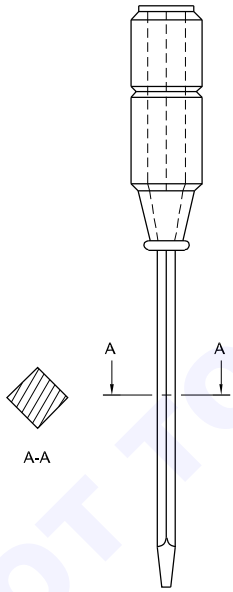
Standard screwdriver (Heavy duty) (Fig 2)

Fig 2



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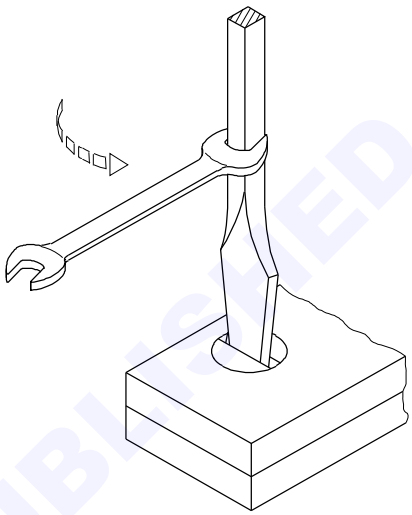
It has a square blade. The shank is also of square section for applying extra twisting force with the end of a spanner. (Fig 3)

Fig 3



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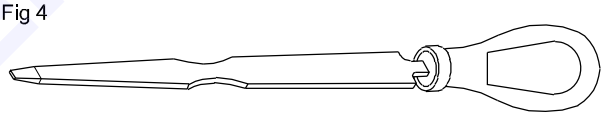
Heavy duty screwdriver (London pattern) (Fig 4)

Fig 4



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It has a flat blade and is mostly used by carpenters for fixing and removing wood screws.

Philips screwdriver (Fig 5)

These are made with cruciform (Fig 6) tips that are unlikely to slip from the matching slots. (Fig 7) Philips recess head screws are shown in Fig 8.

Fig 5

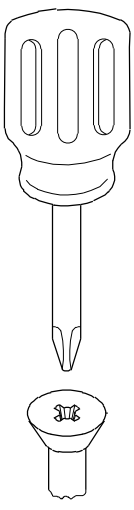

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Fig 6

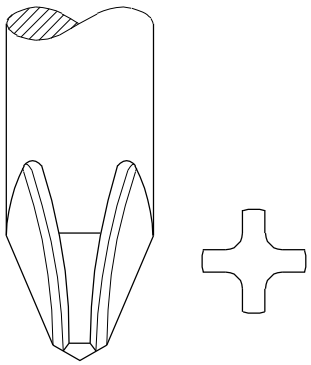

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Fig 7

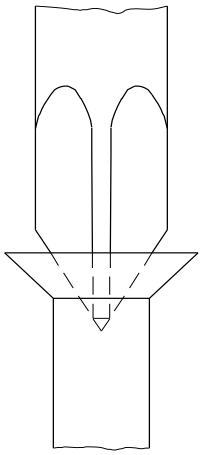

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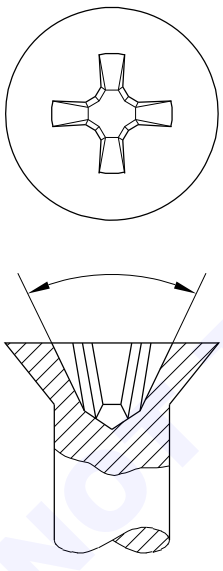
Fig 8



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The sizes of Philips screwdrivers are specified by point size 1, 2, 3 and 4.

Offset screwdrivers (Fig 9)

These are useful in some situations (Fig 10) where the normal screwdriver cannot be used because of the length of the handle. They are also useful for applying greater turning force.

For quicker application ratchet offset screwdrivers are also available with renewable tips. (Fig 11)

Fig 9

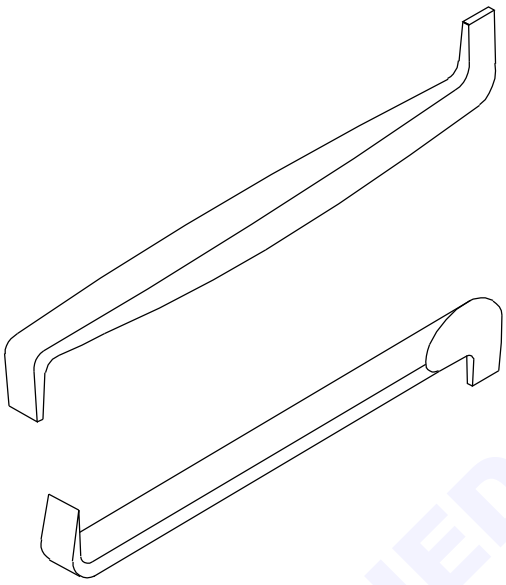

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Fig 10

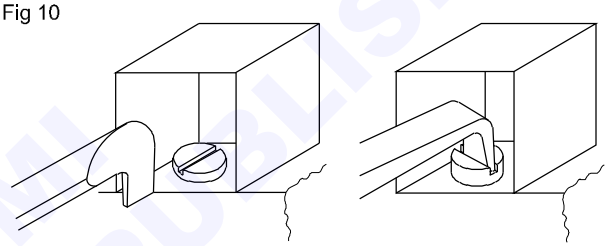

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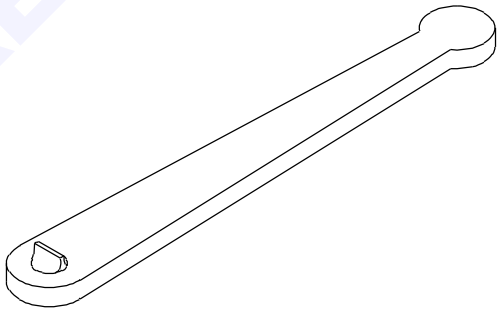
Fig 11



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Specification

Screwdrivers (Fig 12) are specified according to the

- length of the blade
- width of the tip.

Normal blade length: 45 to 300mm. Width of blade : 3 to 10mm.

The blades of screwdrivers are made of carbon steel or alloy steel, hardened and tempered.

Screwdrivers for special uses

Small sturdy screwdrivers are available for use where there is limited space. (Fig 13)

Screwdrivers with blades sheathed in insulation are available for the use of electricians. (Fig 14)

Fig 12

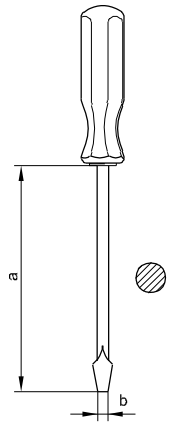

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Fig 13

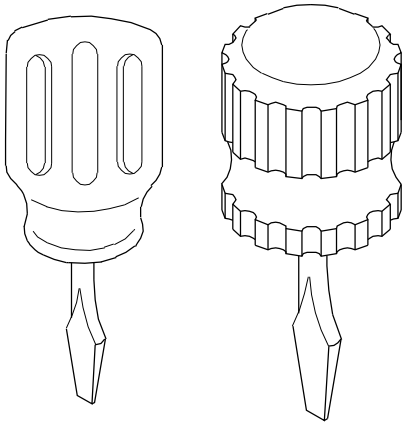

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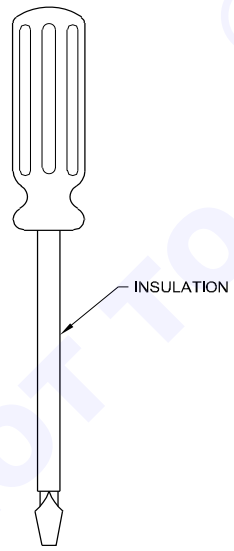
Fig 14



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Precautions

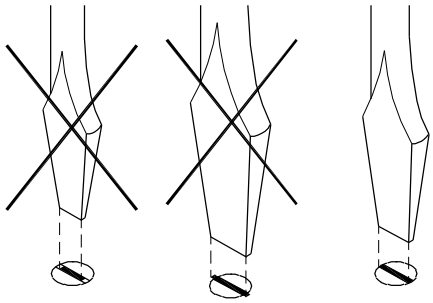
Use screwdrivers with tips correctly fitting into the screw slot. (Fig 15)

Make sure your hand and the handle are dry.

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

While using a Philips screwdriver apply more downward pressure.

Fig 15



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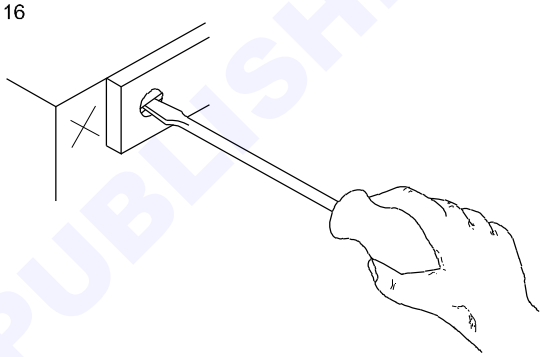
Keep your hand away to avoid injury due to slipping of screwdriver. (Fig 16)

Fig 16



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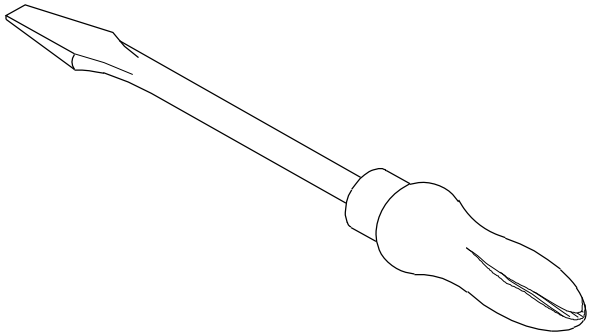
Do not use screwdrivers with split or defective handles. (Fig 17)

Fig 17



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In the case of damaged screwdrivers, the blades can be ground (the faces will be parallel with the sides of the screw slot) and used. While grinding ensure the end of the tip is as thick as the slot of the screw.

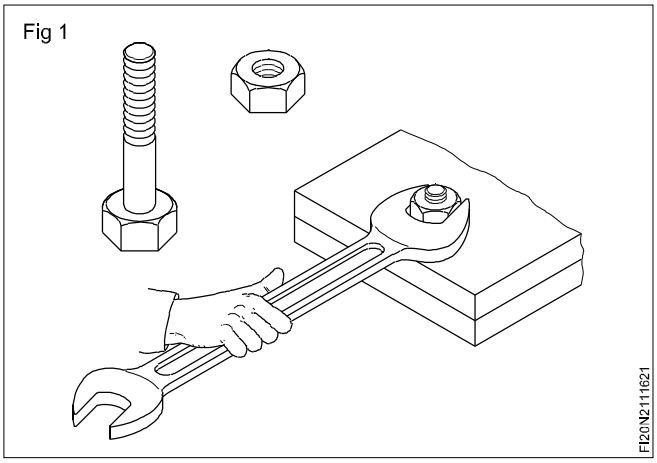
While using screwdrivers on small jobs, place the jobs on the bench or hold them in a vice.

Spanners

Objectives: At the end of this lesson you shall be able to
- **state the uses of different sizes of spanners**
- **identify the size of a spanner.**

A spanner is a hand tool with jaws or opening or a ring at one end or at both ends for tightening or slackening nuts and bolts and screw heads. (Fig 1) It is made of drop-forged, high tensile or alloy steel and heat treated for strength.

Fig 1



Types of spanners

- Open end spanners
- Ring spanners

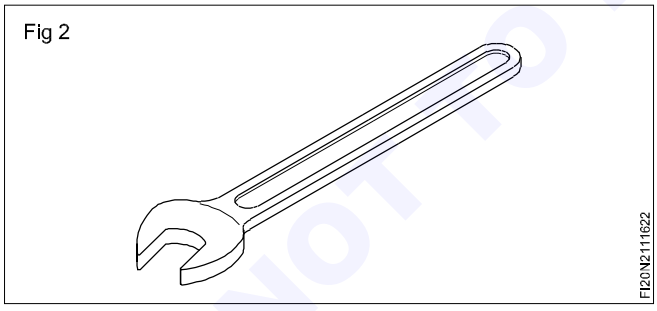
Open end spanners

They can be single ended or double ended.

Single-ended spanners

These are general purpose spanners. Single-ended spanners are mostly supplied with machine tools for a specific purpose. (Fig 2)

Fig 2



Double-ended spanners

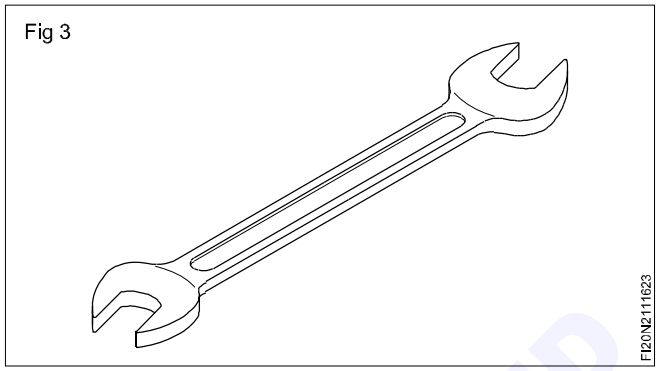
Double-ended spanners are standard spanners having two different size openings. Some spanners are made of chrome vanadium steel.

They are available in a set of 8, Nos 8 to 27 mm. (Fig 3)

8x10, 9x11, 12x13, 14x15, 16x17, 18x19, 20x22 and 24x27 mm.

Bigger than 27 mm size open end spanners are also available.

Fig 3



Ring spanners (Figs 4,5 & 6)

Fig 4

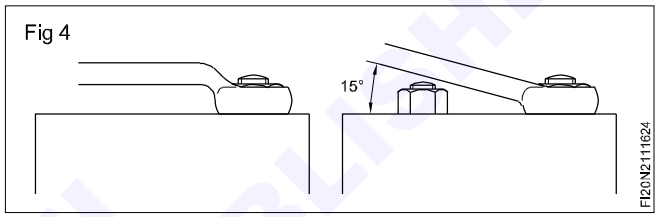


Fig 5

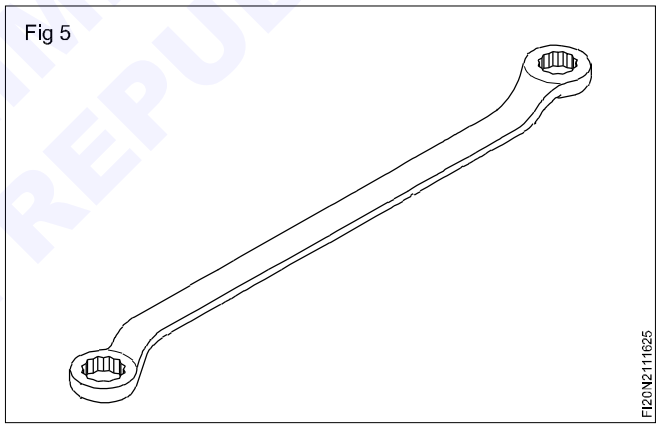
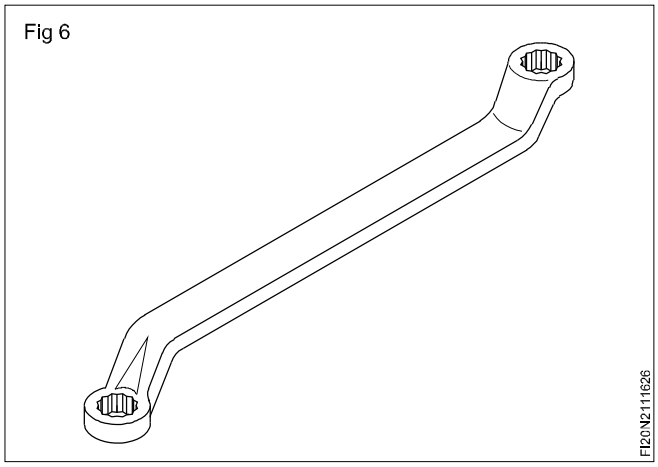


Fig 6



These types of spanners are used where obstruction close to the side of a nut prevails (Fig 4) and application of open-ended spanners is not possible.

These are available in a set of 8 Nos. (8 to 27 mm)

8x9, 10x11, 12x13, 14x15, 16x17, 18x19, 20x22 and 24x27 mm.

Sizes and identification of spanners

Spanners for metric bolts, nuts and screws are marked with the size across the jaw opening in mm.

Special purpose spanners

- Tube or tubular box spanners (Figs 7 & 8)

Fig 7

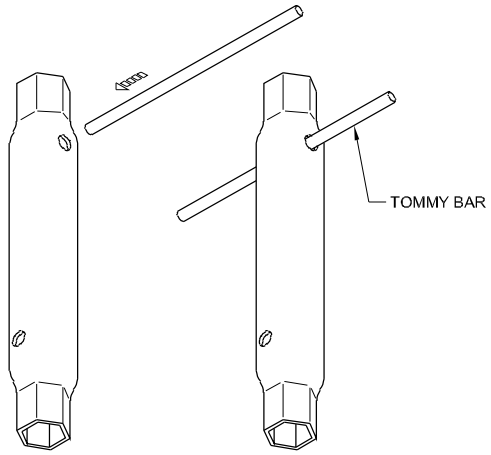
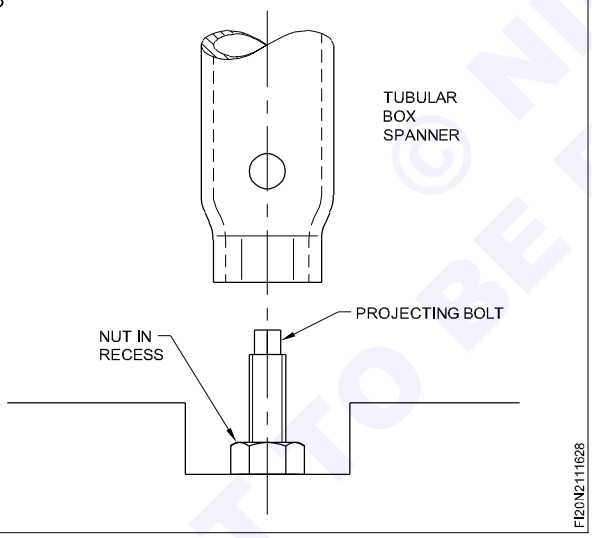
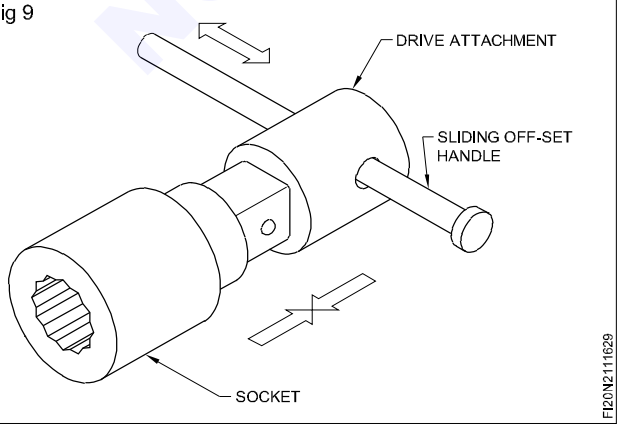


Fig 8



- Socket spanners (Fig 9)

Fig 9



- Adjustable spanners (Figs 10 &11)

Fig 10

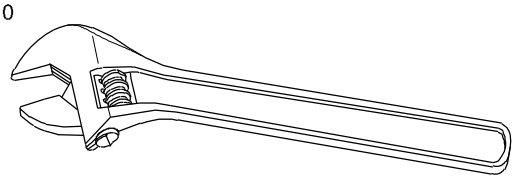
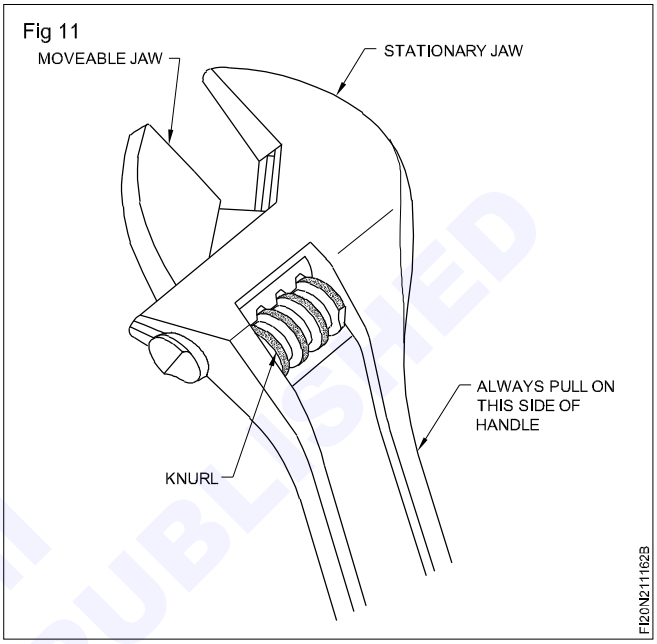


Fig 11



- Hook spanners (C-spanner) (Figs 12 & 13)

Fig 12

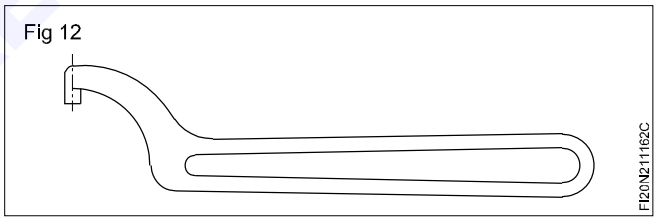
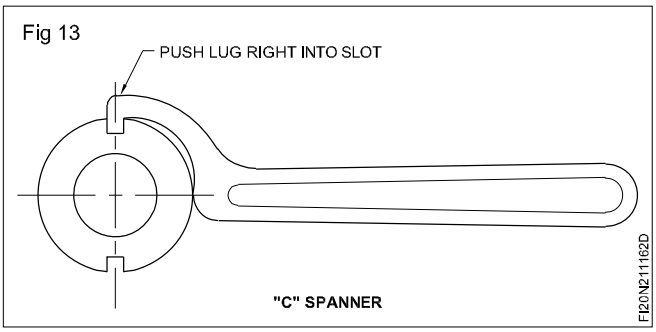


Fig 13



Power tools

Objectives: At the end of this lesson you shall be able to
- **define power tool, torque and torque wrench**
- **state care and maintenance of power tools.**

What does power tools mean?

Power tool is a device that is activated by a power source apart from manual labor. There are various types of power tools, e.g., electric screwdriver, hammer drills, and fast screw guns. The tools are used construction and several do it your self jobs such as productions, assembly, packaging, and maintenance. They are available in multiple sizes and shapes and are simple to operate.

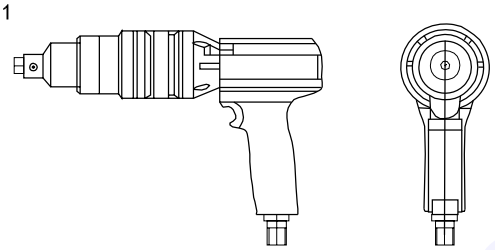
Power wrench (Fig 1)

A power wrench is type of wrench that is powered by other means than human force. A typical power source is compressed air. There are two main types of power wrenches:

1 Impact wrenches and

2 Air ratchet or pneumatic ratchet wrenches

Fig 1



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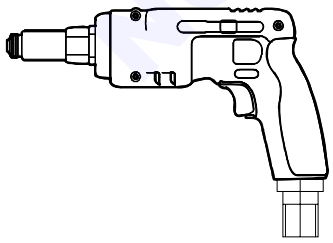
Air ratchet wrench

An air ratchet wrench is very similar to hand powered ratchet wrenches in that it has the same square drive, but an air motor is attached to turn the socket drive. Pulling the trigger activates the motor which turns the socket drive. A switch is provided to change the direction of socket drive.

This type of power wrench is designed more for speed and less for torque. If high levels of torque are desired an impact wrench should be used.

Pneumatic torque wrench (Fig 2)

Fig 2



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Pneumatic torque wrench setting torque on bolts.

A pneumatic torque wrench is a primary torque multiplier or a gear box that is mated to a pneumatic air motor. At the end of the gear box is a reaction device that is used to absorb the torque and allows the tool operator to use it with very little effort. The torque output is adjusted by controlling the air pressure.

These planetary torque multiplier gearboxes have multiplication ratios up to 125:1 and are primarily used anywhere accurate torque is required on a nut and bolt, or where a stubborn nut needs to be removed.

The pneumatic torque wrench is sometimes confused with a standard impact wrench due to their similar appearance. A pneumatic torque wrench is driven by continuous gearing and not by the hammers of an impacting wrench. A pneumatic torque wrench has very little vibration and excellent rebeatability and accuracy.

Torque capabilities of pneumatic torque wrenches range from 118Nm, up to a maximum of 47,600Nm.

Air requirements

A pneumatic motor using compressed air is the most common source of power for pneumatic torque wrenches. CFM requirements are usually 20-25 CFM of air consumption per tool.

CFM - Cubic feet/minute (or) PSI - Pounds/square inch.

Torque wrenches

Screwdrivers are available - manual, electric and pneumatic with a clutch that slips at a preset torque. This helps the user tighten screws to a screws to a specified torque without damage or over - tightening. Cordless drills designed to use as screwdrivers often have such a clutch.

Torque

- Torque is the application of a force acting at a radial distance and tending to cause rotation
- Torque is used to create tension in thread fasteners
- When the nut and bolt are tightened the two plates are clamped together. The thread converts the applied torque into tension in the bolt shank. This turn is converted into clamping force. The amount of tension created in the bolt is critical.

Torque wrench

A tool for setting and adjusting the tightness of nuts and bolts to a desired value is called torque wrench.

Fastener tightening

- Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench.
- When reading a bar type torque wrench, look straight down at the scale.
  - Viewing from an angle can give a false reading.
- Only pull on the handle of the torque wrench.

- do not allow the beam of the wrench to touch any thing.

- Tighten bolts and nuts incrementally
- Typically,this should be to one-half specified torque, to three-fourth torque, to full torque, and then to full torque a second time.

Maximum Tightening Torque

Screw Size	Maximum Torque
M4	270 Nm
M5	5.40 Nm
M6	9.50 Nm
M8	22.0 NM
M10	44.0 NM

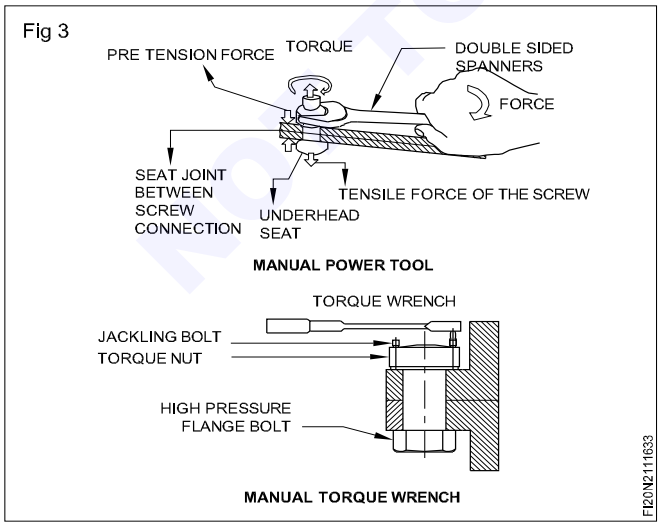
Power Screwdriver

A power screwdriver will merely give us a screw driving capability at a quick and efficient manner. They are designed to work at a slower rate than typical power drills. They however have more torque drills, giving us the ability for more power, such as drilling screws into materials without having to do any predrilling. Solid models will give us torque limiters and allow you to set the maximum torque to save the head of the screw or any mishaps of snapping.

Uses of power screwdrivers will really depend on the person and project out there, but are less versatile since the attachments are as of variety when compared to drills. We know many who have both a power screwdriver and drill for more versatility in their work flow. They can also help is in hard-to-reach spots and corners since they are usually they are less weight drills and only take one hand to use.

Explanation on the creation of a clamping force (Fig 3)

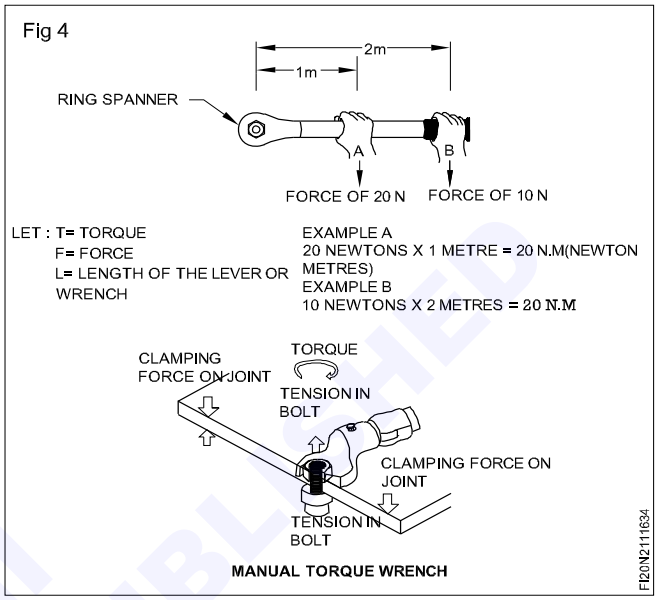
Fig 3



The tension in the bolt creates a clamping force (generally referred to as the preload) between the two parts
If the clamping force is too low, the fasteners can work loose due to vibrations or movement between the component parts
If a clamping force is too high, the fastener may permanently stretch and no longer apply the required clamping force.
In severe cases the fastener may fail in assembly or during use when under loaded

How to calculate torque (Fig 4)

Fig 4



Torque is the result of multiplying the valve of force applied by the distance from the point of application

Comparing the two examples below (A and B) it will be noted that the same resultant torque can be achieved with a lower force if the distance from the nut/bolt is increased

It should also be realised that some torque wrenches are length dependent which means that the actual torque applied to the fastener varies if the hand position on the wrench is varied - even with the wrench preset. This occurs if the pivot point of the wrench mechanism is not coincidental with the point of application of torque.
(Fig 5 to 10)

Fig 5

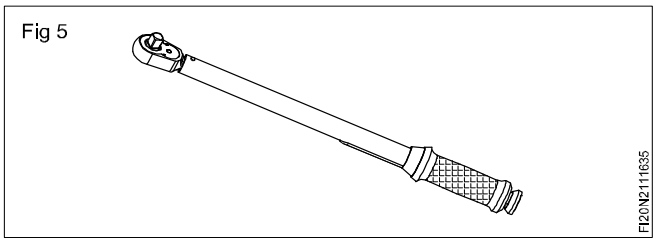


Fig 6

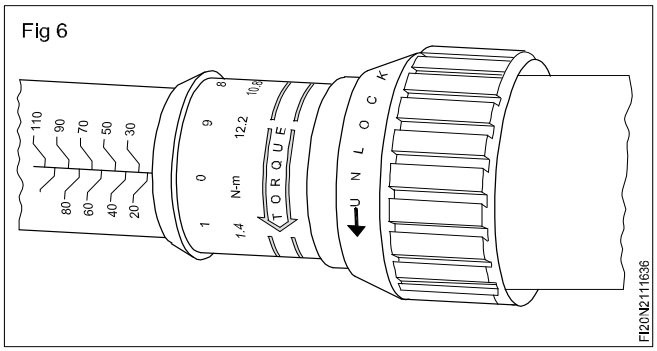


Fig 7

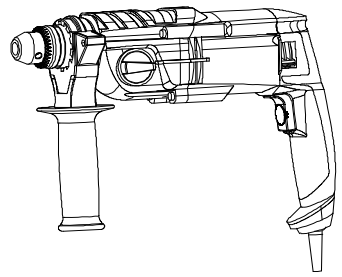


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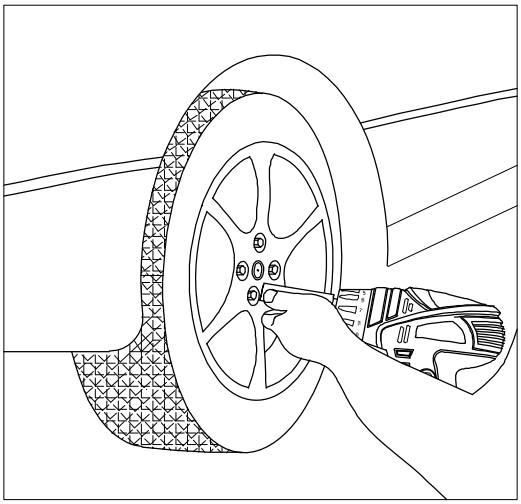
Fig 8



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Maintenance of power tools

Power tools and other machines are designe for long life, but each requires some care and maintenance to meet its life expectancy. Properly storing power tools, performing maintenance as needed, and replacing machine parts will extend a tool's life to its full potential and deliver more value to its owner.

Proper storage

Our three guidelines for tool storage are:

1 Store tools in an area protected from the elements (like moisture).

2 Store tools in a clean and organized space.

3 Store tools in a well-ventilated area.

Keeping tools out of the elements protects them from damage and wear. A clean and organized storage space will promote safety, and keeping tools well-ventilated will help them run smoothly when it's time to pull them out of storage.

It might take a little extra time to put everything back in place at the end of the day or completion of a project, but storing tools the right way will always be worth the effort.

Care and maintenance

Before being stored, most power tools can use a little cleaning and a couple of quick checks for damage or other problems. Here's some maintenance tips for keeping those tools in good shape.

- Use a tooth brush and a soft cloth to wipe debris from power tool casings before storage.

Fig 9

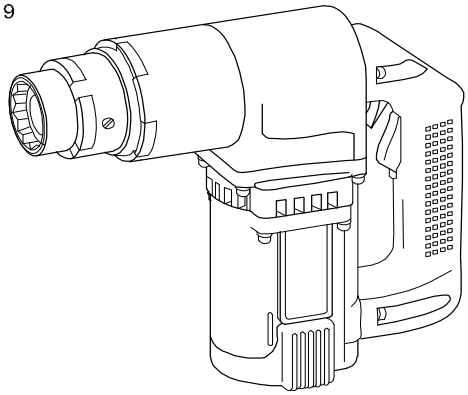

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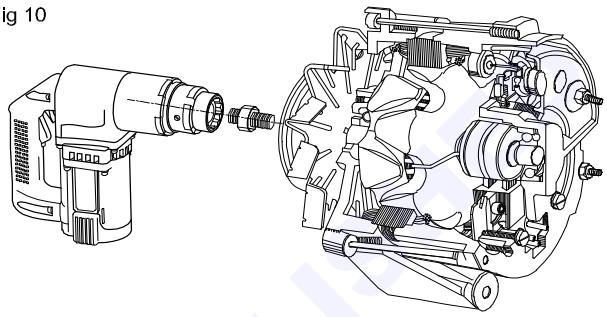
Fig 10



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- If available, use an air compressor to clean out power tool vents. A little air will go a long way. When a machine or tool can breathe more, it will run cooler and wear more slowly. For an "Air compressors 101" article -click here,
- Lubricate power tool parts that need to be lubricated. Following instructions in the tool's user manual will be help here.
- Check the parts that hold a tool together, screws and other fasteners. Tighten up anything that might have been shaken loose during operation.
- Electrical cords should be checked with each use of a power tool.
- A bad power cord can be dangerous and should be replaced before the tool is used again. For more information about power cords - click here.
- Keep blades and other cutting accessories sharp. Check bits and other accessories for wear and damage.
- Follow any other maintenance guidelines for a tool or machine explained in its user manual.

Replacing parts

Like cars and other machinery, many power tool parts are designed for wear and replacement. The expected service life of a power tool takes the replacement of certain parts into account.

Some examples of parts that commonly need to be replaced on power tools are : Carbon brushes, switch assemblies, power cords, accessories, bearings, and tires. Performing the checks and maintenance suggested in the section above is important for catching tool performance issues right when they start acting up.

Making tool repairs at the first sign of performance trouble can prevent damage to other parts of machine or tool.

Locking devices - Nuts - Types

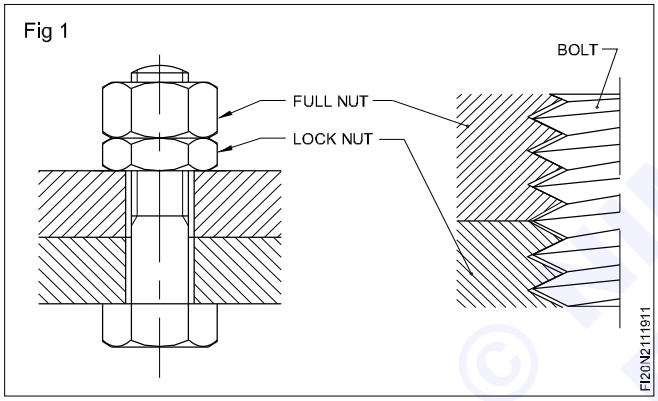
Objectives : At the end of this lesson you shall be able to
- **state the different types of locking devices**
- **state the uses of locking devices.**

Nuts used along with bolts in assembly may loosen due to vibration. Different types of nut-locking devices are used depending on the severity of the condition in which the fastener is used. The following are the most commonly used types.

Lock-nut

A thin nut with both faces machined is placed below a nut in the assembly. (Fig 1) Both nuts are tightened over the bolt one after the other. Then using two spanners pressure is exerted on both nuts by turning in opposite directions. Both nuts are held together by friction.

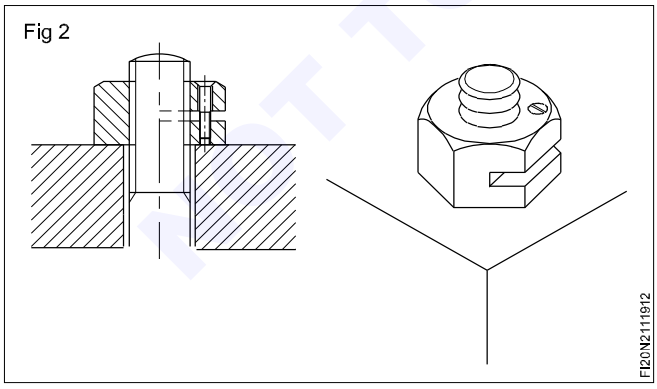
Fig 1



Sawn nut (Wiles nut)

In this type of locking, a slot is cut half way across the nut. A screw is fitted with a clearance hole on the top part and matching thread on the lower part of the nut. (Fig 2) Tightening of the nut provides positive locking for the nut.

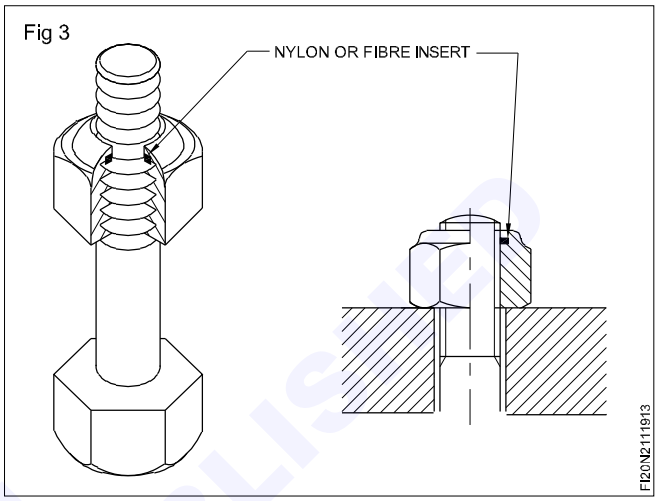
Fig 2



Self-locking nut (Simmonds nut)

This is a special nut with a nylon or fibre ring insert placed in the upper part of the nut. The internal diameter of the ring is smaller than the core diameter of the bolt thread. The nut while tightening cuts its own thread on the nylon insert. This provides a positive grip and prevents the nut from loosening due to vibration. (Fig 3)

Fig 3

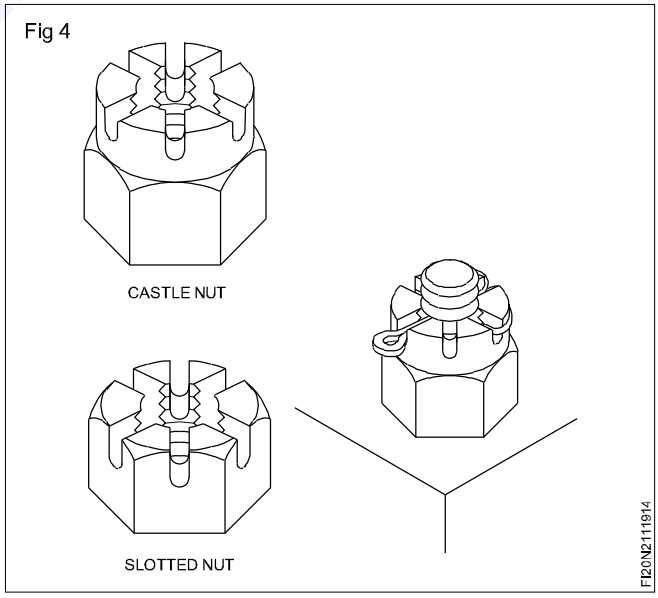


Slotted and castle nuts

These nuts have special provision in the form of slots for fixing split pins for locking the nuts.

Slotted nuts are hexagonal shaped throughout. (Fig 4) in the case of castle nuts, the top part of the nut is cylindrical in shape.

Fig 4



Slotted and castle nut with split pin

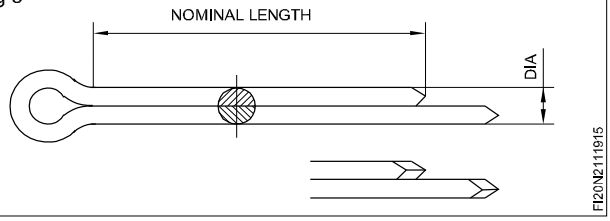
The position of the nut can be locked using a split pin.

Split pins are designated by the nominal size, nominal length, the number of the Indian Standard and the materials (for materials other than steel only).

The nominal size is the diameter of the hole for receiving the split pins.

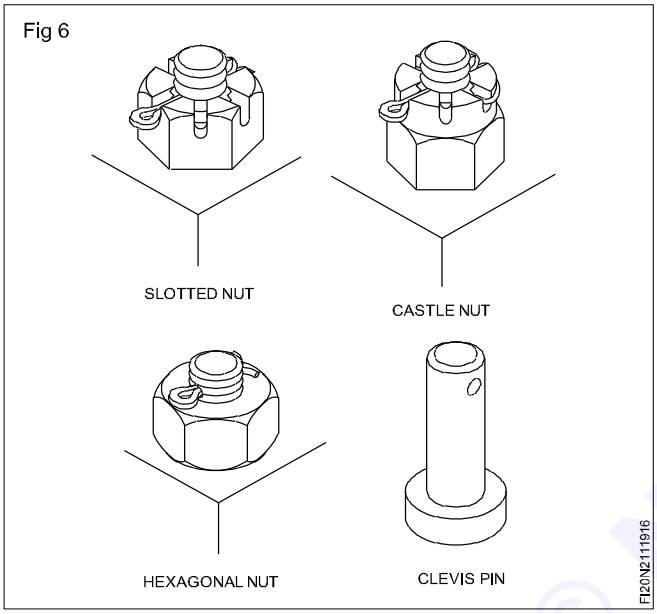
The nominal length is the distance from the underside of the eye to the end of the short leg. (Fig 5)

Fig 5



Split pins are used for locking slotted nuts, castle nuts, hexagonal nuts, clevis pins etc. and are used in different ways. (Fig 6)

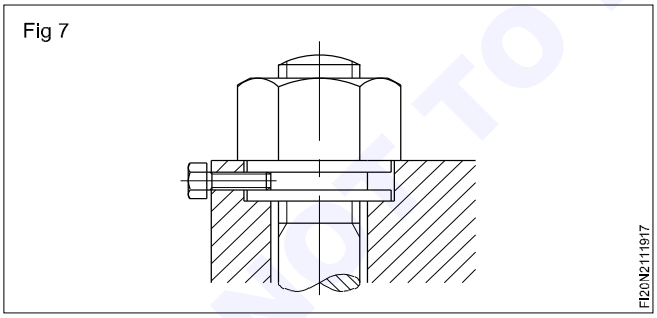
Fig 6



Grooved nut (Penning nut)

This is a hexagonal nut with the lower part made cylindrical on the cylindrical surface. There is a recessed groove in which a set screw is used to lock the nut. (Fig 7)

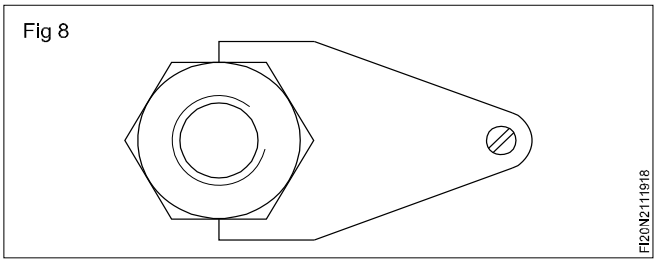
Fig 7



Locking plate

For preventing the nut from loosening locking plates are fixed on the outside of the hexagon nut. (Fig 8)

Fig 8

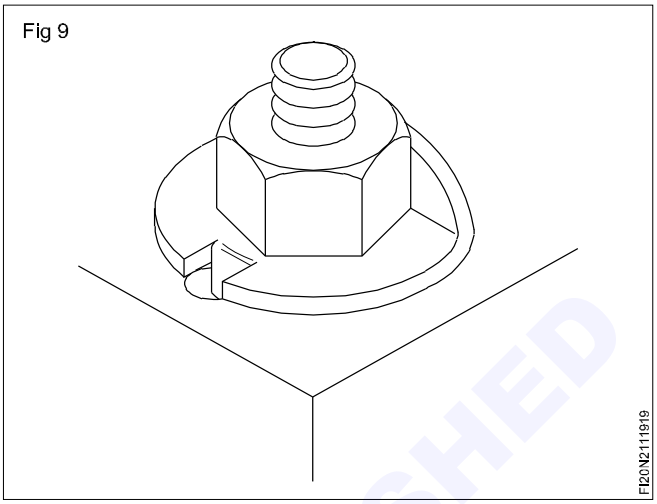


Lock-washers with lug

In this arrangement of locking a hole is drilled for accommodating the lug. (Fig 9)

The movement of the nut is prevented by folding the washer against the nut.

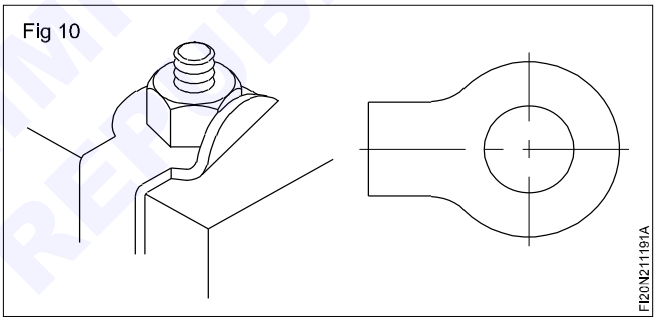
Fig 9



Tab washers (Fig 10)

Tab washers can be used for locking the nuts which are located near an edge or corner.

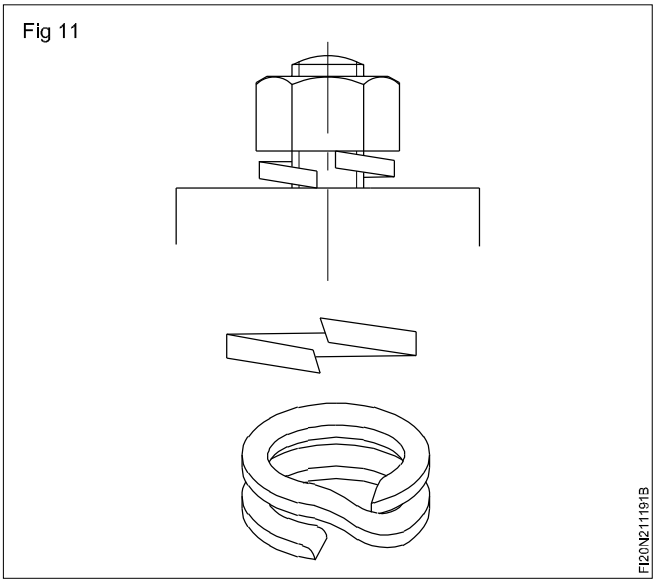
Fig 10



Spring washers (Fig 11)

Spring washers are available with a single or a double coil. These are placed under a nut in the assembly as washers. The stiff resistance offered by the washer against the surface of the nuts serves to prevent loosening.

Fig 11



Various types of keys

Objectives : At the end of this lesson you shall be able to
- **list the types of keys**
- **state the specification of keys**
- **state the standard taper of key**
- **state the uses of key pullers.**

Key

Key is a metallic piece of wedge inserted between a shaft and hub, parallel to the axis of shaft. It is proportionate to the shaft dia.

Purpose

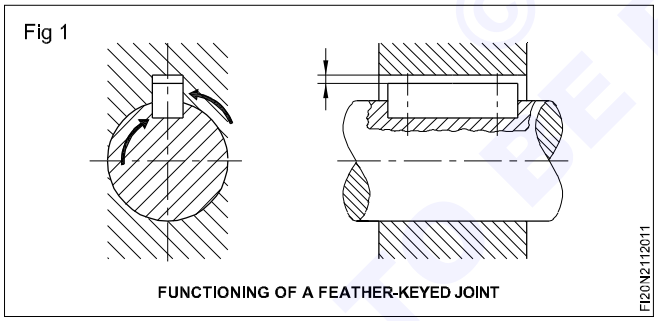
A key is an insert which is housed in the keyway to fit together a hub or a pulley to transmit torque. A keyway is provided on the shaft and also on the hub or on a pulley to connect together the conjugate parts by inserting the key in between. The key can be withdrawn at will to disengage the mating components.

Common types

Parallel key or feather key (Fig 1)

This is the most commonly used key, used for transmitting unidirectional torque. A hub or a pulley is engaged to the shaft by a key which prevents relative motion. The functioning of the feather key assembly is shown in Fig 1.

Fig 1



FUNCTIONING OF A FEATHER-KEYED JOINT

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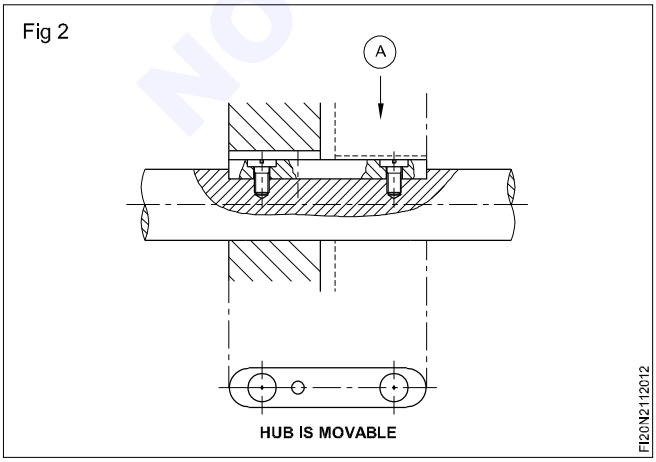
In many cases the key is screwed to the shaft keyway. (Fig 2)

Fig 2



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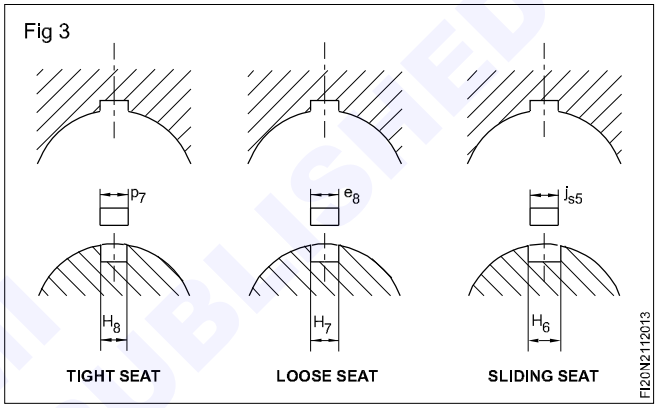
Where axial movement of the hub is required, a clearance fit is provided between the hub and the shaft and the hub and the key. Three types of fits are shown for feather key in Fig 3.

Fig 3



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Approximate proportion of parallel or taper keys.

If D is the dia. of the shaft, width of the key W = 1/4D+ 2 mm.

Nominal thickness T = 2/3 w.

Example

Diameter of shaft = 40 mm

$$\text{Width} = \frac{1}{4} \times 40+2 = 12 \text{ mm}$$

$$\text{Thickness} = \frac{2}{3} \times 12 = 8 \text{ mm}$$

Thickness at the large end is the nominal thickness of the taper key.

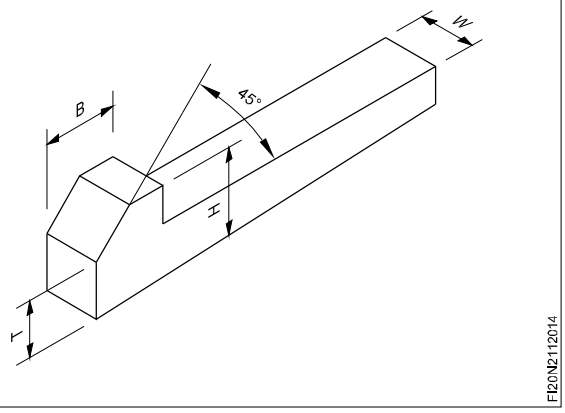
Taper is 1 in 100 on the top face only.

Taper and jib-headed key (Fig 4 & 5)

The key is having a jib-head with a taper (1 in 100) on the top face. It is driven on to the keyway by hammering on the jib to have a tight fit. The taper rectangular key without a jib-head is also in use. A jib-headed key can be with drawn easily and used for transmitting more torque. It is not good for high speed applications.

Approximate proportion of jib-headed key (Fig 4)

Fig 4



$H = 1.75T$

$B = 1.5\,T$

$W = \frac{1}{4}D+2$

Nominal thickness $T = \frac{2}{3}W$

Angle of chamfer = 45°

Example

Diameter shaft = 46 mm

$$\text{Width(w)} = \frac{1}{4} \times 46+2 = 11.5+2$$

= 13.5 rounded off to 14 mm.

$$\text{Thickness(T)} = \frac{2}{3} \times 13.5 = 9 \text{ mm}$$

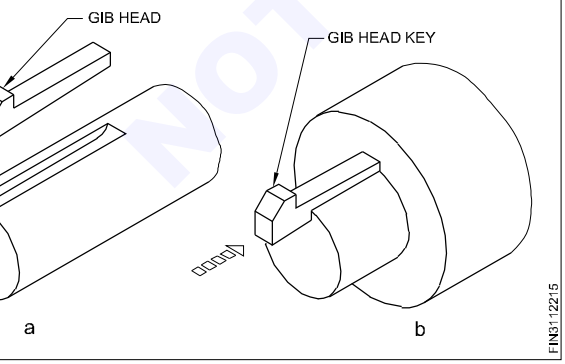
H = 1.75 x 9 = 15.75

say 16 mm

B = 1.5x9 = 13.5 mm.

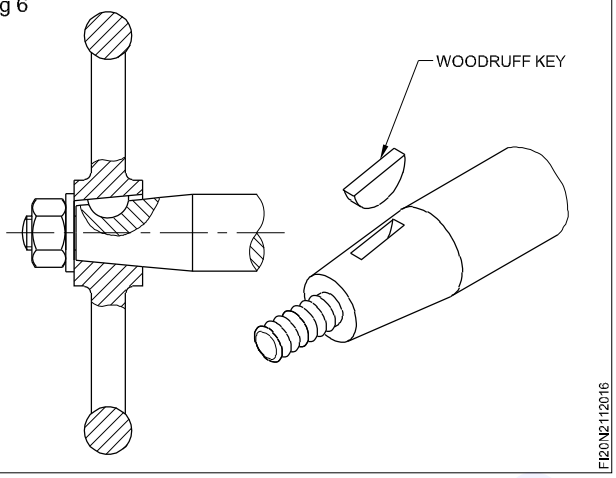
Woodruff key (Fig 5)

Fig 5



It is a semicircular key used for transmitting light torque. It fits on to the shaft on which matching recesses are cut. The top portion of the key projects out and fits in the keyway cut on the hub. (Fig 6)

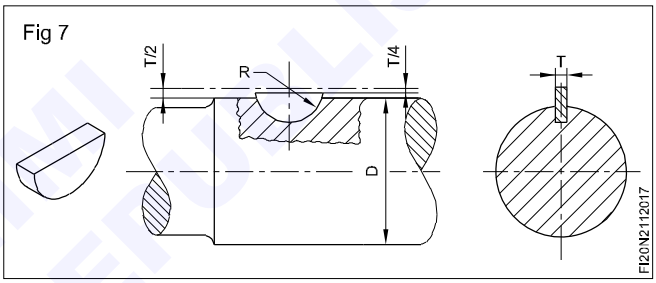
Fig 6



This key is particularly useful on tapered fittings or shafts. Its key way is milled to the profile of the key on the shaft which tends to weaken the shaft. This type of key positions itself in the keyway to accommodate the hub to have an easy assembly.

Approximate proportion of woodruff key (Fig 7)

Fig 7



$$\text{Radius of the key (R)} = \frac{D}{3}$$

$$\text{Thickness(T)} = \frac{D}{6}$$

Example

For shaft ø 30.

R = 30/3 = 10 mm

T = 30/6 = 5 mm

Keys and splines: Keys and splines are used for transmitting torque from a rotating shaft to a hub/wheel or from a hub/wheel to the shaft. (Fig 8)

Keys of different types and splines are used depending on the requirements of transmission.

Hollow saddle key: One face of this key has a curvature to match with that of the shaft surface. It has a taper of 1 in 100 and is driven in through the keyway. (Fig 9)

The hub is held on the shaft due to friction. This key is useful only for light duty transmission.

Fig 8

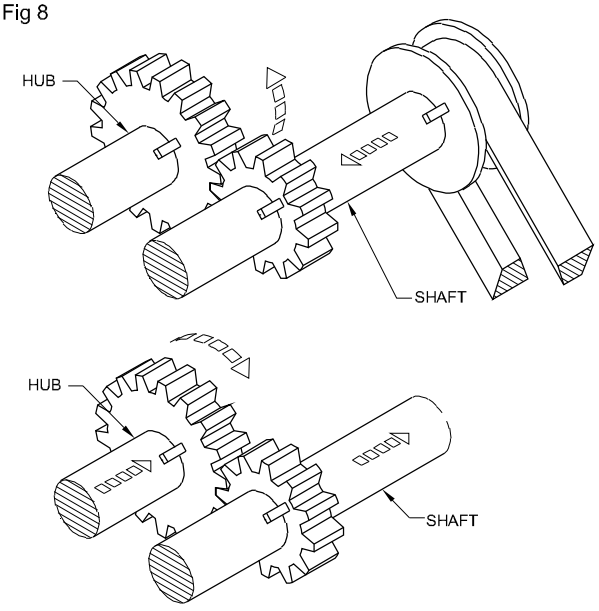
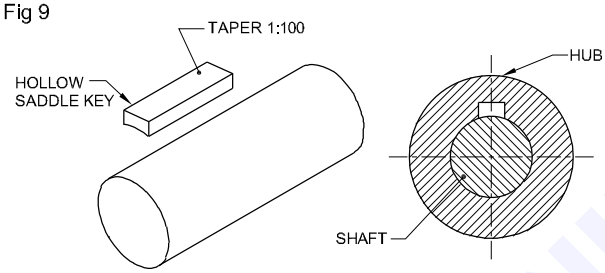


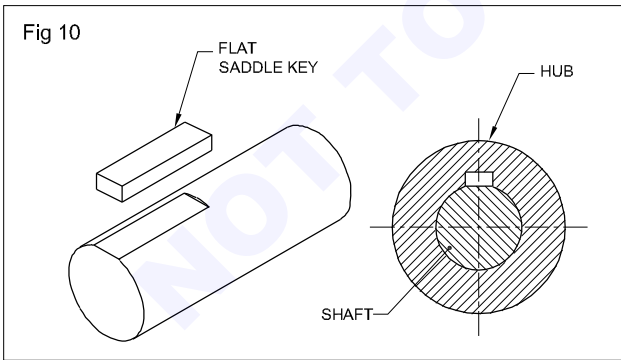
Fig 9



Flat saddle key: This key has a rectangular cross-section.

For fitting this key in the assembly a flat surface is machined on the shaft. (Fig 10) The key is placed between the flat surface of the shaft and the keyway on the hub. This is considered to be stronger than the hollow saddle key. This is not suitable for heavy duty transmission.

Fig 10



Approximate proportion

If D is the diameter of the shaft,

width of the key (W) = $\frac{1}{4}$ D+2 mm

nominal thickness (T) = $\frac{1}{3}$ W.

Example

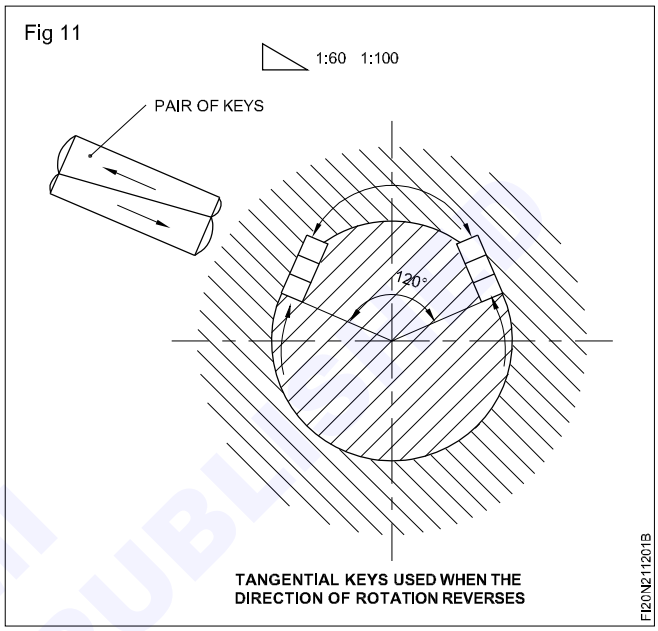
diameter shaft = 24 mm

W = $\frac{1}{4}$ x 24+2 = 8 mm

T = $\frac{1}{3}$ x 8 = 2.7 or 3 mm.

Tangential key (Fig 11)

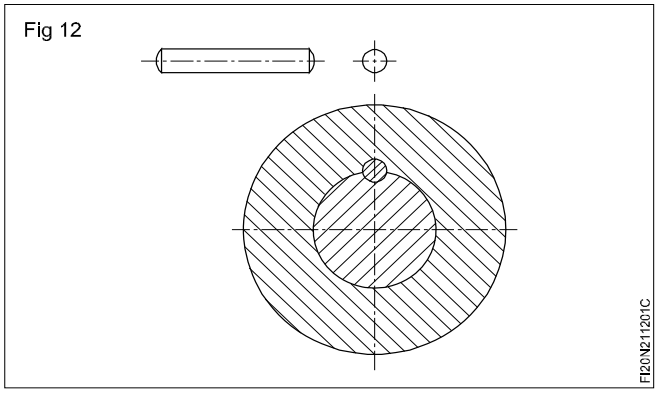
Fig 11



These keys are used when very high torque of impact type is to be transmitted in both directions of rotation. Common applications are found in flywheels, rolling mills etc. A tangential key consists of two taper rectangular wedges, positioned one over the other in opposite directions. Two sets of keys are fixed at 120° angle as shown in Fig 11 and should be such that the broad side is directed along a tangent to the shaft circle while the narrow side sits along the radius of the shaft.

Round key (Fig 12)

Fig 12



It is of cylindrical cross-section and is used in assemblies to secure the mating components where the torque is light. The key is fitted parallel to the shaft into the drilled hole made partly on to the shaft and partly on to the mating part.

Approximate proportion of round key

If dia. of the shaft = D

Dia. of the key (d) = $\frac{1}{6}$ D

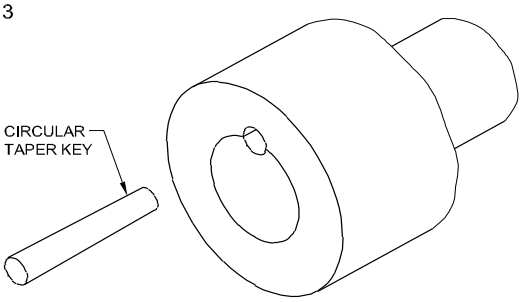
Example

Dia. of shaft = 30 mm

Dia of key = $\frac{1}{6}$ x 30 = 5 mm

Circular taper key: In this case both the shaft and the hub have semicircular keyways cut on them. (Fig 13) The taper key is driven in while assembling. This key is suitable only for light transmission.

Fig 13



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Sunk key: This key has a rectangular cross-section and it fits into the keyway cut on both the shaft and the hub. Sunk keys are either parallel or tapered. (Figs 14 and 15)

Fig 14

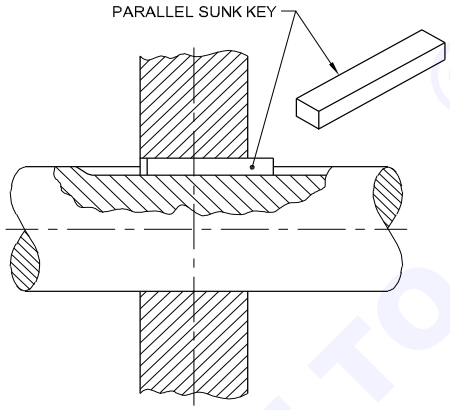

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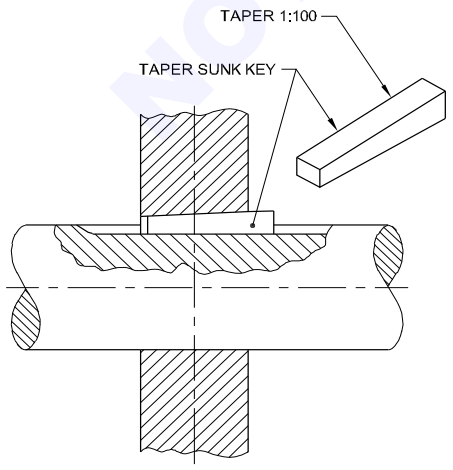
Fig 15



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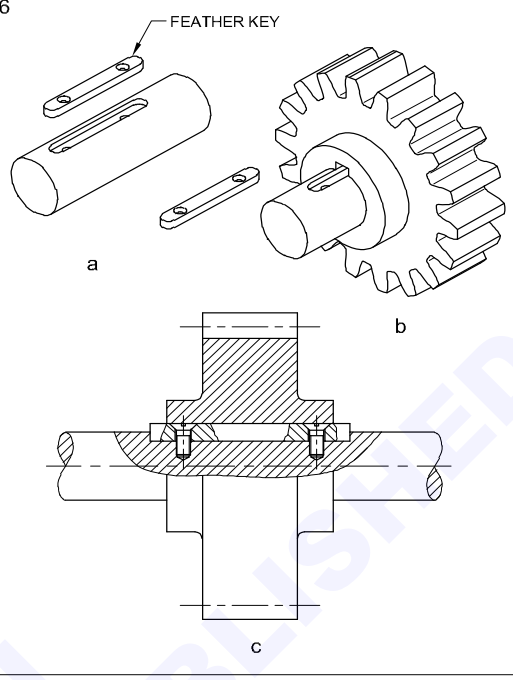
Feather key: This is parallel key with rounded ends. This is useful when the hub/pulley has to slide axially on the shaft to some distance. (Figs 16a, b and c) This key may be either tightly fitted in the keyway or screwed in.

Fig 16



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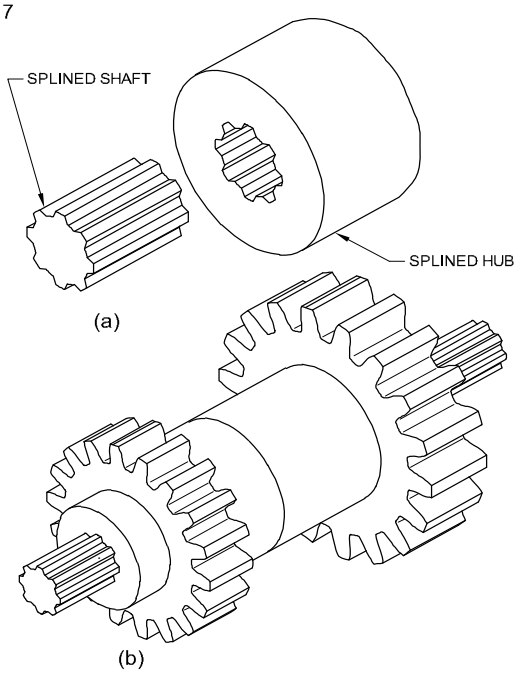
Splines: Splines are ridges (or) teeth on a drive shaft that mesh with grooves in a mating piece and transfer torque to it, maintaining the angular correspondence between them.

An alternative to spline is a key way and key

Splined shaft and serrated shaft: Splined shafts along with splined hubs are used particularly in the motor industry. The splined hub can also slide along the shaft, wherever necessary (Figs 17a and b) used while fixing change gears in a lathe and heavy duty drilling machine.

Fig 17



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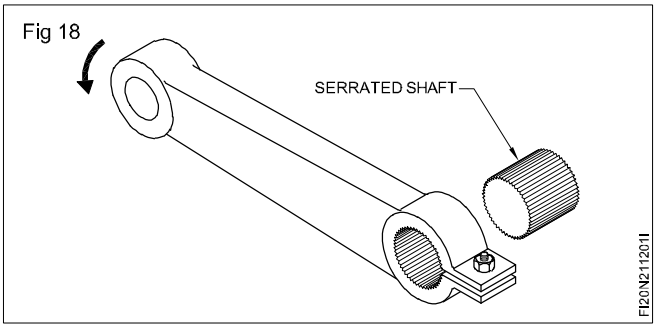
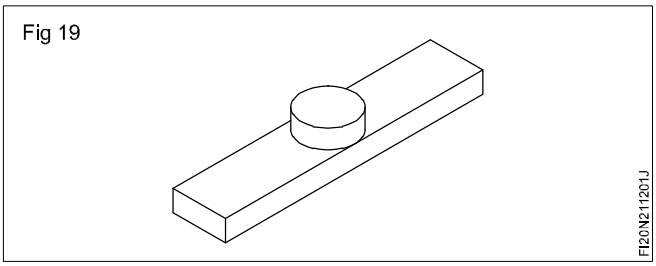
In certain assemblies, serrated shafts are also used for transmission. (Fig 18)

Fig 18



Peg feather key: It is a parallel rectangular key having a round peg at the centre or one edge of the key face. (Fig 19)

Fig 19



The peg will fits into the hole of the shaft or stationary member of a unit assembly to prevent the sliding of the key.

A peg feather key is used at the bottom of the tail stock barrel to prevent the barrel from rotation. It is also used in a drilling machine spindle while moves along with quill when the spindle in rotation.

Some of the key dimensions as per IS is given in table 1, 2, 3 & 4.

Key puller

Key puller is used for the safe removal of keys from the shaft of any type of machine, motor, blower, compressor, etc.

It is generally used for the keys from 5mm to 35mm width.

Advantages

- Safe and fast removal
- Perpendicular removal
- No damage to shafts & keys
- Saves time & labour costs & costs

Easy-to-use

1 Turn wheel (A) to move the jaws (1) up or down so that they are aligned with housing (2)

2 Turn wheel (B) to fit the size of the key allowing ± 1 mm space.

3 Turn wheel (B) hand tight to secure the key with the jaws.

4 Then turn wheel (A) to extract the key perpendicularly.

5 Turn wheel (A) to move the jaws down, turn wheel (B) to open the jaws and free

Fig 20

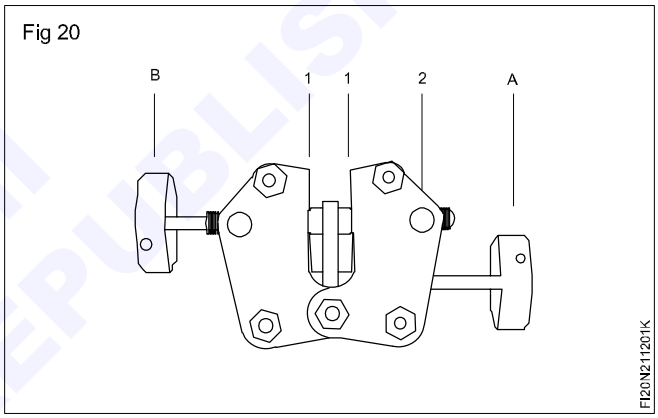


Table 1

Dimensions for keys

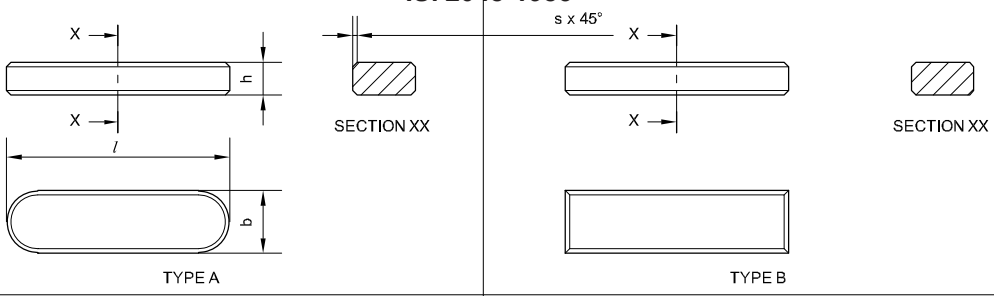
(IS 2048 - 1983)

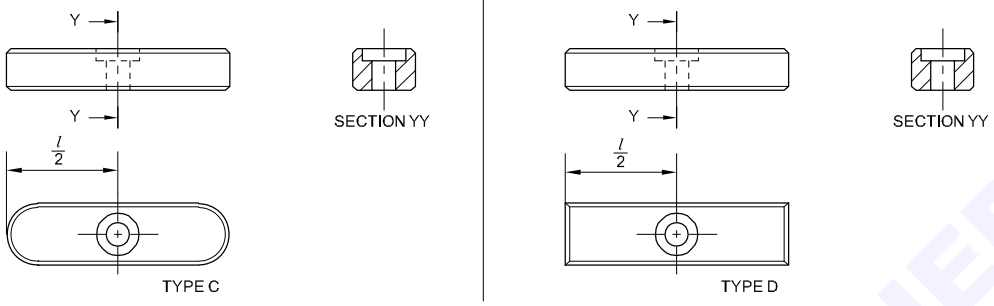
All dimensions in millimetres

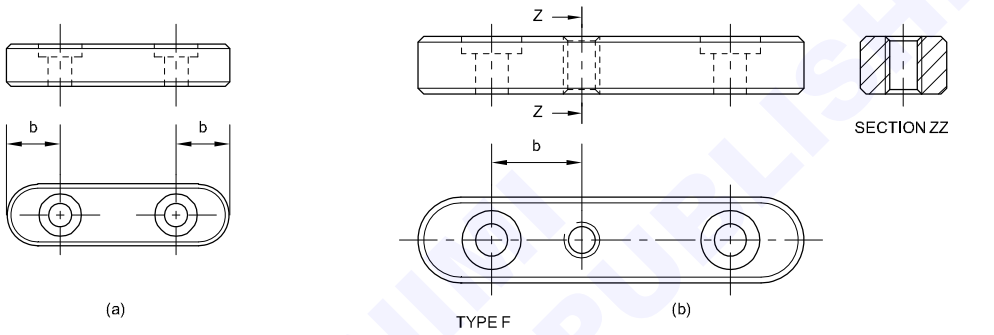
b	Tol on b h9	h	Tol on h*	s		Range of Key Length l		Range of Key Length (for Machine tools only)	
				Min	Max	Min	Max	Min	Max
4	0 – 0.030	4	0 – 0.030	0.16	0.25	8	45	10	45
5		5		0.25	0.40	10	56	12	56
6		6		0.25	0.40	14	70	16	70
8		7		0.25	0.40	18	90	20	90
10	0 – 0.036	8	0 – 0.090	0.40	0.60	22	110	25	110
12		8		0.40	0.60	28	140	32	140
14	0 – 0.043	9		0.40	0.60	36	160	40	160
16		10		0.40	0.60	45	180	45	180

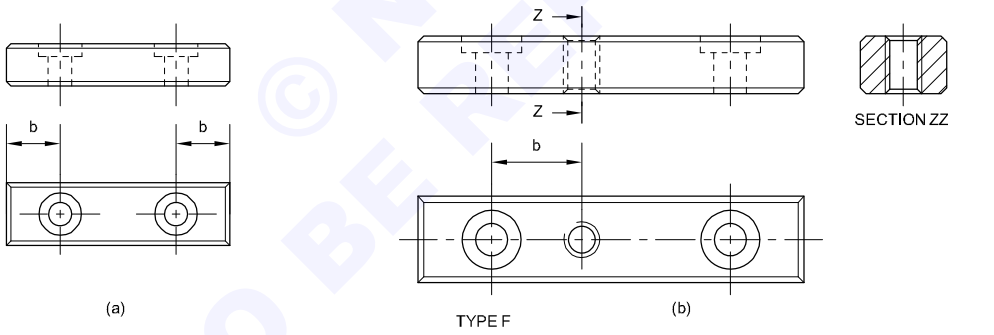
Note - Keys with b = 4 to 40 are meant for machine tools application also.

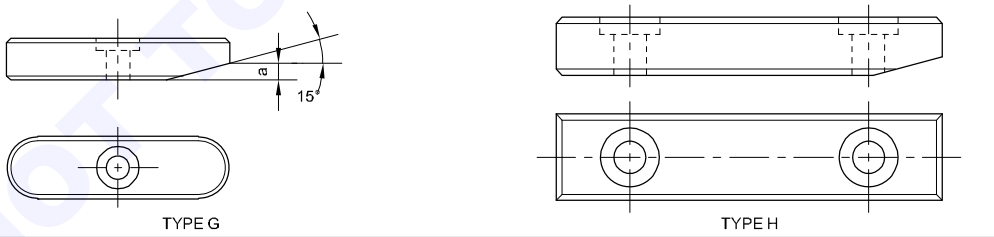
* Tol on h: Square section h9; Rectangular Section h11.

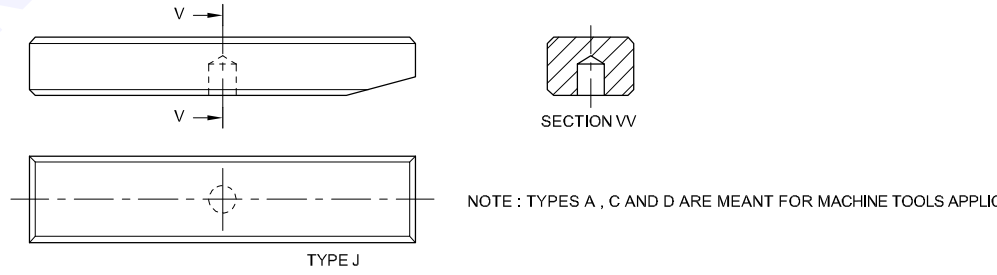












SUNK AND FEATHER KEYS

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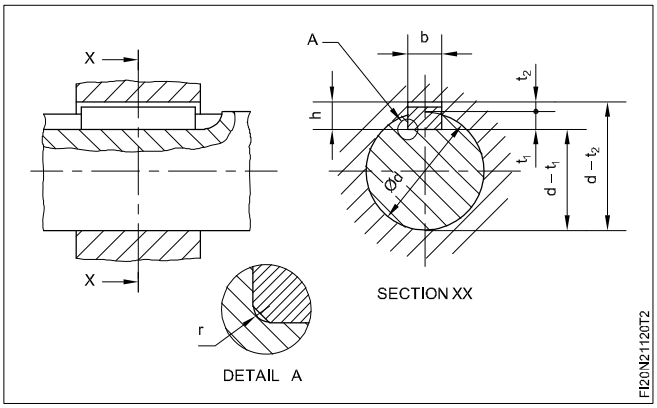
Table 2

Dimensions for keyways

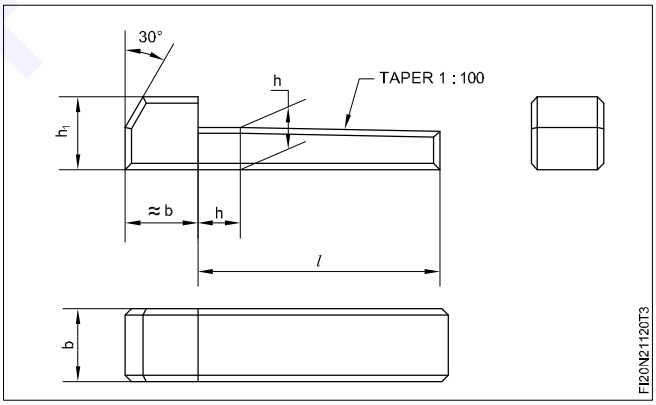


Range of shaft dia d		Key	Keyway									Range of shaft dia d		Keyway for Machine Tools Application			
		b x h	b	Tol on b				t1	Tol	t2 on t1	Tol on t2						
				Running fit		Light drive fit		Force fit									
Above	Upto			Shaft H9	Hub D10	Shaft N9	Hub Js9	Shaft & Hub P9									
22	30	8 x 7	8	+ 0.036	+ 0.098	0	+ 0.018.0	- 0.015	4.0		3.3		22	30	5.4 -		1.7 -	
30	38	10 x 8	10	0	+ 0.040	- 0.036	- 0.018.0	- 0.051	5.0		3.3		30	33	6		2.1	
38	44	12 x 8	12	+ 0.043	+ 0.120	0	_ 0.021.5	- 0.018	5.0		3.3		38	44	6	+ 0.2	2.1	
44	50	14 x 9	14	0	+ 0.050	- 0.43	- 0.021.5	- 0.061	5.5	0	3.8	0	44	50	6.5	0	2.6	
50	58	16 x 10	16						6.0	+ 0.2	4.3	+ 0.2	50	58	7.5		2.6	

Table 3

Indian Standard specification for GIB Head keys and keyways

All dimensions in millimetres

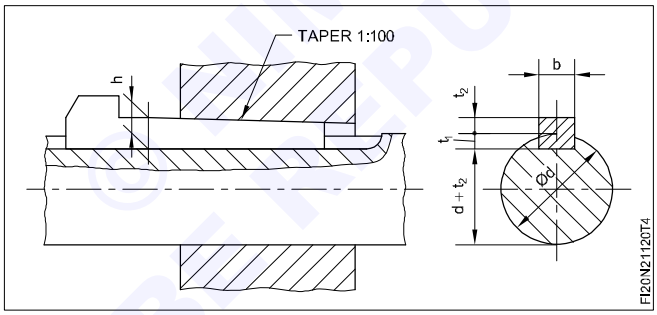


b	Tol on b h9	h	Tol on h*	s		Range of Key length, l		h1
				Min	Max	Min	Max	
4		4		0.16	0.25	14	45	7
5	0	5	0	0.25	0.40	14	56	8
6	– 0.030	6	– 0.030	0.25	0.40	16	70	10
8		7		0.25	0.40	20	90	11
10	0 – 0.036	8		0.40	0.60	25	110	12
12		8	0 – 0.090	0.40	0.60	32	140	12
14		9		0.40	0.60	40	160	14
16	0 – 0.043	10		0.40	0.60	45	180	16

Table 4

Details of keyway and key

All dimensions in millimetres



Range of Shaft Dia d		Key	Keyway							
		b x h	b	Tol on b D10	t1	Tol on t1	t2	Tol on t2	r	
Above	Upto								Min	Max
22	30	8 x 7	8		4.0		2.4		0.16	0.25
30	38	10 x 8	10	+ 0.098 + 0.040	5.0		2.4		0.25	0.40
38	44	12 x 8	12		5.0		2.4		0.25	0.40
44	50	14 x 9	14		5.5		2.9		0.25	0.40
50	58	16 x 10	16	+ 0.120 + 0.050	6.0	0 + 0.2	3.4	0 + 0.2	0.25	0.40

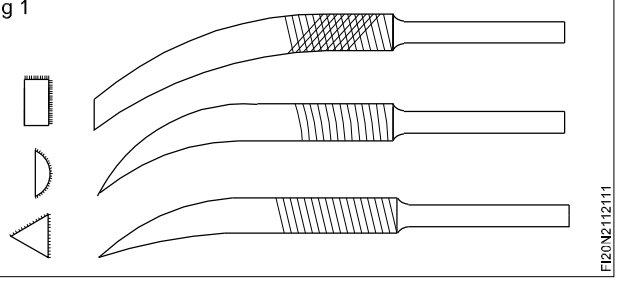
Special Files

Objectives : At the end of this lesson you shall be able to
- **describe the different types of special files**
- **state the uses of special file.**

In addition to the common type of files, files are also available in a variety of shapes for 'special' applications. These are as follows.

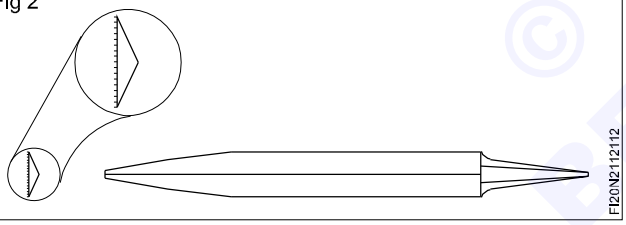
Riffler files (Fig 1): These files are used for die-sinking, engraving and in silversmith's work. They are made in different shapes and sizes and are made with standard cuts of teeth.

Fig 1



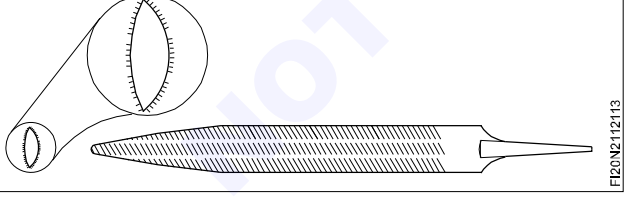
Barrette file (Fig 2): This file has a flat, triangular face with teeth on the wide face only. It is used for finishing sharp corners.

Fig 2



Crossing file (Fig 3): This file is used in the place of a half round file. Each side of the file has different curves. It is also known as "fish back" file.

Fig 3



Rotary files (Fig 4): These files are available with a round shank. They are driven by a special machine with a portable motor and flexible shaft. These are used in diesinking and mould-making work.

Mill saw files (Fig 5): Mill saw files are usually flat and have square or rounded edges. These are used for sharpening teeth of wood-working saws, and are available in single cut.

Fig 4

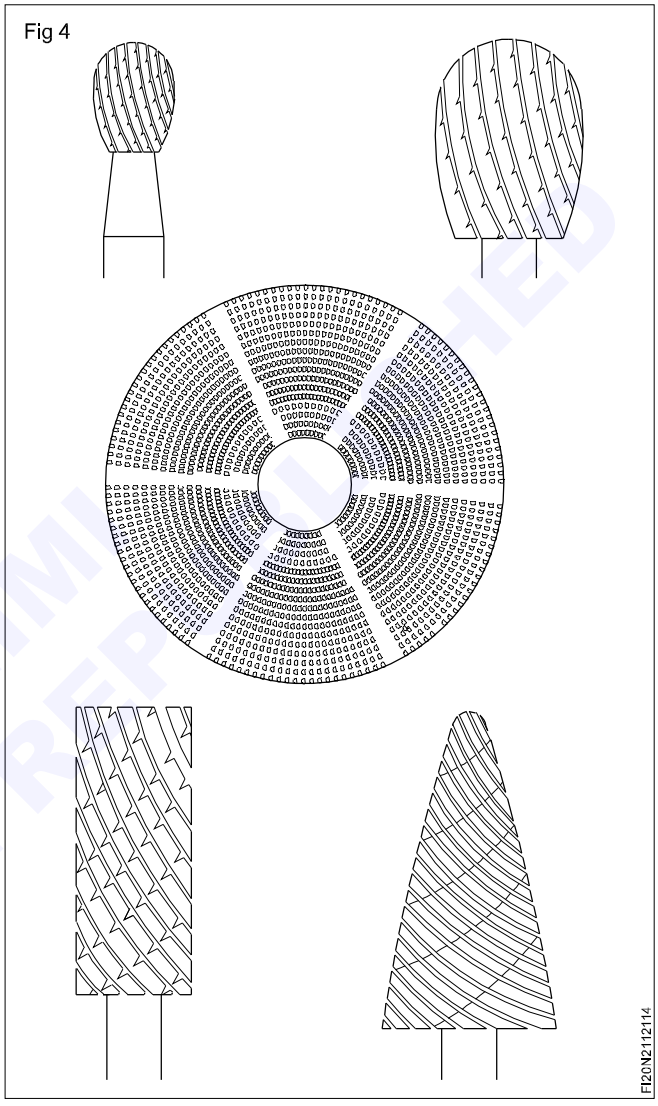
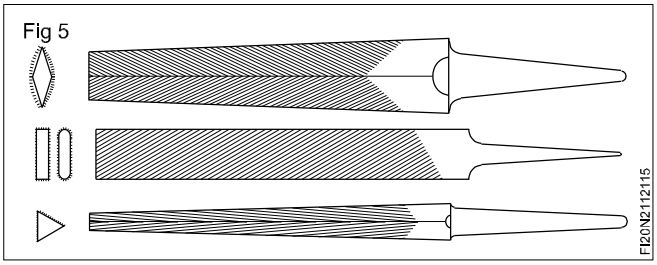
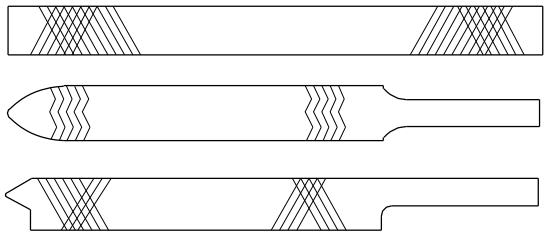


Fig 5



Machine files for hand filing machine (Fig 6): Machine files are of double cut, having holes or projections to fix to the holder of the filing machine. The length and shape will vary according to the machine capacity. These files are suitable for filing the inner and outer surfaces, and are ideal for diesinking and other tool-room work.

Fig 6



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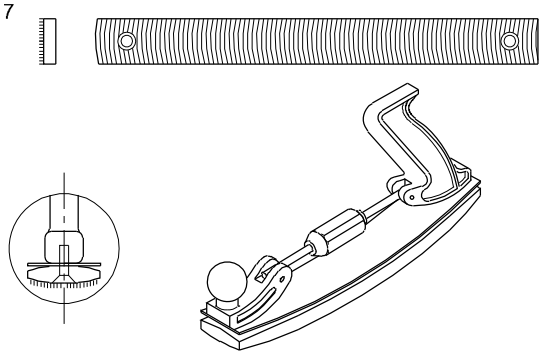
Tinker's file (Fig 7): This file has a rectangular shape with teeth only at the bottom face. A handle is provided on the top. This file is used for finishing automobile bodies after tinkering.

Fig 7



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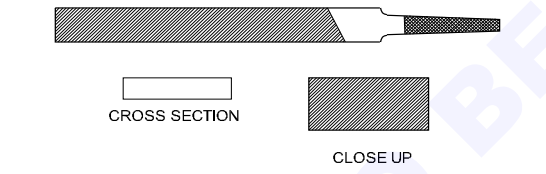
Pillar file (Fig 8)

A usually double-cut file that is rectangular in section, parallel in width with one safe edge, and tapered in thickness form the middle both ways and that is especially suitable for narrow work.

Fig 8



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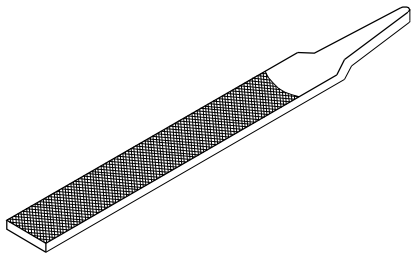
Dread naught file (Fig 9)

A file is a metalworking, wood working and plastic working tool used to cut fine amounts of material from a work piece. It most commonly refers to the hand tool style, which takes the form of a steel bar with a case hardened surface and a series of sharp, parallel teeth. Most files have a narrow, pointed tang at one end to which a handle can be fitted.

Fig 9



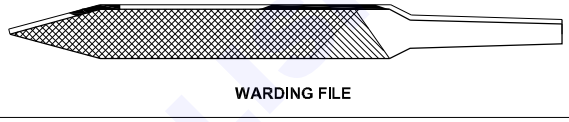
FI20N2112119

A similar tool is the rasp. This is an older form, with simpler teeth. As they have larger clearance between teeth. As they have larger clearance between teeth, these are usually used on softer, non-metallic materials.

Related tools have been developed with abrasive surfaces, such as diamond abrasives or silicon carbide.

Warding files (Fig 10)

Fig 10



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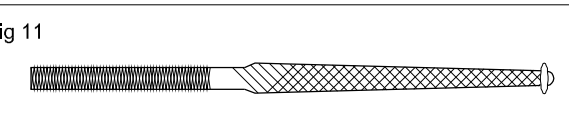
Warding files are tapered to a point for narrow space filing. They have double cut faces and single cut edges. Warding files are used for lock repair or for filling ward notches in keys.

Swiss pattern files (Fig 11)

Swiss pattern files are made to more exact measurements than American pattern files. They are primarily finishing tools used on all sorts of delicate and intricate parts. Swiss pattern files come in a variety of styles, shapes, sizes, and double and single cuts to insure precision smoothness.

Fig 11



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Template and gauges

Objectives : At the end of this lesson you shall be able to
- **define template with its uses and advantages**
- **define gauges their necessity and types.**

Templates: Templates are used to check the contour of the profile of a workpiece for conformance to shape or form templates are made from steel sheet. They are also called profile gauge.

Benefits of templates

1 To avoid repetitive measuring and marking the same dimension, and where many identical parts are required.

2 To avoid unnecessary wastage of material and from information given on drawing, it is almost impossible to anticipate exactly where to begin in order that the complete layout can be economically accommodated.

3 To act as a guide for cutting processes.

4 As a simple means of checking bend angles and contours.

Information given on templates

Written on templates may be as follows:

1 Job or contract number

2 Size and thickness of plate

3 Quantity required

4 Bending or folding instructions

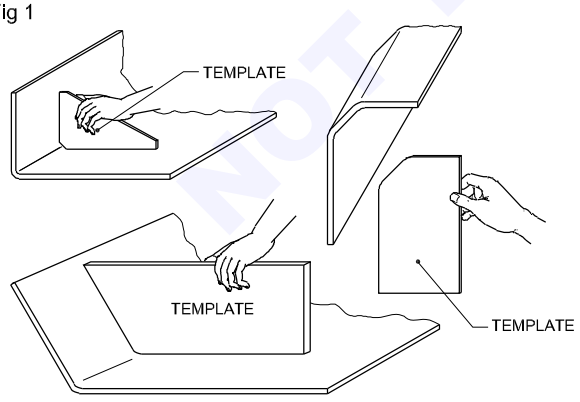
5 Drilling requirement

6 Cutting instructions

7 Assembly reference mark.

Templates as a means of checking is shown in Fig 1 to 6

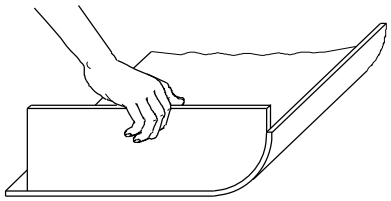
Fig 1



CHECKING ANGLES WITH A TEMPLATE

FI20N2112311

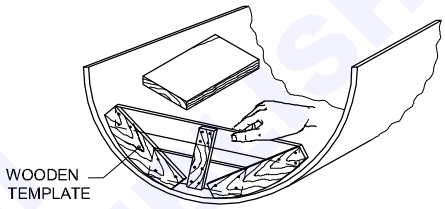
Fig 2



CHECKING THE CONTOUR OF A RADIUSED CORNER

FI20N2112312

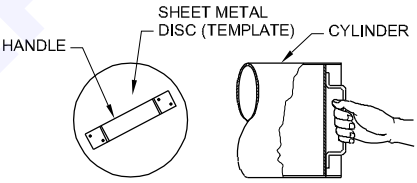
Fig 3



CHECKING THE CONTOUR OF A ROLLED PLATE

FI20N2112313

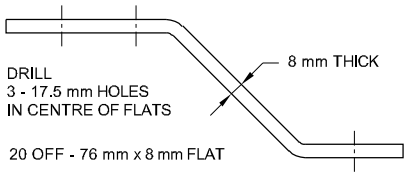
Fig 4



TEMPLATE USED FOR CHECKING CONTOUR OF CYLINDRICAL WORK SUCH AS DUCTWORK.

FI20N2112314

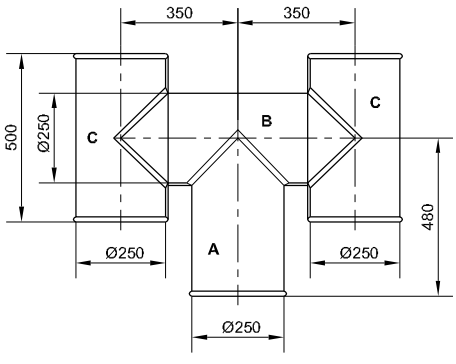
Fig 5



THE USE OF TEMPLATES AS A MEANS OF CHECKING

FI20N2112315

Fig 6



CHIMNEY SMOKE COWL

FI20N2112316

Templates for setting out sheet metal fabrications: For economy reasons, many patterns are made for marking out the sheet metal prior to cutting and forming operations. Fig 7,8 show a smoke cowl. Here a template is required to check and to mark out the contours of the intersection joint lines for the parts A,B & C whose developed sizes are marked out in the flat with the appropriate datum lines.

Fig 7

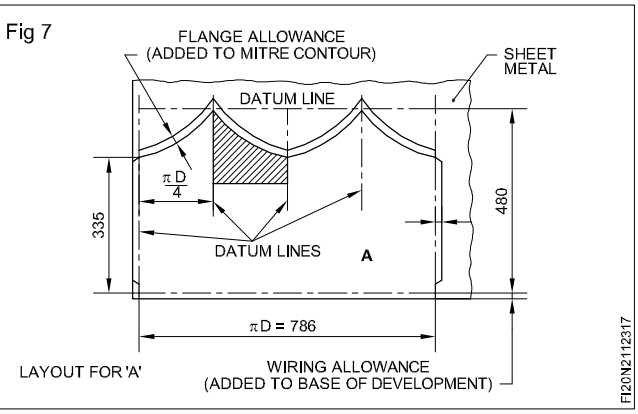
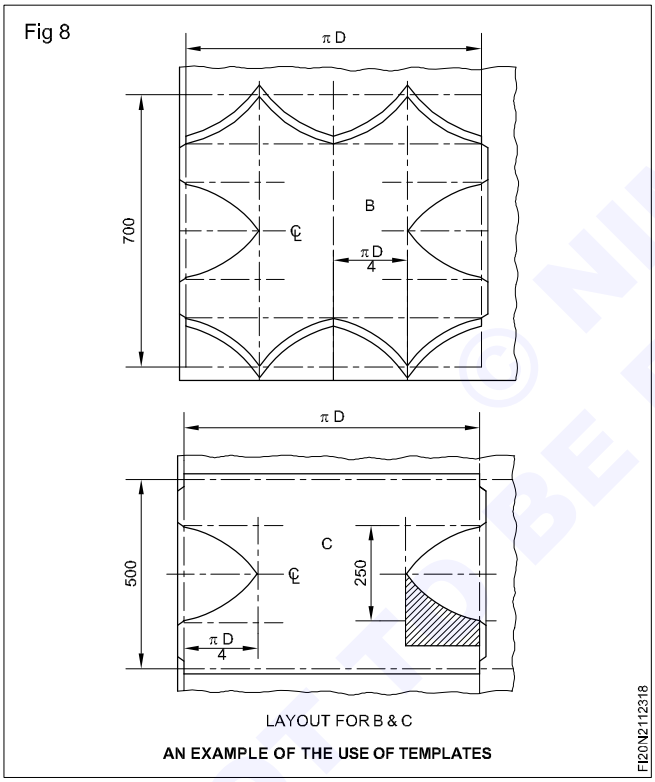


Fig 8



AN EXAMPLE OF THE USE OF TEMPLATES

Fig 9 shows a square to round transformer is an isometric view of the sheet metal trans forming piece which is used to connect a circular duct to a square duct of equal area of cross section. In this example the dia of the round duct is 860 mm and length of one side of the square duct is 762 mm and the distance between the two ducts is 458 mm and sheet thickness is 1.2 mm.

Fig 9

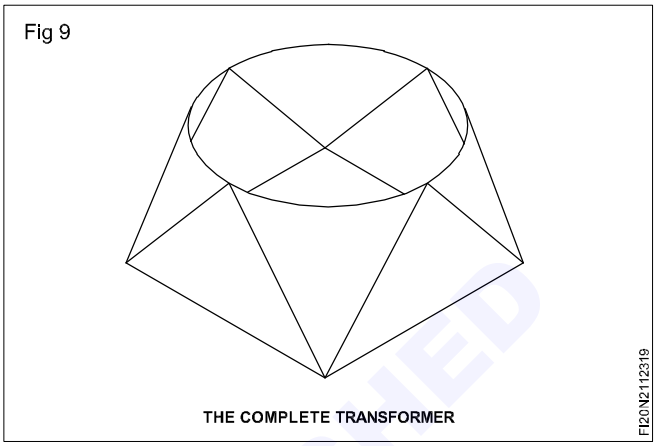
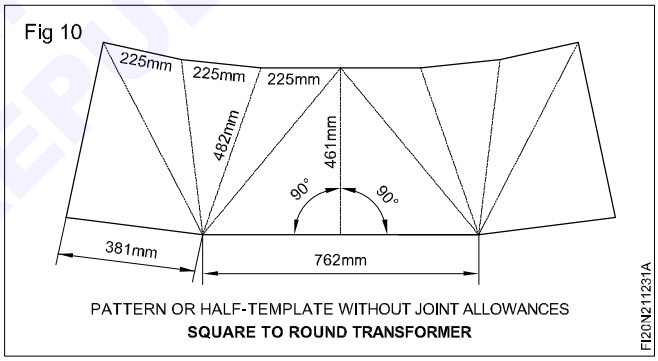


Fig 10 shows a scale development pattern on which are marked the full size dimensions. This type of drawings are supplied by the drawing office for marking out purposes. Allowances for the seams and the joints must be added to the layout.

Fig 10



Screw pitch gauge

Objectives : At the end of this lesson you shall be able to
- **state the purpose of a screw pitch gauge**
- **state the features of a screw pitch gauge.**

Purpose

A screw pitch gauge is used to determine the pitch of a thread.

It is also used to compare the profile of threads.

Constructional features

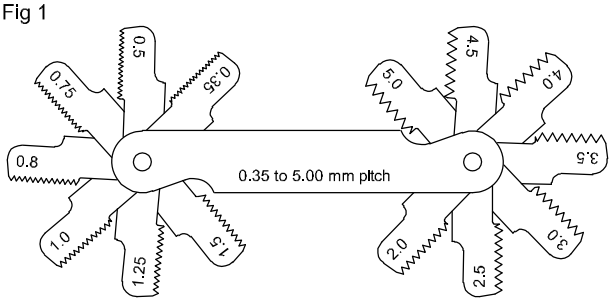
Pitch gauges are available with a number of blades assembled as a set. Each blade is meant for checking a particular standard thread pitch. The blades are made of thin spring steel sheets, and are hardened.

Some screw pitch gauge sets will have blades provided for checking British Standards threads (BSW, BSF etc.) at one end and the metric standard at the other end.

The thread profile on each blade is cut for about 25 mm to 30 mm. The pitch of the blade is stamped on each blade. The standard and range of the pitches are marked on the case. (Fig 1)

For obtaining accurate results while using the screw pitch gauge, the full length of the blade should be placed on the threads. (Fig 2)

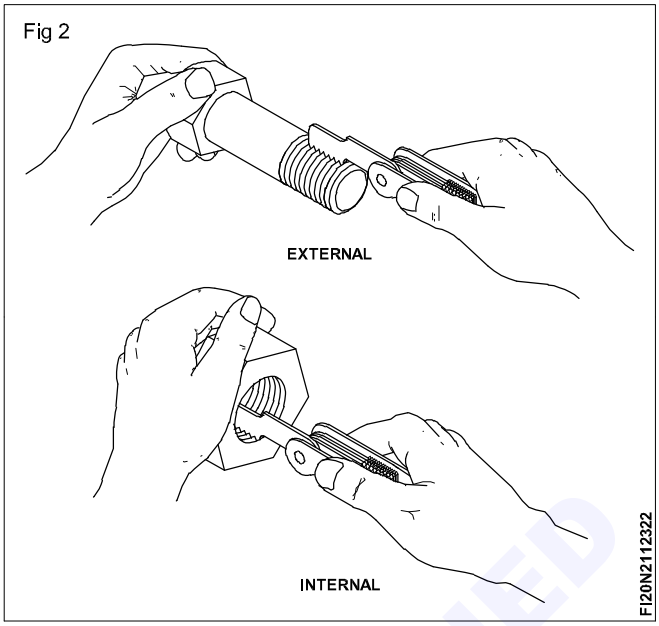
Fig 1



SCREW PITCH GAUGE

FI20N2112321

Fig 2



FI20N2112322

Simple and standard workshop gauges

Objectives : At the end of this lesson you shall be able to
- **state what is radius and fillet gauge**
- **mention the sizes and uses of feeler gauge.**

Radius and fillet gauges: Components are machined to have curved formation on the edges or at the junction of two steps. Accordingly they are called radius and fillets. The size of the radius is normally provided on a drawing. The gauges used to check the radius formed on the edges of diameters are fillet and the gauges used to check the fillets are called fillets gauges.

They are made of hardened sheet metal each to a precise radius. They are used to check the radii by comparing the radius on a part with the radius of the gauges.

Fig 1 shows the application of radius gauge to check the radius formed externally. Fig 2 shows the application of a fillet gauge to check the fillet formed on a turned component. The other typical applications are:

Fig 1

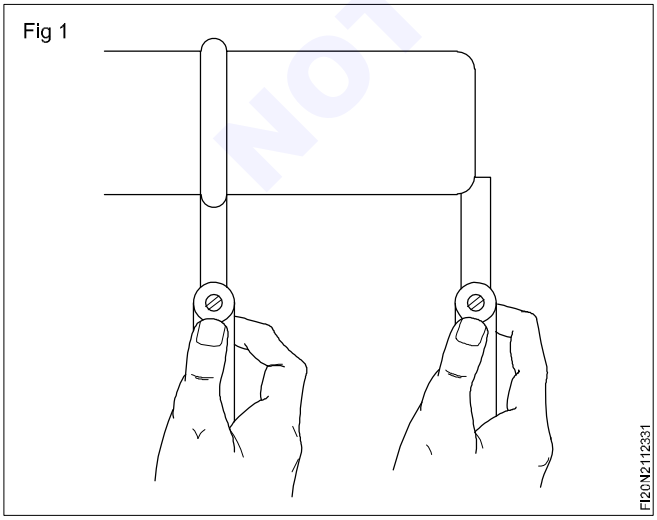


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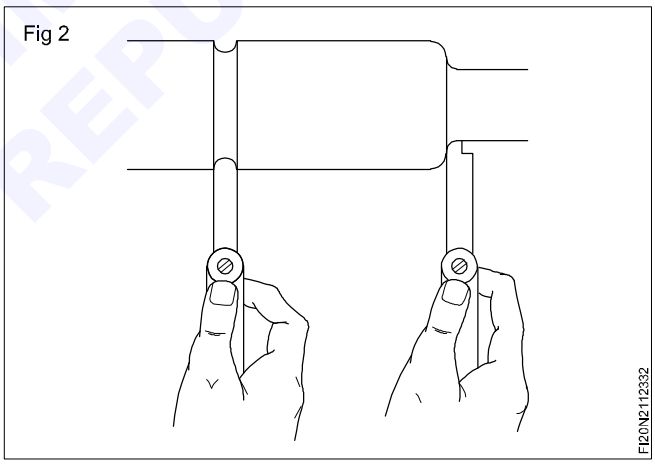
Fig 2



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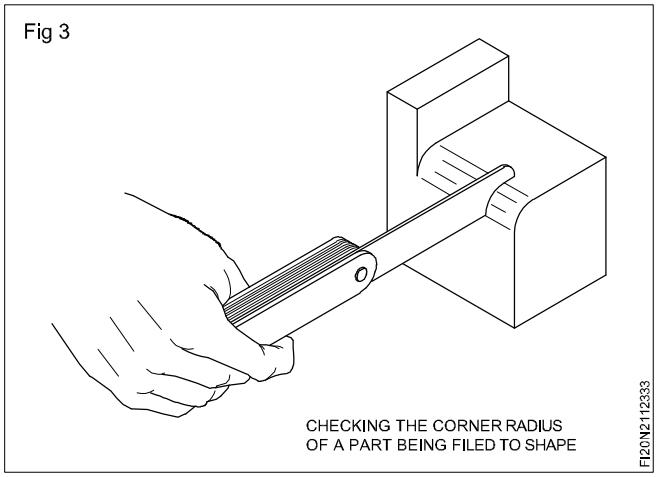
– Checking the corner radius of a part being filed to shape. (Fig 3)

Fig 3

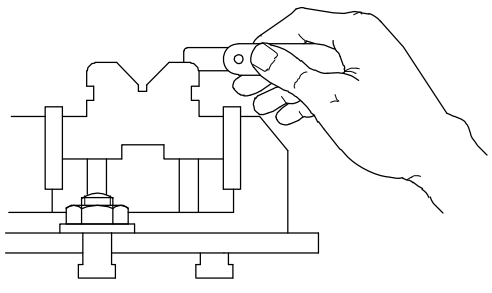


CHECKING THE CORNER RADIUS OF A PART BEING FILED TO SHAPE

FI20N2112333

– Checking a radius formed by a milling cutter. (Fig 4)

Fig 4

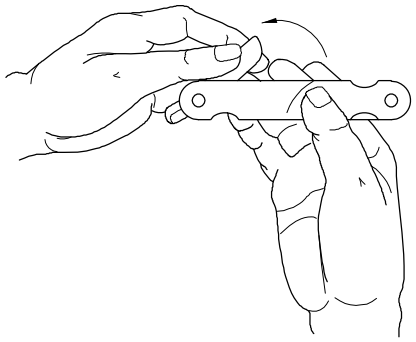


CHECKING A RADIUS FORMED BY A MILLING CUTTER

FI20N2112334

The radius and fillet gauges are available in sets of several blades which fold into a holder when not in use. (Fig 5)

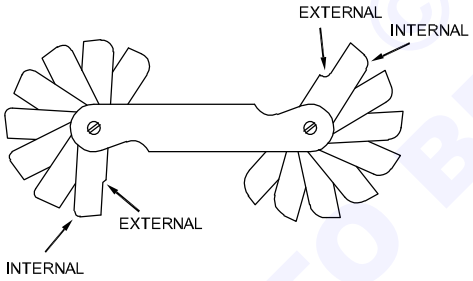
Fig 5



FI20N2112335

Some sets have provisions to check the radius and fillet on each blade. (Fig 6)

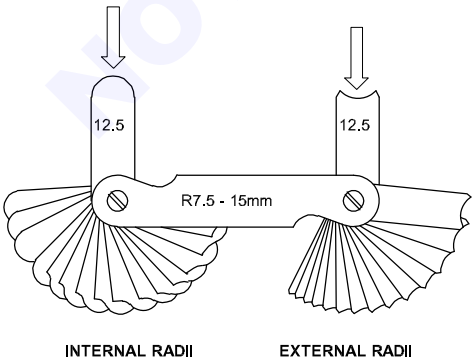
Fig 6



FI20N2112336

And some sets have separate sets of blades to check the radius and fillet. (Fig 7)

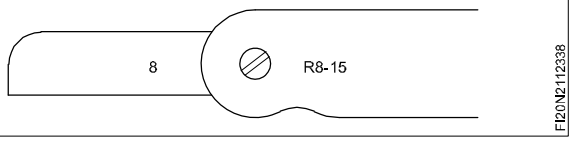
Fig 7



FI20N2112337

Each blade can be swung out of the holder separately, and has its size engraved on it. (Fig 8)

Fig 8



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Fillet gauges are available in sets to check the radii and fillets from:

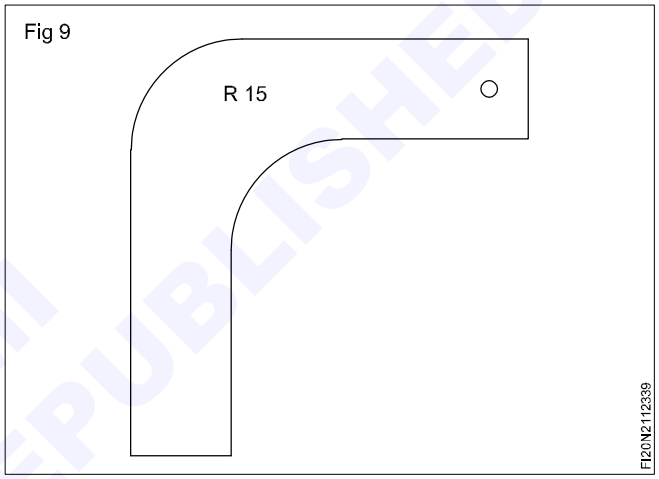
1 to 7 mm in steps of 0.5 mm

7.5 to 15 mm in steps of 0.5 mm

15.5 to 25 mm in steps 0.5 mm.

Individual gauges are also available. They usually have internal and external radii on each gauge and are made in sizes from 1 to 100 mm in steps of 1 mm. (Fig 9)

Fig 9



FI20N2112339

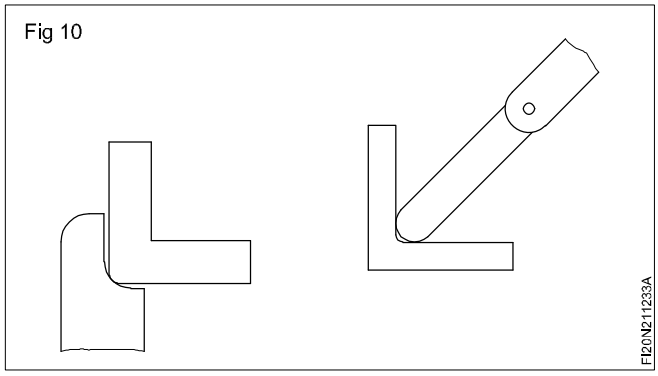
Before using the radius gauge, check that it is clean and undamaged.

Remove burrs from the workpiece.

Select the leaf of the gauge from the set corresponding to the radius to be checked.

Fig 10 shows that the radius of the fillet and that of the external radius are smaller than the gauge.

Fig 10



FI20N211233A

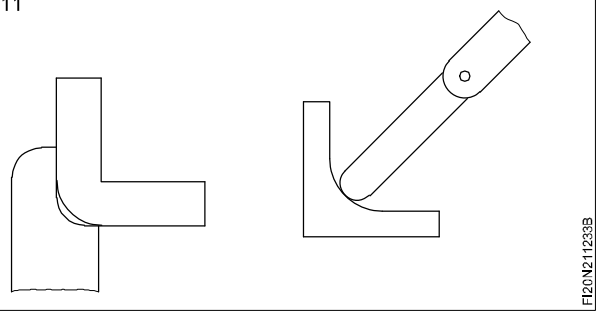
Try a smaller gauge to determine the radius dimension.

File or machine the workpiece if it has to be of the radius of the gauge.

Figure 11 shows that the radius of the fillet and that of the external radius are larger than the gauge.

Try a larger gauge if you need to find the radius dimension.

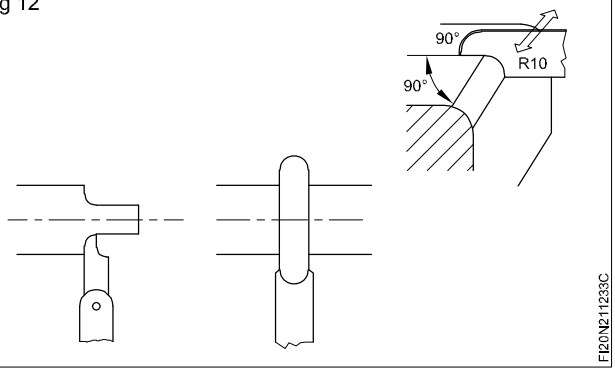
Fig 11



FI20N211233B

Fig 12 shows the workpiece having the same radius as that of the gauge that is being used for checking.

Fig 12



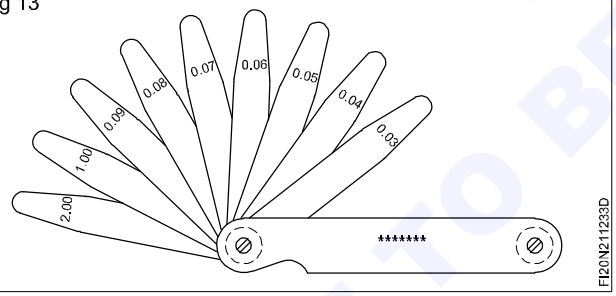
FI20N211233C

Feeler gauge and uses

Features: A feeler gauge consists of a number of hardened and tempered steel blades of various thicknesses mounted in a steel case. (Fig 13)

The thickness of individual leaves is marked on it. (Fig 13)

Fig 13



FI20N211233D

B.I.S. Set: The Indian Standard establishes four sets of feeler gauges Nos.1,2,3 and 4 which differ by the number of blades in each and by the range of thickness (minimum is 0.03 mm to 1 mm in steps of 0.01 mm). The length of the blade is usually 100 mm.

Example

Set No.4 of Indian Standard consist of 13 blades of different thicknesses.

0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.15, 0.20, 0.30, 0.40, 0.50.

The sizes of the feeler gauges in a set are carefully chosen in order that a maximum number of dimensions can be formed by building up from a minimum number of leaves.

The dimension being tested is judged to be equal to the thickness of the leaves used, when a slight pull is felt while withdrawing them. Accuracy in using these gauge requires a good sense of feel.

Feeler gauges are used:

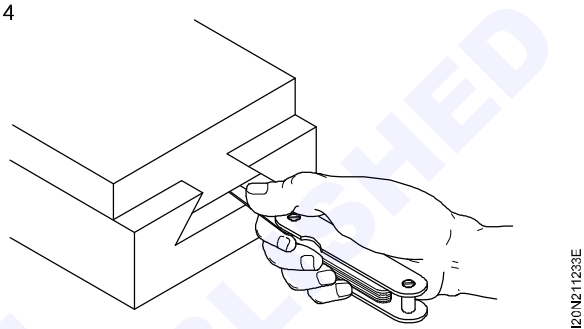
– To check the gap between the mating parts

– To check and set the spark plug gaps

– To set the clearance between the fixture (setting block) and the cutter/tool for machining the jobs

– To check and measure the bearing clearance, and for many other purposes where a specified clearance must be maintained. (Fig 14)

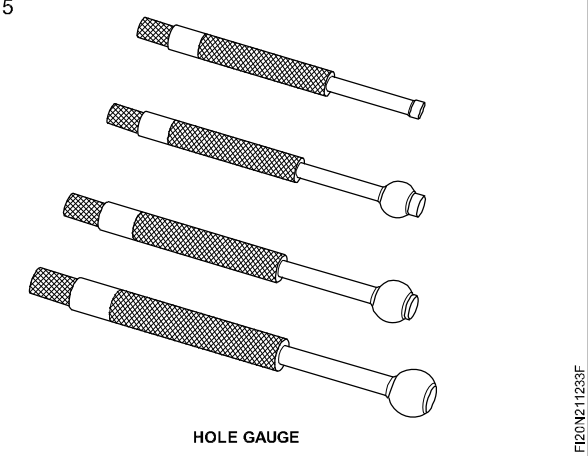
Fig 14



FI20N211233E

Hole gauge: Hole gages is used to determine the diameter of a hole. While their function is similar to bore gages, they are less precise, much simpler tools that require measurement of a transferred dimension. This gauge is made up of hardened steel, it consisting of precision machined split half ball on each gage for high-accuracy, two-point contact measuremtns throughout the entire column of small bores. (Fig 15)

Fig 15



HOLE GAUGE

FI20N211233F

Care and Maintenance of Gauges

- Before using a gauge, check the gauge for any rust, flaw, burr etc. If rust, flaw or burr is found, remove it.
- Do not hit the gauge by strong force
- Inspect a gauge periodically in consideration of wear, frequency in use and other factors
- Do not use gauges for any other purpose than Inspection.

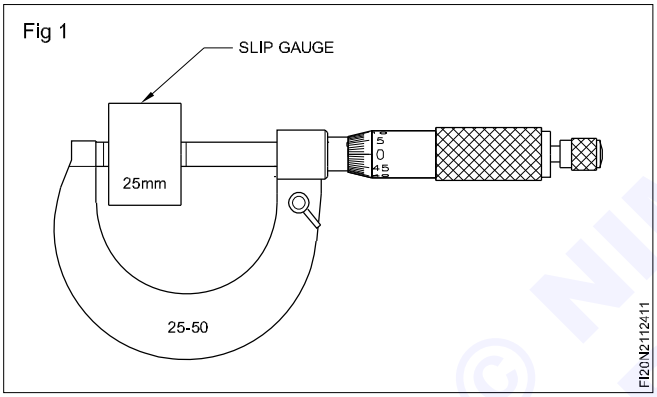
Slip Gauges

Objectives : At the end of this lesson you shall be able to
- **define the features of slip gauges**
- **state the different grades of slip gauges**
- **state the number of slips in standard**
- **state the precautions and application of slip gauges.**

Slip gauges

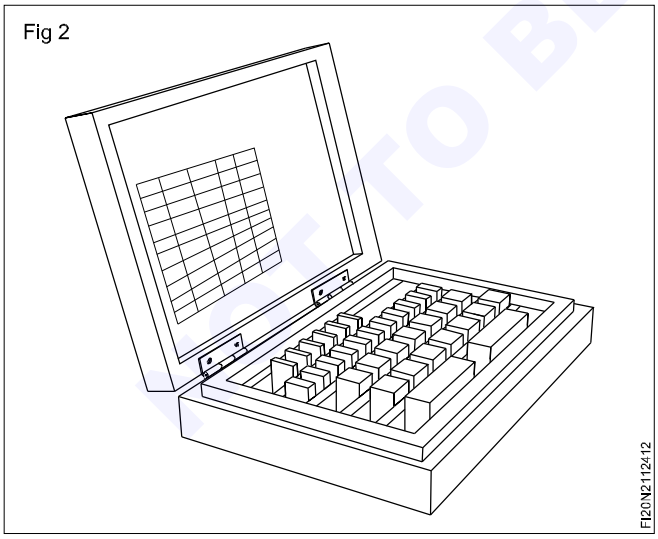
Slip gauges are gauge blocks used as standards for precision length measurement. (Fig 1) These are made in sets and consist of a number of hardened blocks, made of high grade steel with low thermal expansion. They are hardened throughout, and heat treated further for stabilization. The two opposite measuring faces of each block are lapped flat and parallel to a definite size within extremely close tolerances.

Fig 1



These slip gauges are available in various sets with different numbers. (Fig 2) (Ref.Table 1)

Fig 2



A particular size can be built up by wringing individual slip gauges together. (Figs 3 & 4)

Wringing is the act of joining the slip gauges together while building up to sizes.

Some sets of slip gauges also contain protector slips of some standard thickness made from higher wear-resistant steel or tungsten carbide. These are used for protecting the exposed faces of the slip gauge pack from damage.

Fig 3

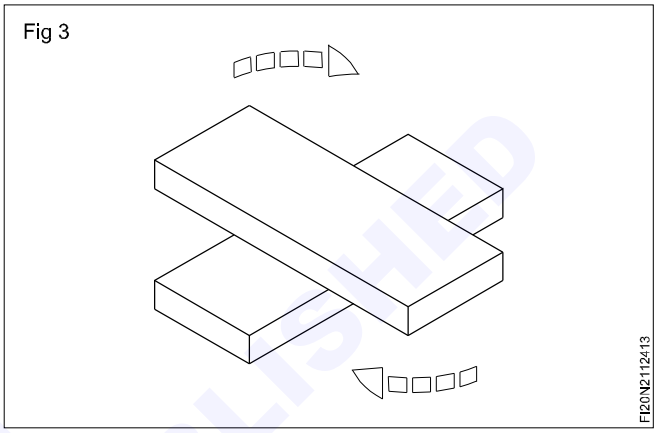
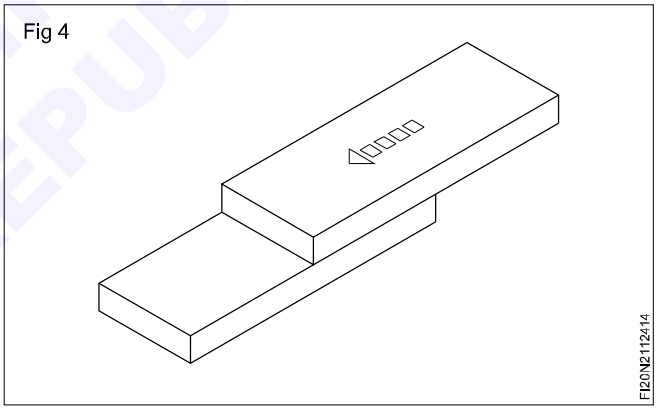


Fig 4



Grades

Grade '00' accuracy

It is a calibration grade used as a standard for reference to test all the other grades.

Grade '0' accuracy

It is an inspection grade meant for inspection purposes.

Grade I accuracy

Workshop grade for precision tool room applications.

Grade II accuracy

For general workshop applications.

B.I.S. recommendations

Three grades of slip gauges are recommended as per IS 2984. They are:

- Grade '0'
- Grade I
- Grade II.

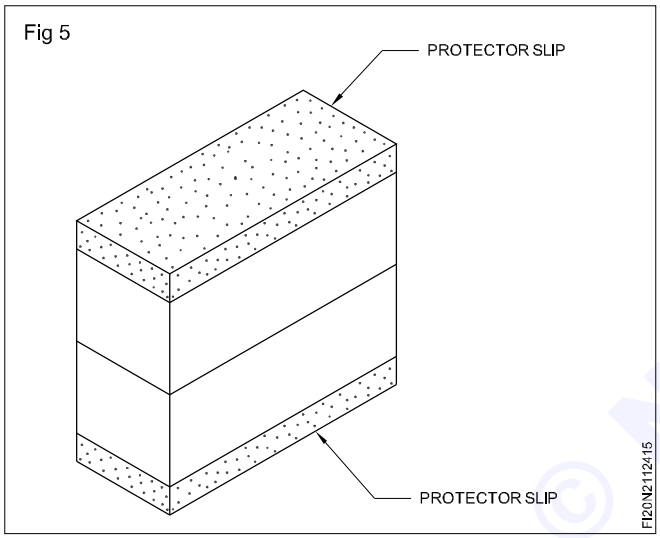
Care and maintenance points to be remembered while using slip gauges.

- Use a minimum number of blocks as far as possible while building up a particular dimension.
- While building the slip gauges, start wringing with the largest slip gauges and finish with the smallest.

While holding the slip gauges do not touch the lapped surfaces.

If available use protector slips on exposed faces.(Fig 5)

Fig 5



After use, clean the slips with carbon tetrachloride and apply petroleum jelly for protection against rust.

Before use, remove petroleum jelly with carbon tetrachloride. Use chamois leather to wipe the surfaces.

TABLE 1

Different sets of slip gauges

Set of 112 pieces (M112)

Range (mm)	Steps (mm)	No.of pieces
Special piece	1.0005	1
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25.0 to 100.0	25.00	4
Total pieces		112

Set of 103 pieces (M103)

Range (mm)	Steps (mm)	No.of pieces
1st series 1.005	-	1
2nd series 1.01 to 1.49	0.01	49
3rd series 0.5 to 24.5	0.5	49
4th series 25 to 100	25.00	4
Total pieces		103

Set of 46 pieces (M46)

Range (mm)	Steps (mm)	No.of pieces
1st series 1.001 to 1.009	0.001	9
2nd series 1.01 to 1.09	0.01	9
3rd series 1.10 to 1.90	0.10	9
4th series 1.00 to 9.00	1.00	9
5th series 10.00 to 100.00	10.00	10
Total pieces		46

Selection and determination of slip gauges for different sizes

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

- **determine slip gauges for different sizes.**

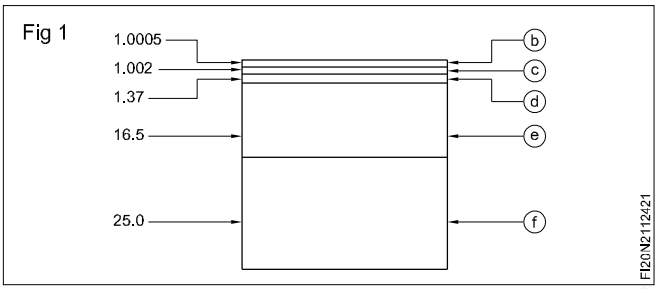
For determining a particular size, in most cases a number of slip gauges are to be selected and stacked one over the other by wringing the slip gauges.

While selecting slip gauges for a particular size using the available set of slip gauges, first consider the last digit of the size to be built up. Then consider the last or the last two digits of the subsequent value and continue to select the pieces until the required size is available.

Example (Without using protector slips)

Building up a size of 44.8725mm with the help of 112 piece set. (Table 1)

Fig 1



Set of 112 pieces (M112)

Range (mm)	Steps (mm)	No.of pieces
1.0005	--	1
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 24.5	0.5	49
25.00 to 100.0	25.00	4
Total pieces		112

TABLE 1

Procedure	Slip pack	Calculation
a First write the required dimension		44.8725
b Select the slip gauge having the 4th decimal place	1.0005 subtract	1.0005 43.872
c Select 1st series slip that has the same last figure	1.002 subtract	1.002 42.870
d Select the 2nd series slip that has the same last figure and that will leave 0.0 or 0.5 as the last figure	1.37 subtract	1.37 41.5
e Select a 3rd series slip that will leave the nearest 4th series slip	16.5 subtract (41.5 - 25 = 16.5)	16.5 25.00
f Select a slip that eliminates the final figure Add	25.0 subtract	25.00
	44.8725	00.00

Maintenance of measuring instruments

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

- **state the preventive measures to be taken for protecting precision measuring instruments.**

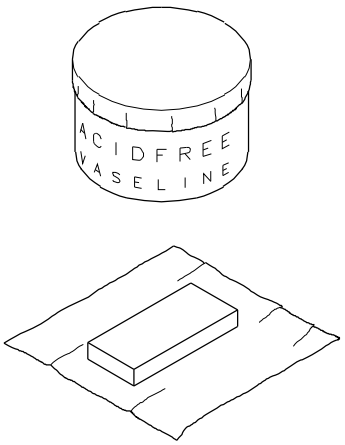
Precision measuring instruments play an important role in maintaining the quality of the products. Measuring instruments are also very expensive. It is important that the instruments are well looked after and maintained by the person who uses it.

Protection against corrosion

High atmospheric humidity and sweat from hands can cause corrosion to instruments. Avoid this.

Acid-free vaseline (petroleum jelly) applied lightly on the instruments can give protection against corrosion. (Fig 1)

Fig 1



Be sure that the instruments are thoroughly cleaned and free from water or moisture before applying vaseline.

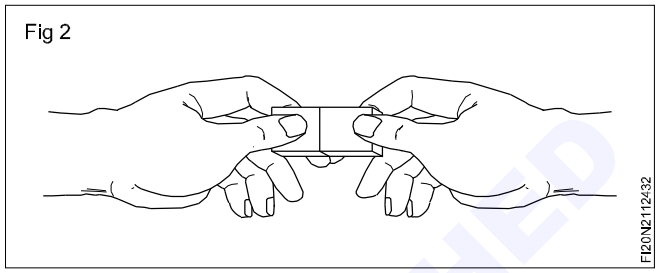
Use chamois leather for giving a light coating of vaseline.

Always clean the slip gauges with carbon tetrachloride and apply petroleum jelly after use.

Remove burrs and metal particles. Burrs on workpieces can cause scratches and damages to measuring equipment. They can also damage other workpieces.

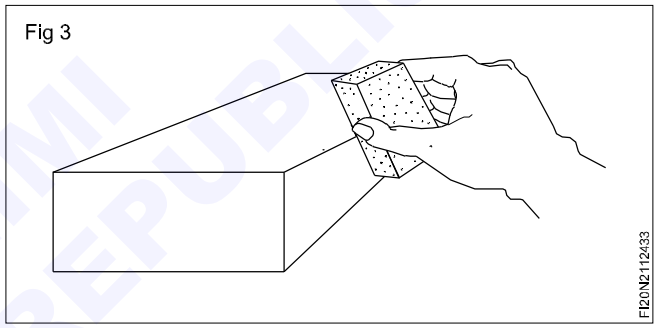
Metal or other particles between the measuring faces of slip gauges will make it impossible for them to adhere to each other.(Fig 2)

Fig 2



Remove burrs from the workpieces with an oilstone. (Fig 3)

Fig 3



Use chamois leather to wipe the carbon tetrachloride after cleaning.

Use a felt pad or rubber mat for placing the instruments while working.

Handle the instruments with care and do not allow them it to mix up with other tools.

Application of slip gauges

Objectives: At the end of this lesson you shall be able to
- **name the different accessories used along with slip gauges**
- **state the uses of different accessories.**

Slip gauges can be put to a variety of precision work when used along with certain special accessories.

Measuring external and internal sizes

Slip gauges can be used for checking external and internal measurements. For this purpose a set of high precision special jaws are used along with a holder. (Figs 1,2 & 3)

Fig 1

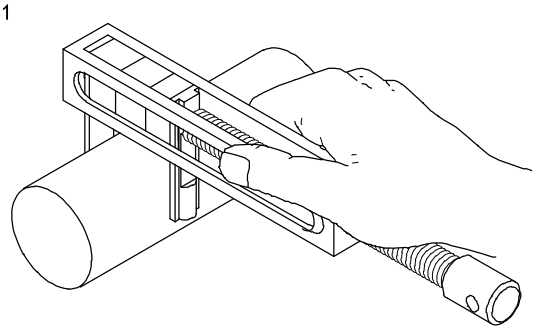


Fig 2

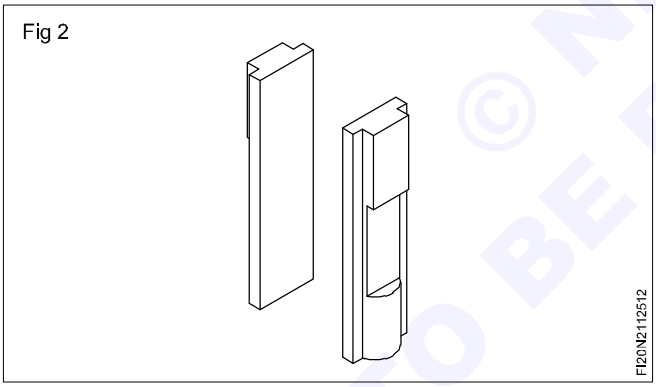
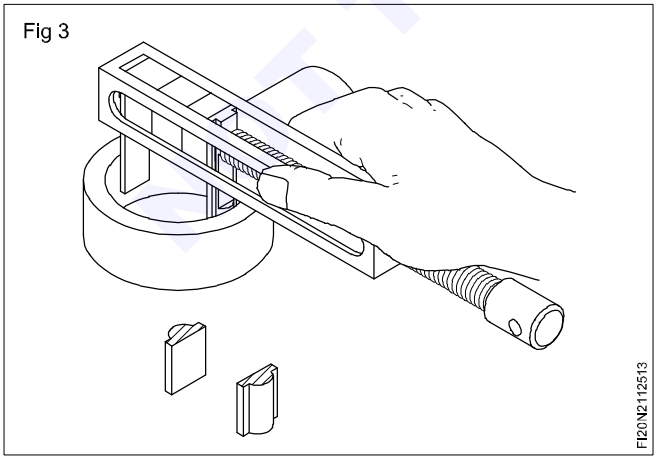
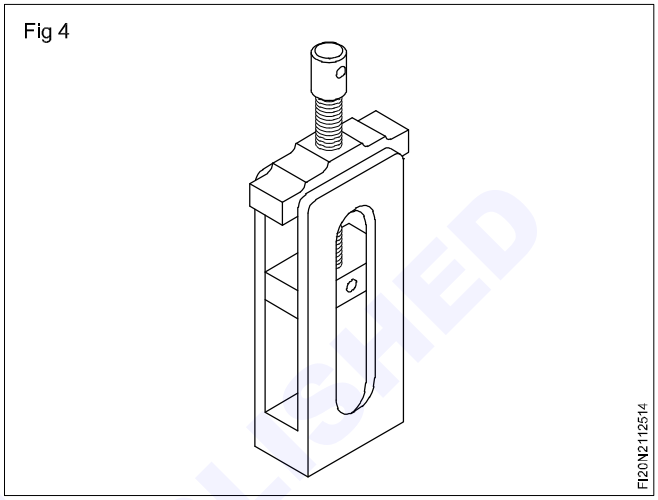


Fig 3



The pair of special jaws (Fig 2) will have a flat surface at one end and a curved surface at the other end to facilitate external and internal measurements. The slip gauge holder can be used for a variety of applications. (Fig 4)

Fig 4



Using as a height gauge

A height gauge can be built up by using a base block, (Fig 5) slip gauge holder, scriber point (Fig 6) and the required slip gauges. The height gauge (Fig 7) built up with these accessories can be used for very accurate layout work.

Fig 5

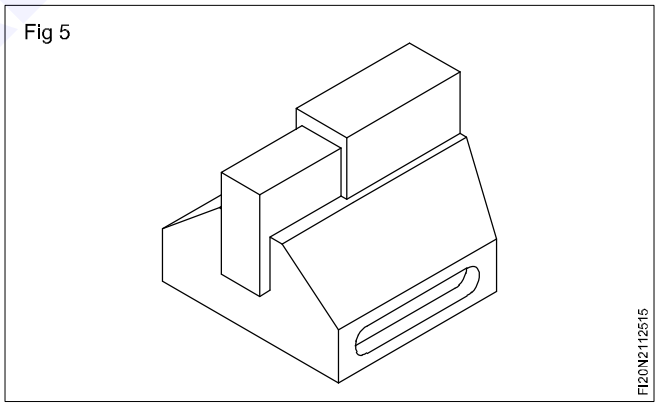


Fig 6

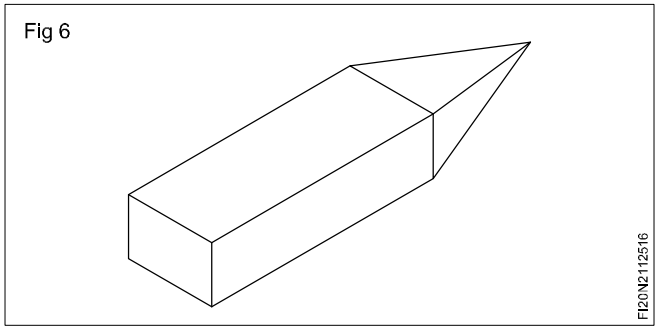
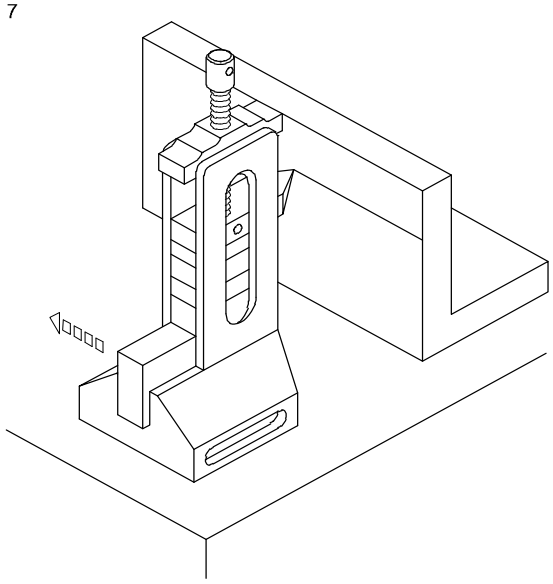


Fig 7



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For drawing circles

Compasses (Fig 8) of different lengths can be built up using the slip gauge holder, radii scriber (Fig 9) and a centre point. (Fig 10)

Fig 8

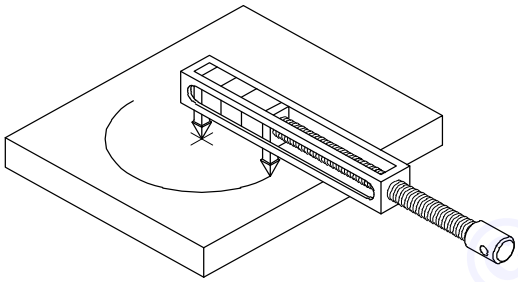

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Fig 9

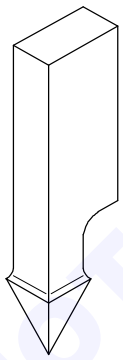

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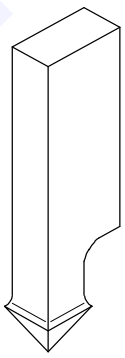
Fig 10



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Checking height

The height of surfaces can be checked by the use of a flat jaw (Figs 11 & 12) along with a base and a slip gauge holder.

Fig 11

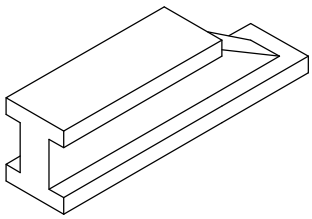

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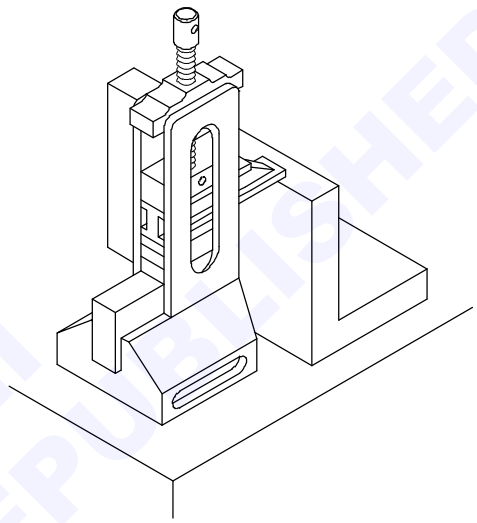
Fig 12

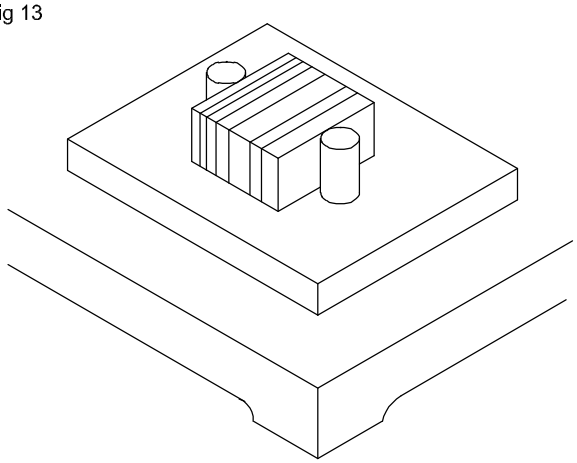


FI20N211251C

Checking centre distance of holes

With the help of precision cylindrical pins, the centre distance between holes can be accurately measured. (Fig13)

Fig 13



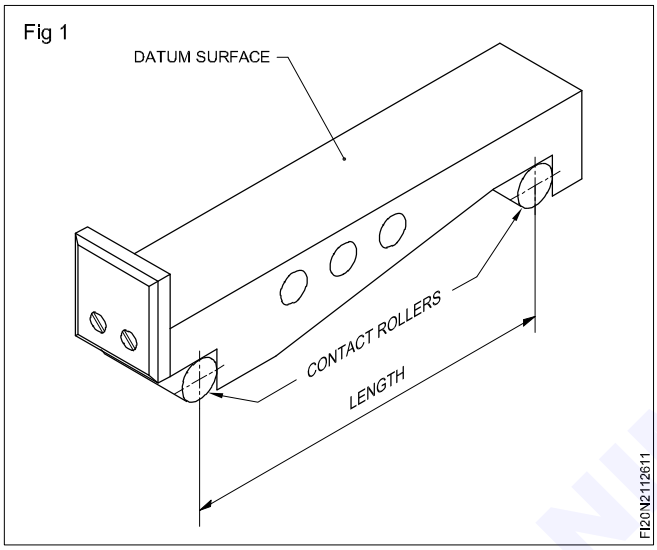
FI20N211251D

Sine bar principle application and specification

Objectives : At the end of this lesson you shall be able to
- **state the principle of a sine bar**
- **specify the sizes of sine bar**
- **state the features of sine bars**
- **state the different uses of sine bar using slip gauges.**

A sine bar is a precision measuring instrument for checking and setting of angles. (Fig 1)

Fig 1

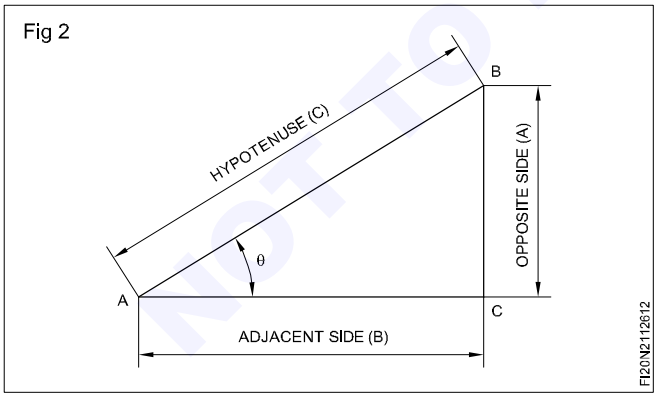


The principle of a sine bar

The principle of a sine bar is based on the trigonometrical function.

In a right angled triangle the function known as Sine of the angles is the relationship existing between the opposite side to the angle and the hypotenuse. (Fig 2)

Fig 2

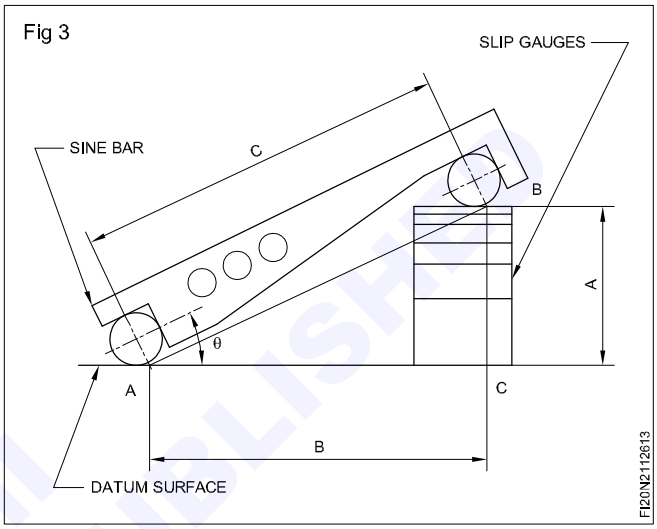


It may be noted that for setting the sine bar to different angles, slip gauges are used.

A surface plate or marking table provides the datum surface for the set up.

The sine bar, the slip gauges and the datum surface upon which they are set form a right angled triangle. (Fig 3) The sine bar forms the hypotenuse (c) and the slip gauge stack forms the side opposite (A).

Fig 3



$$\text{Sine of the angle } \theta = \frac{\text{Opposite side}}{\text{Hypotenuse}}$$

$$\text{Sine } \theta = \frac{A}{C}$$

Features

This is a rectangular bar made of stabilized chromium steel.

The surfaces are accurately finished by grinding and lapping.

Two precision rollers of the same diameter are mounted on either end of the bar. The centre line of the rollers is parallel to the top face of the sine bar.

There are holes drilled across the bar. This helps in reducing the weight, and also it facilitates clamping of sine bar on angle plate.

The length of the sine bar is the distance between the centres of the rollers. The commonly available sizes are 100 mm, 200 mm, 250 mm and 500 mm. The size of a sine bar is specified by its length.

Uses

Sine bars are used when a high degree of accuracy to less than one minute is needed for

– measuring angles (Fig 4)

– marking out (Fig 5)

– setting up for machining. (Fig 6)

Fig 4

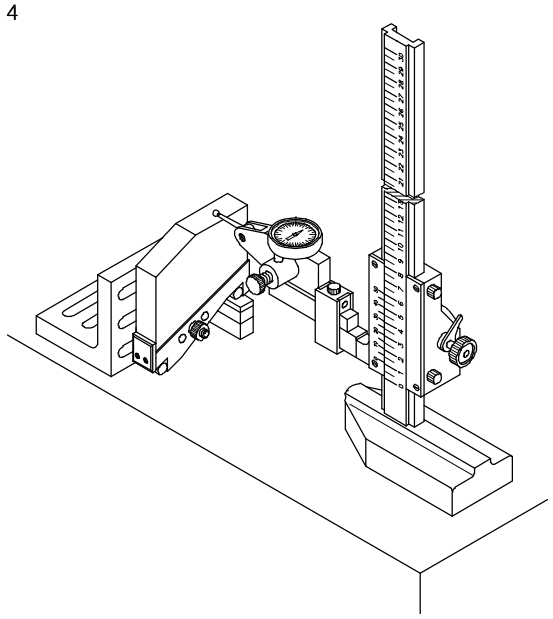


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Fig 6

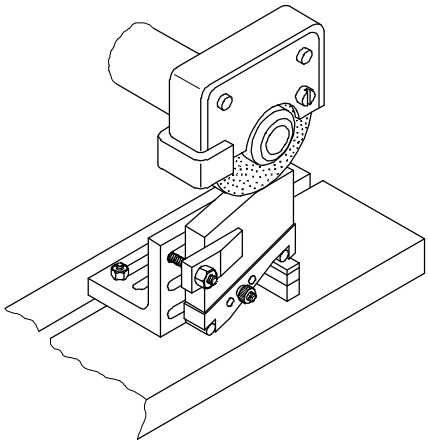

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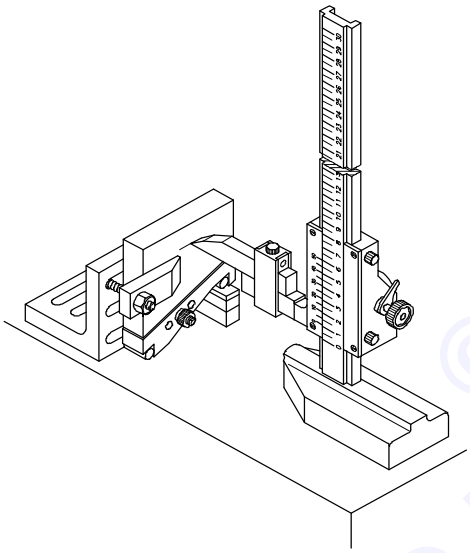
Fig 5



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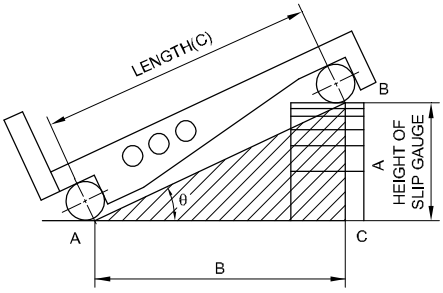
Determining taper using sine bar and slip gauges

Objectives: At the end of this lesson you shall be able to
- **determine correctness of a known angle**
- **calculate the height of slip gauges to a known angle.**

Sine bars provide a simple means of checking angles to a high degree of accuracy of not less than one minute upto 45^0.

The use of a sine bar is based on trigonometric function. The sine bar forms the hypotenuse of the triangle and the slip gauges the opposite side. (Fig 1)

Fig 1



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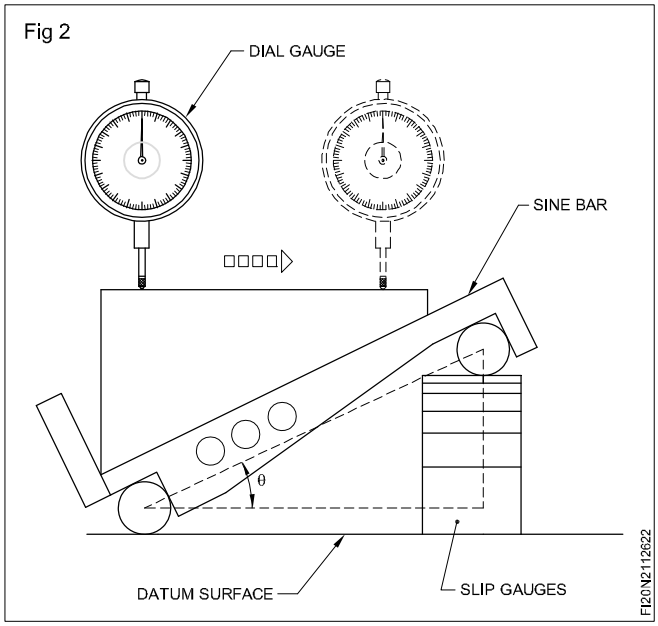
Checking the correctness of a known angle

For this purpose first choose the correct slip gauge combination for the angle to be checked.

The component to be checked should be mounted on the sine bar after placing the selected slip gauges under the roller. (Fig 1)

A dial test indicator is mounted on a suitable stand or vernier height gauge. (Fig 2) The dial test indicator is then set in first position as in the figure and the dial is set to zero.

Fig 2

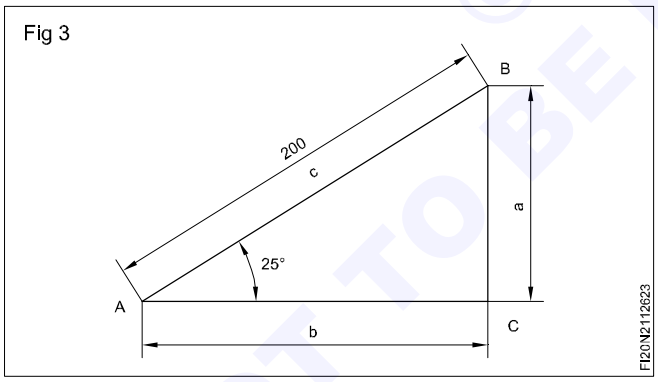


Move the dial to the other end of the component (second position). If there is any difference then the angle is incorrect. The height of the slip gauge pack can be adjusted until the dial test indicator reads zero on both ends. The actual angle can then be calculated and the deviation, if any, will be the error.

Method of calculating the slip gauge height

Example (Fig 3)

Fig 3



Exercise 1

To determine the height of slip gauges for an angle of 25° using a sine bar of 200 mm long.

$\theta = 25^0$ $\quad \text{Sine}\ \theta = \frac{a}{c}$

$a = C \text{ Sine } \theta$

$= 200 \times 0.4226$

$a = 84.52$ mm

The height of the slip gauge required is 84.52 mm.

The value of sine θ can be obtained from mathematical tables. (Natural trigonometrical functions)

Tables are also available with readily worked out sine bar constants for standard sine bar lengths.

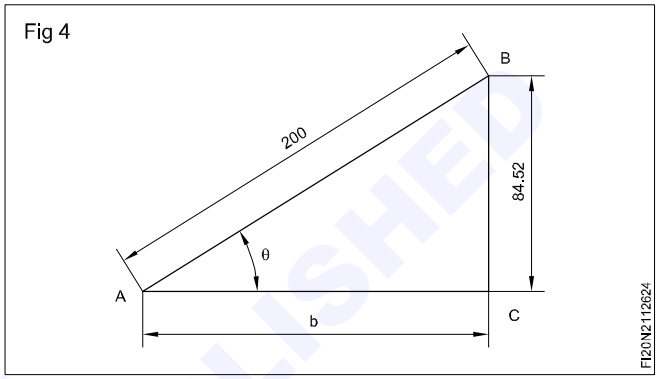
Calculating the angle for tapered components

Exercise 2

The height of the slip gauge used is 84.52 mm. The length of the sine bar used is 200 mm.

What will be the angle of the component? (Fig 4)

Fig 4



$$\text{Sine}\theta = \frac{a}{c}$$

$$= \frac{84.52}{200}$$

$\text{sine } \theta = 0.4226$

The angle whose sine value is 0.4226 is 25^0. Hence the angle of tapered component is 25^0.

Classroom Assignment

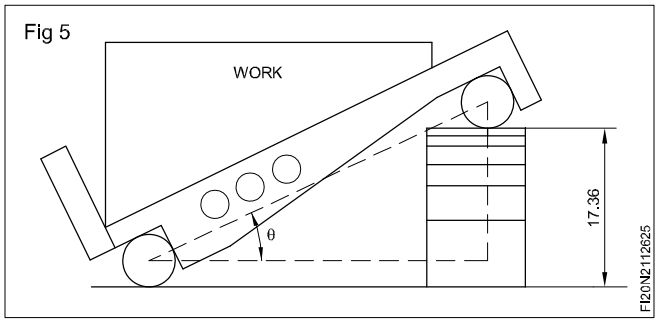
1 What will be the angle of the workpiece if the slip gauge pack height is 17.36 mm and the size of the sine bar used is 100 mm? (Fig 5)

Answer _____

2 Calculate the height of the slip gauge pack to raise a 100 mm sine bar to an angle of 3^0 35'.

Answer _____

Fig 5



Procedure to check adherence to specification and quality standards

Objectives : At the end of this lesson you shall be able to
- **state procedure to check adherence to specification**
- **state quality standards.**

Procedure to check adherence to Specification:

During the term, supplier shall manufacture all products supplied to purchaser in accordance with the specifications provided by purchaser, supplier's standard operating procedures, quality requirements and industry standards.

Why it is important to follow the manufacturer's specifications in operating machine, the reason is manufacturer instructions provide us with technical information that can help form a risk assessment, that will then allow us to develop suitable controls and wear protective equipment to protect us againt the hazards associated to a machine (or) equipment.

Quality Standards

Quality standards are defined as documents that provide requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that materials, products, processes, and services are fit for their purpose.

Standards provide organizations with the shared vision, understanding, procedures, and vocabulary needed to meet the expectations of their stakeholders. Because standards present precise descriptions and terminology, they offer an objective and authoritative basis for organizations and consumers around the world to communicate and conduct business.

Principles of Quality Standards

Organizations turn to standards for guidelines, definitions, and procedures that help them achieve objectives such as:

- Satisfying their customers' quality requirements
- Ensuring their products and services are safe
- Complying with regulations
- Meeting environmental objectives
- Protecting products against climatic or other adverse conditions
- Ensuring that internal processes are defined and controlled

Use of quality standards is voluntary, but may be expected by certain groups of stakeholders Additionally, some organizations or government agencies may require suppliers and partners to use a specific standard as a condition of doing business.

Quality Standards

Topic:	**Standard:**
Quality Management	ISO 9000
	ISO 9001
Auditing	ISO 19011
Environmental Management	ISO 14000
	ISO 14001
Risk Management	ISO 31011
Social Responsibility	ISO 26000
Sampling by Attributes	Z1.4
Sampling by Variables	Z1.9
Food Safety	ISO 22000

For the global economy: Businesses and organizations complying to quality standards helps products, services, and personnel cross borders and also ensures that products manufactured in one country can be sold and used in another.

For consumers: Many quality management standards provide safeguards for users of products and services, but standardization can also make consumers' lives simpler. A product or service based on an international standard will be compatible with more products or services worldwide, which increases the number of choices available across the globe.

Lapping

Objectives: At the end of this lesson you shall be able to
- **state the purpose of lapping**
- **state the features of a flat lapping plate**
- **state the use of charging a flat lapping plate**
- **state the method of charging a cast iron plate**
- **distinguish between wet lapping and dry lapping.**

Lapping is a precision finishing operation carried out using fine abrasive materials.

Purpose: This process:

– improves geometrical accuracy

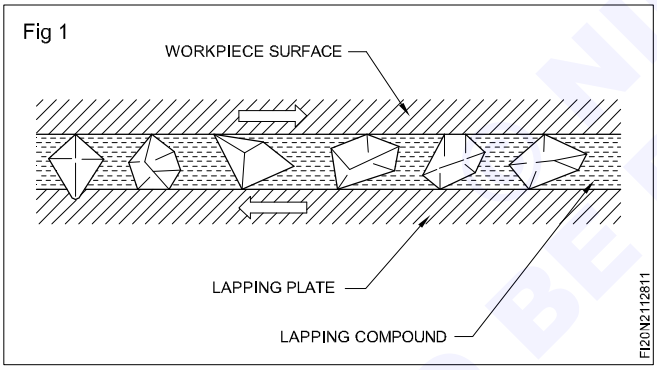
– refines surface finish

– assists in achieving a high degree of dimensional accuracy

– improve the quality of fit between the mating components.

Lapping process: In the lapping process small amount of material are removed by rubbing the work against a lap charged with a lapping compound. (Fig 1)

Fig 1



The lapping compound consists of fine abrasive particles suspended in a 'vehicle' such as oil, paraffin, grease etc.

The lapping compound which is introduced between the workpiece and the lap chips away the material from the workpiece. Light pressure is applied when both are moved against each other. The lapping can be carried out manually or by machine.

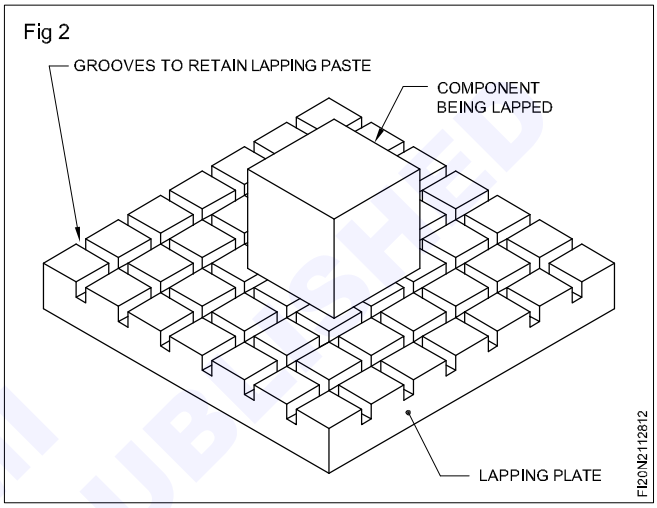
Hand lapping of flat surfaces: Flat surfaces are hand-lapped using lapping plate made out of close grained cast iron. (Fig 2) The surface of the plate should be in a true plane for accurate results in lapping.

The lapping plate generally used in tool rooms will have narrow grooves cut on its surface both lengthwise and crosswise forming a series of squares.

While lapping, the lapping compound collects in the serrations and rolls in and out as the work is moved.

Before commencing lapping of the component, the cast iron plate should be CHARGED with abrasive particles.

Fig 2



This is a process by which the abrasive particles are embedded on to the surfaces of the laps which are comparatively softer than the component being lapped. For charging the cast iron lap, apply a thin coating of the abrasive compound over the surface of the lapping plate.

Use a finished hard steel block and press the cutting particles into the lap. While doing so, rubbing should be kept to the minimum. When the entire surface of the lapping plate is charged, the surface will have a uniform gray appearance. If the surface is not fully charged, bright spots will be visible here and there.

Excessive application of the abrasive compound will result in the rolling action of the abrasive between the work and the plate developing inaccuracies.

The surface of the flat lap should be finished true by scraping before charging. After charging the plate, wash off all the loose abrasive using kerosene.

Then place the workpiece on the plate and move along and across, covering the entire surface area of the plate. When carrying out fine lapping, the surface should be kept moist with the help of kerosene.

Wet and dry lapping: Lapping can be carried out either wet or dry.

In wet lapping there is surplus oil and abrasives on the surface of the lap. As the workpiece, which is being lapped, is moved on the lap, there is movement of the abrasive particles also.

In dry method the lap is first charged by rubbing the abrasives on the surface of the lap. The surplus oil and abrasives are then washed off. The abrasives embedded on the surface of the lap will only be remaining. The embedded abrasives act like a fine oilstone when metal pins to be lapped are moved over the surface with light pressure. However, while lapping, the surface being lapped is kept moistened with kerosene or petrol. Surfaces finished by the dry method will have better finish and appearance. Some prefer to do rough lapping by wet method and finish by dry lapping.

Lap materials and lapping compounds

Objectives: At the end of this lesson you shall be able to
- **name the different types of lap materials**
- **state the qualities of different lap materials**
- **name the different types of abrasive materials used for lapping**
- **distinguish between the application of different lapping abrasives**
- **state the function of lapping vehicles**
- **name the different lapping vehicles**
- **name the solvents used in lapping.**

The material used for making laps should be softer than the workpiece being lapped. This helps to charge the abrasives on the lap. If the lap is harder than the workpiece, the workpiece will get charged with the abrasives and cut the lap instead of the workpiece being lapped.

Laps are usually made of:

– close grained iron

– copper

– brass or lead

The best material used for making lap is cast iron, but this cannot be used for all applications.

When there is excessive lapping allowance, copper and brass laps are preferred as they can be charged more easily and cut more rapidly than cast iron.

Lead is an inexpensive form of lap commonly used for holes. Lead is cast to the required size on steel arbor. These laps can be expanded when they are worn out. Charging the lap is much quicker.

Lapping abrasives: Abrasives of different types are used for lapping.

The commonly used abrasives are:

– Silicon Carbide

– Aluminium Oxide

– Boron Carbide and

– Diamond

Silicon carbide: This is an extremely hard abrasive. Its grit is sharp and brittle. While lapping, the sharp cutting edges continuously break down exposing new cutting edges. Due to this reason this is considered as very ideal for lapping hardened steel and cast iron, particularly where heavy stock removal is required.

Aluminium oxide: Aluminium oxide is sharp and tougher than silicon carbide. Aluminium oxide is used in un-fused and fused forms. Un-fused alumina (aluminium oxide) removes stock effectively and is capable of obtaining high quality finish.

Fused alumina is used for lapping soft steels and non-ferrous metals.

Boron carbide: This is an expensive abrasive material which is next to diamond in hardness. It has excellent cutting properties. Because of the high cost, it is used only in specialised application like dies and gauges.

Diamond: This being the hardest of all materials, it is used for lapping tungsten carbide. Rotary diamond laps are also prepared for accurately finishing very small holes which cannot be ground.

Lapping vehicles: In the preparation of lapping compounds the abrasive particles are suspended in vehicles. This helps to prevent concentration of abrasives on the lapping surfaces and regulates the cutting action and lubricates the surfaces.

The commonly used vehicles are:

– water soluble cutting oils

– vegetable oil

– machine oils

– petroleum jelly or grease

– vehicles with oil or grease base used for lapping ferrous metals.

Metals like copper and its alloys and other non-ferrous metals are lapped using soluble oil, bentomite etc.

In addition to the vehicles used in making the lapping compound, solvents like water, kerosene, etc. are also used at the time of lapping.

Abrasive of varying grain sizes from 50 to 800 are used for lapping, depending on the surface finish required on the component.

Lap external and internal cylindrical surfaces

Objectives: At the end of this lesson you shall be able to
- **state the features of external and internal cylindrical laps**
- **identify the different types of laps used for cylindrical surfaces**
- **state the method of charging the cylindrical laps**
- **state the precautions to be observed while lapping cylindrical surfaces.**

In manufacturing processes where a very high degree of accuracy is required as in the case of jigs and fixtures etc. lapping becomes necessary. For finishing holes, which are hardened, lapping is very essential.

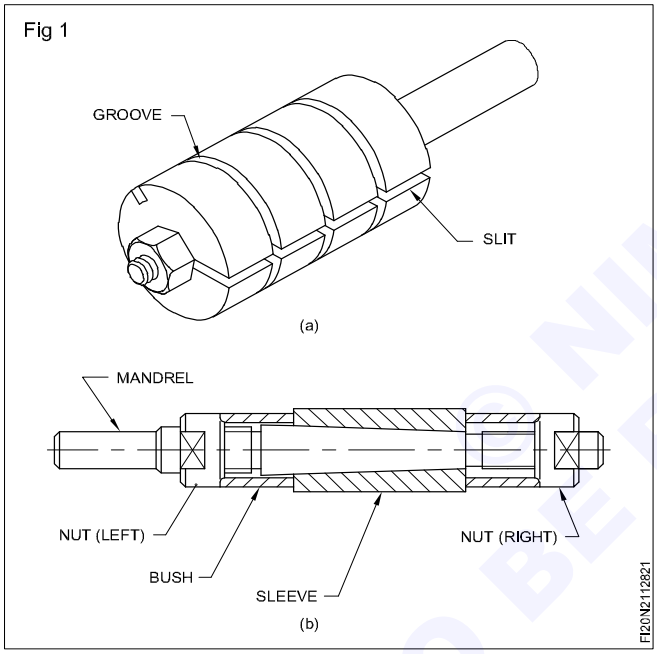
Lapping internal cylindrical surfaces

Solid or adjustable types of laps are used for lapping internal cylindrical surfaces/holes. (Fig 1a)

Laps of larger sizes are made of cast iron. Small diameter laps are made of copper or brass as cast iron is brittle. Laps for holes are commercially available.

They are adjustable and have interchangeable sleeves made of copper. (Fig 1b)

Fig 1



Laps with a capability of slight adjustment in size can also be prepared in the shop floor. (Figs 2 & 3)

Fig 2

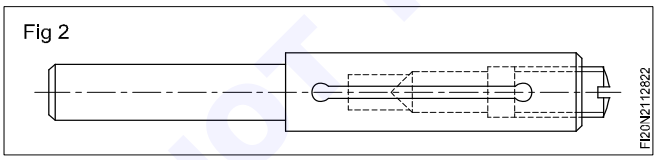
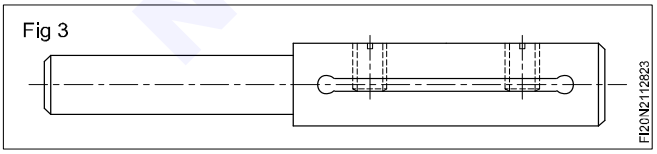


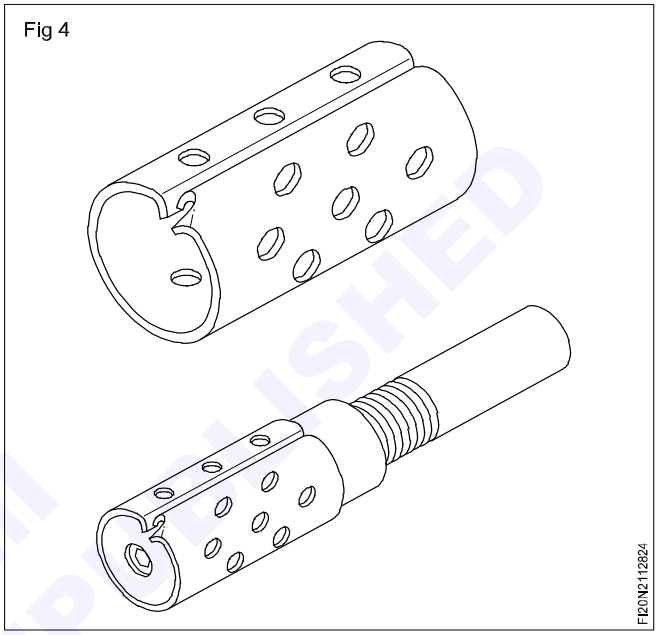
Fig 3



Grooves cut on the surfaces of the lap help in retaining the abrasive compound (Fig 1a) and the slits cut provide for ex-pansion. Commercially available laps are sometimes provided with holes which can hold the lapping compound. (Fig 4). Holes can be lapped manually or by using special lapping machines. A sensitive drill press can also be used for rotating the laps. While lapping, the lap should fill the hole and kept tight.

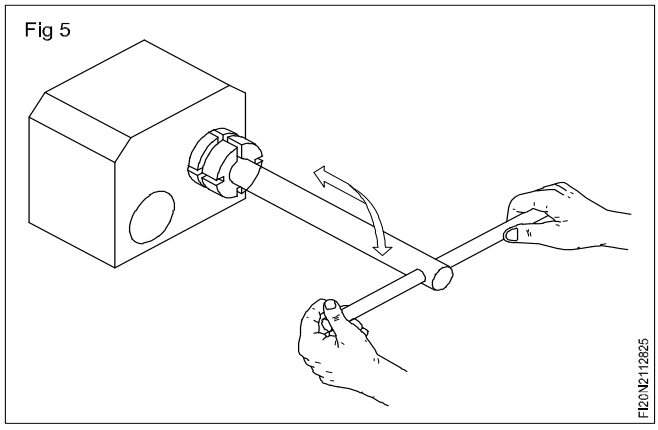
Use of adjustable laps is very helpful for this. The length of the lap should be longer than the hole being lapped to ensure straightness of the hole throughout.

Fig 4



The lap should not be removed from the hole while lapping, and should travel the full length of the bore. (Fig 5)

Fig 5



While lapping, the lap should be pushed forward in the bore giving a clockwise movement at the same time.

Lapping external cylindrical surfaces

Adjustable ring laps of various designs are available for lapping external cylindrical surfaces.

The simplest form is a split bush with clamping screws, which permits some adjustment of sizes. (Fig 6)

The adjustable ring lap will have slots cut on it which permit the feeding of the lapping compound and adjustment of sizes. (Fig 7)

Another type of ring lap with interchangeable bushes is also available. In a single holder different sizes of bushes can be used. (Fig 8)

Fig 6

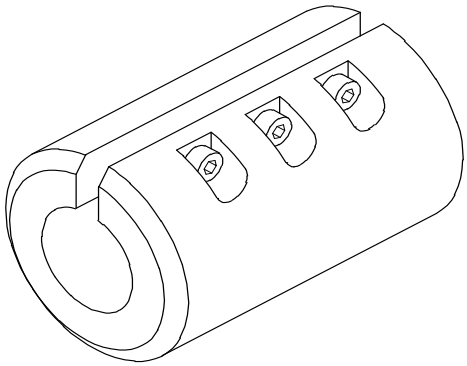


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Fig 7

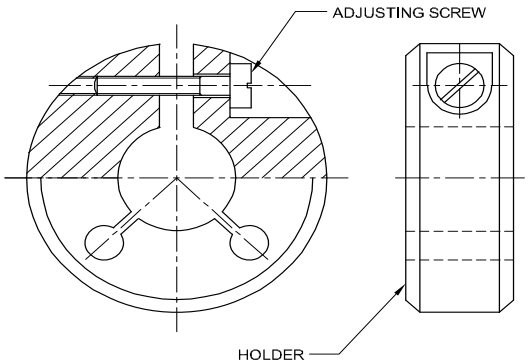

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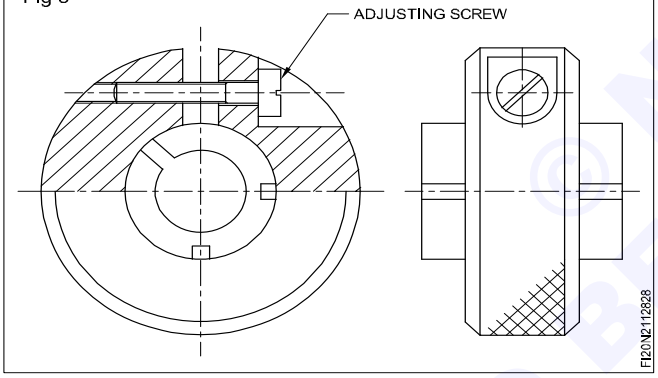
Fig 8



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External threads can also be lapped using ring laps. (Fig 9) This usually consists of interchangeable threaded bushes cor-responding to the external thread to be lapped. A slight adjustment of sizes is also possible. Ring laps are usually made of closely grained cast iron.

Ring lapping can be done manually (Fig 10) or by holding the work on the lathe while the split ring is moved over the cylindrical surface. (Fig 11)

While lapping, the ring lap should slide forward and backward along the workpiece rotating the lap at the same time in alternate directions.

For lapping large diameters, special laps can be prepared and used. (Fig 12)

Charging cylindrical laps

For charging cylindrical laps for internal work, a thin coating of prepared abrasive compound is spread over the surface of a hard steel block. The lapping compound is then rubbed with a cast iron or copper block. The lap is rolled over the cast iron block by pressing it down firmly so that the abrasive grains will be firmly embedded on the surface of the lap.

Fig 9

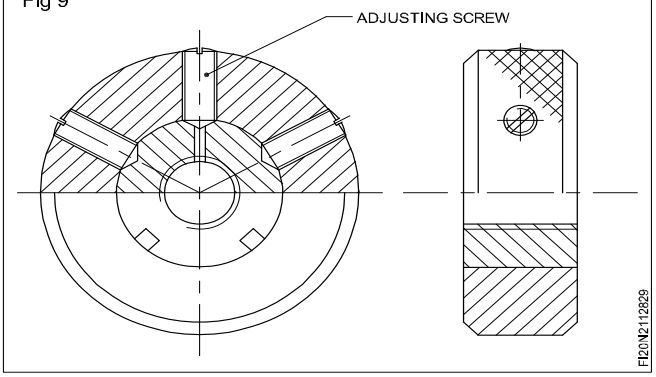

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Fig 10

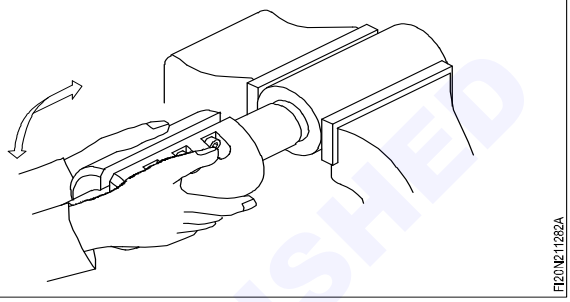

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Fig 11

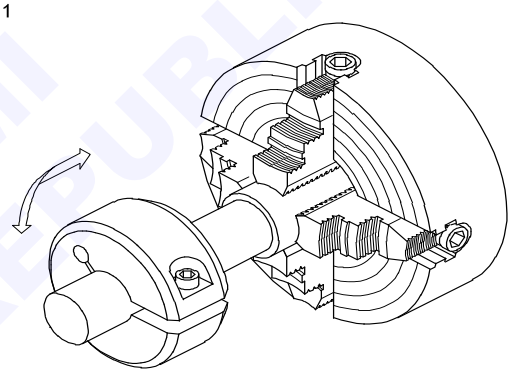

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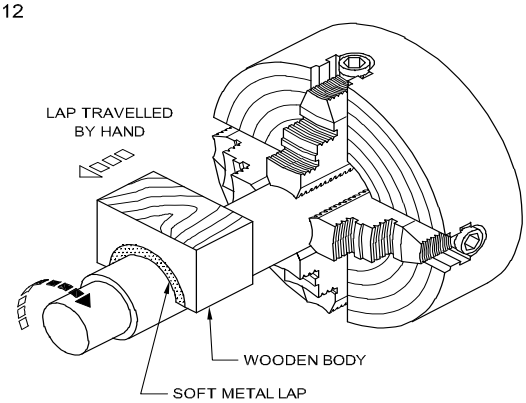
Fig 12



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The external cylindrical laps can be charged by pressing the abrasive inside the bore with the help of hard steel rollers which are slightly smaller than the diameter of the lap.

Precautions to be observed while lapping

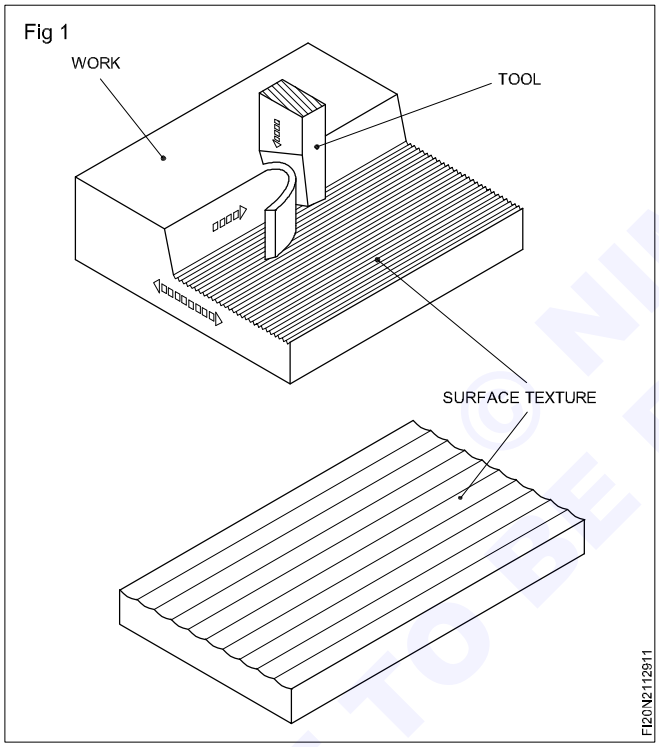
- Do not dwell in the same place while lapping.
- Keep the lap moist always.
- Do not add fresh abrasive during lapping; recharge if necessary.
- Do not apply excessive pressure while lapping.

Surface finish importance

Objectives : At the end of this lesson you shall be able to
- **state the meaning of surface texture**
- **distinguish between roughness and waviness**
- **state the need for different quality surface textures**
- **state the meaning of 'Ra' valve**
- **interpret 'Ra' and roughness grade number in drawings.**

When components are produced either by machining or by hand processes, the movement of the cutting tool leaves certain lines or patterns on the work surface. This is known as surface texture. These are, in fact, irregularities, caused by the production process with regular or irregular spacing which tend to form a pattern on the workpiece. (Fig 1)

Fig 1



The components of surface texture

Roughness (Primary texture)

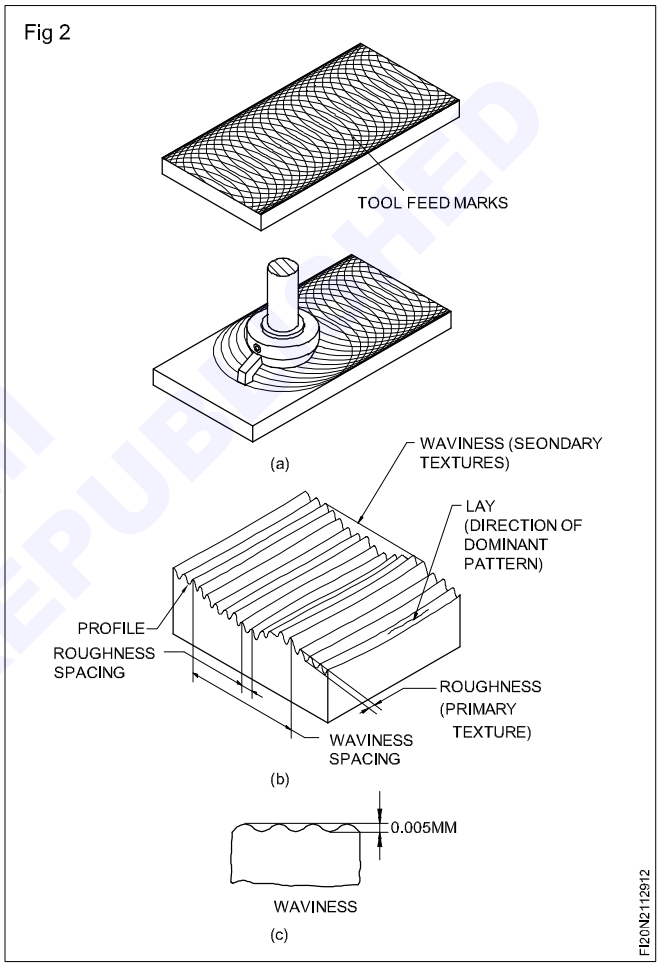
The irregularities in the surface texture result from the inherent action of the production process. These will include traverse feed marks and irregularities within them. (Fig 2a)

Waviness (Fig 2b & 2c)

This is the component of the surface texture upon which roughness is superimposed. Waviness may result from machine or work deflections, vibrations, chatter, heat treatment or warping strain.

The requirement of surface quality depends on the actual use to which the component is put.

Fig 2



Examples

In the case of slip gauges (Fig 3) the surface texture has to be extremely fine with practically no waviness. This will help the slip gauges to adhere to each other firmly when wrung together.

The cylinder bore of an engine (Fig 4) may require a certain degree of roughness for assisting lubrication needed for the movement of the piston.

For sliding surfaces the quality of surface texture is very important.

When two sliding surfaces are placed one over the other initially the contact will be only on the high spots. (Fig 5) These high spots will wear away gradually. This wearing away depends on the quality of the surface texture.

Fig 3

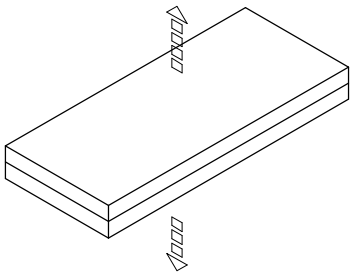


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Fig 4

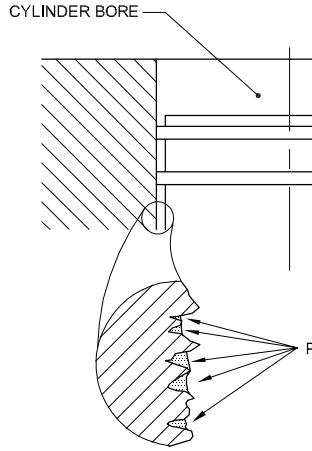

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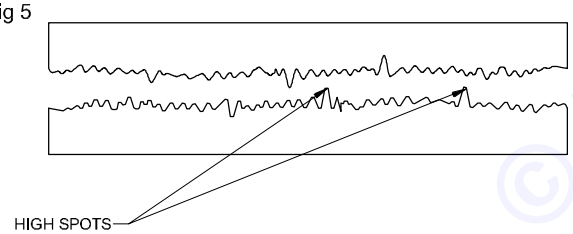
Fig 5



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Due to this reason it is important to indicate the surface quality of components to be manufactured.

The surface texture quality can be expressed and assessed numerically.

'Ra' Values (Dimensional therome)

The most commonly used method of expressing the surface texture quality numerically is by using Ra value. This is also known as centre line average (CLA).

The graphical representation of Ra value is shown in Figures 6 & 7. In Figure 6 a mean line is placed cutting through the surface profile making the cavities below and the material above equal.

Fig 6

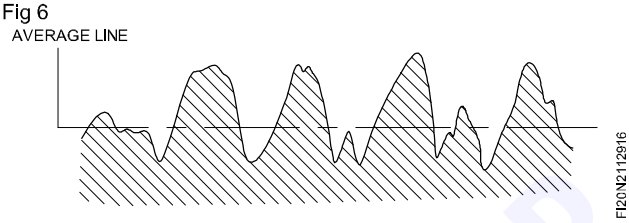

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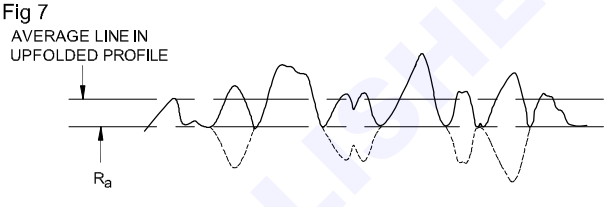
Fig 7



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The profile curve is then drawn along the average line so that the profile below this is brought above.

A new mean line (Fig 7) is then calculated for the curve obtained after folding the bottom half of the original profile.

The distance between the two lines is the 'Ra' value of the surface.

The 'Ra' value is expressed in terms of micrometre (0.000001m) or (m), this also can be indicated in the corresponding roughness grade number, ranging from N_1 to N_{12}.

When only one 'Ra' value is specified, it represents the maximum permissible value of surface roughness.

Surface texture measuring instruments

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

- **distinguish the features of mechanical and electronic surface indicators**
- **name the parts of a mechanical surface indicator**
- **identify the features of electronic surface indicators (taly-surf)**
- **state the functions of the different features of electronic surface indicators.**

The use of surface finish standards which we have seen earlier is only a method of comparing and determining the quality of surface. The result of such measurement very much depends on the sense of touch and cannot be used when a higher degree of accuracy is needed.

The instruments used for measuring the surface texture can be of a mechanical type or with electronic sensing device.

Mechanical surface indicator

This instrument consists of the following features. (Fig 1)

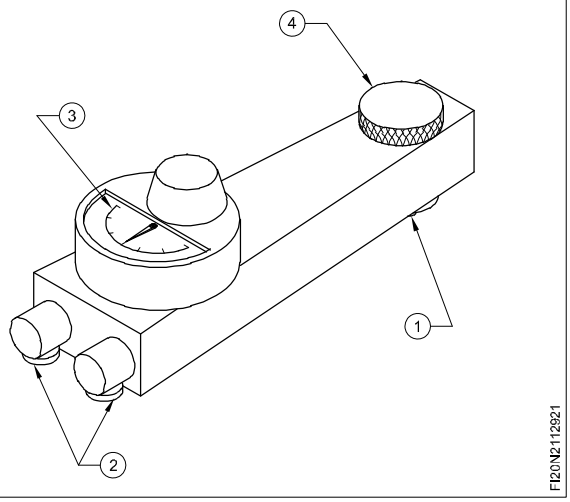
1 Measuring stylus

2 Skids

3 Indicator scale

4 Adjustment screw

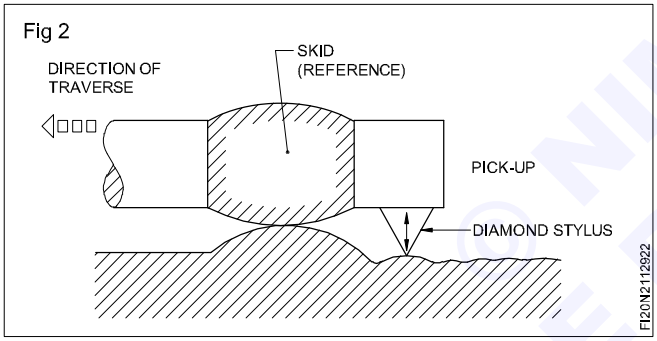
Fig 1



The stylus is made of diamond, and its contact point will have a light radius.

When the stylus is slowly traversed across the test surface the stylus moves upward or downward depending on the profile of the surface. (Fig 2) This movement is amplified and transferred to the dial of the surface indicator. The pointer movement indicates the surface irregularities.

Fig 2



When using a mechanical surface indicator, measurement must be read as it is moved over the surface, and then a profile curve is drawn manually to compute the mean value.

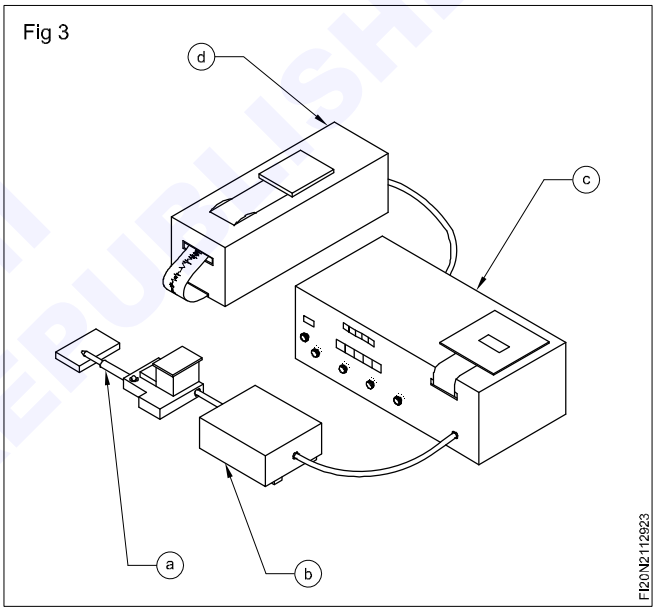
There are different types of electronic surface measuring devices; one type of such an instrument used in workshops is the taly-surf.

Taly-surf (Electronic surface indicator)

This is an electronic instrument for measuring surface texture. This instrument can be used for factory and laboratory use. (Fig 3)

The measuring head of this unit consists of a stylus (a) and a motor race (b) which controls the movement of the instrument head across the surface. The movement of the stylus is converted to electrical signals. These signals are amplified in the surface analyser/amplifier (c) which calculates the surface parameter and presents the result on a digital display or in the form of a diagram through a recorder (d).

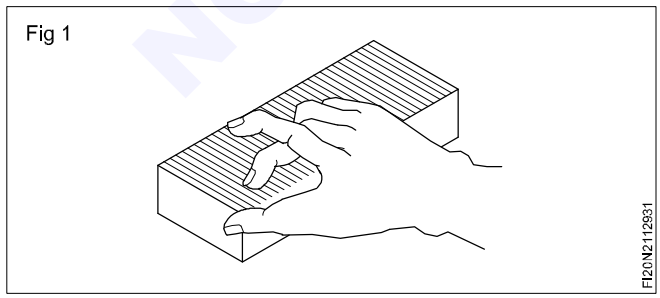
Fig 3



Surface quality

Various components are manufactured by different machining processes. The surfaces of the components differ in their appearance as well as `feel' when we move our hand over the surface. (Fig 1)

Fig 1



The surface will have ups and downs. These ups and downs are due to the tool marks. The pattern of these tool marks depends on the machining processes. The irregular patterns of tool marks depend on the feed, speed, tool angles, depth of cut etc. So all the machined surfaces are rough due to the inherent tool marks left in the machining processes. The surface appearance of components is shown in Figs 2 to 4.

Fig 2

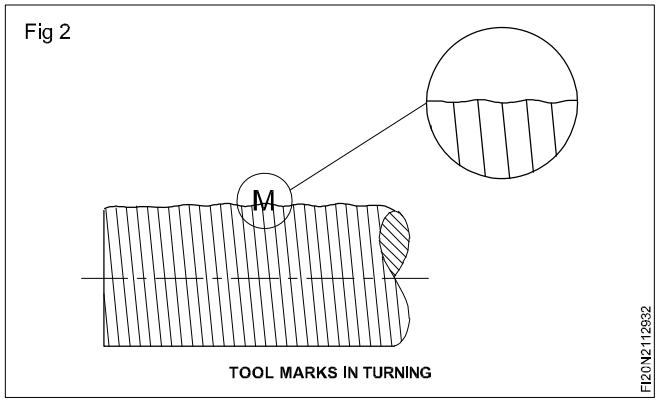
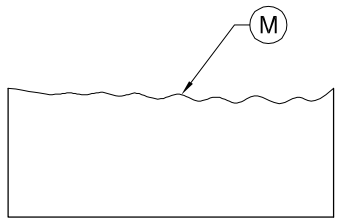


Fig 3



TOOL MARKS IN MILLING

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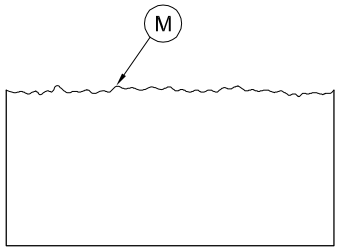
Fig 4



TOOL MARKS IN SHAPING. PLANING, SLOTTING

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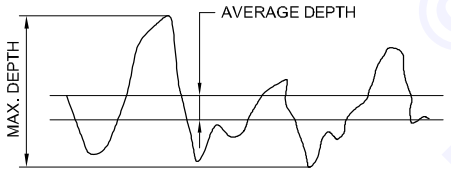
In other words, the selection process and setting of machining parameters are dictated by the type of surfaces quality demanded in the drawing of the part.

Surface roughness measurement

To control the roughness of a surface precisely, we need to define and establish a measuring system for it.

Roughness is defined as the average height or depth from the hill to the valley of a surface pattern (Fig 5) and it is possible to measure this by instruments specially designed for this purpose.

Fig 5



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This instrument has a very sharp stylus. (Fig 6) This stylus is moved across the surface to be measured mechanically over a short distance and during this time the instrument calculates the average depth and displays the value as a roughness number.

Surface finish standard

One method of determining the surface roughness is by using a surface finish standard. (Fig 7) This is a box which consists of 20 blocks of a specific surface finish obtained by a specific machining operation.

Fig 6

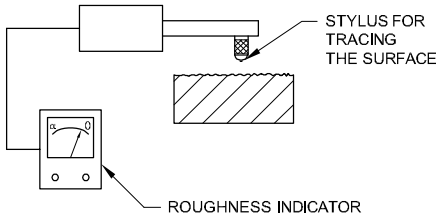

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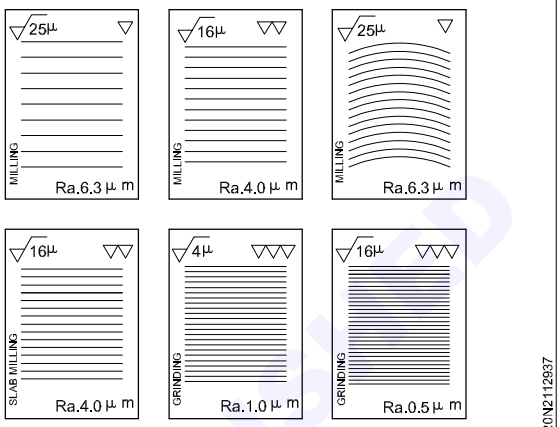
Fig 7



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The type of machining operation is marked on each block together with the surface roughness number for height and width. Using the surface finish standard, we can make comparisons between the machined surface and the standard surface using our sense of touch.

However, this method is sometimes not accurate enough and the individual must be very sensitive to the different surface roughness.

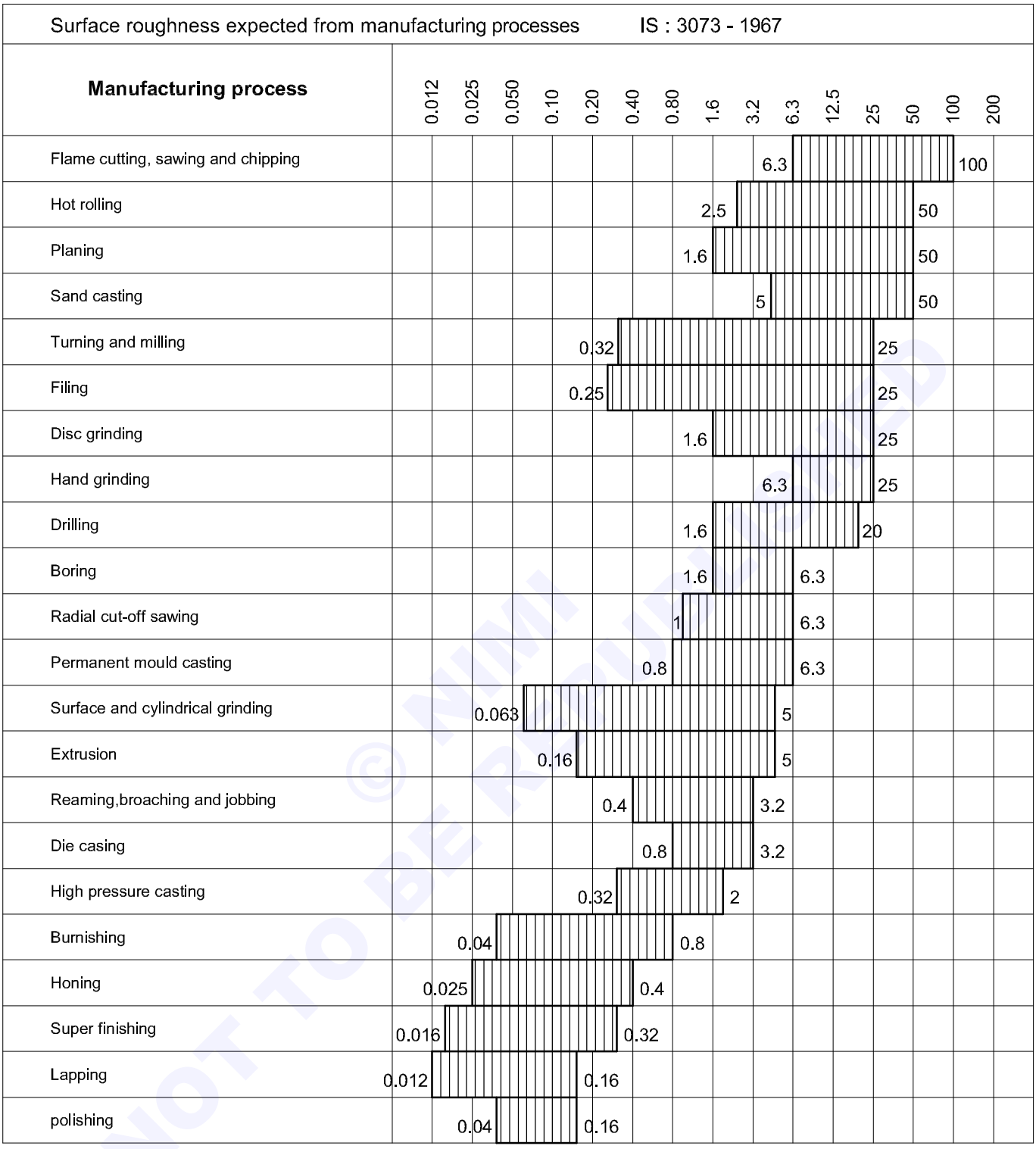
If the degree of accuracy of checking is high, then the application of a sensitive instrument is inevitable.

In order to obtain the required surface quality, it is necessary to choose the appropriate manufacturing process. Table-1 appended here gives an idea about the different processes and range of surface quality attainable.

For more detailed information on surface texture, symbols and their representations refer to IS:10719.

TABLE 1

Surface roughness expected from manufacturing processes IS : 3073 - 1967



Honing

Objectives: At the end of this lesson you shall be able to
- **define honing**
- **state the principle of honing**
- **name the various applications of honing**
- **state the methods of honing**
- **compare the features of the honing tools used in manual and power stroking**
- **name the different honing stones(abrasive) and state their uses**
- **list the cutting fluid used in honing.**

Honing

Honing is a super finishing process carried out using abrasive sticks for the removal of stock from metallic and non-metallic surfaces.

This process:

- produces high surface finish
- corrects the profiles of cylindrical surfaces
- removes taper.

Working principle

The honing tool with abrasives mounted on it is held on the spindle of a machine which can be rotated in its axis.

As the spindle rotates, a reciprocating motion is also given to the tool. The surface produced will have a cross hatched pattern. (Figs 1 & 2) This pattern of the surface texture provides better lubrication in cylindrical bores.

Application

Honing is used for finishing of bores in ferrous and non-ferrous materials.

Honing can be done in hardened or un-hardened state.

Bores of any size, length, blind or through, tandem or interrupted surfaces can also be honed.

Honing can be carried out on drilling or other machines which have arrangement for rotary and reciprocating motion simultaneously.

A rotary motion can be given by the spindle and the reciprocating motion can be either manual or by power depending on the type of machine used.

For mass production special honing machines are used.

Methods of honing

Manual stroking/Power stroking

Manual stroking is preferred for large quantities when tolerances are extremely close.

Many operators prefer this because of the flexibility in operation.

This eliminates the use of expensive fixtures to hold the work.

Fig 1

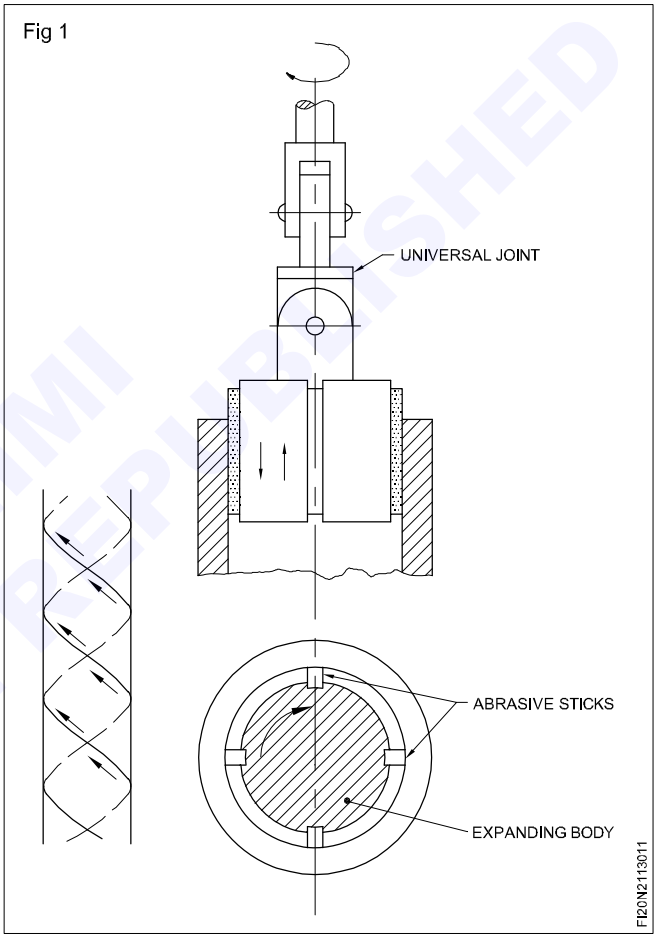
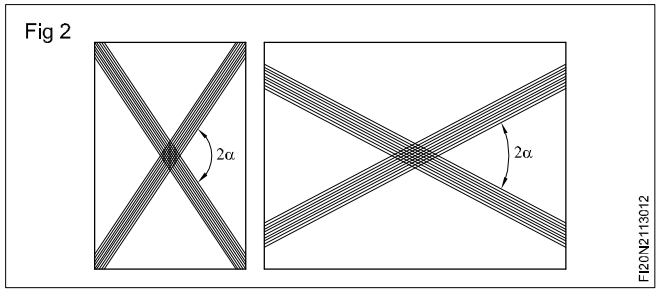


Fig 2



Jobs can be quickly changed from one type to another.

Jobs can be reversed from end to end for accurate honing and correction. The stroke length can be altered depending on the actual requirement of the individual workpiece.

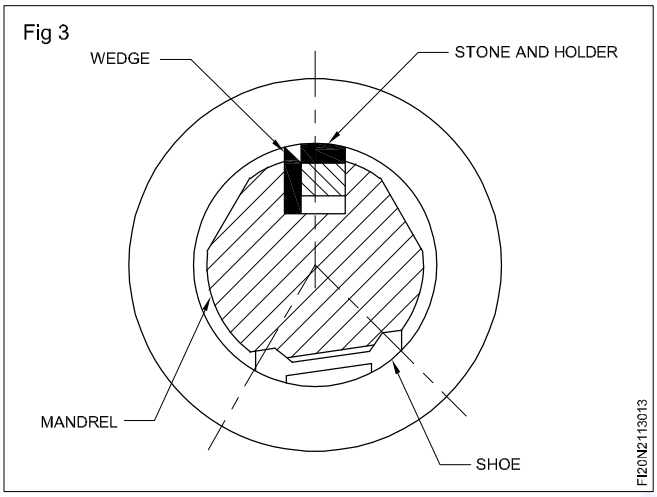
Power stroking is used for honing all types of workpieces. Power stroking may prove to be economical particularly in the case of small parts.

Note

Sometimes for final finishing, manual stroking is employed after power stroking.

The tools used for manual stroking consist of a mandrel, an abrasive stone with holder and a pair of shoes made of wear resistant material with respect to workpiece materials. (Fig 3)

Fig 3



The wedge controls the feeding of the abrasive stone. The shoes stabilize and guide the tool in the workpiece.

Power stroke tools will have abrasive stones at equal distance all around the circumference of the tool. For feeding the abrasive stones, expanding cones are provided. The tools are usually of a self-aligning type with a double universal joint.

Honing stones

Honing stones consist of particles of aluminium oxide, silicon carbide or diamond bonded together with vitrified clay, cork, carbon or metal. The honing stones have a porous structure and this helps for chip clearance.

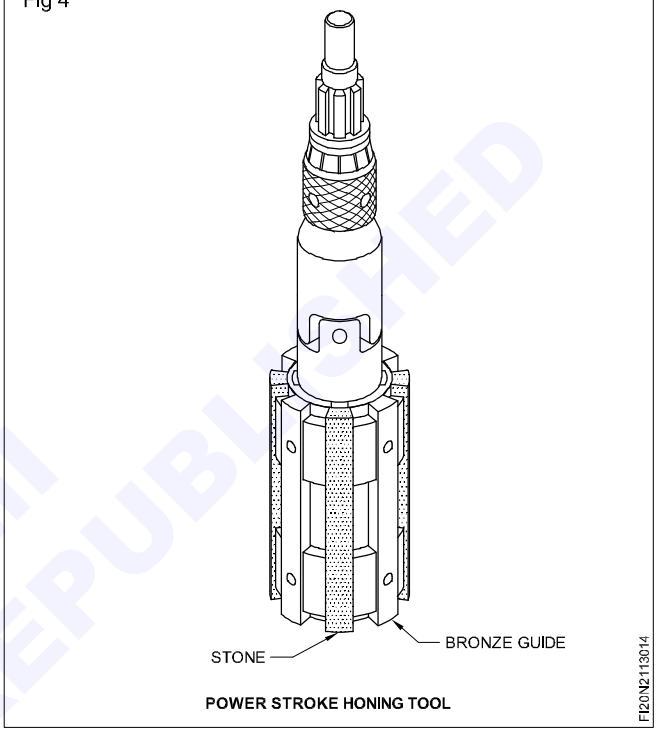
The grit size of abrasives used ranges from 36 to 600 but the most commonly used sizes are 120 to 320.

Uses of different abrasives

Aluminium oxide	Steel
Silicon carbide	Cast iron & non-ferrous metals
Diamond	Tungsten, ceramics etc.

Power stroke honing tool shown in Fig 4.

Fig 4



Cutting fluids

Cutting fluids are used while honing. The mineral oil commonly used in machining operations is diluted in proportion of one part of oil with four parts of kerosene before it is used for honing.

Frosting

Objectives : At the end of this lesson you shall be able to
- **define frosting**
- **state the aim of frosting**
- **describe the method of frosting.**

Frosting

Frosting is a process in which scraped metal surface is decorated with the use of hand scraper.

Frosting can also be called as flaking

When a patterened finish is formed on a polished or scraped flat surface

Why frosting is used

Frosting used as a way of increasing oil retention on scraped or polished surfaces.

This is important with machine parts in order to keep them lubricated and moving smoothly instead sticky and jerky movement.

Without the frosting, the oil would runway, leaving just the two metal surfaces in contact with each other, which is likely to cause seizure of the machine.

How to carry out frosting or flaking with an engineer's scraper

Engineer's scraper frosting technique

Step 1 - Stand comfortably

Stand with the end of the scraper handle resting just beneath your shoulder, and contact with the workpiece.

Fig 1

Step 2 - Position your hands

Use your non-dominant hand to hold the scraper about 1/2 - 3/4 of the way up the scraper and apply enough pressure to keep the handle in contact with your body and the tip in contact with workpiece.

Step 3 - Hit scraper

Using an upwards motion with your dominant hand, firmly hit the scraper towards you, striking the scraper at between 1/4 - 1/3 of the way up the scraper.

Fig 2

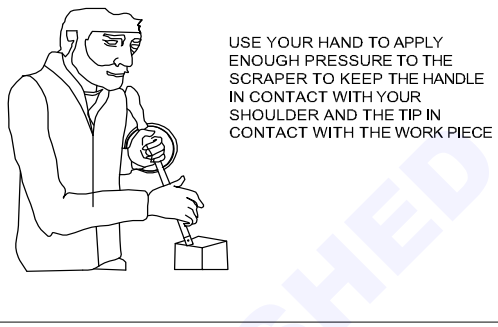
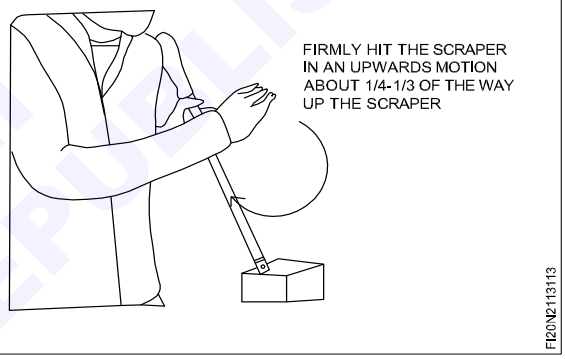


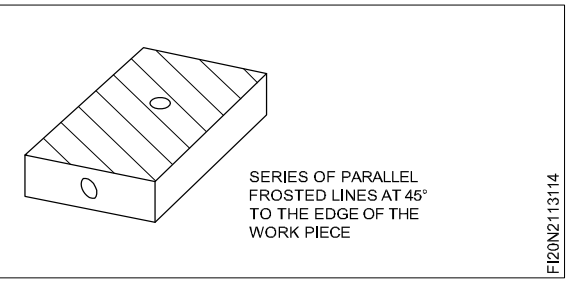
Fig 3



Step 4 - Repeat hitting motion

Repeat step 3 to produce a straight, frosted line across the workpiece at an angle of approximately 45 degree of the edge of the workpiece. Then repeat this to produce a series of parallel frosted lines across the workpiece.

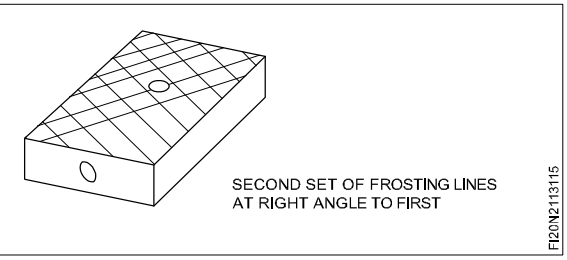
Fig 4



Step 5 - Repeat at right angles

Repeat step 4 at a right angle to your original frosted lines.

Fig 5



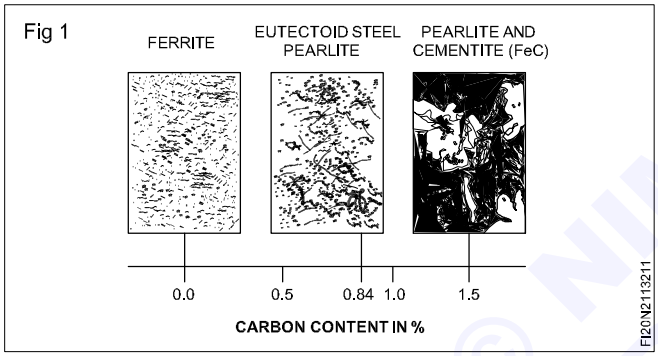
Heat treatment of plain carbon steels

Objectives: At the end of this lesson you shall be able to
- **state the purpose of heat treatment of steel**
- **state the types of structure, constituets and properties of plain carbon steels.**

Heat treatment and its purpose

The properties of steel depend upon its composition and its structure. These properties can be changed to a considerable extent, by changing either its composition or its structure. The structure of steel can be changed by heating it to a particular temperature, and then, allowing it to cool at a definite rate. The process of changing the structure and thus changing the properties of steel, by heating and cooling, is called 'heat treatment of steel'.

Types of structure of steel (Fig 1)



The structure of steel becomes visible when a piece of the metal is broken. The exact grain size and structure can be seen through a microscope. Steel is classified according to its structure.

Steel is an alloy of iron and carbon. But the carbon content in steel does not exceed 1.7%.

Ferrite

Pig iron or steel with 0% carbon is FERRITE which is relatively soft and ductile but comparatively weak.

Cementite

When carbon exists in steel as a chemical compound of iron and carbon it is called 'iron carbide' or CEMENTITE. This alloy is very hard and brittle but it is not strong.

Eutectoid/Pearlite steel

A 0.84% carbon steel or eutectoid steel is known as PEARLITE steel. This is much stronger than ferrite or cementite.

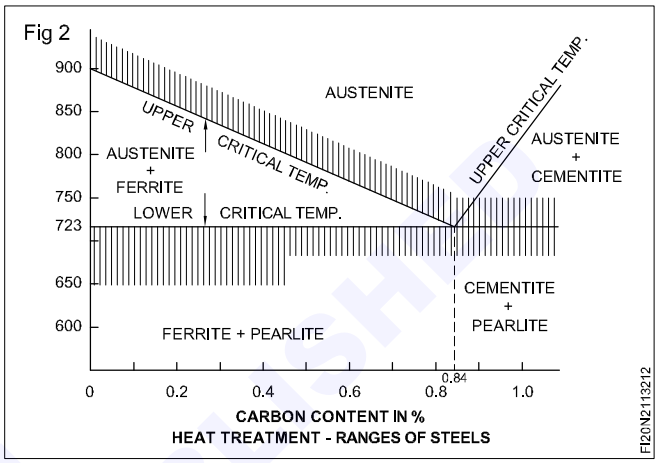
Hypereutectoid steel

More than 0.84% carbon steel or hypereutectoid steel is pearlite and cementite.

Hypoeutectoid steel

Less than 0.84% carbon steel or hypoeutectoid steel is pearlite and ferrite.

Structure of steel when heated (Fig 2)



If steel is heated, a change in its structure commences from 723°C. The new structure formed is called 'AUSTENITE'. Austenite is non-magnetic. If the hot steel is cooled slowly, the old structure is retained and it will have fine grains which makes it easily machinable.

If the hot steel is cooled rapidly the austenite changes into a new structure called 'MARTENSITE'. This structure is very fine grained, very hard and magnetic. It is extremely wear-resistant and can cut other metals.

Heat treatment processes and purpose

Because steel undergoes changes in structure on heat-ing and cooling, its properties may be greatly altered by suitable heat treatment.

The following are the various heat treatments and their purposes.

Hardening:	To add cutting ability.
	To increase wear resistance.
Tempering:	To remove extreme brittleness caused by hardening to an extent.
	To induce toughness and shock resistance.
Annealing:	To relieve strain and stress.
	To eliminate strain/hardness.
	To improve machinability.
	To soften the steel.
Normalising:	To refine the grain structure of the steel.

Heating and quenching steel for heat treatment

Objectives: At the end of this lesson you shall be able to
- **distinguish between the lower critical and the upper critical temperatures**
- **state the three stages in the heat treatment process**
- **determine the upper critical temperature for different plain carbon steels from the diagram.**

Critical temperatures

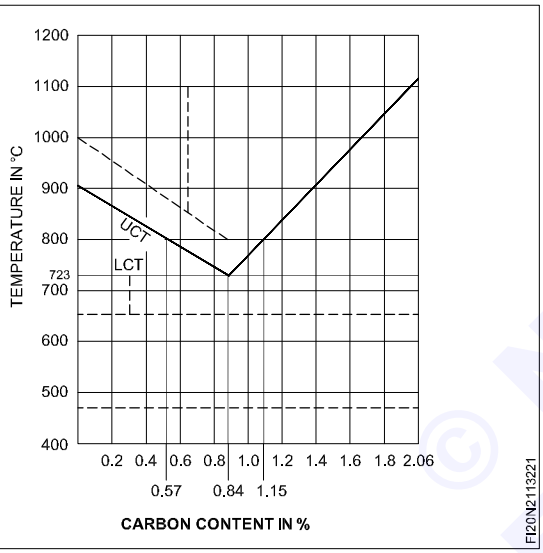
Lower critical temperature

The temperature, at which the change of structure to austenite starts - 723°C, is called the lower critical temperature for all plain carbon steels.

Upper critical temperature

The temperature at which the structure of steel completely changes to AUSTENITE is called the upper critical temperature. This varies depending on the percentage of carbon in the steel. (Fig 1)

Fig 1



Example

0.57% and 1.15% carbon steel: In these cases the lower critical temperature is 723°C and the upper critical temperature is 800°C.

For 0.84% carbon steel, both LCT and UCT are 723°C. This steel is called eutectoid steel.

Three stages of heat treatment

- Heating
- Soaking
- Quenching

When the steel on being heated reaches the required temperature, it is held in the same temperature for a period of time. This allows the heating to take place throughout the section uniformly. This process is called soaking.

Heating steel

This depends on the selection of the furnace, the fuel used for heating, the time interval and the regulation in bringing the part up to the required temperature. The heating rate and the heating time also depend on the composition of the steel, its structure, the shape and size of the part to be heat-treated etc.

Soaking time

This depends upon the cross-section-of the steel, its chemical composition, the volume of the charge in the furnace and the arrangement of the charge in the furnace. A good general guide for soaking time in normal condi-tions is five minutes per 10 mm of thickness for carbon and low alloy steels, and 10 minutes per 10 mm of thickness for high alloy steels.

Preheating

Steel should be preheated at low temperatures up to 600°C as slowly as possible.

Quenching

Depending on the severity of the cooling required, different quenching media are used.

The most widely used quenching media are:

- brine solution
- water
- oil
- air.

Brine solution gives a faster rate-of cooling while air cooling has the slowest rate of cooling.

Brine solution (Sodium chloride) gives severe quenching because it has a higher boiling point than pure water, and the salt content removes the scales formed on the metal surfaces due to heating. This provides a better contact with the quenching medium and the metal being heat-treated.

Water is very commonly used for plain carbon steels. While using water as a quenching medium, the work should be agitated. This can increase the rate of cooling.

The quenching oil used should be of a low viscosity. Ordinary lubricating oils should not be used for this purpose. Special quenching oils, which can give rapid and uniform cooling with less fuming and reduced fire risks, are commercially available. Oil is widely used for alloy steels where the cooling rate is slower than plain carbon steels.

Cold air is used for hardening some special alloy steels.

Hardening of carbon steel

Objectives: At the end of this lesson you shall be able to
- **state the hardening of steel**
- **state the purpose of hardening steel**
- **state the process of hardening.**

What is hardening?

Hardening is a heat-treatment process in which steel is fitted to 30 - 50°C above the critical range. Soaking time is allowed to enable the steel to obtain a uniform temperature throughout its cross-section. Then the steel is rapidly cooled through a cooling medium.

Purpose of hardening

To develop high hardness and wear resistance properties.

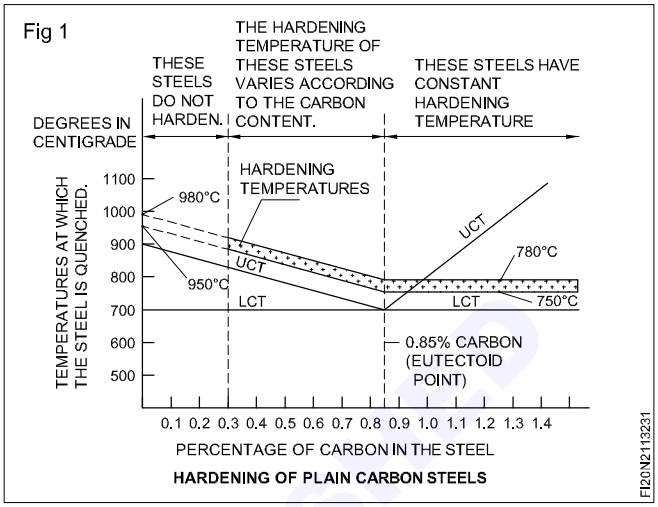
Hardening affects the mechanical properties of steel - like strength, toughness, ductility etc.

Hardening adds cutting ability.

Process of hardening

Steel with a carbon content above 0.4% is heated to 30-60°C above the upper critical temperature. (Fig 1) A soaking time of 5 mts. / 10 mm thickness of steel is allowed. (Fig 1)

Fig 1



Then the steel is cooled rapidly in a suitable medium. Water, oil, brine or air is used as a cooling medium, depending upon the composition of the steel and the hardness required.

Tempering the hardened steel

Objectives: At the end of this lesson you shall be able to
- **state what is tempering**
- **state the purpose of tempering**
- **relate the tempering colours and temperatures with the tools to be tempered**
- **state the purpose of tempering of steels.**

What is tempering?

Tempering is a heat-treatment process consisting of reheating the hardened steel to a temperature below 400°C, followed by cooling.

Purpose of tempering the steel

Steel in its hardened condition is generally too brittle to be used for certain functions. Therefore, it is tempered.

The aims of tempering are:

- to relieve the internal stresses
- to regulate the hardness and toughness
- to decrease the brittleness
- to restore some ductility
- to induce shock resistance.

Process of tempering the steel

The tempering process consists of heating the hardened steel to the appropriate tempering temperature and soaking at this temperature, for a definite period.

The period is determined from the experience that the full effect of the tempering process can be ensured only, if the tempering period is kept sufficiently long. Table 1 shows the tempering temperature and the colour for different tools.

TABLE 1

Tools or articles	Temperature in degrees (C)	Colour
Turning tools.	230	Pale straw.
Drills and milling cutters.	240	Dark straw.
Taps and shear blades.	250	Brown.
Punches, reamers, twist drills.	260	Reddish brown
Rivets, snaps.	270	Brown purple.
Press tools, cold chisels	280	Dark purple.
Cold set for cutting steels.	290	Light blue.
Springs, screw drivers	300	Dark blue.
	320	Very dark blue.
	340	Greyish blue.
For toughening without undue hardness.	450-700	No colour.

Annealing of steel

Objectives: At the end of this lesson you shall be able to
- **state the annealing of steel**
- **state the purpose of annealing**
- **state the process of annealing.**

The annealing process is carried out by heating the steel above the critical range, soaking it for sufficient time to allow the necessary changes to occur, and cooling at a predetermined rate, usually very slowly, within the furnace.

Purpose

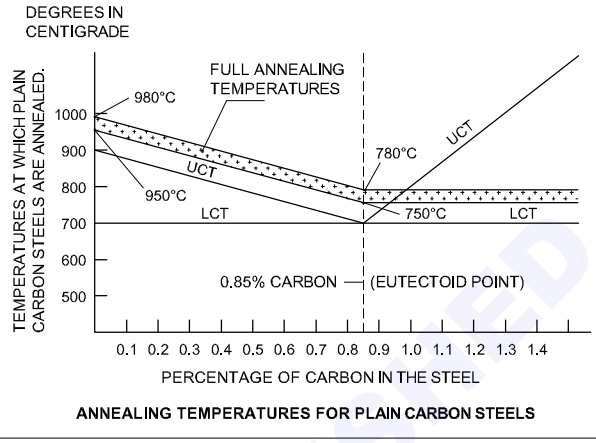
- To soften the steel.
- To improve the machinability.
- To increase the ductility.
- To relieve the internal stresses.
- To refine the grain size and to prepare the steel for subsequent heat treatment process.

Annealing process

Annealing consists of heating of hypoeutectoid steels to 30 to 50°C above the upper critical temperature and 50°C above the lower critical temperature for hypereutectoid steels. (Fig 1)

Soaking is holding at the heating temperature for 5 mts./ 10 mm of thickness for carbon steels.

Fig 1



ANNEALING TEMPERATURES FOR PLAIN CARBON STEELS

The cooling rate for carbon steel is 100 to 150°C/hr.

Steel, heated for annealing, is either cooled in the furnace itself by switching off the furnace or it is covered with dry sand, dry lime or dry ash.

Normalising steel

Objectives: At the end of this lesson you shall be able to
- **state the meaning of normalising steel and its purpose**
- **state the process of normalising steel**
- **state the precaution to be taken while normalising steel.**

The process of removing the internal defects or to refine the structure of steel components is called normalising.

Purpose

- To produce fine grain size in the metal.
- To remove stresses and strains formed in the internal structure due to repeated heating and uneven cooling
- hammering.
- To reduce ductility.
- To prevent warping.

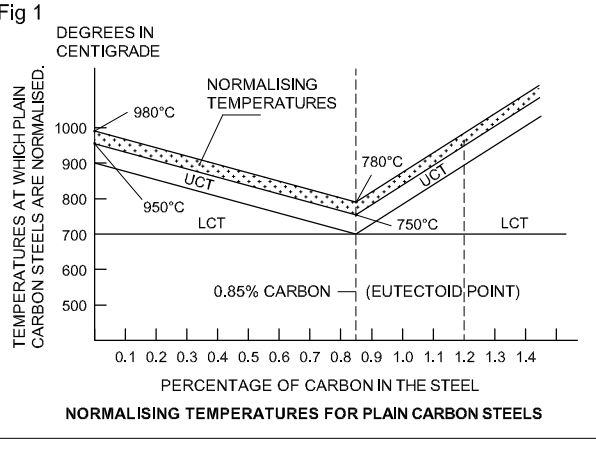
Process

To get the best results from normalising, the parts should be heated uniformly to a temperature of 30 to 40°C above the upper critical temperature (Fig 1), followed by cooling in still air, free from drought, to room temperature. Normalizing should be done in all forgings, castings and work-hardened pieces.

Precautions

Avoid placing the component in a wet place or wet air, thereby restricting the natural circulation of air around the component. Avoid placing the component on a surface that will chill it.

Fig 1



NORMALISING TEMPERATURES FOR PLAIN CARBON STEELS

Surface hardening of steel

Objectives : At the end of this lesson you shall be able to
- **name four different types of surface hardening process**
- **state purpose of case hardening**
- **state the purpose of carburising**
- **state the purpose of liquid carburising**
- **state the process of gas carburising.**

Most of the components must have a hard, wear-resisting supported by a tough, shock-resisting core for surface condition and longer life. This combination of properties can be obtained in a single piece by surface hardening. (Fig 1)

Types of surface hardening

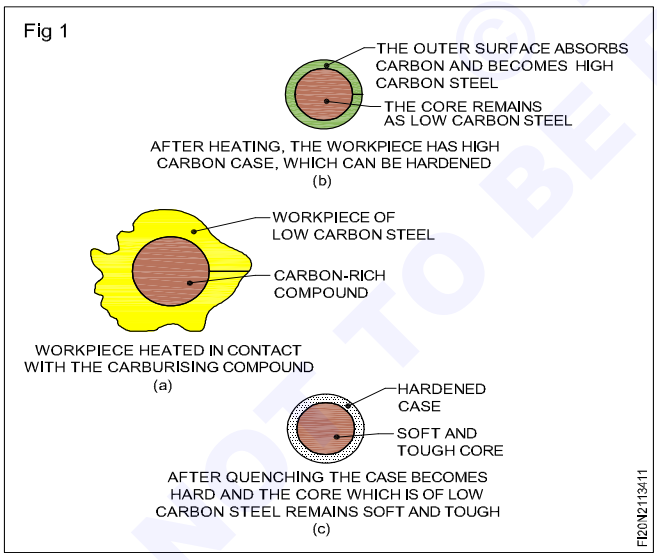
- Case hardening
- Nitriding
- Flame hardening
- Induction hardening

Case hardening

Parts to be hardened by this process are made from a steel with a carbon content of 0.15% so that they will not respond to direct hardening.

The steel is subjected to treatment in which the carbon content of the surface layer is increased to about 0.9%.

When the carburised steel is heated and quenched, only the surface layer will respond, and the core will remain soft and tough as required. (Fig 1)



The surface which must remain soft can be insulated against carburising by coating it with suitable paste or by plating it with copper.

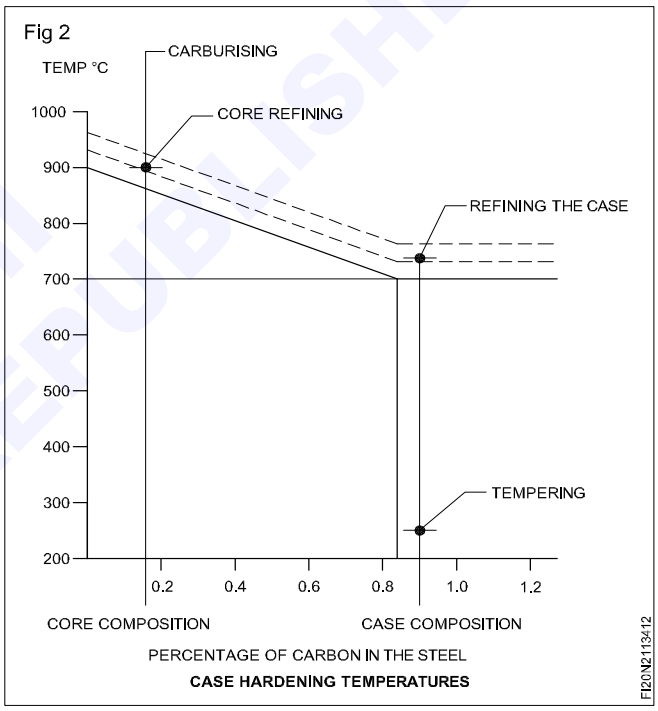
Case hardening takes place in two stages.

1 Carburising in which the carbon content of the surface is increased.
2 Heat treatment in which the core is refined and the surface hardened.

Carburising

In this operation, the steel is heated to a suitable temperature in a carbonaceous atmosphere, and kept at that temperature until the carbon has penetrated to the depth required. The carbon can be supplied as a solid, liquid or gas.

In all cases, the carbonaceous gases coming from these materials penetrate (diffuse) into the surface of the workpiece at a temperature between 880° and 930°C. (Fig 2)



Pack carburising (Fig 3) (solid)

The parts are packed in a suitable metal box in which they are surrounded by the carburising medium.

The lid is fitted to the box and sealed with fireclay and tied with a piece of wire so that no carbon gas can escape and no air acn enter the box to cause decarburisation.

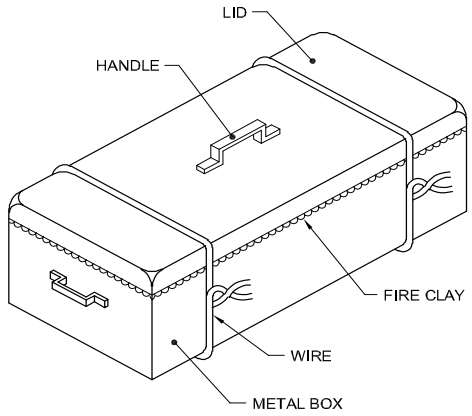
The carburising medium can be wood, bone, leather or charcoal, but an energiser, such as barium carbonate, is added to speed up the process.(Fig 4)

Liquid carburising

Carburising can be done in a heated salt-bath. (Sodium carbonate, sodium cyanide and barium chloride are typical carburising salts.) For a constant time and temperature of carburisation, the depth of the case depends on the cyanide content.

Salt-bath carburising is very rapid, but is not always suitable because it produces an abrupt change in the carbon content from the surface to the core. This produces a tendency for the case to flake.

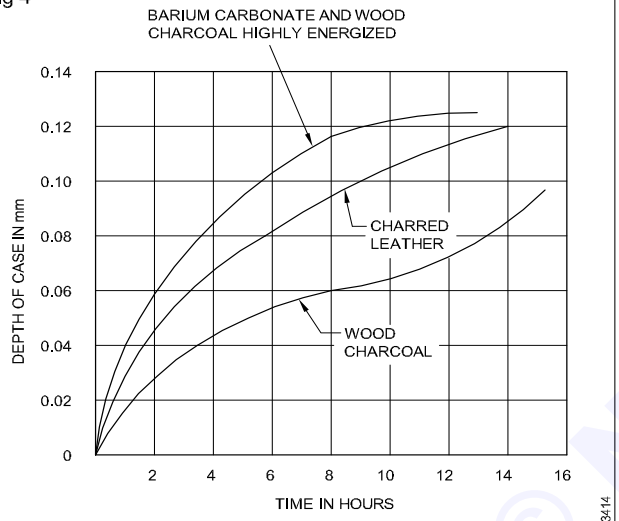
Fig 3



PACK CARBURISING

FI20N2113413

Fig 4



RELATIVE RATE OF CARBURISATION WITH DIFFERENT SOLID CARBURISERS AT 698.8°C

FI20N2113414

This is suitable for a thin case, about 0.25 mm deep. Its advantage is that heating is rapid and distortion is minimum.

Gas carburising

The work is placed in a gas tight container which can be heated in a suitable furnace, or the furnace itself may be the container.

The carburising gas is admitted to the container, and the exit gas is vented. The gas such as methane or propane may be fed directly into the container in which the work is placed.

In a continuous gas carburising furnace, the carburising, quenching and tempering processes are carried out in sequence in the same closed furnace as they progress on a conveyer from one operation to the next.

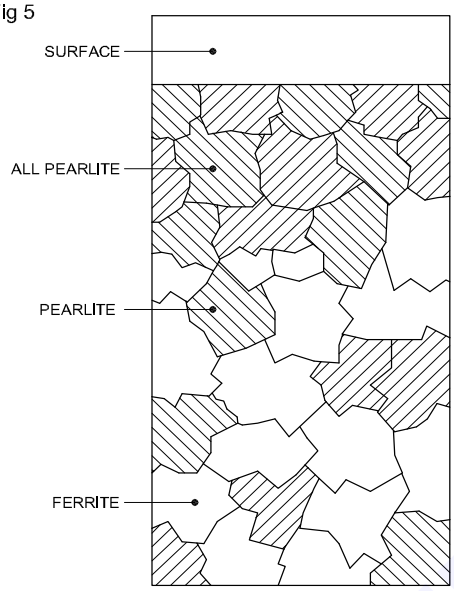
Fig 5 illustrates the appearance of the structure across its section produced by carburising.

Heat treatment

After the carburising has been done, the case will contain about 0.9% carbon, and the core will still contain about 0.15% carbon. There will be a gradual transition of the carbon content between the case and the core. (Fig 2)

Owing to the prolonged heating, the core will be coarse, and in order to produce a reasonable toughness, it must be refined.

Fig 5



THE MICROSTRUCTURE OF CARBURISED STEEL

FI20N2113415

To refine the core, the carburised steel is reheated to about 870° C and held at that temperature long enough to produce a uniform structure, and is then cooled rapidly to prevent grain growth during cooling.

The temperature of this heating is much higher than that suitable for the case, (Fig 2) and, therefore, an extremely brittle martensite will be produced.

The case and the outer layers of the core must now be refined. The refining is done by reheating the steel to about 760°C, to suit the case, and quenching it.

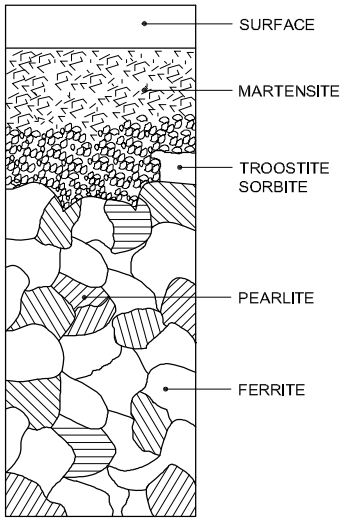
Tempering

Finally the case is tempered at about 200°C to relieve the quenching stresses.

If the part is not required to resist shock, it is unnecessary to carry out the core refining operation; in these conditions, a coarse martensite at the surface may not cause trouble, and so this part may be quenched directly after carburising.

Fig 6 illustrates the appearance of the structure across its section produced by case hardening.

Fig 6



THE MICROSTRUCTURE OF CASEHARDENED STEEL

FI20N2113416

Tapers on keys and cotters

Objectives : At the end of this lesson you shall be able to
- **define taper**
- **state the uses of tapers**
- **distinguish between features of self-holding and self-releasing tapers**
- **state the features of pin tapers & keyway tapers**
- **state why taper is provided on key and cotters.**

Taper

Taper is a gradually narrowing (or) increasing from one end to other end of the object either in thickness (or) cylindrical.

Tapers on key

When key is drive through the keyways fit, fight due to wedge action. This ensure tightness of joint in operation and prevent loosening of the parts. Due to taper it is lasy to remove the key and dismantle the joint. The normal value of taper of key is 1:100.

Taper on cotter

When cotter is driven through slots, it fit, tight due to wedge action. This ensures tightness of joint in operation and prevent loosening of the parts. Due to taper it is easy to remove the cotter and dismantle the joint. The normal value of taper varies from 1:48 to 1:24.

Taper pins

Taper pins like round keys are used for locking collars on shafts and also between shaft and hub for transmission of motion. Taper is 1:50, small end as ref nominal dia. Its ends are spherical and radius equal to dia. of the pin.

Tapers are used for:

- self-alignment/location of components in an assembly
- assembling and dismantling parts easily
- transmitting drive through assembly.

Tapers have a variety of applications in engineering assembly work. (Figs 1,2 & 3)

Tapers of components are expressed in two ways.

- Degree of arc (Fig 4)
- Gradient (Fig 5)

The method adopted for expressing tapers depends on:

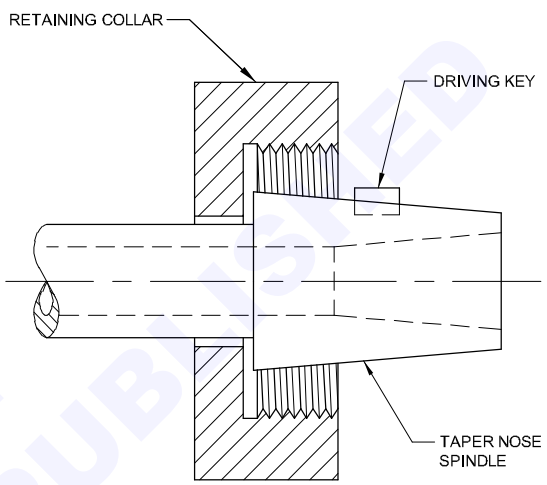
- the steepness of the tapers
- the method adopted for measuring.

Specification of tapers

While specifying taper in drawings it should indicate the:

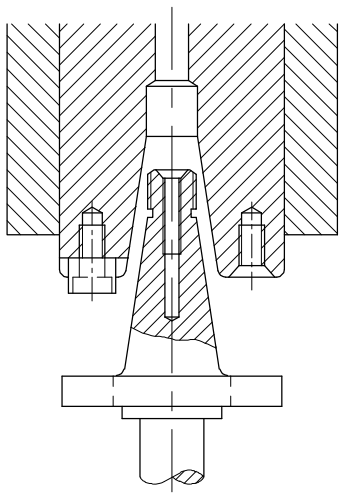
- angle of the taper
- size of the component. (Figs 6,7, 8 & 9)

Fig 1



LATHE-TAPER NOSE SPINDLE

Fig 2



MILLING MACHINE SPINDLE

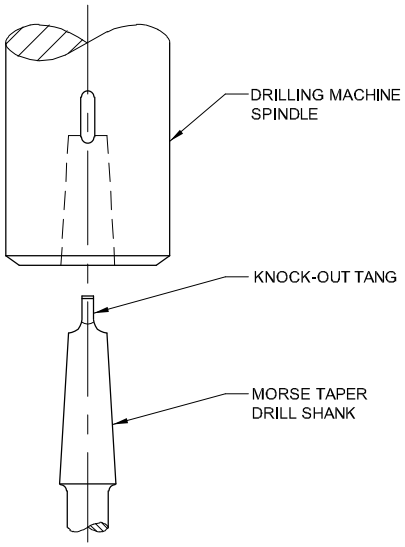
Standard tapers

Tapers for tool-holding

Two types of tapers are used for tool-holding on machines.

- Self-holding tapers
- Self-releasing tapers

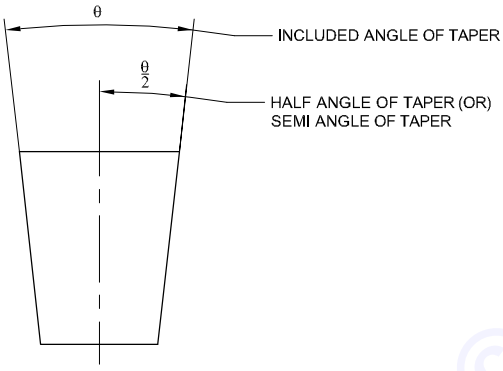
Fig 3



DRILLING MACHINE SPINDLE AND DRILL WITH TAPER SHANK

FI20N2113613

Fig 4



60 SECONDS (") = 1 MINUTE (')

60 MINUTES (') = 1 DEGREE OF ARC (°)

AN ANGLE EXPRESSED IN DEGREES OF ARC

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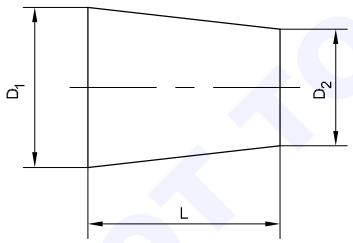
Fig 5



EXAMPLE: IS SELF RELEASE TAPER

(MILLING MACHINE SPINDLE NOSE) IS GIVEN AS: $\frac{7}{24}$

i.e.

$D_1 - D_2 = 7$

$L = 24$

NOTE: L IS MEASURED PARALLEL TO THE AXIS

$$\text{TAPER} = \frac{D_1 - D_2}{L}$$

AN ANGLE EXPRESSED AS A GRADIENT

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Fig 6

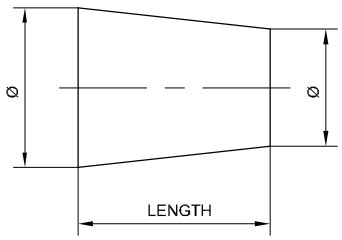

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Fig 7

TAPER Y mm PER X mm ON DIAMETER

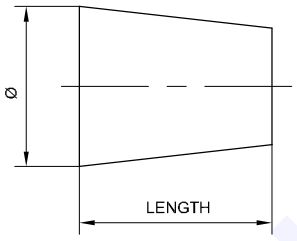

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Fig 8

TAPER IN 1 X ON DIAMETER

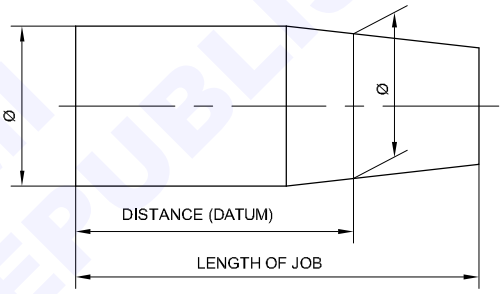

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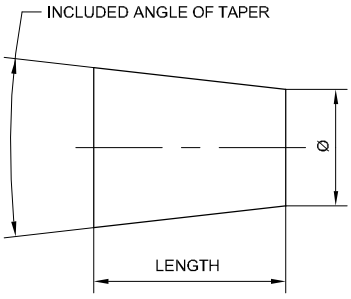
Fig 9



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Self-holding tapers

Self-holding tapers have less taper angle. These are used for holding and driving cutting tools like drills, reamers etc. without any locking device. (Fig 10)

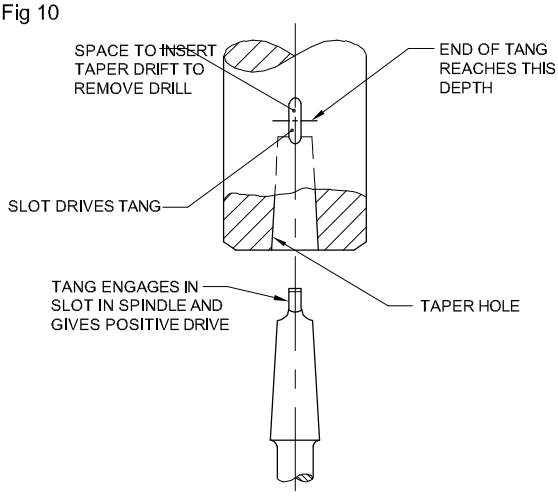
The standard tapers used for this are:

- the metric taper
- the Morse taper.

Metric taper

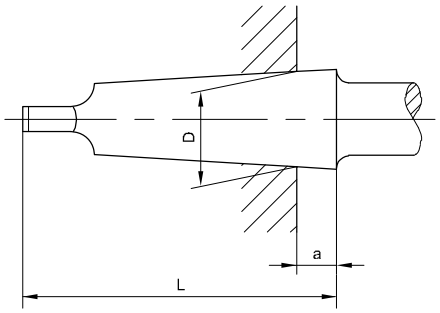
The taper on diameter is 1:20. The commonly used shank sizes in metric tapers are metric 4, 6, 80, 100, 120, 160 and 200.

Fig 10



The shank size indicating the metric taper is the diameter at D. (Fig 11)

Fig 11



Morse taper

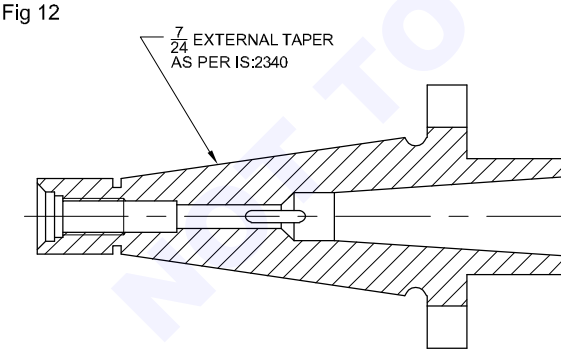
The commonly used taper shank sizes are:

0, 1, 2, 3, 4, 5 and 6.

The taper is varying according to the size of the Morse taper. It varies from 1:19.002 to 1:20.047.

Self-releasing 7/24 tape (Fig 12)

Fig 12



Spindle noses and arbors used on milling machines are usually provided with self-releasing tapers. The standard self-releasing taper is 7/24. This is a steep taper which helps in the correct location and release of the components in the assembly. This taper does not drive the mating component in the assembly. For the purpose of driving, additional features are provided.

The commonly used 7/24 taper sizes are: 30,40,45,50 and 60.

The taper of a 7/24 taper of No.30 will have a maximum diameter of (D) 31.75 mm and No.60, 107.950 mm. All other sizes fall within this range.

Tapers used in other assembly work

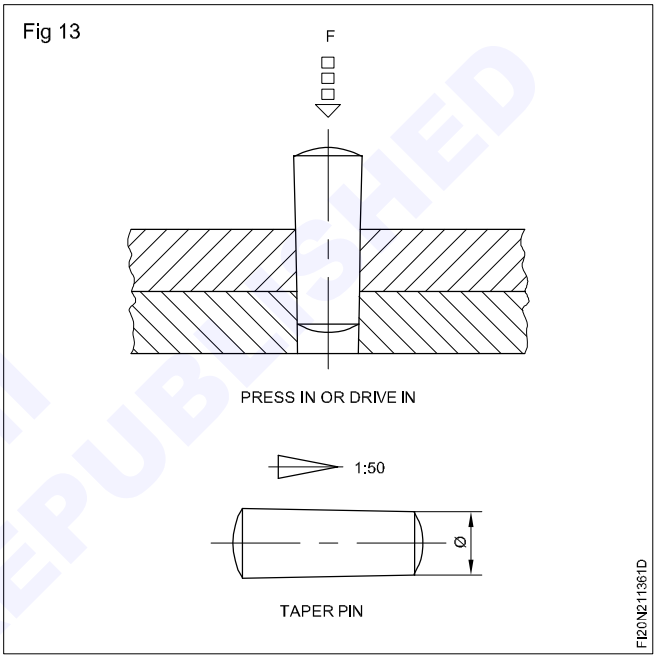
A variety of tapers are used in engineering assembly work. The most common ones are:

- pin taper
- key and keyway taper.

Pin taper

This is the taper used for taper pins used in assembly. (Fig 13)

Fig 13



The taper is 1:50.

The diameter of taper pins is specified by the small diameter.

Taper pins help in assembling and dismantling of components without disturbing the location.

Key and keyway tapers

This taper is 1:100. This taper is used on keys and keyways. (Figs 14 and 15)

Fig 14

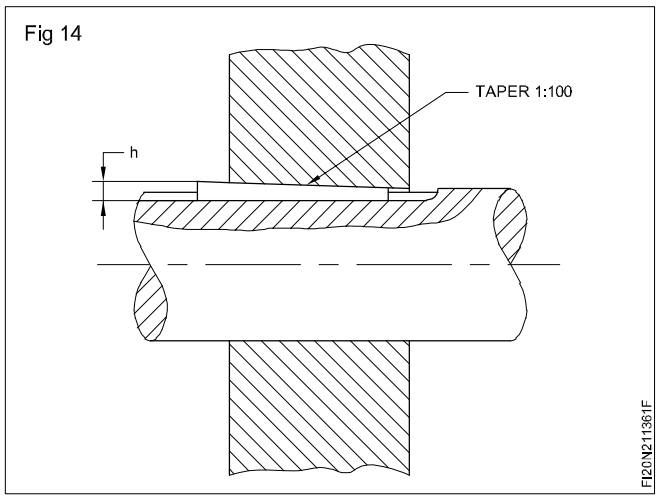
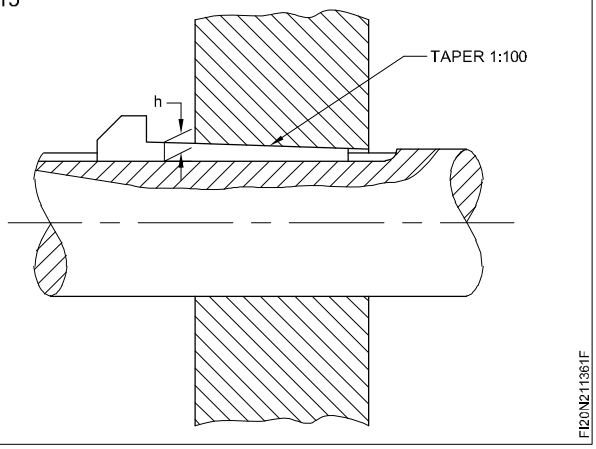


Fig 15



Note

For further information about the tapers used for special application refer to:

IS: 3458 - 1981.

Taper pins are three types:

Type A - pins ground with a surface finish N6

Type B - pins turned with a surface finish N7

Type C - split pins with a surface finish N7

The nominal dia range from 0.6 to 50 mm and of varying lengths 4 to 200 mm according to dia of pin.

Three types of taper pins

Designation: Taper pin shall be designated by name, type A.B or C, nominal dia, nominal length and BIS number.

Taper pin A 16 x 90 IS:6688

Taper pin B 20 x 60 IS:6688

Split taper pin C 5 x 40 IS:6688

General proportion: normal dia of pin = 1/6 (dia of shaft).

Cotter/cotter joint : Cotter is a rectangular wedge with taper on one side of the width, thickness being same. It is used to connect shafts, with reciprocating motion only. The ends of the shafts to be joined are formed into socket and spigot**.** A rectangular slot at right angle to the axis is made with taper on one side to suit the cotter. The socket and spigot are aligned and the cotter is driven in locking them together.

Two cotters are used to join shafts with a sleeve. The enlarged shaft ends with slots are placed facing each other in a sleeve with slots. On driving the cotters, with a bearing surface on the sleeve, the tapered or slope surface of the cotters pull the shafts closer. The clearance on the sleeve and shafts allow the variation of cotters width to certain extent.

Cotter joint: Is also used to connect square or rectangular members. A strap joint with a gib and cotter. One end of the member is made as fork end which takes the end of the other member to prevent the fork end getting bend while driving the cotter a gib is placed. The bending effect on the fork end and how the gibs are made use of. Single gib is used for cotter with slope on one side. Two gibs are used if the cotter has slope on both sides.

Use of pin in connecting shafts: Similar to the cotter, cylindrical pin is also used in connecting shafts. One end of the shaft is made as Fork (fork end) with holes and the end of the other shaft is formed as eye end. The eye end fits into the fork end, holes being in one line. A collared cylindrical pin with a small hole is inserted into the eye and fork. The pin is held in position using a coller and a small taper pin or split pin.

Various coatings for protection by heat & electrical deposits

Objectives : At the end of this lesson you shall be able to
- **state the need for prevention of corrosion**
- **name the different methods of metallic coatings used for preventing crrosion**
- **state the application of different metallic protective coatings**
- **state the treatments to provide pleasing finish.**

Most of the common non-ferrous metals and alloys form their own protective coating when exposed to the atmosphere. Corrosion prevention is largely relevant to iron and steel. For maximum life, accuracy and utility of a component, it is very essential that corrosion is controlled or prevented.

One method of corrosion-proofing is to protect the metallic material from the corroding influences by means of protective coats or deposits which prevent or limit corrosion to acceptable levels.

Protective treatment of metal surface

The type of protective treatment used depends upon:

- the material from which the component is made
- the purpose for which it is used
- the environment in which it is to operate.

Non-metallic coatings

Oil or grease is applied when parts must remain bright (vernier caliper). Grease and oil must be acid free; otherwise the parts will be corroded.

Spraying or coating with paint

Painting is widely used for the protection and decoration of metallic components and structures. Red lead forms an effective protective coat when used as a primer. High quality of paints (oil-bound paints or lacquers) are used according to the purpose.

Enamelling

This is carried out by spraying or sprinkling enamel powder on the surface and baking at a suitable temperature (80 to 100C). The coating is heat-resistant and resistant to chemicals as well. The enamel consists of glass powder, a mixture of quartz, felspar, alumina and

Plastic coatings

These are done for functional as well as for anti-corrosive and decorative purposes. These coatings are applied by immersion in molten plastic or by varnishing. The common oil paints are being replaced by synthetic resin paints, cellulose paints and chlorinated rubber paints.

Metallic coatings

Molten metal bath

This is the coating of mild steel with zinc. There are two alternative processes, namely hot dip galvanising, in which the cleaned and fluxed work is dipped into a bath oof molten zinc, and electrolytic galvanising where the zinc is deposited electolytically on the sheet metal base.

Cladding

In this process a cmposite a billet is made up of the base metal and the coating is done by rolling or drawing the layers of metal on to base metal. (eg. coins) More expensive metals can be saved in this way.

Spraying

Metal spraying is used for a variety of purposes. The process consists of spraying molten or heated particles of metal on a prepared surface with compressed air, Eg. surfaces of shafts is done by depositing wear -resistant alloy steel or plain carbon steels.

General procedure of electroplating

1 Cleaning with organic solvents and/or aqueous alkali.
2 Where the surface is covered by oxides as a result of corrosion, it is cleaned by immersion in acid; again electrochemical enhancement is possible by making the surface anodic.
3 Rinsing with water.
4 Electroplating.
5 Rinsing and drying.
6 Quality control prior to packing and despatch.

Process of Electroplating

Electroplating is carried out in an electrolytic cell. The article to be electroplated is first cleaned with organic solvents to remove oils, grease etc and then treated with dilute HCl and H_2SO_4 to remove oxide scales etc. The cleaned article is then made cathode of the electrolytic cell and is hung on racks placed on cathode bar.

The anode is either coating material or an electrode of inert material like graphite. The electrolyte, which is a soluble salt solution of coating metal is taken in the cell. The anode and cathode are dipped in the electrolytic solution and a direct current of electricity is passed. Plating bath is heated with steam and when cooling is required, it is cooled with water in pipes or coils placed inside the cell or tank outside it. For heating the bath, the immersion electric heaters have also been used. Under the influence of electric current, coating ions migrate to the electrode and get deposited there. Thus a thin coating of the metal is produced on the cathode.

In order to produce brighter and smooth deposits, low temperature, high current density and low metal ion concentration etc are the favourable conditions.

In order to produce brighter and smooth deposits, low temperature, high current density and low metal ion concentration etc. are the favourable conditions.

Chromium Plating

The chrome plating process is a method of applying a thin layer of chromium onto a substrate (metal (or) alloy) through an electroplating procedure.

In simple terms, electroplating is achieved by passing an electric current between two electrodes which are immersed in an electrolyte bath comprising of chromic acid. one of the electrodes will be the substrate which is to be plated. During the flow of electricity between the two electrodes, chromium atoms are deposited in a layer on the electrode to be plated.

Silver Plating

Silver plating involves submerging the Substrate into a bath of silver ions. After passing an electric current through the solution the ions deposit on to the parts surface.

Silver plating is common to numerous industries, including Bearings automative, medical, electronics and telecommunications sectors.

Nickel Plating

Nickel Electro plating is a process of applying a nickel coating onto a metal surface by means of electrolytic deposition. In order for parts to be plated, they must be clean and free of dirt, corrosion and defects so the plating can be applied. In order to prepare a product, it must be cleaned and protected before the plating process. To prepare a part, a combination of cleaning, masking, heat treating, pickling and etching are commonly used.

Galvanizing

Galvanizing is the process of applying a protective zinc coating to iron or steel to prevent rusting. The most common method is hot dip galvanizing in which steel sections are submerged in a bath of molten zinc.

Gauges

Objectives : At the end of this lesson you shall be able to
- **state the features of Go and No - Go gauges**
- **list the types of gauges used in production**
- **explain about the selective and non - selective asembly**
- **state the hole basis and shaft basis system.**

Features of Go and No- Go gauges

Componenets manufactured using mass production methods are checked only to ensure that the sizes are within the prescribed limits. The most economical method of checking such components is by using limit gauges. These gauges are used in inspection because they provide a quick means of checking.

Go and No - Go principle

The Go and No -Go principle of gauging is that the Go - end of the gauge must go into the feature of the component being checked and the No - Go end must not go into the same feature. The dimensions of the Go and No - Go ends of gauges are determined from the limits stated on the dimension of the component to be gauged. The dimension of the Go -end is equal to the minimum permissble dimension and that of the No -Go end is equal to the maximum permissble dimension.

Essential Features

These gauges are easy to handle and are accurately finished. They are generally finished to one tenth of the tolerance they are designed to control. For example, if the tolerance t be maintained is at 0.02mm, then the gauge must be finished to within 0.002mm, of the required size.

These must be resistant to wear, corrosion and expansion due to temperature. The plugs of the gauges are ground and lapped.

The Go -end is made longer than the 'No -Go' end for easy identification. Sometimes a groove is cut on the handle near the 'No -Go' end to distinguish it from the 'Go' end.

The dimension of these gauges are usually stamped on them.

Types of gagues used in production

1 Limit gauge
2 Radius gauge
3 Centre gauge
4 Drill gauge
5 Drill grinding gauge
6 Feeder gauge
7 Screw pitch gauge
8 Angle gauge
9 Wire gauge.

Gauges and types of gauges

Objective: At the end of this lesson you shall be able to
- **define gauges their necessity and types.**

Gauge

Gauge is an inspection tool used to check product dimension with reference to its maximum and minimum acceptable limits. It is, generally, used to segregate acceptable and non-acceptable products in mass production, without the exact dimensions. It is made of tool steel and is heat treated.

Advantages of gauging

Faster checking of the product is within the specified limits.

Less dependence on operator skill and getting affected by operator judgement.

Gauges are economical when compared to measuring instruments.

Instrument used for gauging

1 Snap and ring gauge
2 Plug gauge
3 Screw pitch gauge
4 Template and form gauge
5 Taper gauge

Types of cylindrical plug gauges

Double-ended plug gauge (Fig 1 and 2)

Fig 1

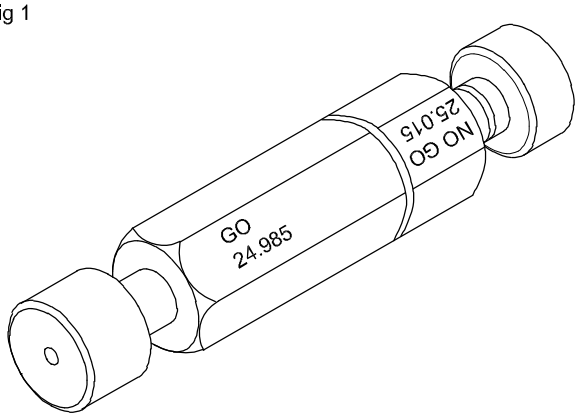
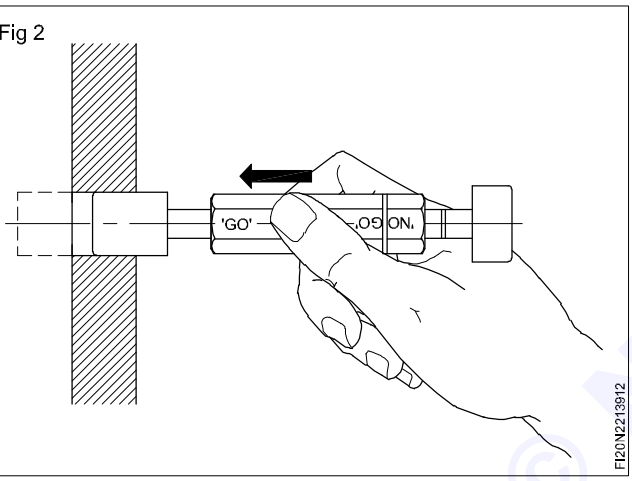


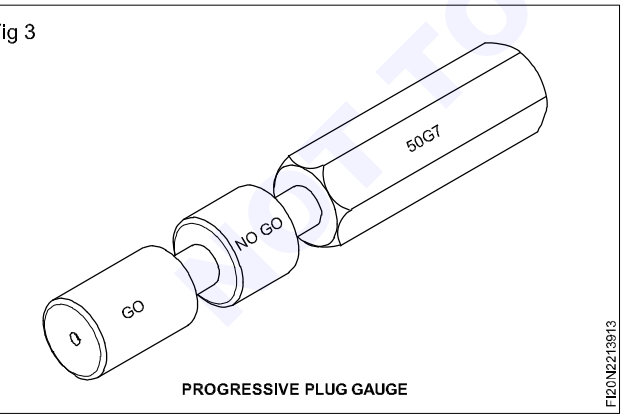
Fig 2



Progressive plug gauge (Fig 3)

Plain cylindrical gauges are used for checking the inside diameter of a straight hole. The ‘Go’ gauge checks the lower limit of the hole and the ‘No- Go’ gauge checks the upper limit. The plugs are ground and lapped. (Fig 3)

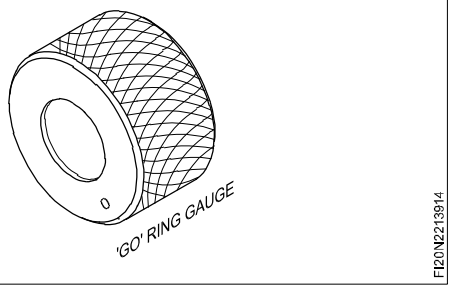
Fig 3



Plain ring gauge (Fig 4)

Plain ring gauges are used to check the outside diameter of pieces. Separate gauges are used for checking ‘Go’ and ‘No- Go’ sizes. A `No-Go’ gauge is identified by an annular groove on the knurled surface.

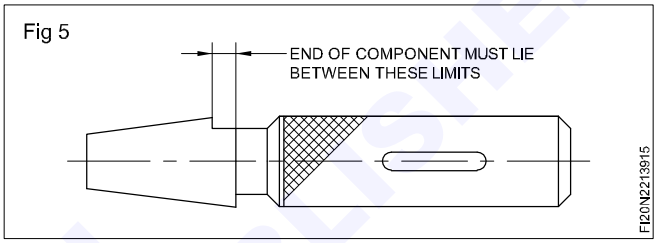
Fig 4



Taper plug gauges (Fig 5)

These gauges made with standard or special tapers are used to check the size of the hole and the accuracy of the taper. The gauge must slide into the hole for a prescribed depth and fit perfectly. An incorrect taper is evidenced by a wobble between the plug gauge and the hole.

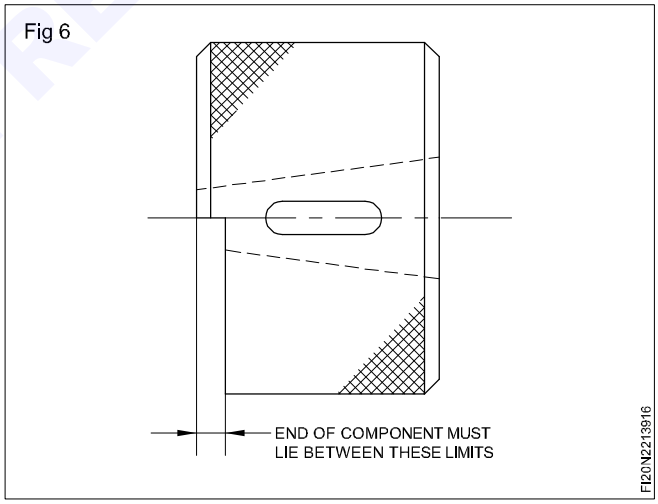
Fig 5



Taper ring gauges (Fig 6)

They are used to check both the accuracy and the outside diameter of a taper. Ring gauges often have scribed lines or a step ground on the small end to indicate the ‘Go’ and ‘No-Go’ dimensions.

Fig 6



Thread plug gauges (Figs 7 and 8)

Internal threads are checked with thread plug gauges of ‘Go’ and `No-Go’ variety which employ the same principle as cylindrical plug gauges.

Thread ring gauges (Fig 9)

These gauges are used to check the accuracy of an external thread. They have a threaded hole in the centre with three radial slots and a set screw to permit small adjustments.

Fig 7

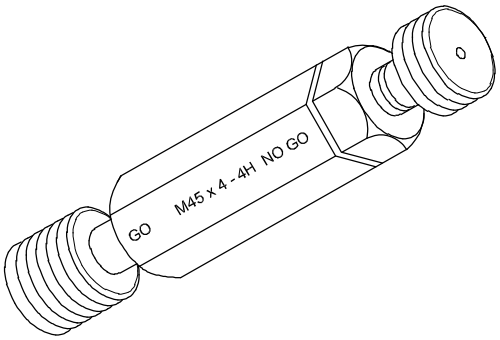


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Fig 8

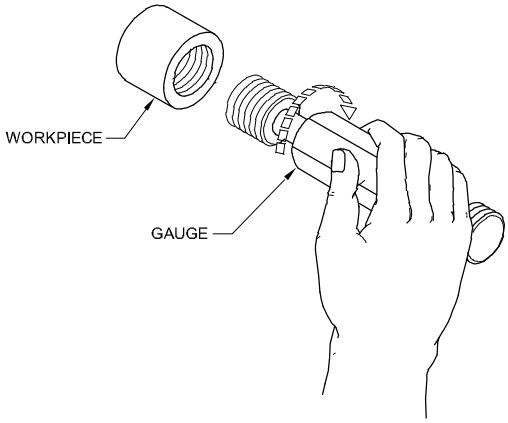

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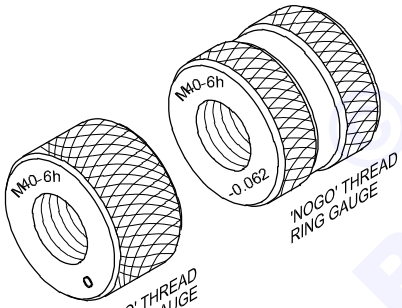
Fig 9



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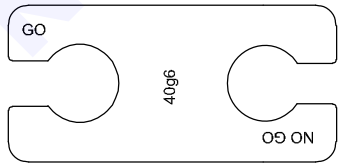
Snap gauges (Figs 10, 11, 12 and 13)

Snap gauges are a quick means of checking diameters and threads to within certain limits by comparing the part's size to the present dimension of the snap gauge.

Fig 10



PLAIN SNAP GAUGE

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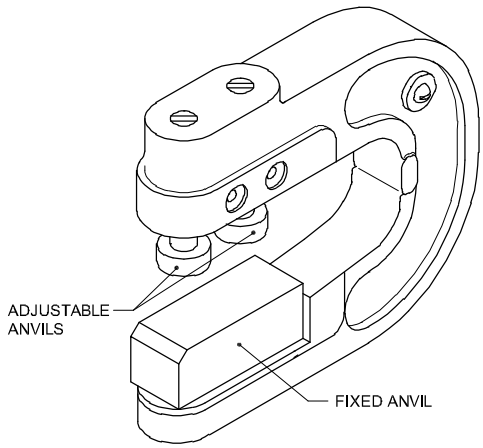
Snap gauges are generally C-shaped and are adjustable to the maximum and minimum limits of the part being checked. When in use, the work should slide into the 'Go' gauge but not into the 'No-Go' gauging end.

Fig 11



ADJUSTABLE SNAP GAUGE

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Fig 12

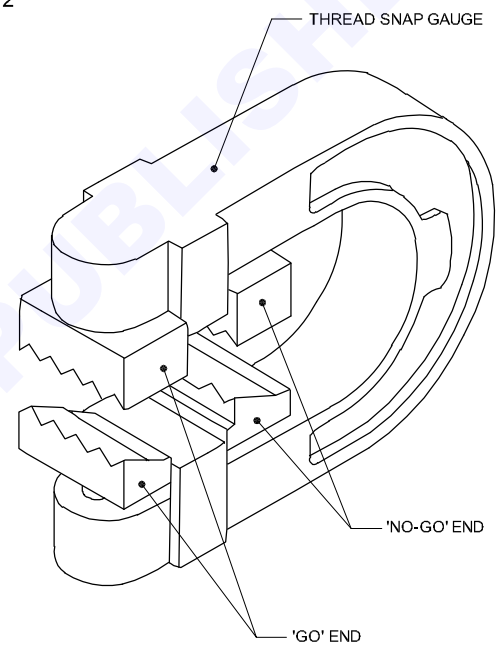

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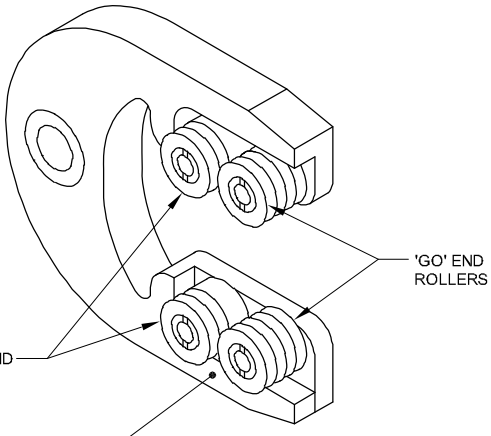
Fig 13



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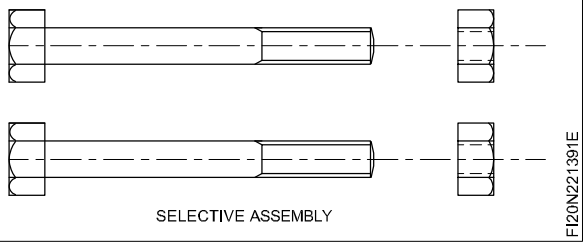
Selective assembly

The figure illustrate difference between a selective assembly and a non - selective assembly. It will be seen in (Fig 14) that each nut fits only one bolt. Such an assembly is slow and costly,and maintanance is difficult because spares must be individually manufactured.

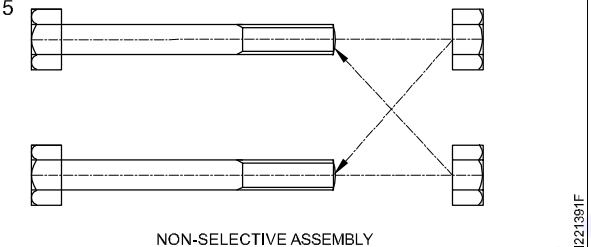
Fig 14



Non - selective assembly

Any nut fits bolts of the same size and thread type. Such an assembly is rapid, and costs are reduced. Maintenance is simpler because spares are easily available. (Fig 15)

Fig 15



Non - selective assembly provides interchangeability between the components.

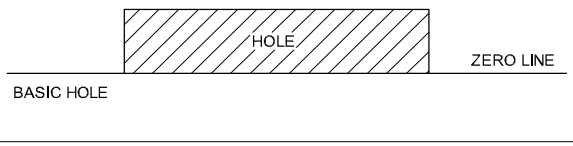
In modern engineering production, i.e. mass production, there is no room for selective assembly. However, under some special circumferences, selective assembly is still justified.

Hole basis system

In a standard system of limits and fits, where the size of the hole is kept constant and the size of the shaft is varied to get the different class of fits, then it is known as the hole basis system.

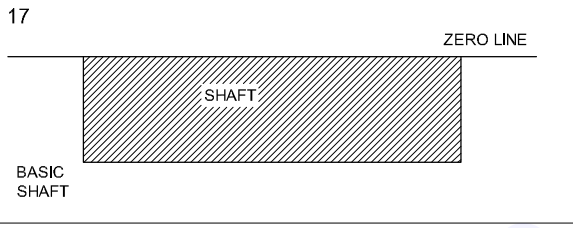
The fundamental deviation symbol ‘H’ is chosen for the holes, when the hole basis system is followed. This is because the lower deviation of the hole ‘H’ is zero. It is known as ‘basic hole’ (Fig 16).

Fig 16



Shaft basis system (Fig 17)

Fig 17

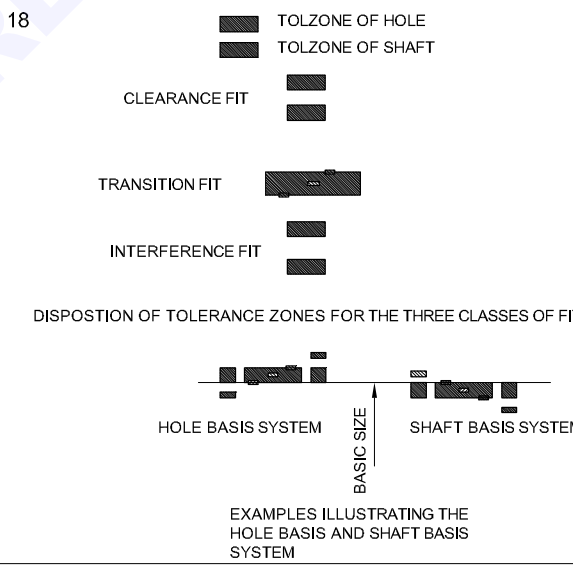


In a standard system of limits and fits, where the size of the shaft is kept constant and the variations are given to the hole for obtaining different class of fits, then it is known as shaft basis. The fundamental deviation symbol ‘ h’ is chosen for the shaft when the shaft basis is follwed. This is because the upper deviation of the shaft ‘h’ is zero. It is known as ‘basic shaft’.

The hole basis system is followed mostly. This is because, depending upon the class of fit, it will be always easier to alter the size of the shaft because, it is external but it is difficult to do minor alterations to a hole. Moreover the hole can be produced by using standard toolings.

The three classes of fits, both under hole basis and shaft basis, are illustrated in figure 18.

Fig 18



Bearings

Objectives : At the end of this lesson you shall be able to
- **state the purpose of bearings**
- **state the characteristics of plain bearings**
- **describe journal bearing & thrust bearing**
- **describe ball bearing and its types**

What are bearings?

Bearings are used in parts having relative motion. The motion may be rotational, reciprocating or a combination of these movements.

Bearings form part of an assembly or mechanism which supports or constrains another part in the assembly.

The need for bearings

A bearing is a part of an assembly, structure or mechanism which supports or acts as a constraint on another part of the assembly. The other part may be stationary but the word 'bearing' is usually used in connection with parts having relative motion which may be rotational, reciprocating or a combination of these movements.

A bearing material should have the following properties.

It should:

- offer the least possible resistance to motion
- have good wear resistance
- be able to absorb sudden loads
- be able to conduct heat away from the bearing surface
- resist corrosive conditions
- have a melting point lower than that of the shaft it supports, so that it runs before shaft seizure occurs.

These requirements may be met by the selection of suitable bearing materials and arrangements with adequate lubrication, where necessary.

Uses

Bearings are used to:

- support and hold the shaft in a fixed position (Figs 1 and 2)
- allow the shaft to run freely
- restrain moving elements
- minimise the rubbing action.

Bearings are generally grouped as:

- plain bearings
- anti-friction bearings.

Fig 1

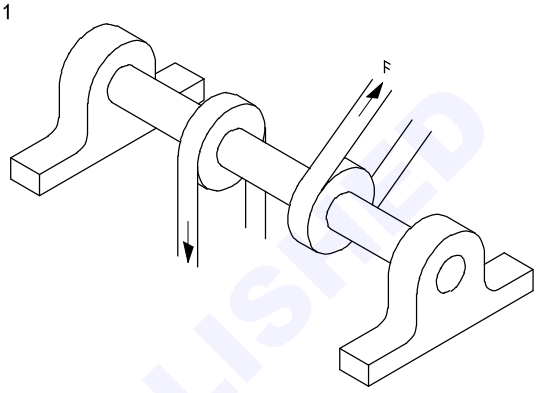
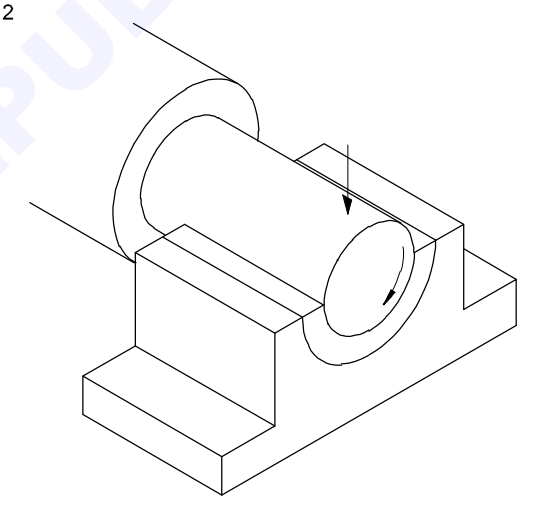


Fig 2



Plain bearings

Depending on the direction of load application they are called radial or journal bearings and thrust bearings.

Radial or journal bearing

In this, the loading is at right angles to the bearing axis. (Fig 3)

Thrust bearing

In this, the loading is parallel to the bearing axis. (Fig 4)

Characteristics of plain bearings

These bearings have a cylindrical shape (Figs 3 and 5) and are fitted in a housing.

Fig 3

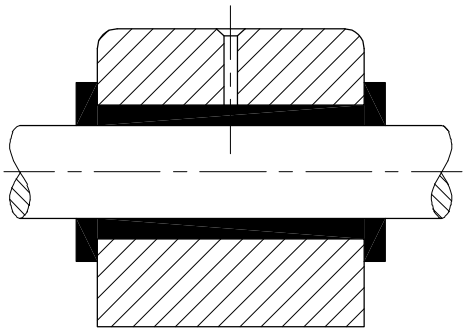


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Fig 4

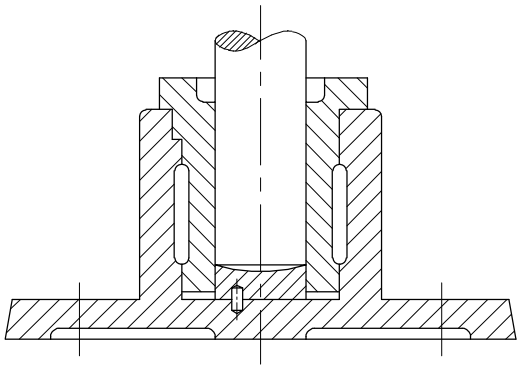

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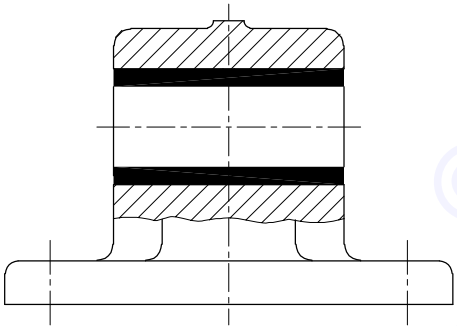
Fig 5



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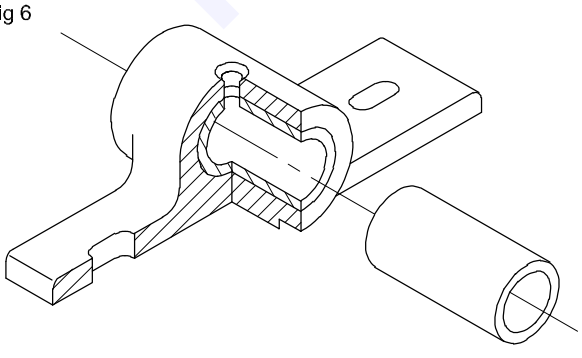
Plain bearings are kept in position without allowing them to rotate along with the shaft. For this purpose they are press fitted in the housing or provided with a key or screws. (Fig 5)

Types of plain bearings

Solid bearings (Fig 6)

These are made of bearing materials in the form of bush and are press fitted in fabricated or cast iron housings.

Fig 6



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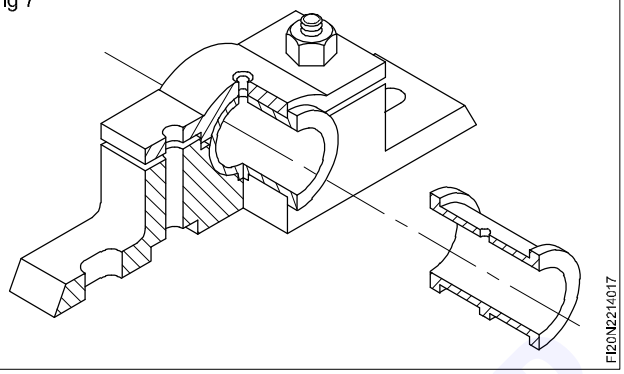
Split bearings (Fig 7)

These bearings are made in halves and assembled in special plumber blocks.

Fig 7



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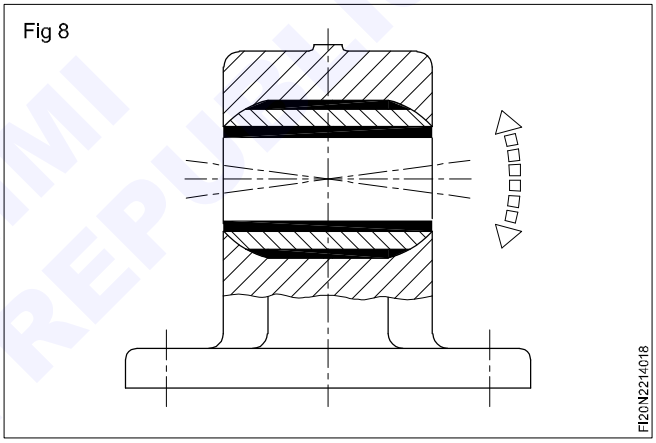
Self-aligning bush bearings (Fig 8)

In this type, the bearing bush is pressed into a special sleeve for self-aligning, in case slight angular misalignment or deflection due to the load between the bearing and the support points occurs.

Fig 8



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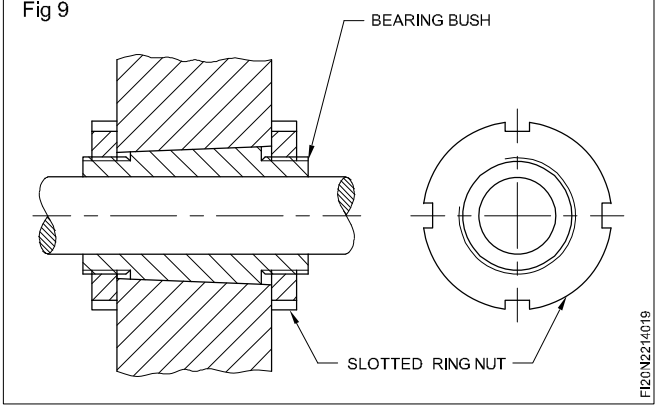
Adjustable slide bearing (Fig 9)

This type of bearing has provision for wear adjustment. The bearing is fitted in the tapered hole of the housing for adjustment of wear. The bearing is drawn inside by means of a nut.

Fig 9



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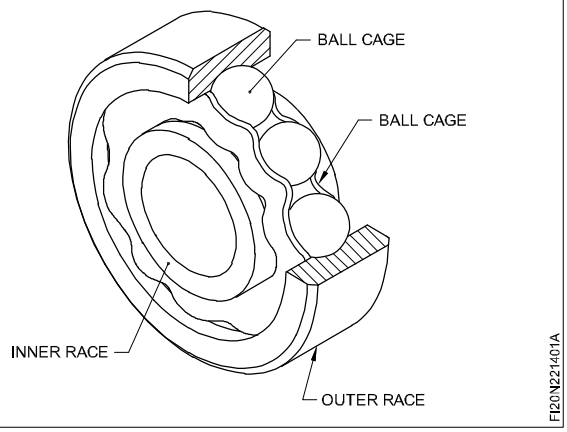
Anti-friction bearing

General features of anti-friction bearings

This bearing consists of rolling elements, races and cage. (Fig 10)

Fig 10



Rolling elements

They are available in different shapes such as balls, parallel rollers, taper rollers, barrels and needles. They are made of chromium (or) chrome-nickel steel with a ground or polished surface. The load of the rotating member is carried by the rolling elements.

Races

The inner and outer races are provided with grooves or race-ways which guide the rolling elements. They are made of high grade chromium steel or chrome-nickel steel. They are hardened, ground and polished.

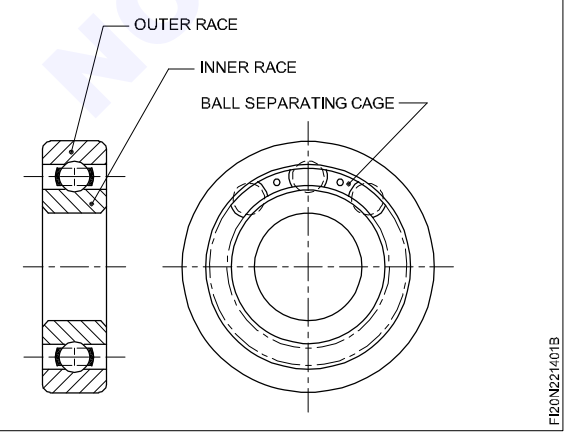
Cage

Each rolling element is separated from the other by means of a 'cage' and it keeps the rolling elements from bunching up. The rolling elements and the cage are retained between the inner and outer races. The rolling elements are retained in the cages to ensure proper fits and equal spacing between the rolling elements. They are made out of brass, steel or plastics.

Ball-bearings

Ball-bearings are the most widely used of all the bearings. (Fig 11)

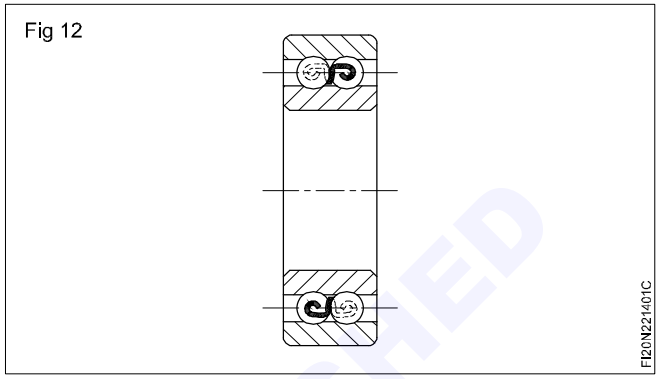
Fig 11



For any given bore diameter, there are usually two or three sizes of outside diameter width, and the load-carrying capacity. The width of these bearings is smaller than the bore diameter. The width (or length) to diameter ratio is much smaller than that of plain bearings. Although principally they are to carry journal loads, the deep groove type of ball races are capable of withstanding the axial thrust.

Self-aligning ball-bearings (Fig 12)

Fig 12



This type of bearings has a spherical bore on the outer race. This bearing can carry journal loads which are slightly inclined due to shaft misalignment.

Ball bearing types

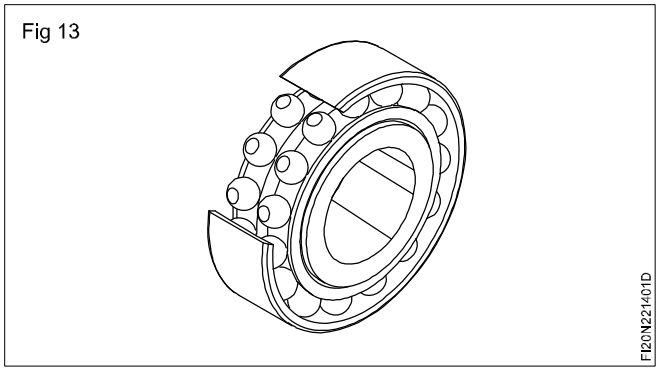
The three most commonly used types of ball bearings are the radial bearing, the angular contact bearing, and the double row ball bearing. The radial ball bearing is designed to accommodate primarily radial loads but the deep groove type will support bidirectional thrust loads up to 35% of the radial load before bearing life becomes progressively shorter. The assembled radial bearing is inseparable and may be equipped with seals, shields, and/or snap rings

Single row ball bearing

Angular contact ball bearings are single row bearings designed so that the line of contact between the balls and inner and outer ring pathways is at an angle to a line 90º to the bearing axis of rotation. The angle between the two lines is called the contact angle. In angular contact ball bearing design. one of the pathway shoulders is removed to allow assembly of a maximum complement of balls for increased load carrying capacity. Angular contact ball bearing support both radial and high one-direction thrust loads.

Double row ball bearing (Fig 13)

Fig 13



This has two angular contact ball bearings mounted back-to-back. This type of mounting has good axial and radial rigidity and provide resistance to overturning moments and angular deflection of the shaft.

The two angular contact ball bearings mounted face-to-face. This type of mounting has the same axial and radial rigidity as back-to-back mounting but less resistance to overturning moments and more compilance to misalignment or bending of the shaft.

The depitcs two angular contact ball bearings mounted in tandem (face-to-face). This mounting arrangement provides resistance to high one-direction thrust loading. The total thrust capacity of the pair is 1.62 times the thrust capacity of one bearing. For even higher thrust loading, three or more angular contact bearings can be mounted in teandem.

Advantages of double row ball bearings

1 Double row ball bearings support heavy radial loads. thrust loads from either direction, or combined radial and thrust loads. They are normally used in positions where radial loads exceed the capacity of a single row bearing with a comparable bore and OD.

2 Double row bearings are designed with the bore and outside diameter the same as single row bearing but are narrower than two single row bearing.

3 Double row ball bearing may offer some economic benefits as well ass handling and maintaining benefits verses single row ball bearings.

Double row angular contact ball bearings

Double row angular contact ball bearings have tow rows of balls arranged back-to-back. The lines of action of the load at the contact between balls and raceways (load lines) diverge at the bearings axis and form anangle of 30^{o} to the radial plane. In essence, they work similarly to having a matched pair of single row angular contact ball bearings either face-to-face or back-to-back. The difference is that double row angular contact ball bearing can tacke a bi-directional axial load in one bearing where it takes a matched pair otherwise. This means the bearings are particularly suitable for accomodating simulataneously acting radial load and axial load in both directions. They are also available with seals or shields.

Double row angular contact ball bearings are available in two numerical series:

- 5200 series - Lights load,higher speed, more/smaller balls per bore diameter
- 5300 series - Heavier load, slower speed, fever/larger balls per bore diameter.

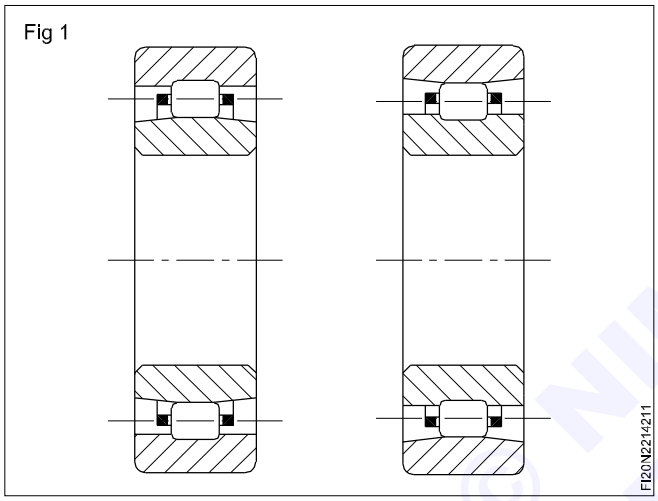
Roller & needle bearings

Objectives : At the end of this lesson you shall be able to
- **describe roller & needle bearing**
- **state types of roller bearing**
- **state the method of fitting bearings.**

Roller bearings (Fig 1)

Roller bearings are available with the grooved race in the outer and inner members. Selection of this depends upon which race is required to be locked. Roller bearings are intended to carry radial journal loads and can carry greater radial loads than ball-bearings of the same size.

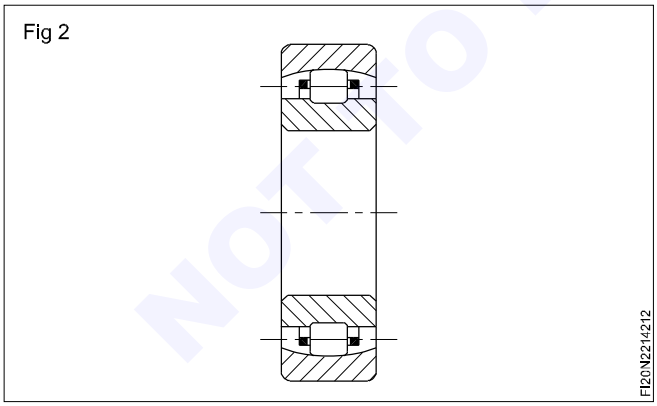
Fig 1



Self aligning roller bearings (Fig 2)

Self aligning roller bearings have barrel-shaped rollers and spherical bores in the outer race. For very heavy radial loads double row roller bearings are also available.

Fig 2



Needle bearings

Rollers of very small diameter, called needle rollers, are shown in (Fig 3). This type of bearing is used where the outside diameter of the bearing is severely restricted because of the limited bearing space in the housing. Fig 4 shows the needles fitted in a circular cage which is push-fit in its housing.

Fig 3

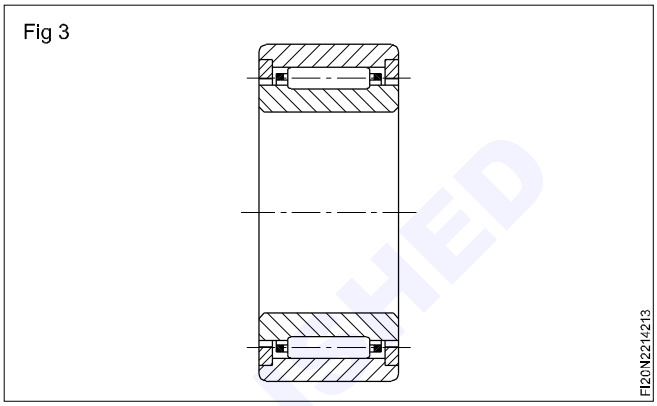
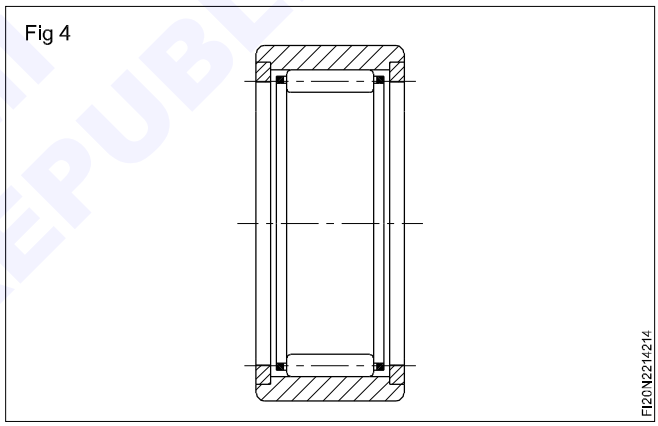


Fig 4

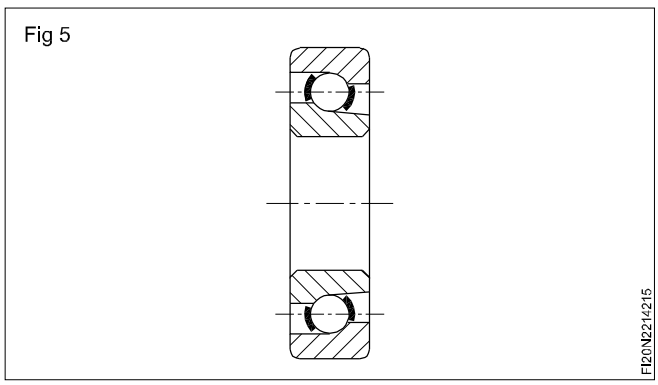


In this design the needles are in contact with the shaft journal.

Angular contact ball-bearing

These bearings are designed to take an axial thrust as well as radial loads. (Fig 5) shows an angular contact ball-bearing (single row).

Fig 5

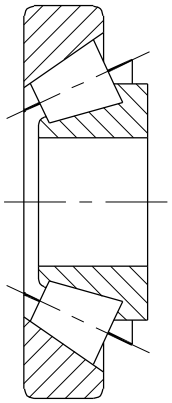


Tapered roller bearings (Fig 6)

These are used for taking high axial thrust loads. Tapered roller bearings with slow tapered cones are used where the axial thrust is more than the radial load.

These bearings are made to take thrust from one direction only. Where there is opposing thrust then the bearings must be mounted as pairs in opposition.

Fig 6



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Thrust ball-bearing

These bearings are useful for taking vertical thrust load (Fig 7) but cannot take any radial load. Special thrust bearings (Fig 8) are available which can also take horizontal end thrusts.

Fig 7

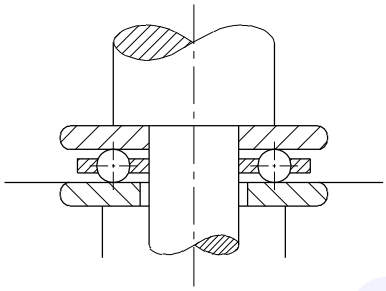

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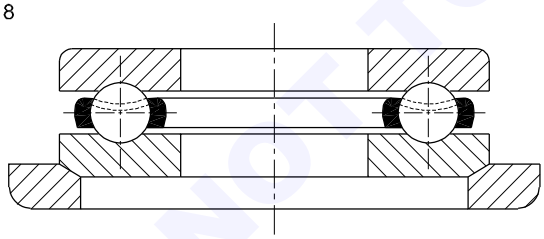
Fig 8



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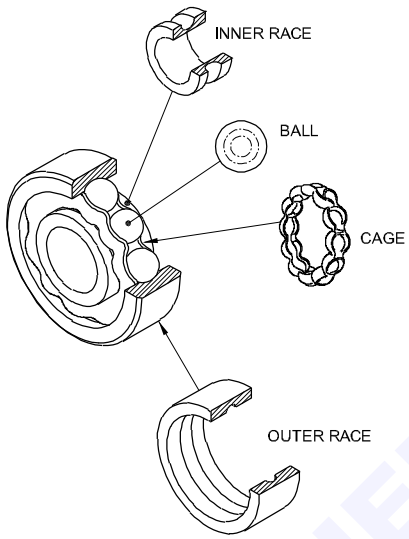
Bearings are the supporting members of a rotating shaft. They provide safe and reliable service when properly applied and maintained.

Rolling contact

Rolling contact bearing is also known as anti-frictional bearing. In this bearing, contacting elements have rolling friction which is much lesser than sliding friction. Bell bearings have point contacting while roller bearings have the contact.

Rolling elements (Fig 9)

Fig 9



COMPONENTS OF BALL BEARING

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A rolling element bearing consists of four basic parts.

- Inner race
- Outer race
- Balls or rollers
- Retainer or cage

The inner race, the outer race and the balls or rollers, support the bearing load. The fourth part, the bearing retainer, serves to position the rolling elements.

Materials

Selection of material and control of material quality are critical in the manufacturing of rolling element bearings.

Bearing steel must posses high strength, toughness, wear resistance, dimensional stability, excellent fatigue resistance and should be free from internal defects.

Importance of proper fit

Proper fit in the rolling contact bearing ensures long services life. If the bearing is fitted too tight, the internal radial clearance will be reduced, and thereby, the rolling elements will get jammed. Consequently it will have premature failure. If the bearing is too loose, it will not take the load. So, a proper fit is very much essential.

In general applications, when the journal (spindle) is rotaing, the inner face will have an interference fit with the journal and the outer race will have a close push fit. In the case of a stationary spindle, when the outer race is the rotating member, the interference fit will be withh the outer race, and the hub and close push fit with the inner race and spindle. The degree of tightness and looseness depends upon the load, speed, temperature and the type of the bearing.

Bearing mounting

Bearing mounting deserves great care. When the bearing is fitted tight into the spindle, pressure should be applied on to the inner race. (Fig 10) If the bearing is pressed into the housing, pressure must be applied on to the outer race. (Fig 11)

Fig 10

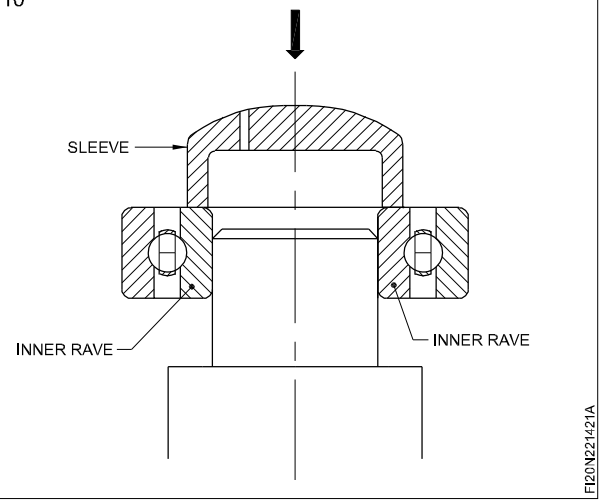
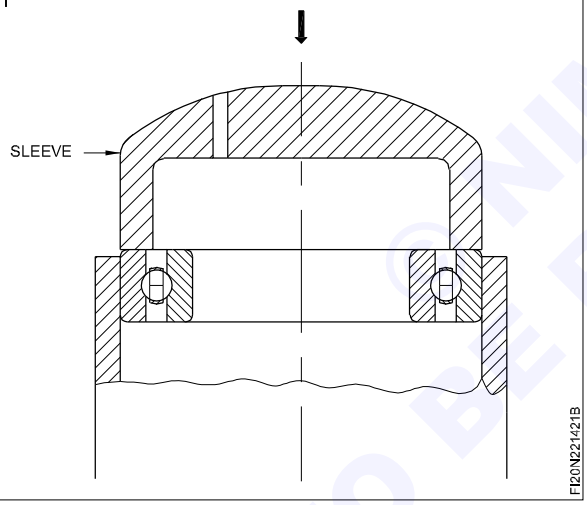


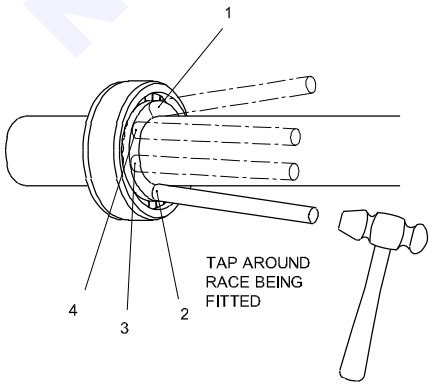
Fig 11



Smear thin lubricating oil on the shaft or housing where the bearing is to be fitted.

Small bearings can be fitted by using mounting sleeves and hammer (Fig 12) or using a copper drift and hammer.

Fig 12

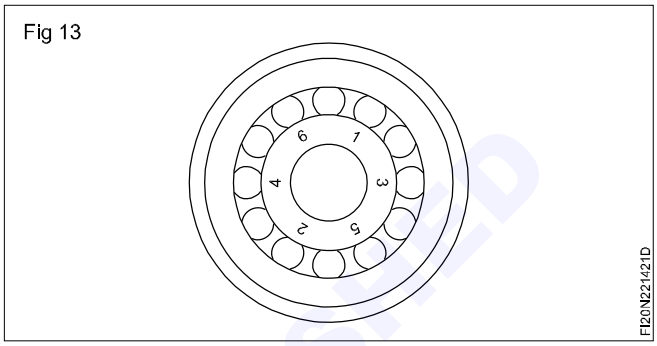


The mounting sleeve should have its faces parallel and flat.

Check frequently that the bearing is driven parallel to the axis of the housing or at right angle to the axis of the shaft.

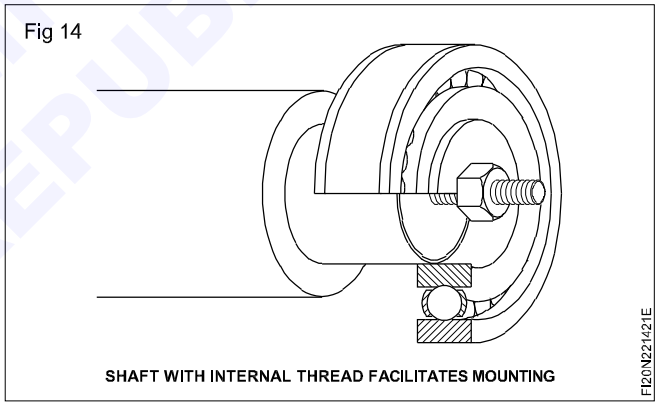
When a suitable bearing puller is not available, as soft metal drift may be used to drive the bearing into position. While striking the bearing onthe inner race, it should be struck progressively on the opposite point of the race as shown in Fig 13.

Fig 13



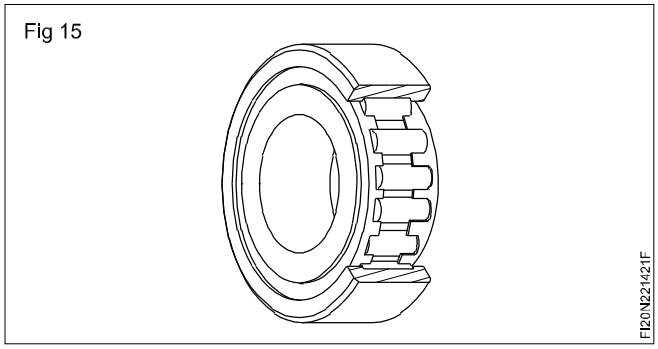
If a shaft is having internal threads at the centre (Fig 14) or external threads, they can be utilised for mounting the bearings.

Fig 14



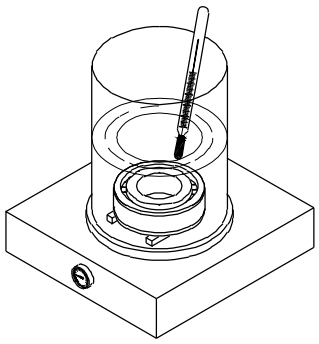
Separable parts of cylindrical roller bearing are more independently. Mount the inner ring first and the outer race with the roller and cage assembly after bit of oiling or greasing. (Fig 15)

Fig 15



When the shaft fit has more interference, one adopt shrinkage fit. For such a fit the inner race should heated up in an oil bath as shown in Fig 16 or by indicate heating process between 90° to 120°C depending the expansion requirement. (Fig 17)

Fig 16



OIL HEATING OF BEARING

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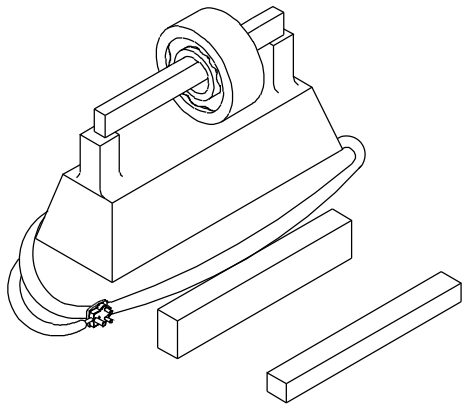
Fig 17



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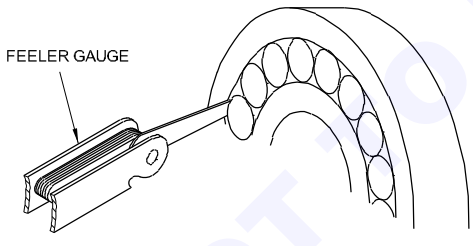
In no case should the rolling contact bearing be heated more than 140°C.

Check the internal clearance of the bearing (Fig 18) after the bearing attains room temperature. When the bearing is having more interference in the housing, the bearing should be cooled in a freezing chamber (-5 to -20°C) and pushed inside the housing easily.

Fig 18



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The inner ring of bearings with the tapered bore is always mounted with an interference fit, usually on a taper adopter sleeve or a withdrawal sleeve. When the bearing driven up the original radial, the internal clearance is reduced. The reduction in clearance required can be referred to in the table provided by the bearing manufacturer. The clearance is measured as shown in Fig 18.

Bearing dismounting

Dismounting of bearing should be done with proper care using proper tools. If proper tools are not used and right techniques are not adopted, the bearing is likely to be damaged and may lead to premature failure.

While using a puller, the pulling legs of the puller should be placed with the inner race. (Fig 19) In certain cases, we use a puller plate (Fig 20) to facilitate the placing of the pulling legs in position so that force is applied on the inner race. Special puller plates (Fig 21) are used along with a two-legged puller so that the pull is applied on the inner race alone.

Fig 19

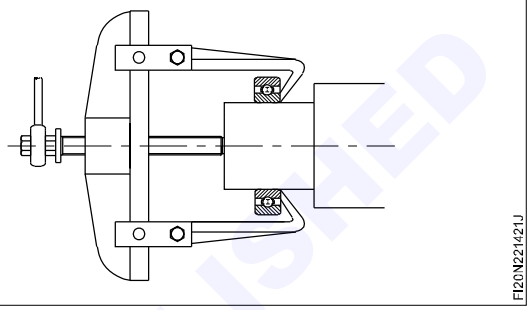

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Fig 20

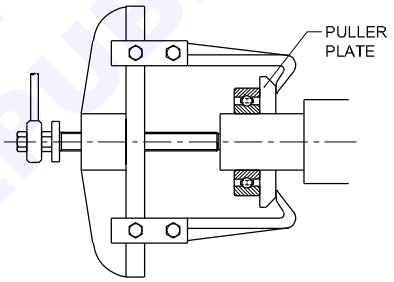

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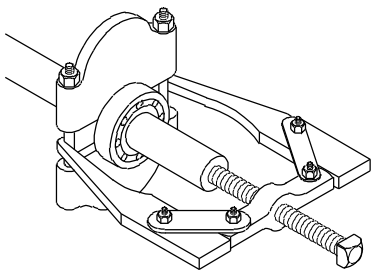
Fig 21



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For detachable inner ring type bearing, the puller legs can be placed with the outer ring as shown in Fig 22 for dismounting the bearing when the outer ring is having asn interference fit in the housing.

A self aligning ball-bearing can be swivelled as shown in Fig 23 fixing the bearing puller to facilitate the dismounting process.

Fig 22

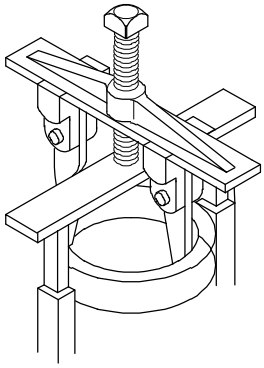

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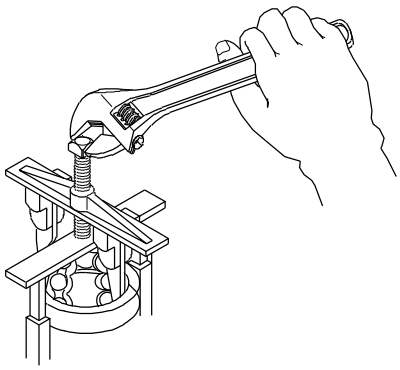
Fig 23



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Care and maintenance

- A good bearing should not be dismantled unless otherwise it is absolutely necessary.
- Bearings should be handled in a dirt/dust free environment. Bearing housing on the shaft should be free from burns or scratches.
- Proper mounting and dismounting tools, and correct techniques should be adopted. Provide proper support for the bearing and shaft during disassembly.
- Direct blows should be not given to the bearing.
- Bearing should not be heated with a naked flame. Before heating ensure that any grease or lubricant does not start a fire.
- Use only the recommended grade and quantity of lubricant for the lubrication of bearing.

Bearing materials

Objectives: At the end of this lesson you shall be able to
- **state the properties of plain bearing materials**
- **name the different materials commonly used for making plain bearings**
- **state the characteristics of different bearing materials.**

The materials used for plain bearings will have properties according to the operating conditions.

In general the bearing materials should have the following properties.

- Good thermal conductivity to carry away heat from the bearing.
- Resistance to corrosion from atmosphere or lubricants.
- Strength to carry the loading of the shaft or sliding member without permanent deformation.
- Ability to operate in the required temperature range.
- Ability for dirt and other foreign matters to embed on the surface and thus prevent seizing of the shaft or sliding member.
- Ability to resist wear.
- Ability to deform slightly for compensating minor mis-alignments and surface irregularities.

Bearing materials (Plain bearings)

White metal

White metals of different composition are used for a various applications.

White metals are either tin or lead-based. Tin-based white metals are often referred to as babbit metals.

White metal bearing alloys also contain small amounts of copper and antimony in varying proportions.

White metal bearings have low load carrying capacity, when compared with other bearing materials. The strength of this metal decreases considerably with increasing temperature. To overcome these defects, a layer of high strength fatigue-resistant material is introduced between the thin white metal layer and a steel backing.

Cadmium based alloy

These alloys have greater resistance to fatigue than white metal bearings, but have poor resistance to corrosion. These alloys usually contain small amounts of nickel, copper and silver.

Bearings made out of these alloys can work at higher temperature and have higer load carrying capacity.

Copper lead alloys

This contains copper and lead. This has a higher load carrying capacity than cadmium based alloys and the operating temperature is higher than for white metal bearings. This alloy is used in heavy duty applications like main and connecting rod bearings and in moderate load and speed applications in turbine and electric motors.

Lead bronze and tin bronze

Lead bronze will contain approximately up to 25% lead and the tin bronze up to 10%. They can be used as single material without any overlay or steel backing.

These bearings find application for intermediate load and speed requirements.

Aluminium alloys

Aluminium, alloyed with small quantities of tin, silicon, cadmium, nickel or copper is also used as bearing metal. Aluminium alloy containing about 20 to 30% of tin and up to 3% of copper is capable of substituting bronze bearings for certain industrial applications.

It is best suited for hard journals. It is necessary to give extra clearance between the bearing and the journal to overcome the effects of high thermal expansion.

Aluminium alloys for bearings are available with special properties needed for higher load carrying, strength and thermal conductivity.

Cast iron

Cast iron is used as bearing metal for light loading and low speed applications.

Sintered alloys

Bearing metals such as plain or lead bronze, iron, stainless steel are also made by the sintering process providing porosity in the metal. The structure of the bearings made by the sintering process is spongy, and can absorb and hold considerable quantity of oil. These bearings in actual use will be of a self-lubricating type. These bearings are used in situations where lubrication is difficult.

Plastics

Plastics of different types are used as bearings because of the following reasons.

- Good resistance to corrosion.
- Silent operation.

- Ability to be moulded in different shapes easily
- Elimination of the need for lubrication.

The most commonly used types of plastic materials are

- laminated phenolics
- nylon
- teflon.

Laminated phenolics

This consists of cotton fabric, asbestos, or other materials bounded with phenolic resin. This material has high strength and shock-resisting properties. The thermal conductivity of this material is low. There should be adequate facilities for cooling the bearings made out of these materials.

Nylon

This is widely used for light loading applications. Nylon bearing needs no lubrication as it has self-lubricating properties.

Teflon

This material has self-lubricating properties, resistance to attack of chemicals, a low co-efficient of friction, and can withstand a wide temperature range. The cost of this material is high and the load-carrying capacity is low.

With the movement of two mating parts of the machine, heat is generated. If it is not controlled the temperature may rise resulting in total damage of the mating parts. Therefore a film of cooling medium with high viscocity is applied between the mating parts which is known as a 'lubricant'.

A 'lubricant' is a substance having an oily property available in the form of fluid, semi-fluid, or solid state. It is the lifeblood of the machine, keeping the vital parts in perfect condition and prolonging the life of the machine. It saves the machine and its parts from corrosion, wear and tear, and it minimises friction.

Purposes of using lubricants

- Reduces friction.
- Prevents wear.
- Prevents adhesion.
- Aids in distributing the load.
- Cools the moving elements.
- Prevents corrosion.
- Improves machine efficiency.

Prevention of rust and corrosion

Objectives : At the end of this lesson you shall be able to
- **state the importance of keeping the work free from rust and corrosion**
- **state the need for prevention of corrosion**
- **name the different methods of metallic coatings used for preventing crrosion**
- **state the different cementation processes**
- **state the application of different metallic protective coatings**
- **state the treatments to provide pleasing finish.**

The importance of keeping the work free from rust and corrosion

Rusting is in the simplest form, the slow eating away of iron and its alloys. Rusting is the same as corrosion, but it is used to describe the corrosion of iron and its alloys only. Rusting is a chemical process in which ferrous reacts with oxygen in the presence of moisture or water, to produce ferric oxides and hydroxides (which are called rust). Rusting causes slow degradation of iron and its alloys. This results in the weakening of the material and ultimate failure. Since iron and its alloys are very widely used (Some examples are pipe lines for water and waste water flow structures like bridges, railway tracks, ships etc.) any degradation in the metal's quality will directly affect these structures our economy, our health and well-being. And thus the prevention of rusting is necessary. There are a number of ways of doing it, such as galvanization, paints, coating etc.

Most common non-ferrous metals and alloys form their own protective coating when exposed to the atmosphere. Corrosion prevention is largely applied to iron and steel. For maximum life, accuracy and utility of a component, it is very essential that corrosion is controlled or prevented. One method of crrosion proofing is to protect the metallic material from the corroding influence by means of protective coats or deposits which prevent or reduce corrosion to acceptable levels.

Protective treatment of metal surface

The type of protective treatment used depends upon:
- the material from which the component is made
- the purpose for which it is used
- the environment in which it is to operate.

There are more or less permanent methods for preventing corrosion. These methods can be grouped as metallic corrosion-resistant coating and non-metallic corrosion-resistant coating.

Commonly used metallic corrosion-resisting coatings

- Hot dipping (galvanising)
- Electroplating
- Cladding
- Metal spraying
- Cementation

Galvanizing

In this process mild steel is coated with zinc. For hot dip galvanizing, the workpieces are initially pickled in hot sulphuric or cold hydrochloric acid to clean the surface, and then fluxed with zinc chloride and ammonium chloride. After this they are dipped in molten zinc. Sometimes a small quantity of aluminium is added which gives a bright appearance and uniform thickness.

The temperature of the zinc bath is usually maintained between 450° and 465°C. The hot-dipped workpieces are then quenched in a water bath. Galvanizing is done for structural work, bolts and nuts, pipes and wires, which are exposed to different atmospheric conditions. This method is highly reliable. It can withstand severe working conditions and the cost is low.

Electroplating

Many metals can be plated on to workpieces electrically, and this process is called electroplating. In electroplating the surfaces of components are coated with another metallic coating for the purpose of obtaining decorative or protective surfaces.

In the electrolytic process the components to be plated are immersed in a solution called the electrolyte. The component to be plated is made as the cathode by connecting the negative pole of a low voltage, high current DC supply. (Fig 1) To complete the circuit, anodes connected to the positive pole of the supply are also immersed in the electrolyte.

The electrolyte supplies the metal ions which are to be deposited on to the components (cathode). The anodes may be soluble and made of the same metal to be plated on the component surface i.e. nickel, copper or zinc.

Certain anodes are insoluble, for example - chromium. In such cases anodes are useful only to complete the circuit in the electrolytic process.

Metals like copper, chromium, cadmium, nickel, silver etc. are used for electroplating.

Cladding

This is a process in which composite billets consisting of a base metal and a coating of corrosion-resistant metal are rolled or drawn. The thickness of the base metal and the coating reduce proportionally. (Fig 2) An application of this is cladding of steel with aluminium.

Fig 1

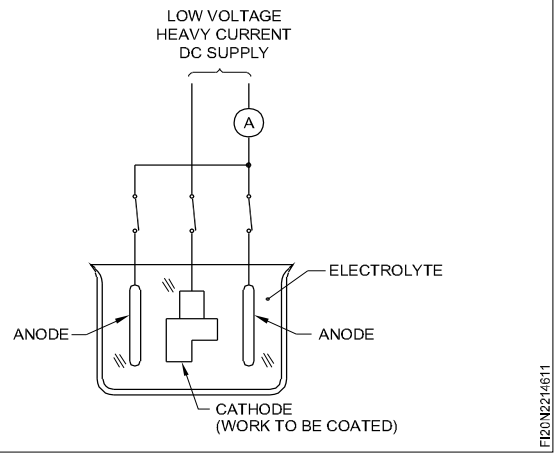
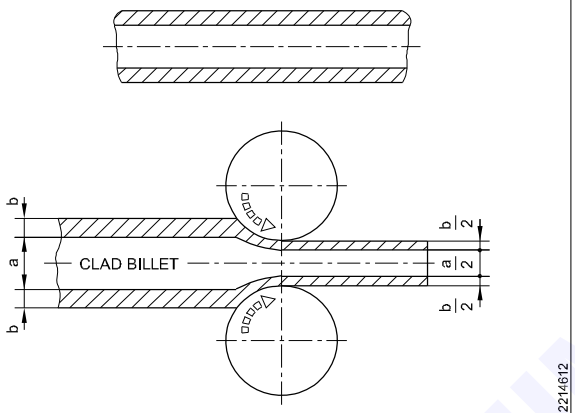


Fig 2



PROPORTIONAL REDUCTION OF CLAD BILLET

Metal spraying

Ferrous metals are sprayed with metal coatings for preventing corrosion, building up worn out shafts, providing wear-resistant surfaces etc. In this process molten particles of metal are sprayed on surfaces which are properly degreased and grit-blasted. Common metals used for metal spraying are - copper, zinc, brass, carbon steel, stainless steel etc.

Cementation

There are three types of cementation process for protecting metal surfaces.

- Sherardising (Zinc coating)
- Calorising (Aluminium coating)
- Chromising (Chromium coating)

Sherardising

In this process the workpieces are initially prepared by acid pickling or grit-blasting. They are then placed in a rotating steel barrel containing zinc powder, and heated to a temperature around 370°C. The time taken for the coating depends on the thickness of the coat. The heated powder bonds to the ferrous workpiece by diffusion and forms a hard even layer of iron/zinc intermetallic compound. The surface of the sherardised components will be slightly rough which provides a good grip for subsequent painting.

Calorising

This process is very similar to sherardising but the powder used is aluminium, and the heating temperature is between 850° C and 1000°C. This is used to protect steel components from corrosion. This process requires a higher temperature and higher humidity than sherardising.

Chromising

This provides a chromium-rich surface. The work to be chromised is baked with aluminium oxide and chromium powder in a temperature of 1300° to 1400°C in an atmosphere of hydrogen to prevent oxidation of chromium. The process is expensive, and due to this reason, it is used only in places where extreme protection is required.

This coating caused by the action of the acids in the atmosphere protects the surface of the copper.

Zinc

A carbonate coating forms on the surface after a period of exposure, and this acts as a protective film that gradually strengthens with time. This coating is grey in colour like the colour of the parent metal itself.

This coating does not crack or peel off due to variation in tem-perature. For this reason zinc is an excellent exterior building material. It gives excellent protection when coated on steel.

Aluminium

Aluminium and its alloys have a great affinity for oxygen. Aluminium surfaces quickly develop a thin, transparent film of aluminium oxide or 'Alumina' which prevents further oxidation and retains bright appearance. However exterior use of aluminium results in the thickening of the oxide film. This film becomes grey in colour and protects the parent metal from further attack. The oxide film on aluminium and its alloys can be artificially thickened by a process called anodising.

Lead

Lead is one of the most corrosion-resistant of all metals. A large quantity of lead is used as sheathing material for underground telephones and power cables. The WHITE OXIDE film resulting from exposure to the atmosphere prevents further attack.

Stainless steel

It has high structural strength as well as resistance to corrosion. Stainless steels are not confined to applications requiring resistance to atmosphere corrosion. They are used extensively for chemical plant and food processing equipment where they combine corrosion resistance at elevated temperatures.

Nickel

Nickel is used extensively for 'NICKEL PLATING' as it has high resistance to chemical attack. When alloyed with copper in the proportion of 2:1 (Nickel two third) 'MONEY METAL' is produced which is extremely resistant to corrosion, particularly to sea water and acid.

Chromium

One of its most important uses is for electroplating metallic surfaces. It is highly resistant to the influence of corrosion and it retains its high polish and colour for a long period.

Pipes and pipe fittings

Objectives : At the end of this lesson you shall be able to
- **state the uses of pipes**
- **name the common types of pipes**
- **identify the standard pipe fittings and state their uses.**

Various types of pipes and tubes are used for the following purposes.

- Domestic hot and cold water supplies.
- Waste water outlets.
- High pressure steam supplies.
- Hydraulic oil supplies.
- Lubricating oil supplies.
- Special fluid and gases for industrial processes.
- Pneumatic systems.
- Refrigeration systems.
- Fuel oil supplies.

The common types of pipes classified according to material are:

- galvanized iron pipes
- mild steel pipes
- cast iron pipes
- C.I. soil pipes
- copper pipes
- aluminium pipes
- brass pipes
- lead pipes
- P.V.C. pipes
- rubber pipes
- plastic pipes
- stoneware pipes.

Standard pipe fitting

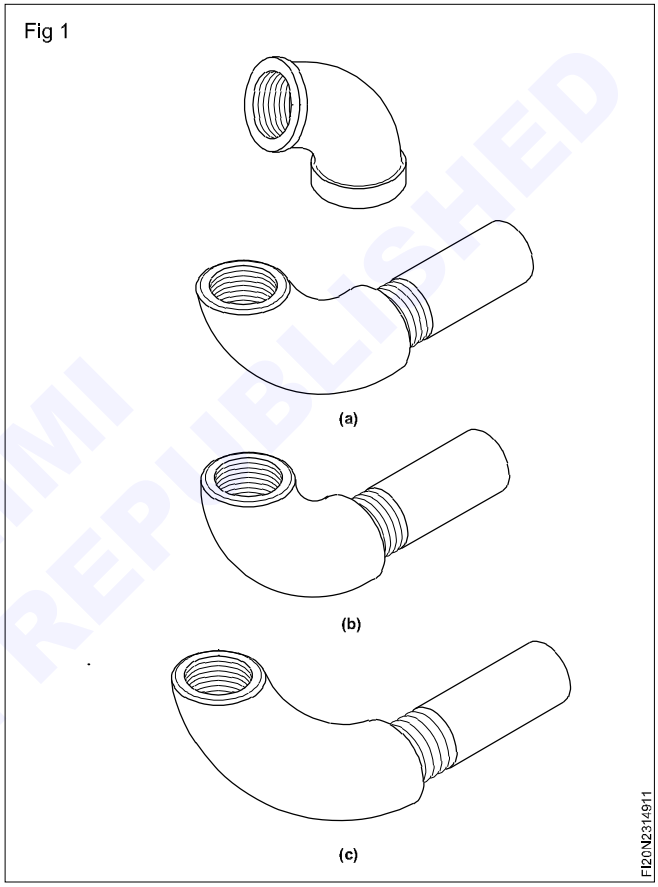
'Pipe fittings' are those fittings that may be attached to water pipes in order to:

- change the direction of the pipe
- connect a branch with a main water supply pipe
- connect two or more pipes of different sizes
- close the pipe ends.

Standard pipe fittings

Elbows (Fig 1)

Fig 1



Elbows and bends provide deviations of 90° and 45° in pipe work systems.

Long radius elbows have a radius equal to 1½ times the bore of the pipe. (Fig 1a)

Short radius elbows have a radius equal to the bore of the pipe.(Fig 1b)

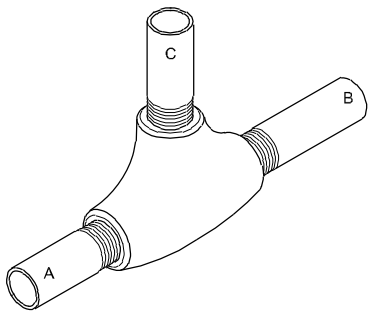
The 45° elbows allow pipe deviation of 45°. (Fig 1c)

Tee branch

A tee joint helps the pipe line to branch off at 90°. The branches may be equal in diameter or there may be one reducing branch.

The dimensions of a branch are always quoted as A x B x C. (Fig 2)

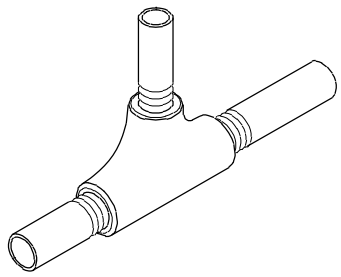
Fig 2



Reducing tee branch

Reducers are fitted where a change in pipe diameter is required.(Fig 3)

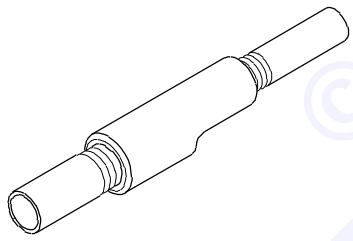
Fig 3



Eccentric reducer

Used mainly in horizontal position.(Fig 4)

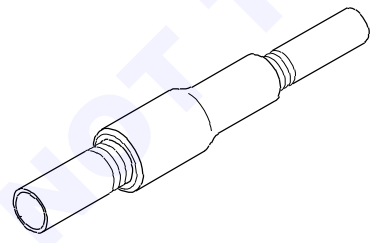
Fig 4



Concentric reducer

Used mainly in vertical position. (Fig 5)

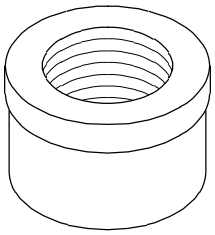
Fig 5



Caps

Caps are used for closing the end of a pipe or fitting which has an external thread. (Fig 6)

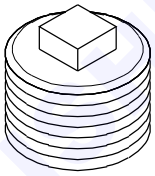
Fig 6



Plug

A plug is used for closing a pipeline which has an internal thread.(Fig 7)

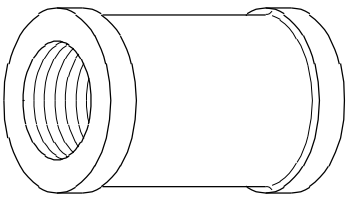
Fig 7



Coupling (Fig 8)

A coupling is used to connect two pipes. Couplings have internal threads at both ends to fit the external threads on pipes.

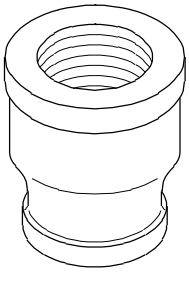
Fig 8



Reducer (Fig 9)

A reducer coupling is used to connect two pipes with different diameters.

Fig 9

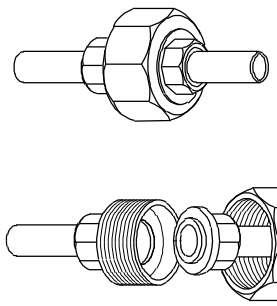


FITTING	SYMBOL
BEND, 90 DEGREES	
BEND, 45 DEGREES	
CROSS	
ELBOW, 90 DEGREES	
ELBOW, 45 DEGREES	
TEE	
REDUCER,CONCENTRIC	
UNION,SCREWED	
PLUG OR CAP	
JOINT/SOCKET	

Union

A device used to connect pipes. Unions are inserted in a pipe-line to permit connections with little change to the position of the pipe. (Fig 10)

Fig 10



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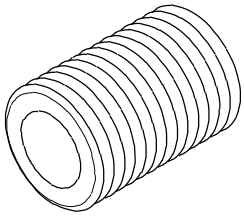
Pipe nipples

Pipe nipples are tubular pipe fittings used to connect two or more pipes of different sizes.

1 Close nipple (Fig 11)

Fig 11



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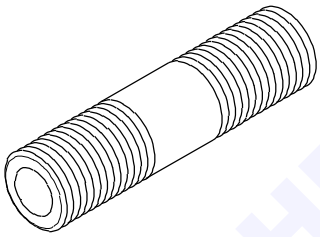
2 Short nipple (Fig 12)

Fig 12



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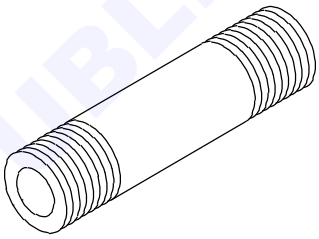
3 Long nipple (Fig 13)

Fig 13



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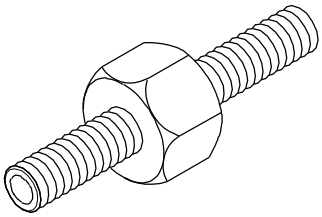
The hexagonal nut

The hexagonal nut in the centre of the nipple is for tightening with a spanner or wrench.(Fig 14)

Fig 14



FI20N231491E

British standard pipe threads

Objectives : At the end of this lesson you shall be able to
- **state parallel and taper pipe threads**
- **determine the wall thickness and threads per inch TPI of BSP threads**
- **state the method of sealing pipe joints**
- **determine blank sizes for threading as per B.S 21-1973 and I.S.2643-1964.**

Pipe threads

The standard pipe fittings are threaded to British Standard pipe gauge (BSP). The internal pipe threads have parallel threads whereas the external pipes have tapered threads as shown in Fig 1.

B.S.P. threads

Galvanized iron pipes are available in sizes ranging from 1/2" to 6" in several different wall thicknesses. The table shows outside diameters and threads per inch from $^{1}/_{2}$" to 4". (Fig 2)

Fig 1

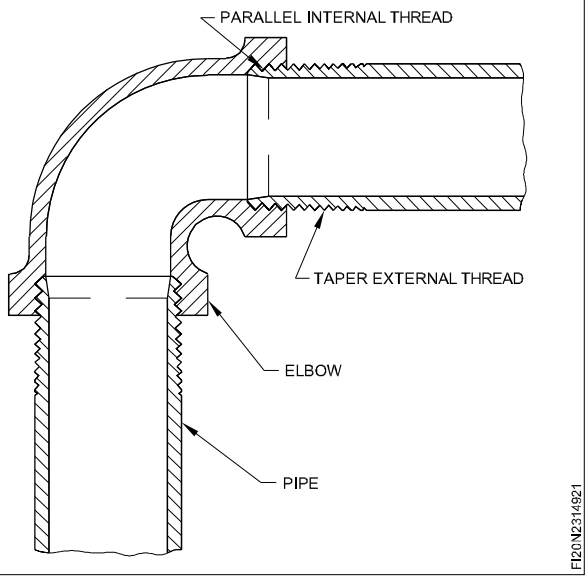
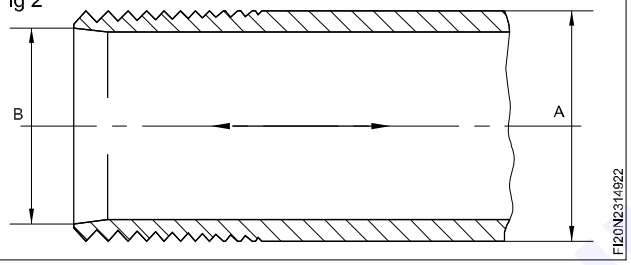


Fig 2



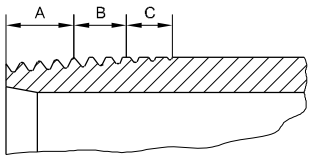
Sealing pipe joint

Fig 3 shows that the pipe has several fully formed threads at the end. (A)

The next two threads have fully formed bottoms but flat tops. (B)

BSP - Pipe sizes or DIN 2999 (inside) (B) +	Threads/ inch	Outside diameter/ mm of the pipe(A)+
1/2”	14	20.955mm
3/4”	14	26.441
1”	11	33.249
11/4”	11	41.910
11/2”	11	47.803
2”	11	59.614
2½”	8	75.184
3”	8	87.884
4”	8	113.030

Fig 3



The last four threads have flat tops and bottoms. (C)

The pipe joint shown in Fig 4 consists of the following.

1 Parallel female thread

2 Tapered male thread

3 Hemp packing

The hemp packing is used to ensure that any small space between two metal threads (male and female threads) is sealed to prevent any leakage.

Fig 4

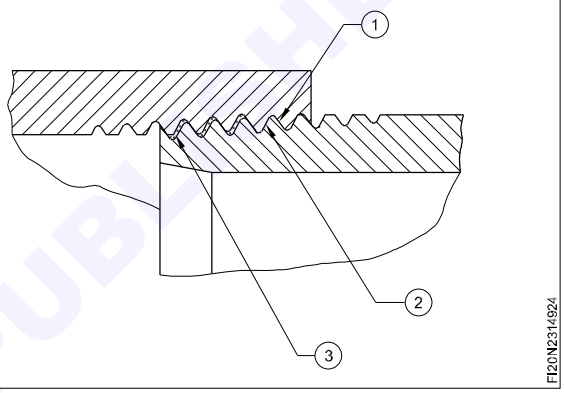


Table-1

Pipe Schedule and Standarad size

Nominal pipe size chart - Nominal pipe dimension in Millimeter (mm)

DN in	OD	5	5s	10	10s	20	30	40	40s	Std	60	80	80s	XS	100	120	140	160	XXS	DN in mm
6	10.3			1.24	1.24			1.73	1.73	1.73		2.41	2.41	2.41						
8	13.7			1.65	1.65			2.24	2.24	2.24		3.02	3.02	3.02						
10	17.1			1.65	1.65		1.85	2.31	2.31	2.31		3.20	3.20	3.20						
15	21.3	1.65	1.65	2.11	2.11		2.41	2.77	2.77	2.77		3.73	3.73	3.73				4.78	7.47	
20	26.7	1.65	1.65	2.11	2.11		2.41	2.87	2.87	2.87		3.91	3.91	3.91				5.56	7.82	
25	33.4	1.65	1.65	2.77	2.77		2.90	3.38	3.38	3.38		4.55	4.55	4.55				6.35	9.09	
32	42.2	1.65	1.65	2.77	2.77		2.97	3.56	3.56	3.56		4.85	4.85	4.85				6.35	9.70	
40	48.3	1.65	1.65	2.77	2.77		3.18	3.68	3.68	3.68		5.08	5.08	5.08				7.14	10.16	
50	60.3	1.65	1.65	2.77	2.77		3.18	3.91	3.91	3.91		5.54	5.54	5.54				8.74	11.07	
65	73	2.11	2.11	3.05	3.05		4.78	5.16	5.16	5.16		7.01	7.01	7.01				9.53	14.02	
80	88.9	2.11	2.11	3.05	3.05		4.78	5.49	5.49	5.49		7.62	7.62	7.62				11.13	15.24	
90	101.6	2.11	2.11	3.05	3.05		4.78	5.74	5.74	5.74		8.08	8.08	8.08					16.15	
100	114.3	2.11	2.11	3.05	3.05		4.78	6.02	6.02	6.02		8.56	8.56	8.56		11.13		13.49	17.12	
125	141.3	2.77	2.77	3.40	3.40			6.55	6.55	6.55		9.53	9.53	9.53		12.70		15.88	19.05	
150	168.3	2.77	2.77	3.40	3.40			7.11	7.11	7.11		10.97	10.97	10.97		14.27		18.26	21.95	
200	219.1	2.77	2.77	3.76	3.76	6.35	7.04	8.18	8.18	8.18	10.31	12.70	12.70	12.70	15.09	18.26	20.62	23.01	22.25	
250	273	3.40	3.40	4.19	4.19	6.35	7.80	9.27	9.27	9.27	12.70	15.09	12.70	12.70	18.26	21.44	25.40	28.58	25.40	
300	323.8	3.96	3.96	4.57	4.57	6.35	8.38	10.31	9.53	9.53	14.27	17.48	12.70	12.70	21.44	25.40	28.58	33.32	25.40	
350	355.6	3.96	3.96	6.35	4.78	7.92	9.53	11.13	9.53	9.53	15.09	19.05	12.70	12.70	23.83	27.79	31.75	35.71		
400	406.4	4.19	4.19	6.35	4.78	7.92	9.53	12.70	9.53	9.53	16.66	21.44	12.70	12.70	26.19	30.96	36.53	40.49		
450	457	4.19	4.19	6.35	4.78	7.92	11.13	14.27	9.53	9.53	19.05	23.83	12.70	12.70	29.36	34.93	39.67	45.24		
500	508	4.78	4.78	6.35	5.54	9.53	12.70	15.09	9.53	9.53	20.62	26.19	12.70	12.70	32.54	38.10	44.45	50.01		
550	559	4.78	4.78	6.35	5.54	9.53	12.70			9.53	22.23	28.58		12.70	34.93	41.28	47.63	53.98		
600	610	5.54	5.54	6.35	6.35	9.53	14.27	17.48	9.53	9.53	24.61	30.96	12.70	12.70	38.89	46.02	52.37	59.54		
650	660			7.92		12.70				9.53				12.70						
700	711			7.92		12.70	15.88			9.53				12.70						
750	762	6.35	6.35	7.92	7.92	12.70	15.88			9.53				12.70						
800	813			7.92		12.70	15.88	17.48		9.53				12.70						
850	864			7.92		12.70	15.88	17.48		9.53				12.70						
900	914			7.92		12.70	15.88	19.05		9.53				12.70						
950	965									9.53				12.70						
1000	1016									9.53				12.70						
1050	1067									9.53				12.70						
1100	1118									9.53				12.70						
1150	1168									9.53				12.70						
1200	1219									9.53				12.70						
DN in mm	OD	5	5s	10	10s	20	30	40	40s	Std	60	80	80s	XS	100	120	140	160	XXS	DN in mm

ASME B36. 10M-2015: Welded and Seamless Wrought Steel Pipe

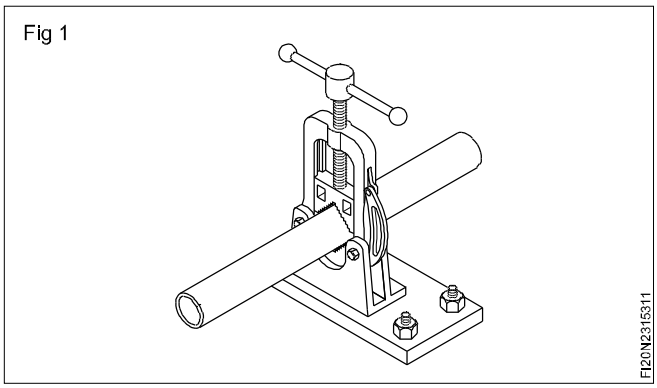
ASME B36. 19M-2004: Stainless Steel Pipe (For 5S, 10S, 40S and 80S)

Uses of pipe fitting tools

Objectives : At the end of this lesson you shall be able to
- **name the different types of pipe vices**
- **state the uses of pipe vices**
- **name the parts of a pipe cutter**
- **compare the constructional features of a pipe cutter and a multi-wheel chain pipe cutter**
- **state the care and maintenance aspects concerning pipe cutters.**

Pipe vice (Fig 1)

Fig 1

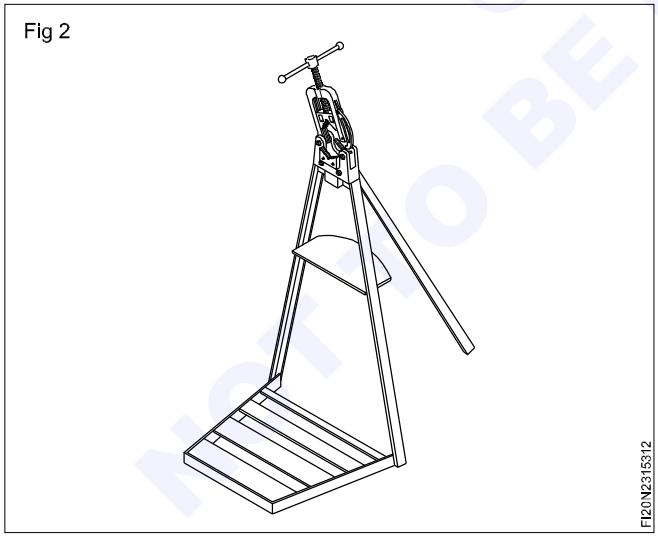


The pipe to be cut/bent/threaded must be held steadily and it must be prevented from rotating by holding it in a pipe vice.

It is a device used for holding and locating pipes. It can be used to hold pipes up to 63mm diameter.

Portable folding pipe vice (Fig 2)

Fig 2

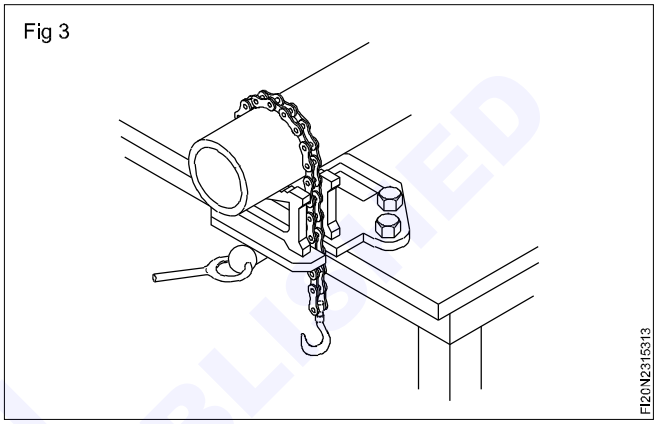


This vice can be folded and carried easily to any working place. This is similar to the quick-releasing type pipe vice.

Chain pipe vice (Fig 3)

This vice is used to hold larger diameter pipes up to 200mm diameter. The pipe is gripped by means of a chain and the serrations provided on the vice jaws.

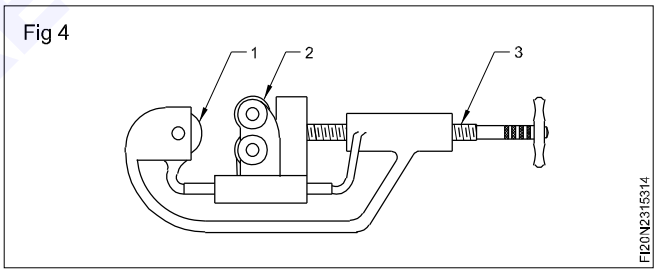
Fig 3



Pipe cutter

The wheel pipe cutter is used to make a square cut on the pipe. It consists of (1) a cutter wheel, (2) two guide rollers and (3) an adjusting screw. (Fig 4)

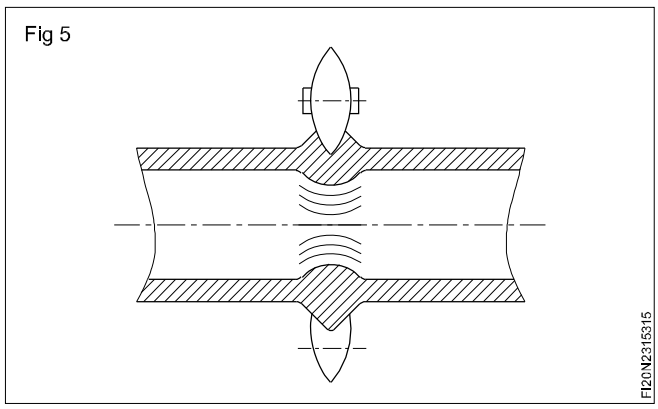
Fig 4



The cutter wheel tends to crush rather than cut the pipe. If it is blunt, it needs replacement.

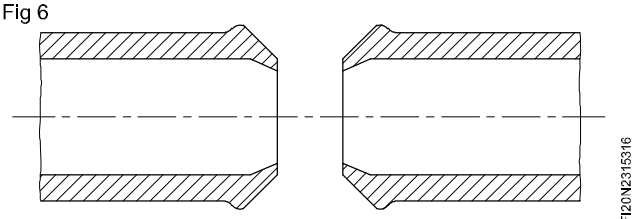
This type of pipe cutter does not remove any materials but the cutter squeezes the metal and forces it ahead of the cutter until the pipe is cut through the wall thickness. (Fig 5)

Fig 5



This type of cutting leaves a large ridge on the inside of the pipe which would obstruct the flow. (Fig 6) The pipe must be deburred or reamed by a pipe reamer.

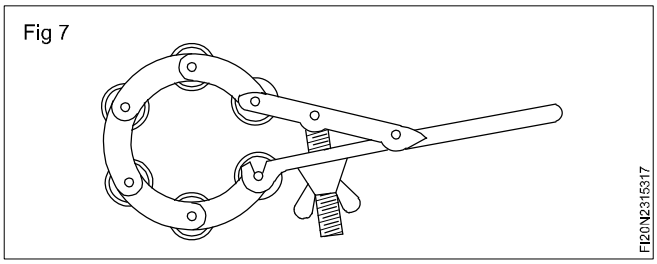
Fig 6



Multi-wheel chain pipe cutter

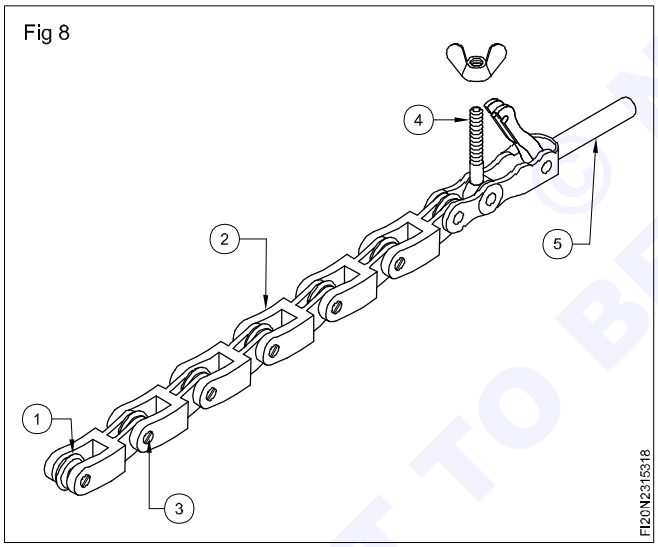
A multi-wheel chain pipe cutter can be adjusted to cut any diameter of pipe by adding on extra wheels and links. (Fig 7) The type and the size of the cutter is selected according to the diameter of pipe to be cut.

Fig 7



It consists of the following parts. (Fig 8)

Fig 8



1 Hardened cutting wheels

2 Links

3 Screw for joining links and wheels

4 Tension adjustment screw

5 Cutter handle

Care and maintenance of pipe cutters

Before using the cutter check the wheels, pins and links for any damage.

Replace the wheels, pins and links if damaged.

As the wheel revolves around the pin, any wear on the pin will cause the wheel to wobble and the cut will not run square to the pipe. This may result in a:

- chipped wheel (Fig 9)
- worn out pin. (Fig 10)

Fig 9

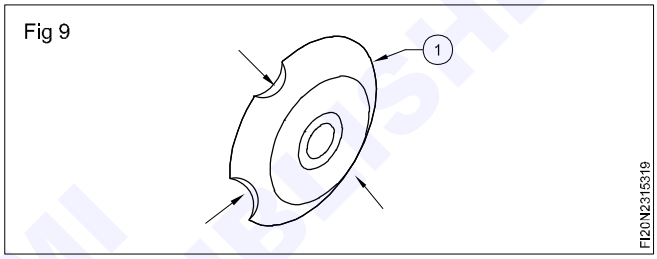
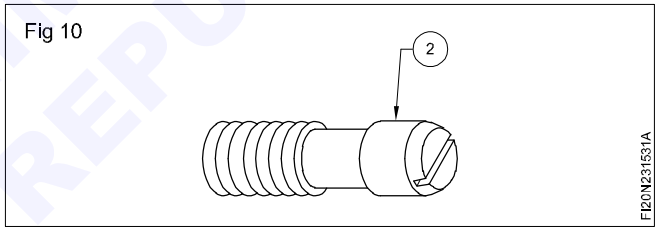


Fig 10



During pipe cutting, small flakes of metal break away and clog up the links and cutting wheels. Clean the links and wheels using a wire brush and soak the cutter in paraffin or kerosene to wash out the small particles of dirt and flakes.

After cleaning, apply a light oil on all moving parts, links and wheels for easy cutting operation and to prevent rust forming on the tool.

Store the cutter and protect the wheels from possible damage when not in use.

Plumbing tools - Pipe wrench and chain pipe wrench

Objectives : At the end of this lesson you shall be able to
- **name the elements of a pipe wrench and chain pipe wrench**
- **state the uses of pipe and chain pipe wrenches**
- **state the care and maintenance of pipe wrenches.**

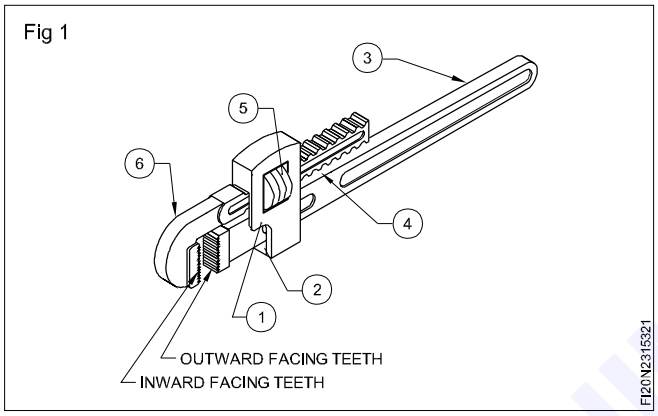
Pipe wrenches

These are adjustable pipe wrenches with different shapes. They are used for:

- holding and gripping pipes
- assembling and dismantling of pipes and fittings.

The Stillson pipe wrench (Fig 1) is designed as a heavy duty tool to withstand rough handling and heavy work. The jaws give an immediate and positive grip.

Fig 1



It may be used for all pipes with 15 mm to 50 mm diameters. Pipe wrenches are selected according to the pipe size.

Parts (Fig 1)

The Stillson pipe wrench consists of the following parts.

1 Pivot

2 Spring

3 Handle or lever

4 Spring

5 Adjusting nut

6 Moveable jaw

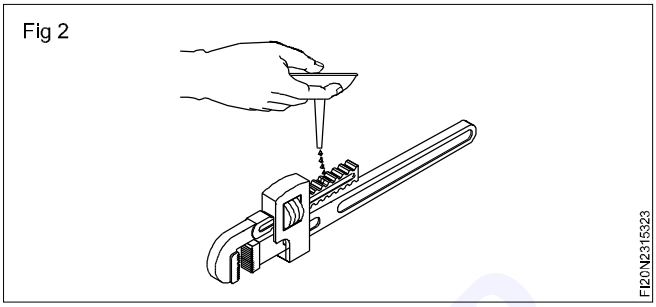
While using this pipe wrench, the jaws must be placed over the workpiece to their full depth and tightened by means of the adjusting nut.

Care and maintenance

The ability of the pipe wrench to grip the pipe is directly related to the condition of the teeth.

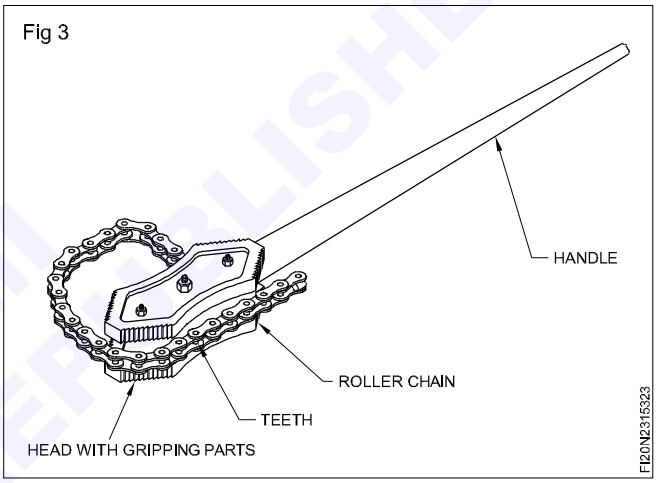
- Cleaning the teeth and sharpening them with a triangular file can restore some wrenches to useful condition.
- Oil should be applied to the adjustment nut periodically to prevent rusting. (Fig 2)

Fig 2



Chain pipe wrench (Fig 3)

Fig 3



Chain pipe wrenches are used for pipes with diameters of 50 mm to 150 mm. They may be used for gripping cylindrical or irregular objects.

Application of chain pipe wrench

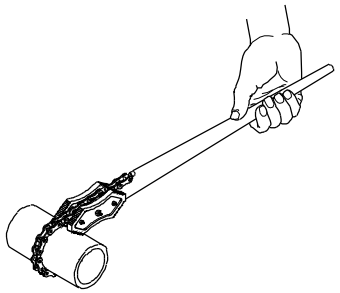
To use a chain pipe wrench, the head is placed on the pipe and the chain pulled round the circumference of the pipe. The chain is then engaged with the large teeth in the centre of the head.

The movement of the lever in the direction indicated by the arrow in the figure causes the serrated edges of the head to wedge firmly against the pipe giving a firm grip. (Fig 4)

The chain pipe wrench is a heavy gripping tool and should not be used for pipes with less than 50 mm diameter.

Apply oil or grease on the cutting edges when not in use.

Fig 4



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Pipe wrenches

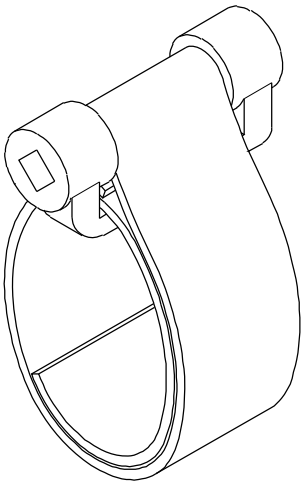
Objectives : At the end of this lesson you shall be able to

- **state the different types of pipe wrenches - strap wrench and foot print wrench**
- **state the uses of each type of wrench.**

Strap wrench (Fig 1)

Strap wrenches are used on finished tubular surfaces to avoid marking or damaging. These wrenches have metallic straps by which the surfaces can be tightly gripped.

Fig 1



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Footprint wrench (Fig 2)

These are used for gripping and turning pipes and round stocks in confined places.

The required size is adjusted by placing the pivot pin in the different holes of the solid handle.

The grip is obtained by squeezing both the solid handles together. (Fig 3)

The selection of hole should be such that the handles are not too far as this may result in uncomfortable holding of the handles.

Fig 2

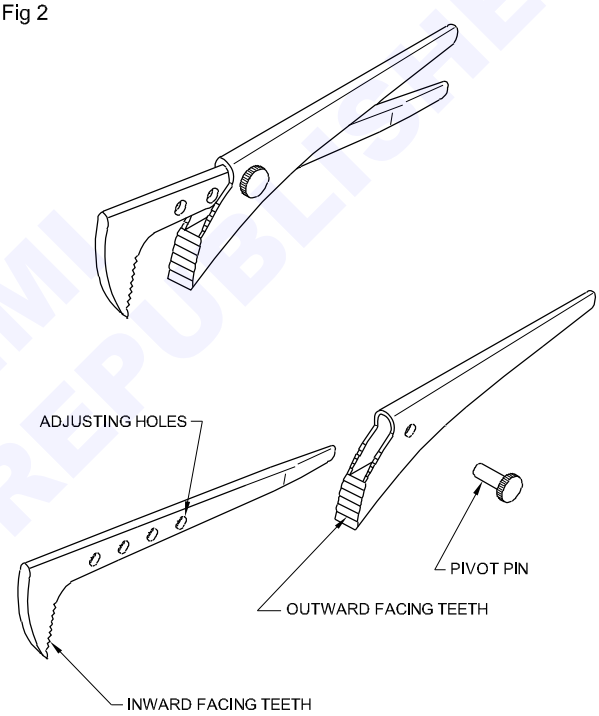

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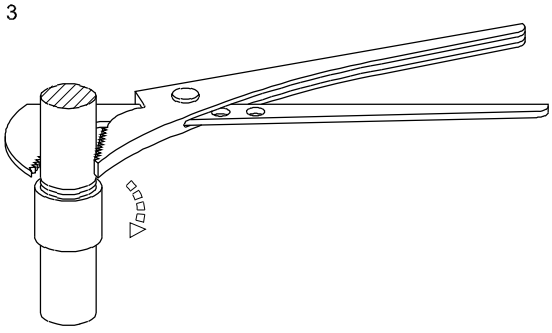
Fig 3



FI20N2315333

Pipe bending machines

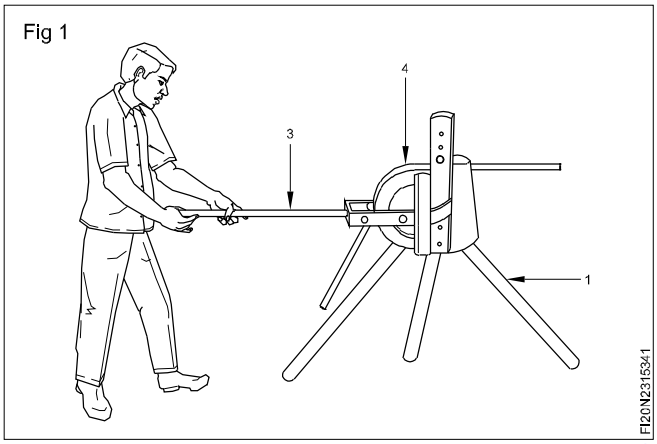
Objectives : At the end of this lesson you shall be able to
- **identify the three most common pipe benders**
- **differentiate their constructional features**
- **name the parts of bending machines**
- **state the uses of bending machines.**

There are some situations in plumbing jobs, where it is preferable to bend a pipe rather than use a pipe fitting.

The most common pipe benders are listed here.

Portable hand operated pipe bender (Fig 1)

Fig 1



The portable hand-operated pipe bender consists of the following parts

1 Tripod stand

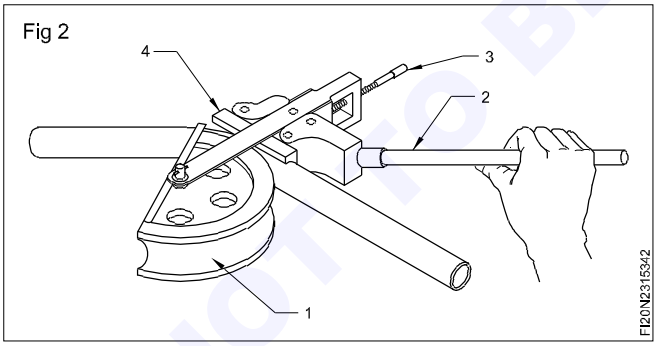
2 Pipe stop lever

3 Handle or lever

4 Inside former

Bench type hand operated pipe bender (Fig 2)

Fig 2



This consists of the following parts. It is used for bending galvanized iron and steel pipes.

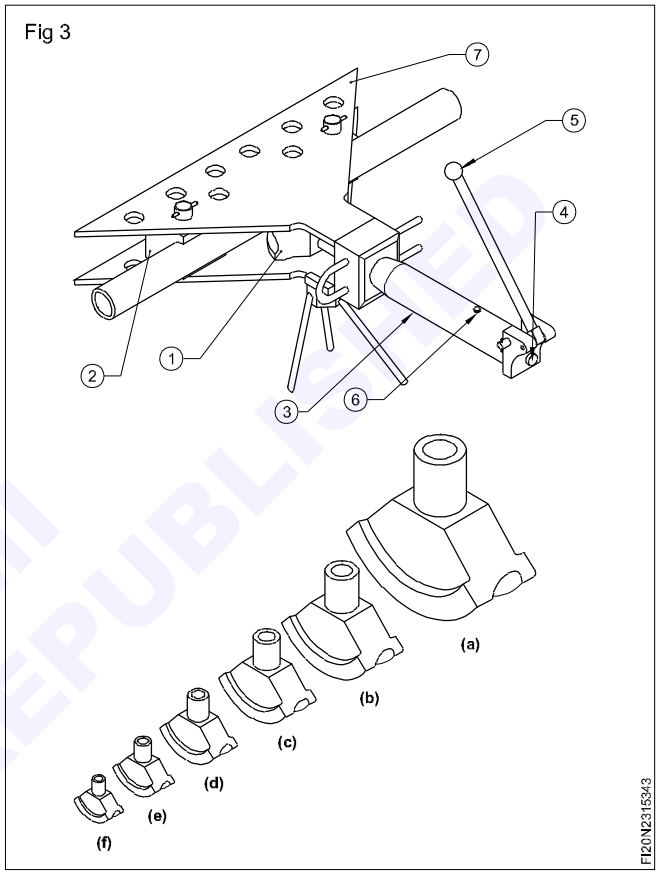
1 Inner former

2 Lever or handle

3 Adjusting screw with lock nut

4 Pipe guide

Fig 3



Hydraulic bending machine (Fig 3)

This machine can be used for bending G.I and M.S.pipes without sand filling to any direction.

It consists of the following the parts.

1 Inner former

2 Back former

3 Hydraulic ram

4 Pressure release valve

5 Operating lever

6 Bleed screw

7 Base plate

Inner formers are interchangeable and are able to bend pipes up to 75 mm diameters. (Figs 3a, b, c, d, e & f)

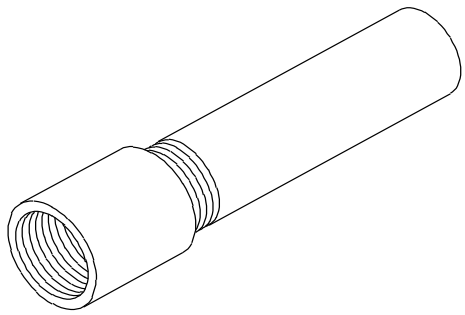
Pipes, dies, die stocks and taps

Objectives : At the end of this lesson you shall be able to
- **identify die sets, die stocks and pipe taps**
- **name the parts of a die stock**
- **state the method of checking pipe threads.**

Pipe dies

Most of the G.I. pipes that plumbers install are threaded at both ends. The pipes are available in lengths of 6 metres and it will be necessary to cut the pipe to the required length and thread it. (Fig 1)

Fig 1



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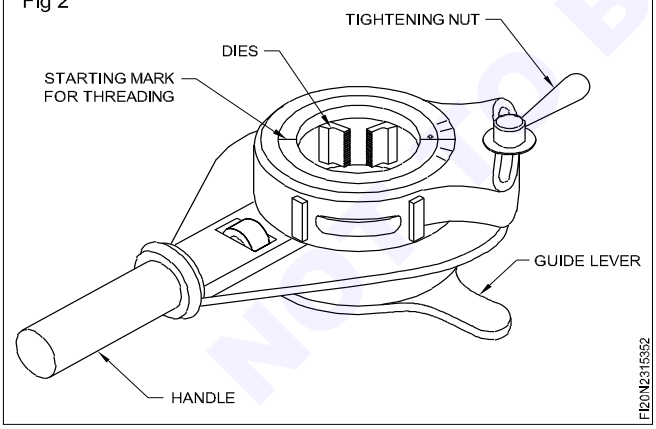
The threads on G.I. pipes and fittings for water supply systems are the standard pipe threads. External pipe threads are cut by pipe dies available in sizes from 1/4" to 4".

The dies must be sharp so that they will cut metal rather than push it around. Dies which push the metal around instead of cutting freely cause threads to break.

Die stocks

Die stocks are required to turn the dies. The ratchet type die stock is preferred because it permits the operator to use his body weight to rotate the die while standing to one side of the pipe. (Fig 2) Die stocks are adjustable.

Fig 2



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Die sets

Each die is clearly marked with its type of thread and range of pipe for which it is suitable. Each die has an identification number, that is 1 to 4. Die sets are available in various sizes.

These dies must always be used and stored as a set. (Fig 3)

Pipe threads are usually cut with threading dies and can be checked by using the pipe ring gauge.(Fig 4)

Fig 3

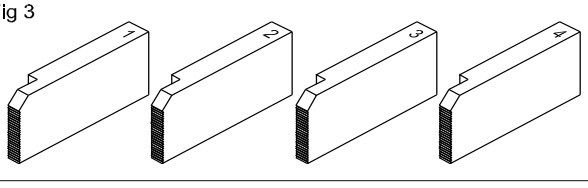

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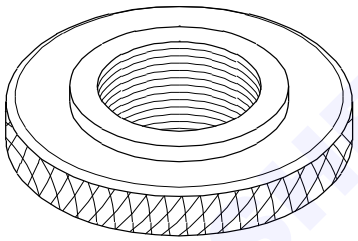
Fig 4



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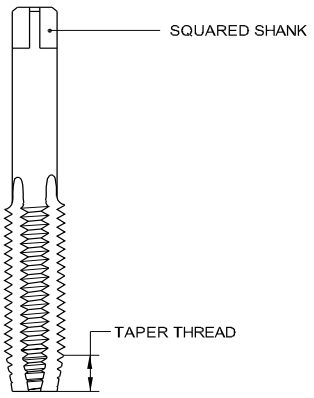
Pipe taps

Internal pipe threads are usually cut with standard taper pipe taps. (Fig 5)

In gauging internal pipe threads, the pipe plug thread gauge

Fig 5



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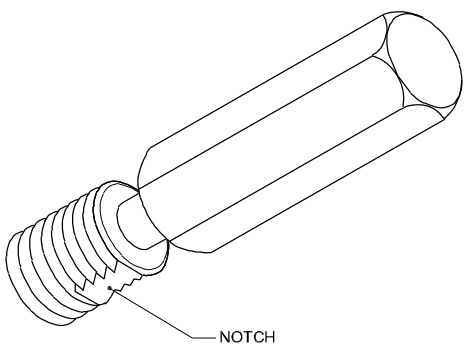
In gauging internal pipe threads, the pipe plug thread gauge should be screwed tight by hand into the pipe until the notch on the gauge is flush with the face. When the thread is chamferred the notch should be flushed with the bottom of the chamfer. (Fig 6)

Fig 6



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Standard pipe fitting method

Objectives : At the end of this lesson you shall be able to
- **identify the standard pipe fitting**
- **dismantling the pipe fitting**
- **assemble the pipe fitting**
- **explain the rain water harvesting.**

Standard pipe fitting: 'Pipe fittings' are those fittings that may be attached to pipes in order to:

– change the direction of the pipe

– connect a branch with a main water supply pipe

– connect two or more pipes of different sizes

– close the pipe ends

Long radius elbows have a radius equal to $1^1/_2$ times the bore of the pipe.

Short radius elbows have a radius equal to the bore of the pipe.

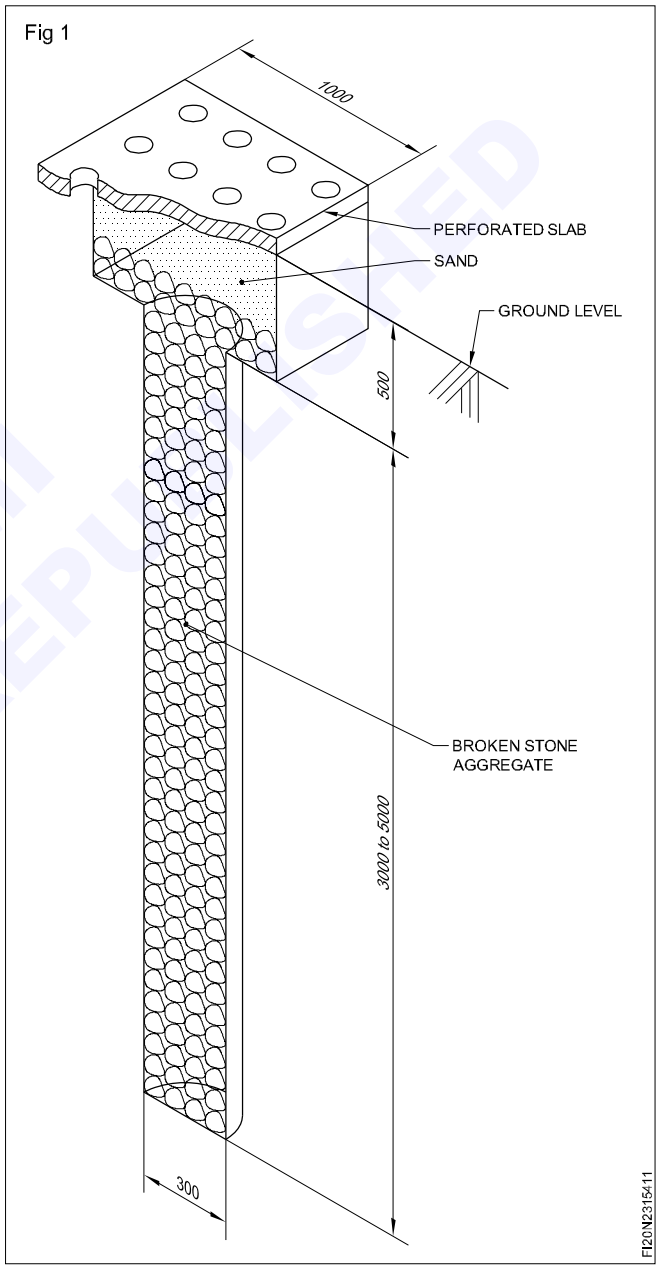
The 45^0 elbows allow pipe deviation of 45^0.

Tee branch: A tee branch helps the pipe line to branch off at 90° . The branches may be equal in diameter or there may be one reducing branch.

Dismantling: The term dismantling implies carefully separating the parts without damage and removing. This may consists of dismantling one or more parts as specified or according to the usage.

Rain water harvesting: Collection of rain water when it rains for use during non monsoon months is called rain water harvesting. When rainfall occurs in heavy during a short spell if it is not collected, it floods the area or run off to sea. It is quite possible to put all the water into soil below with little effort and less expenditure so that rain water is not lost but goes to recharge ground water table. (Fig 1)

Fig 1



Benefits of harvesting

- Ground water table raises.
- Reduce the sainity.
- Avoid flooding.

Method of rainwater harvesting

- Percolators/ soakpit
- Percolation trenches
- Service well cum reckage well method

Maximum plot area to be kept as unpaved so that the rain water can percolate to ground.

The rain water from season 1st rain should normally not to be used for percolation to recharge structures. For such water, suitable arrangement for bypass in pipe system should be introduced.

A suitable provision should be made if possible to allow rain water to percolate to ground water after passing it through settlement tank because such rain water contain silt which is deposited on sand bed reduces the percolation rate.

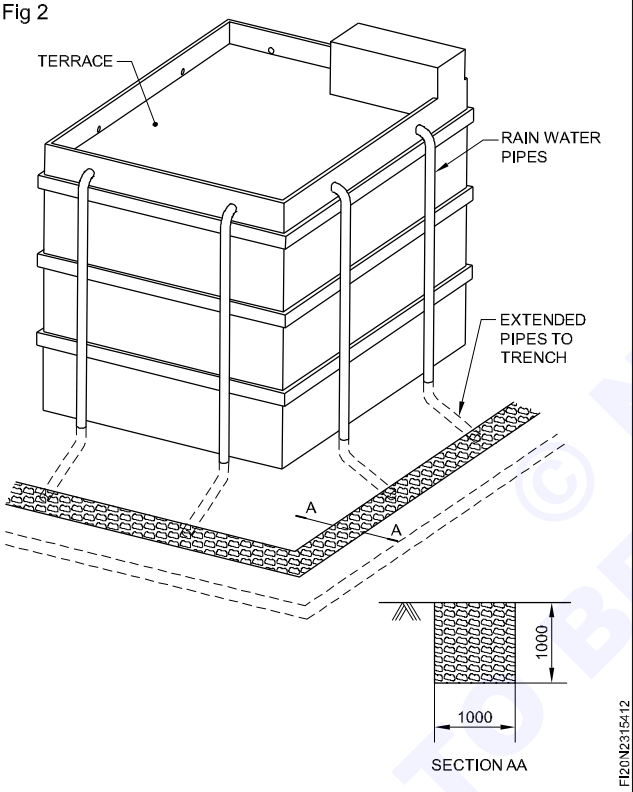
The recharge structure should be made on a plot at the places of lower levels/ elevations so that rain water may flow towards it under normal gravitation flow.

On a vast and sloppy land patch, the contour bunds preferably of mud with height varying from 15cm to 30cm should be made to store run off temporarily over the katcha land area, thus allowing more time for percolation of water to the ground water and arresting the flow of run off to the drains/ sewers.

For recharge of run off from roads suitable arrangements in the foot path by introducing some katcha area should be made.

In large residential and office complexes the drive ways, pucca path and areas should had some katcha area which may facilitate rain water to percolate to ground water. (Fig 2)

Fig 2



Ideal conditions for rain water harvesting and artificial recharge to ground water. Artificial recharge techniques are adopted where:

- Adequate space for surface storage is not available specially in urban areas.
- Water level is deep enough (more than 8m) and adequate sub- surface storage is available.
- Permeable strata is available at shallow/ moderate depth upto 10 to 15mtr.
- Where adequate quality of surface water is available for recharge to ground water.
- Ground water quality is bad and our aim is to improve it.
- Where there is possibility of intrusion of saline water especially in coastal area.
- Where the evaporation rate is very high from surface water bodies.

The decision whether to store or recharge rain water depends on the rain fall pattern of a particular region.

- If the rainfall period between two spells of the rain is short i.e. two to four months, in such situation a small domestic size water tank for storing rain water for drinking and cooking purpose can be used.
- In other regions where total annual rainfall occurs only during 3 to 4 months of monsoon and the period between two such spells is very large i.e. 7 to 8 months, so it is feasible to use rain water than for storage which means that huge volumes of storage container are required.

Repair and maintenance of household water taps

Objectives : At the end of this lesson you shall be able to
- **name the parts of a water tap**
- **state the functions of each part**
- **state the constructional features of a water tap**
- **state the common defects in water taps, their causes and remedies.**

Repair and maintenance of household water taps

There are many old and new designs of taps in the market. It is advisable to read the manufacturer's instructions when repairing and replacing washers or packing materials.

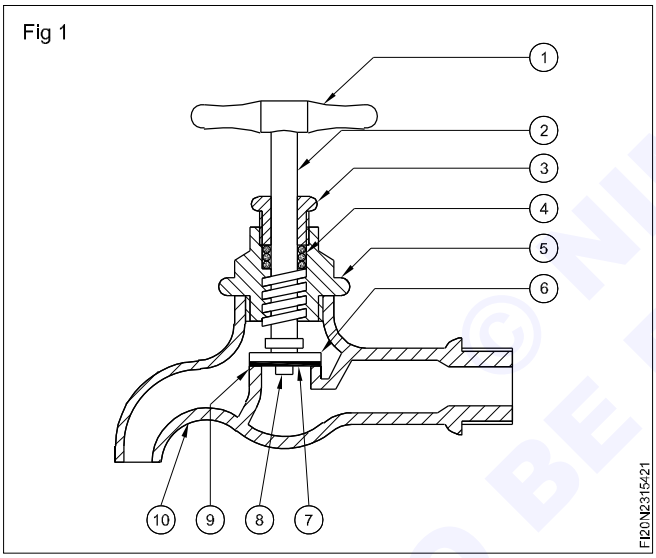
All types of screw-down water taps have two parts which must be maintained.

The packing of the stuffing box for the spindle or shaft.

The washer (rubber,leather or fibre) on the metal disk-holder or valve disk.

Fig 1 shows the inside parts of a screw-down type water tap.

Fig 1



1 Handle

2 Spindle/ shaft

3 Gland nut

4 Stuffing box/ packing

5 Bonnet

6 Metal disk-holder/ valve disk

7 Washer (rubber/ leather/ fibre)

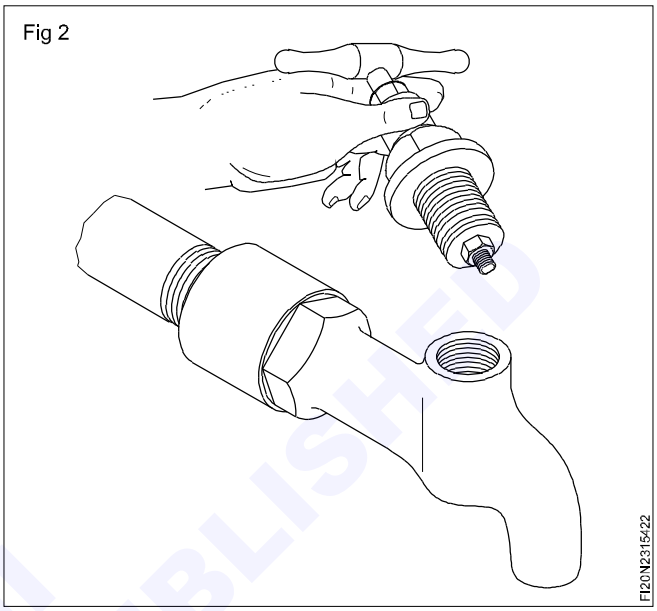
8 Retainer nut/ washer nut

9 Valve seat

10 Body of the tap.

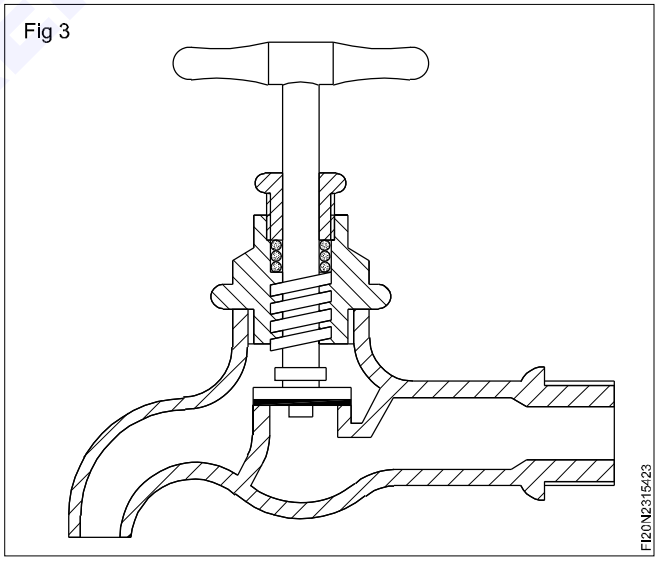
The body of the water tap contains the seat. The bonnet which holds the working parts is screwed on to the body. (Fig 2)

Fig 2



When the water tap is screwed down, the washer is squeezed between the two metal faces and this makes the joint watertight. (Fig 3)

Fig 3



The spindle has a handle at the upper end and a threaded screw at the other end.

Resting in the bottom of the spindle is the metal disk-holder containing the rubber washer which is held in position by a nut underneath.

The stuffing box at the top of the water tap has a soft graphite grease hemp packing. As the stuffing box screw is tightened, this packing is compressed, thus making a watertight joint.

Defects in the working of screw-down water taps

Defects	Causes	Remedy
Water flowing or dripping from the tap even when firmly closed.	Worn out or defective washer. Piece of grit, rust or other foreign matter on the washer. Defective seating.	Replace washer. Remove foreign matter. Reseat tap.
Water flowing from around the spindle or stuffing box screws. screw.	Defective packing in stuffing box. Screw of stuffing box not screwed down tightly.	Replace packing with greased hemp. Tighten stuffing box
Spindle continuously slipping when	Spindle thread worn out.	Replace tap.
turned and tap will not shut off. Tap hard to turn on and off.	Stuffing box packing dry. Spindle bent.	Renew packing with greased hemp of some oil into the stuffing box. Renew tap.
Loud noise in the tap when turned on.	Valve loose on the spindle. Washer loose on valve.	Renew tap. Renew the valve of the washer.

Visual Inspection

Objectives : At the end of this lesson you shall be able to
- **explain visual inspection and its need**
- **state advantages and disadvantages of visual inspection.**

Testing

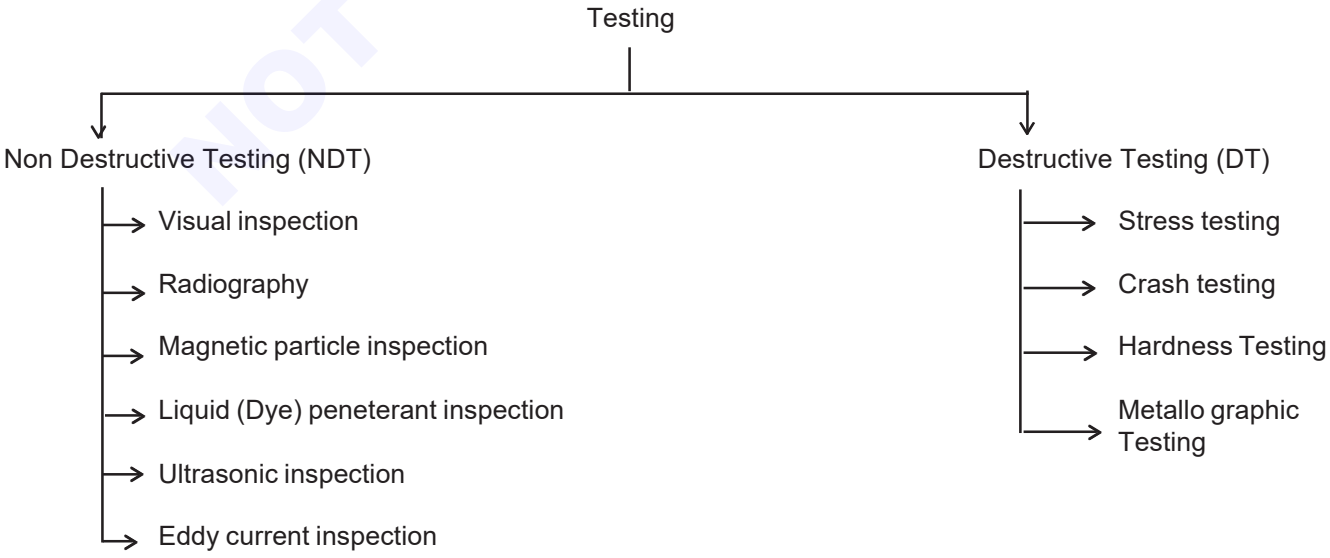
The method by which the presence, quality, genuiness of anything is determined is called testing.

Testing is trial of the quality of something

in our industry or project management testing is done for mechanical properties such as

1 Strengh
2 Ductility
3 Hardness
4 Elasticity
5 Toughness
6 Shape
7 Surface finish
8 Colour etc.

Testing is two types



Visual inspection

Visual inspection is a non destructive testing method used to evaluate the item, by just observation. Visual inspection is used to inspection is used to inspect the

- Surface condition of the item
- Alignment of mating surfaces
- Dimensions and settings as per design

Visual inspection is usually the first method employed for locating defects

Visual inspection is the outlet & most common NDT method

Mechanical and optional aids may be necessary to perform visual inspection such as

Optical AIDS	Mechanical AIDS
Magnifying glass	Vernier calliper
Microscopes	Micrometer
Fibro scopes	Depth gauges
Video cameras	Feeler gauges

Types of visual inspections

a Direct visual testing

b Remote visual testing

c Translucent visual testing

Direct visual testing

It may usually made when access is sufficient to place the eye within 600mm on the surface to be examined and angle between plane of vision & surface shall not be less than 30°.

Translucent visual inspection

It is a supplement of direct visual inspection. The method uses the help of artificial lighting which is contained in illuminator that produces directional lighting. The lighting must be so that there are no surface glares or reflections from surface under examination.

Advantages of visual inspection

1 Does not require any special equipments other than good eyesight.

2 It is very inexpensive from other methods of non destructive testing

3 It provides immediate results.

4 It requires minimum training to the inspector

5 Visual inspection is highly portable as less accessories to inspect are needed.

Disadvantages of visual inspection

1 The accuracy of the visual inspection depends largely on the experience and knowledge of the inspector

2 Only large defects, discontinuities can be detected.

3 Possibility of misinterpretation of scratches as cracks.

4 It may be limited to detection of surface dimensional defects only.

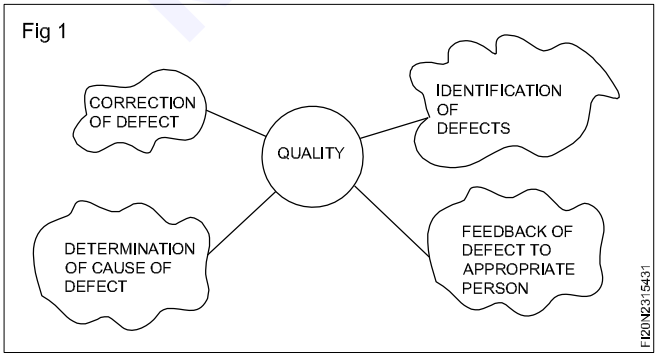
Quality control & inspection

Objectives : At the end of this lesson you shall be able to
- **define inspection, its types**
- **define qualiy and its characteristics**
- **explain quality control and its need**
- **define SPC (statistical process control).**

Inspection and quality control (Fig 1)

An inspection is most generally an organised examination or formal evaluation exercise. which may include measurement, testing, gauging, comparision of materials or items.

Fig 1



An inspection determines if the material or item is in proper quantity and quality

Inspection can be done

1 Individually

2 Lot by lot

Inspection is generally divided into three categories

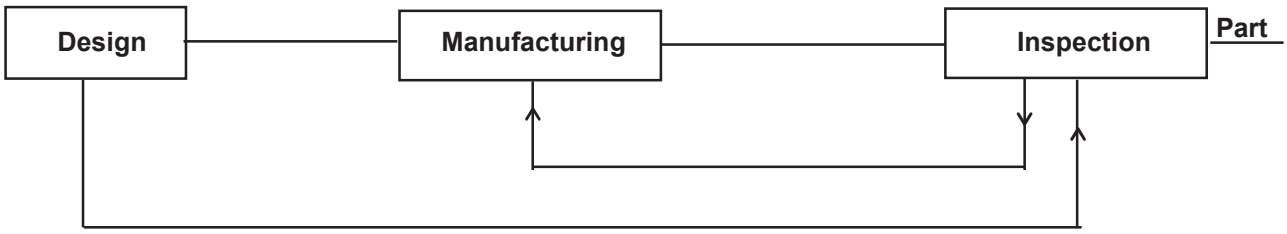
1 Recieving inspection

2 Inprocess inspection

3 Final inspection/ product quality control

Inspection:

Inspection can be termed as the watch dog of manufacturing process



Inspection process is mostly manual

The role of inspection is to verify and validate the VARIANCE DATA and it does not involve separating the good from bad.

PDCA cycle model

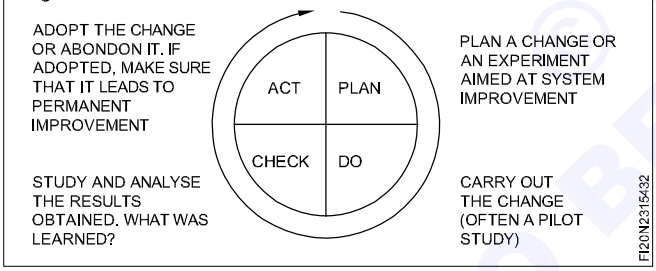
PDCA cycle model is also known as DEMING CYCLE/ STEWHART CYCLE, CONTROL CYCLE.

This model is implement to improve the quality and effectiveness of process with in product life cycle management and project management. (Fig 2)

It contains of 4 steps

- Plan
- DO
- Check
- Act

Fig 2



Objective of inspection

Acess conformity with design specifications

Improve product quantity and reliability

Elements of inspection process

- Interpretation of quality requirements
- Sampling of the material to be inspected.
- Examination of the material from the sample to be inspected.
- Decision and action against the inspection of sample weather to pass or reject.

Quality

- Quality is in conformance to the requirements or specifications
- Quality is fitness for use

The quality of product or service is the fitness of that product or service for meeting or exceeding its intended use as required by the customer.

- Quality of a product or a service defined by one or more elements. These elements are known as quality characteristics
- Quality characteristics can be classified into these categories

1 Structural charcteristics (Length of part, weight of can, strength of beam, viscosity of fluid, etc)

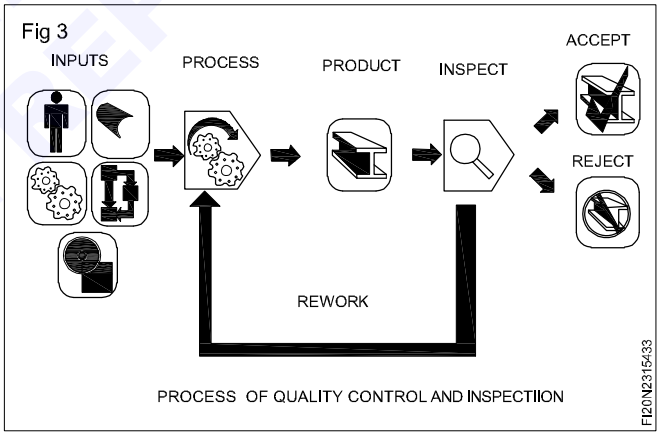
2 Sensory characteristics (taste of good food, beauty of model, smell of fragnance, etc.)

3 Time oriented charcteristics(warrenty, reliability, maintainablity etc.)

4 Ethical charcteristics (Honesty, courtsey, friendliness, etc).

Quality control (Fig 3)

Fig 3



PROCESS OF QUALITY CONTROL AND INSPECTIION

Quality control is a short process by which entities review the quality of all factors involved in production

ISO 9000 design quality control (QC) as:

" A part of quality management focussed on fulfilling quality requirements"

This approach emphasisies on three aspects.

1 Elements such as controls, job management, degined well managed process, performance and integrety. Criteria, identification of records.

2 Competence such as knowledge, skills, experience & qualifications

3 Soft elements such as personnel, integrity, confidence organizational culture, motivation, team spirit & quality relationship.

Inspection is a major component of quality control, where physical product is examined visually (or the end results of service are analyzed). Product inspectors will be provided with list of descriptions of un acceptable product defects such as cracks or surface blemishes.

Need of quality control

Every operation is connected with the quality of the product it is important that quality requirements be statisfied and production schedules are met. The satisfaction of end user mainly depended on quality

Quality control is needed for

1 Encourage quality conciousness

2 Satisfaction of consumers

3 Reduction in production cost

4 Effective utilisation of resources

5 Increased good will among the consumers

6 Reducing inspection cost

7 Increase in sales

8 Best quality in available resources

SPC (Statistical process control)

If a product is to meet or exceed customer expectations, generally it should be produced by a process that is stable or repeatable. More precisely, the process must be capable of operating with little variability around the target or nominal dimensions of the product's quality characteristics. Statistical process control (SPC) is a powerful collection of problem-solving tools useful in a achieving process stability and improving capability through the reduction of variability.

SPC is one of the greatest technological developments of the twentieth century because it is based on sound underlying principles, is easy to use, has significant impact and can be applied to any process. Its seven major tools are

1 Histogram or stem-and-leaf plot

2 Check sheet

3 Pareto chart

4 Cause-and-effect diagram

5 Defect concentration diagram

6 Scatler diagram

7 Control chart

Although these tools, often called "the magnificent seven," are an important part of SPC they comprise only its technical aspects. The proper deployment of SPC helps create an environment in which all individuals in an organization seek continuous improvement in quality and productivity. This environment is best developed when management becomes involved in the process. Once this environment is established. Routine application of the magnificent seven becomes part of the usual manner of doing business, and the organization is well on its way to achieving its quality improvement objectives.

Of the seven tools, the shewhart control chart is probably the most techincally sophisticated. It was developed in the 1920s by Walter A. Shewhart of the Bell Telephone Laboratories. To understand the statistical concepts that from the basis of SPC we must first describe Shewhart's theory of variability.

Drilling jig types and uses

Objectives: At the end of this lesson you shall be to

- **what is jig**
- **list the different types of drill jig and their uses**

Introduction to jigs

A jig is a device in which a work piece/component is held and located for a specific operation in such a way that it will guide one or more cutting tools to the same zone of machining.

Types of drill jigs

Drill jigs may be divided into two types

- Open
- Closed

Open jigs are used when the operation is to be done only on one side of the piece. Closed jigs (Box jig) are used when the operations are to be done on more than one side of the piece. Jigs are identified according to the way they are built. Most commonly used jigs are:

- Template jig
- Plate jig
- Table jig
- Sandwich jig
- Angle plate jig
- Modified angle plate jig
- Box jig
- Channel jig
- Leaf jig
- Indexing jig
- Solid jig
- Post jig
- Trunnion jig

Types of drill jigs

Template jigs

This type of jigs fits over on or into the work and is not usually clamped. They are simple and cheap. They may or may not have guide bushes. When bushes are not used the whole jig plate may be (Fig 1)

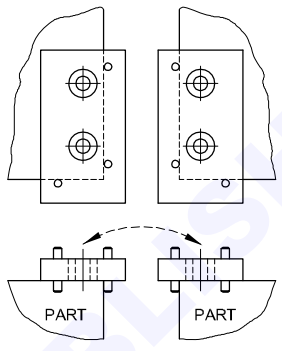
The design of a particular type of jig will be based on:

- the position wherein the drilling or its allied operation/ operations are to be performed
- the shape of the piece part.

Plate jig

This jig consists of a drill plate which rests on the component to be drilled. For correct positioning/locating, pins and clips are provided. For heavier piece parts, sometimes clamps are not used. Generally a base plate will not be available for this type of jigs. (Figs 1, 2 and 3)

Fig 1



TEMPLATE JIG

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Fig 2

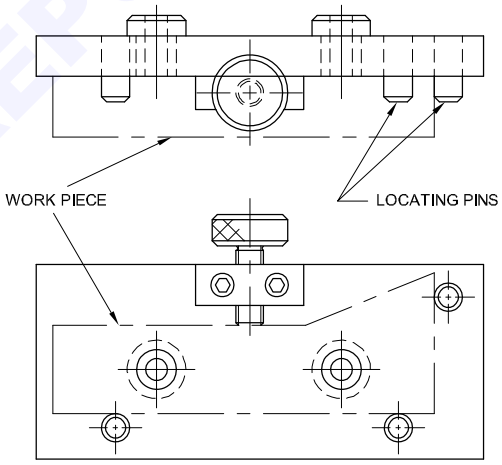

PLATE JIG

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Fig 3

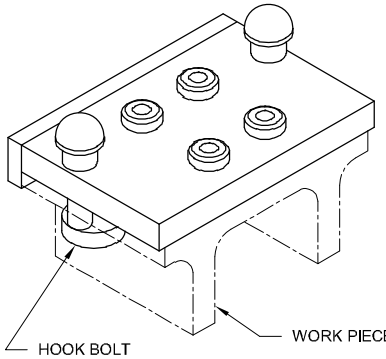

PLATE JIG

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Table jig (Turnover jig)

This is used when it is necessary to locate the piece part from its face. For accurate seating of the jig on the machine table, four legs will be provided on this type of jig. (Fig 4)

Fig 4

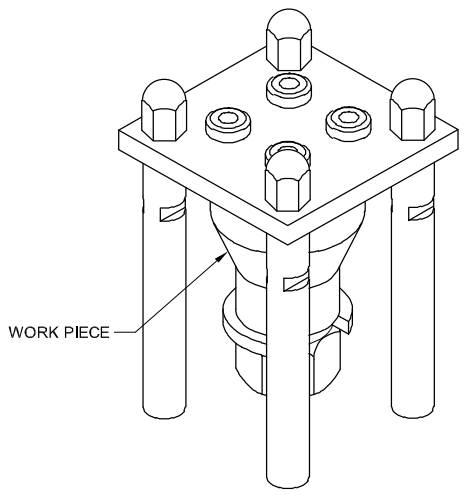

TABLE OR TURNOVER JIG

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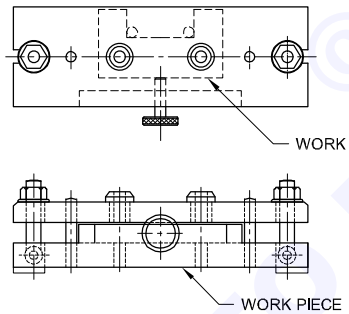
Sandwich jig

This is ideal for thin or soft workpieces which may bend or warp due to force while machining. In this type of jigs, the component will be sandwiched between the base plate and the drill plate. (Fig 5)

Fig 5



SANDWICH JIG

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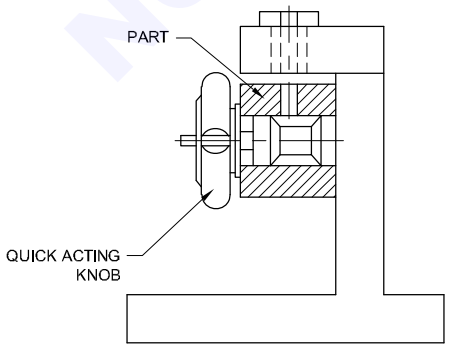
Angle plate jig

These jigs are used to hold work which are to be drilled at right angles to their mounting locators. (Fig 6)

Fig 6



ANGLE - PLATE JIG

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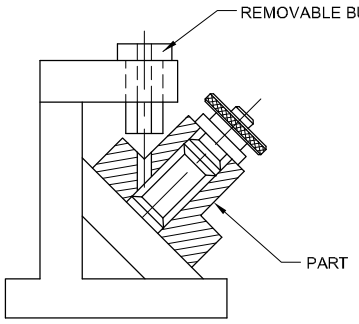
Modified angle plate jig

These jigs are used for drilling at angles other than 90°. (Fig 7)

Fig 7



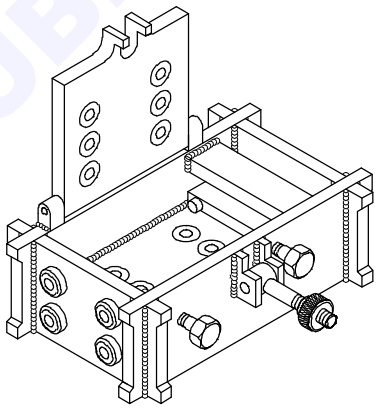
MODIFIED ANGLE - PLATE JIG

FI20N2415717

Box jig

This is made in the form of a box or a frame work. The component is located and clamped at one position but drilling can be done from different directions as required. When a box jig contains bushings on two or more sides for drilling from different directions, it is called a tumble jig. (Fig 8) This jig is meant for small components only.

Fig 8



BOX JIG

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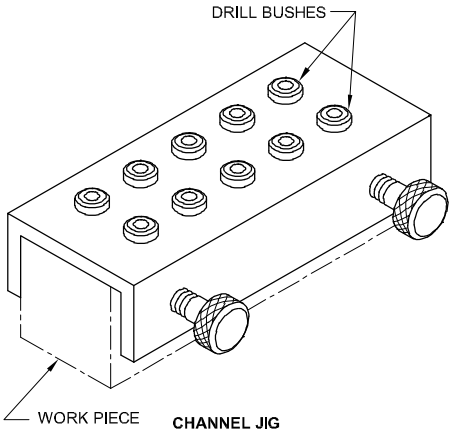
Channel jig

They are the simplest form of box jigs.

The workpiece is held between two sides and machined from the third. (Fig 9)

Fig 9



CHANNEL JIG

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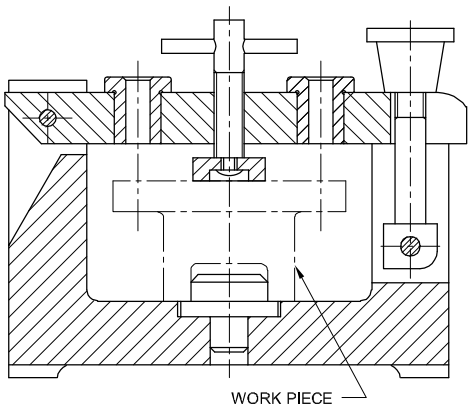
Latch or leaf jig

This type of jig will have a hinged cover with the latch clamps for easy loading and unloading of components. The cover with latch must be positively located and clamped so that the bushes are accurately located with respect to the component. (Fig 10)

Fig 10

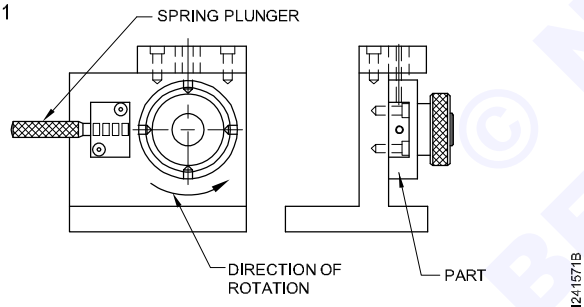


LATCH JIG

Indexing jig

Indexing jigs are used to accurately space holes on other machined area around a part. The jig uses the part being machined as a reference plate. A spring loaded plunger indexes the part. (Fig 11)

Fig 11

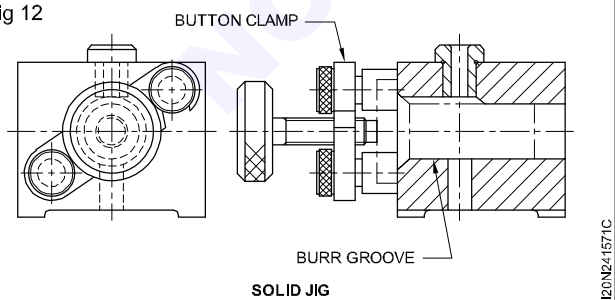


INDEXING JIG

Solid jig

This can be used while drilling small piece parts. The body of this type of jig is machined from a solid block of steel. (Fig 12)

Fig 12

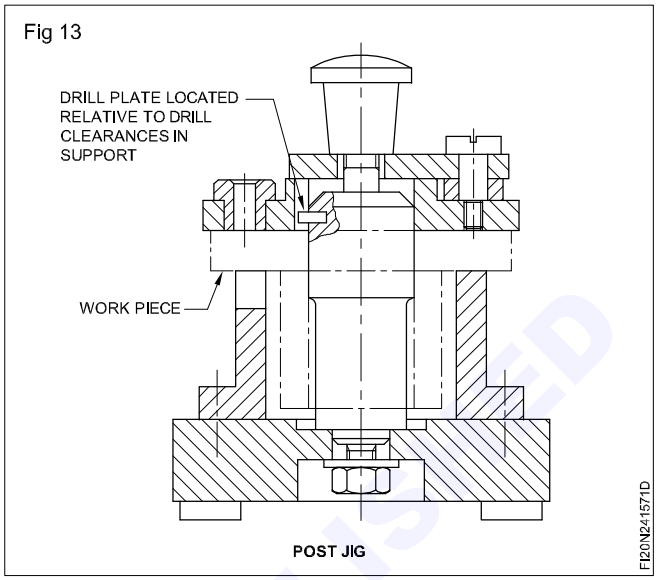


SOLID JIG

Post jig

This is used for location from a bore. The post should be as short as possible to facilitate loading and at the same time it must be long enough to support the workpiece. (Fig 13)

Fig 13

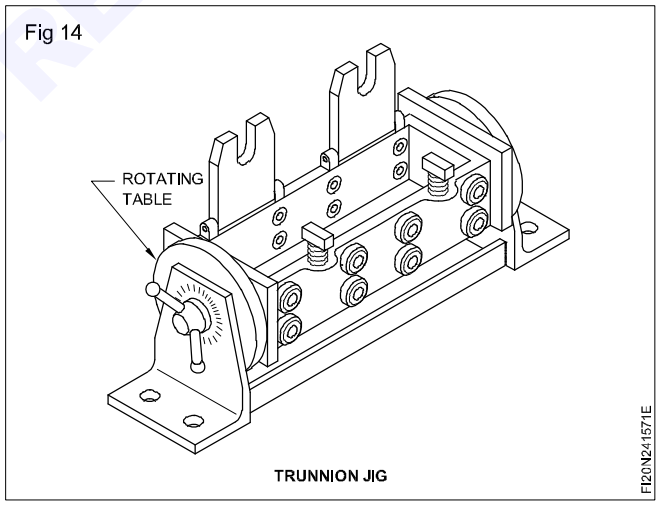


POST JIG

Trunnion jig

This can be used when large or awkwardly shaped workpieces are to be drilled from different directions. This is a further modification of the box jig which is carried on trunnions and rotated from station to station and positioned, using an indexing device. (Fig 14)

Fig 14



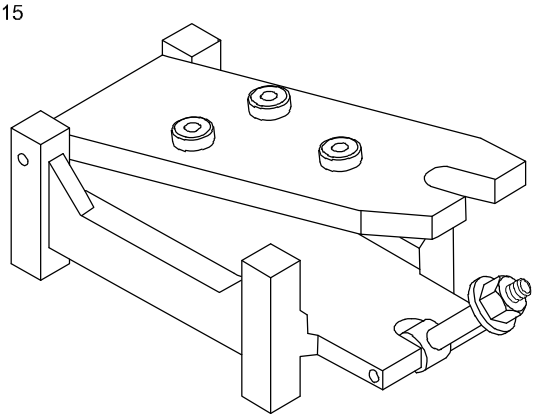
TRUNNION JIG

A jig is a special device which holds, supports, locates and also guides the cutting tool during operation. Jigs are designed to accommodate on or more components at a time.

Jigs are available for drilling or boring.

Drilling jigs are used to drill , ream, tap and to perform other allied operations. (Figs 15 & 16)

Fig 15



DRILL JIG

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Boring jigs are used to bore holes which are either too large to drill or of odd size. (Fig 17)

Fig 17

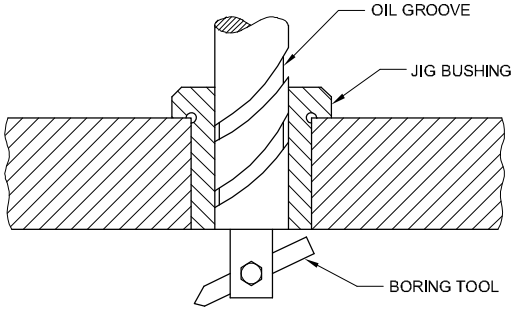

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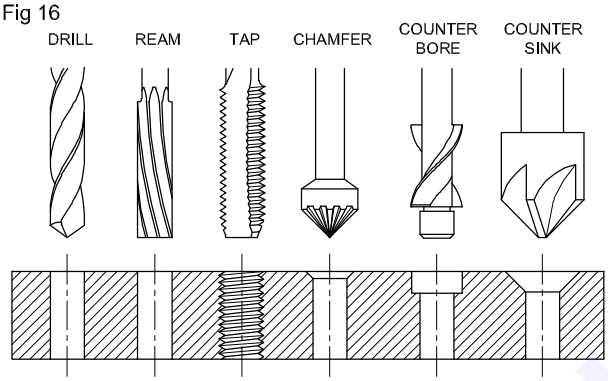
Fig 16



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Constructional features of drill jig

Objectives: At the end of this lesson you shall be to

- **list the different parts of a drill jig and also their uses**
- **state the different types of drill bushes and their uses**
- **state the different types of locators and clamps used in jigs.**

The basic features of a drill jig are (Fig 1)

- base plate or jig body
- drill plate or jig plate
- drill bushes locating pins
- clamps.

Base plate

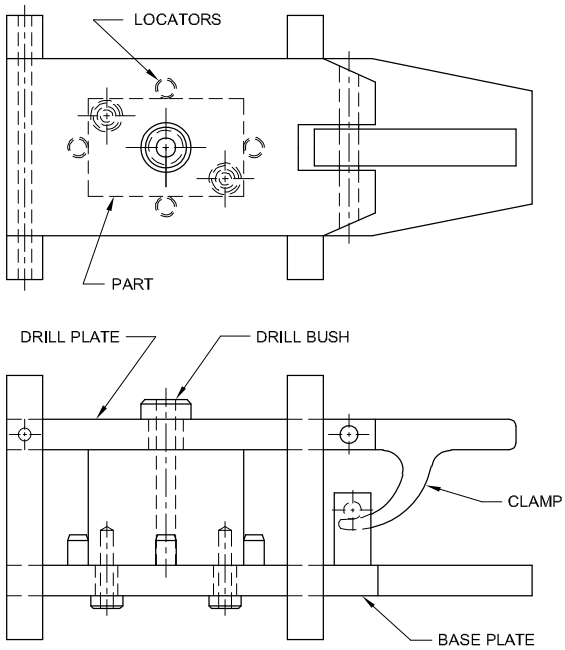
This provides a rigid support for mounting piece parts, locating pins etc.

In some drill jigs like plate and clamp jigs there will be no base plate.

Drill plate

It holds the drill bushes. Cutting tools are guided by means of the drill bushes. Unbushed holes made on the drill plate are sometimes used for small runs.

Fig 1



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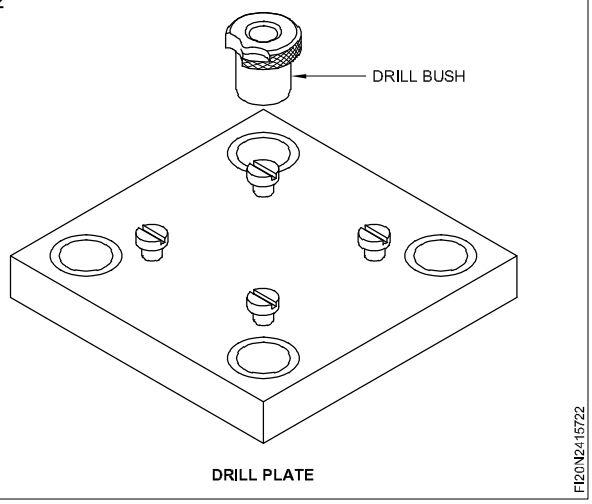
Drill bushes

They are used to locate and guide drills, reamers, taps and any other revolving tools commonly used to make or modify holes. (Fig 2)

Fig 2



These are hardened and ground to exact sizes to ensure the needed repeatability in the jig. Standard size bushes are also available.

Types of drill bushes

- Press fit bushes
- Renewable bushes
- Liner bushes

Press fit bushes are made in two forms.

- Head
- Headless

These bushes are used where frequent change of bushes is not anticipated. (Figs 3 and 4)

Fig 3

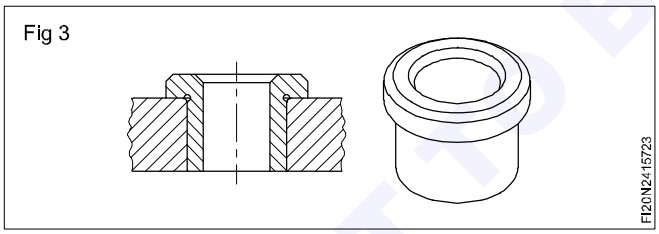
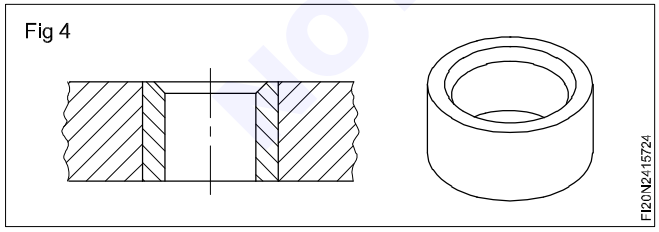


Fig 4

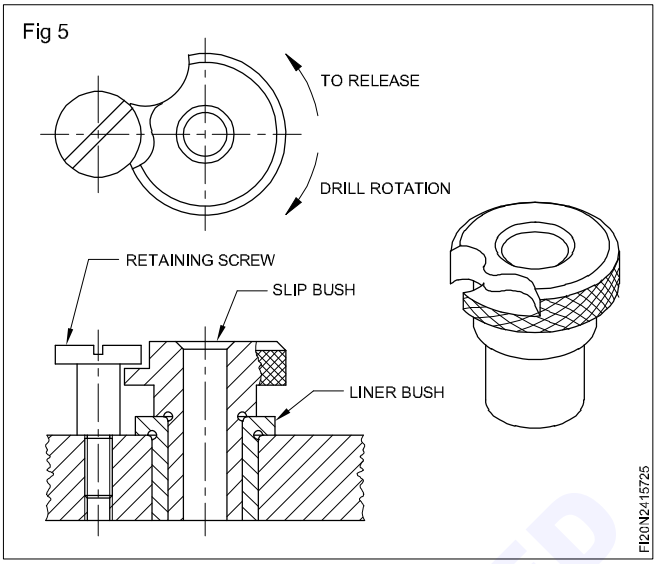


Renewable bushes are divided into two groups.

Slip renewable bushes (slip bushes)

These bushes are used when more than one operation is performed in the same location. (Eg:drilling and reaming) These bushes are used with press-fitted liner bushes and a lock clamp. (Fig 5)

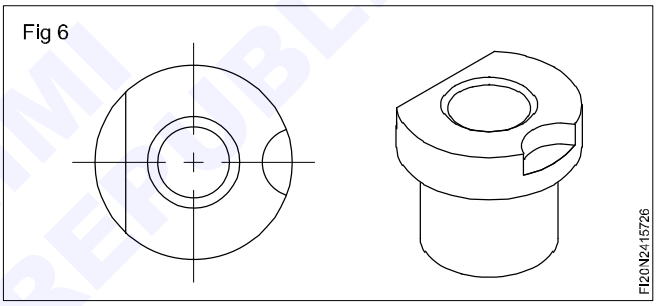
Fig 5



Fixed renewable bushes

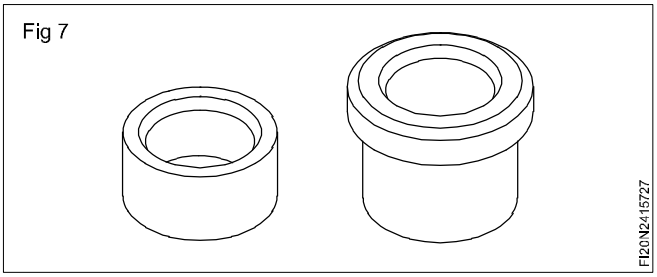
These bushes are used where only one operation is to be performed with each bush, whereas several bushes may be used during the life of the jig. These are also held in a liner and retained by a screw. (Fig 6)

Fig 6



Liner bushes are used to provide a hardened hole where renewable bushes are located. Liner bushes are press-fitted to the jig plate.(Fig 7)

Fig 7



Locating pins or locaters are used

- to restrict the movement of the component
- to position the piece part with respect to the tool
- to facilitate easy loading and unloading of component piece parts
- to assist the operator for correct loading (fool proofing).

Different types of locating pins are used according to the shape of the component and also according to the hole locators. A few types of locating pins are shown in Figs 8 to 16.

Fig 8

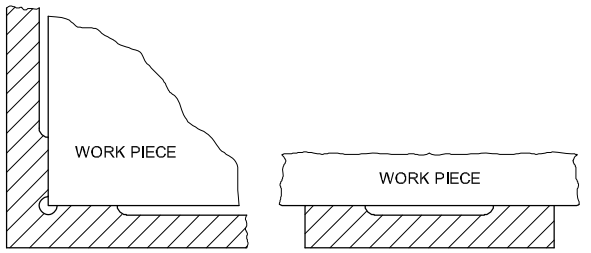


Fig 9

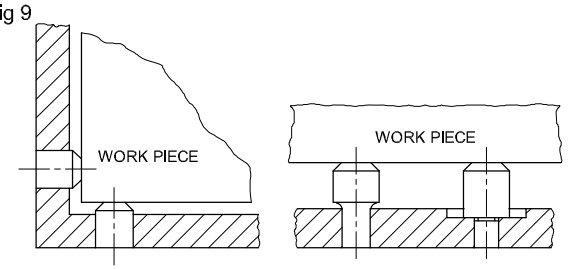


Fig 10

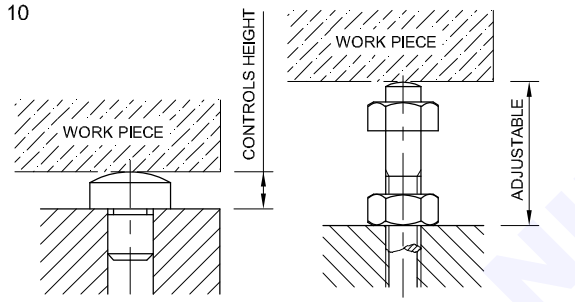


Fig 11

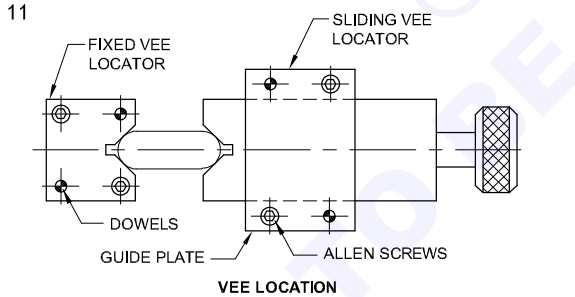


Fig 12

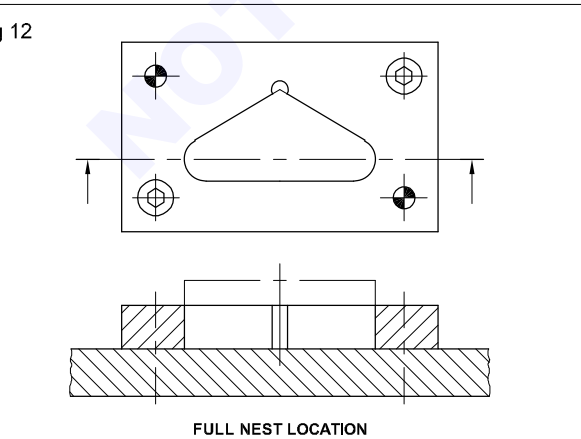


Fig 13

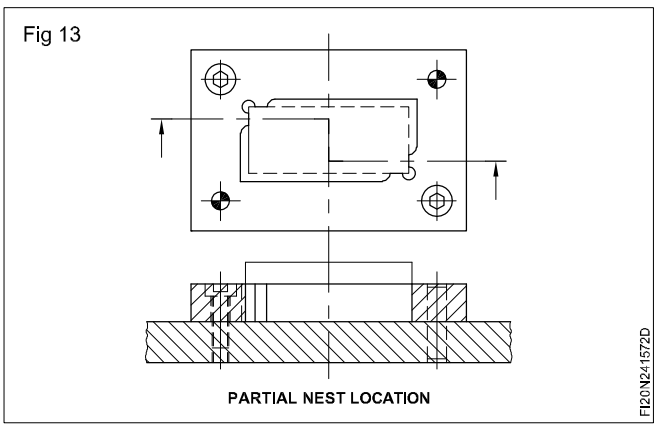


Fig 14

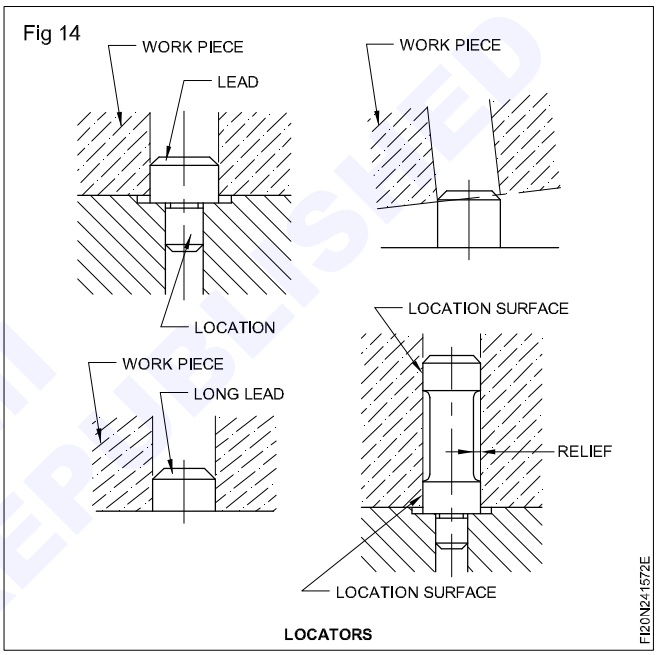


Fig 15

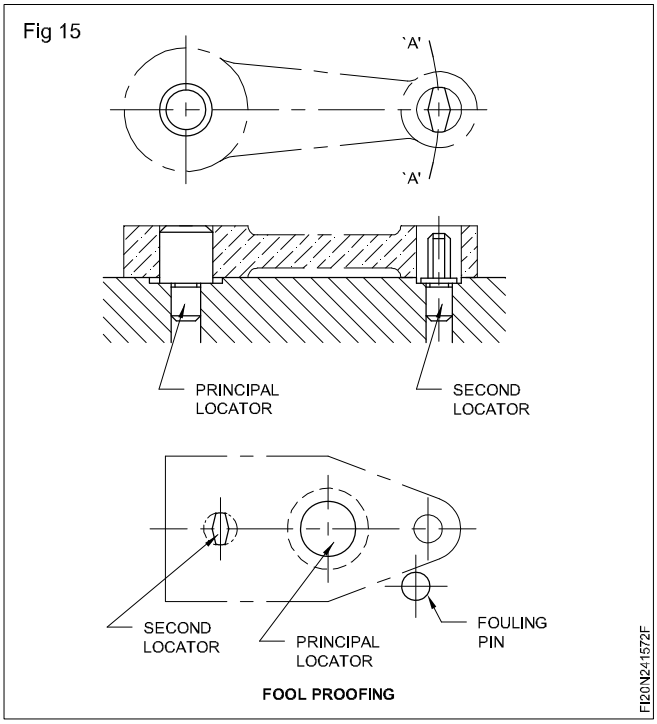
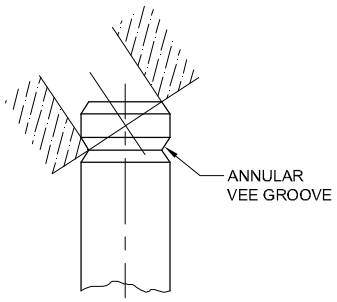


Fig 16



SPECIAL LEAD TO PREVENT JAMMING

FI20N241572G

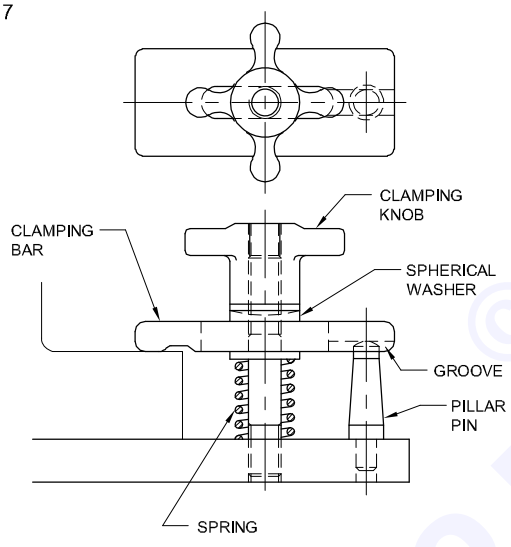
Clamps

Clamps in jigs are meant for holding the component in position against the cutting force. They also help in rapid loading and unloading of the components. Clamps are fitted in such a way that they do not interfere with the cutting operation.

The commonly used types of clamps are:

strap clamp (Fig 17)

Fig 17

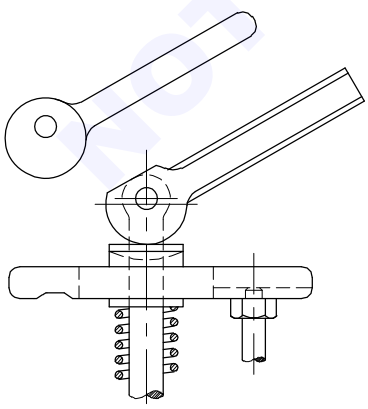


STRAP CLAMP

FI20N241572H

- cam clamp (Fig 18)

Fig 18

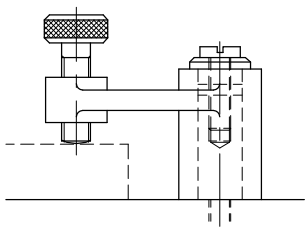


CAM CLAMP

FI20N241572I

- screw clamp (Fig 19)

Fig 19

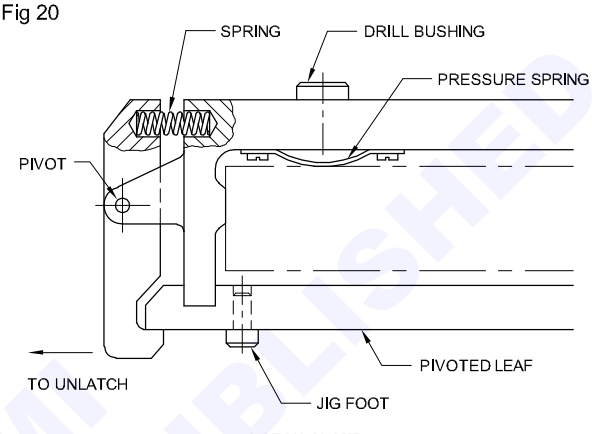


SCREW CLAMP

FI20N241572J

- latch clamp (Fig 20)

Fig 20

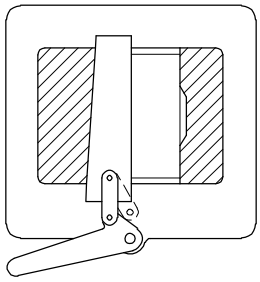


LATCH CLAMP

FI20N241572K

- wedge clamp (Fig 21)

Fig 21

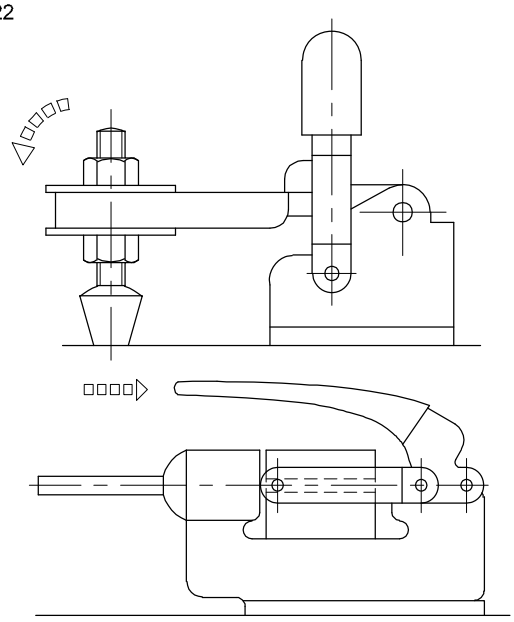


WEDGE CLAMP

FI20N241572L

- toogle clamp (Fig 22)

Fig 22

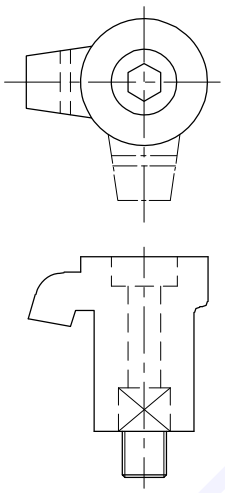


TOGGLE CLAMP

FI20N241572M

- hook clamp (Fig 23)

Fig 23



HOOK CLAMP

FI20N241572N

Fixtures - Types and uses

Objectives: At the end of this lesson you shall be to
- **what is fixture**
- **list the different type of fixture and their uses**

Introduction to fixture

A fixture is a production tool used to locate accurately and to hold securely one or more work- pieces so that the required machining operations can be performed. A fixture should be securely fastened to the table of the machine upon which the work is done. The main purpose of a fixture is to locate the work quickly and accurately,support it properly ,and hold it securely.

Classification of fixtures

Fixtures are classified by the type of machine on which they are used. If a fixture is made for a milling machine it is called a milling fixture. Some of the most commonly used fixtures are turning fixture, milling fixture, welding fixture, boring fixture, assembly fixture, inspection fixtures etc.

The elements of jigs and fixtures are

- location
- clamping
- tool guiding or setting
- body base or frame

Types of fixtures

Types of fixtures are determined mainly by how the tool is used. Because of the increased tool forces, fixtures are built stronger and heavier than jigs. The most common type of fixtures are

Plate fixture

These are the simplest form of fixtures. It is made from a flat plate which has locater and clamps to locate and hold the part (Fig 1).

Fig 1

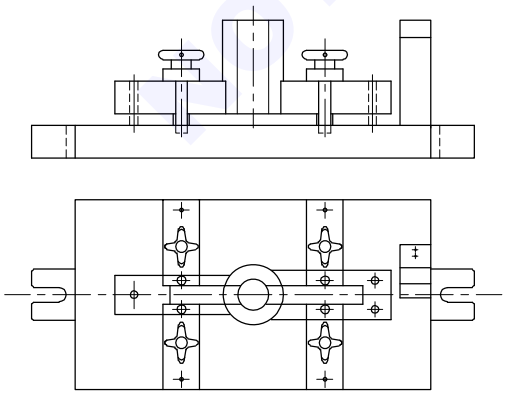


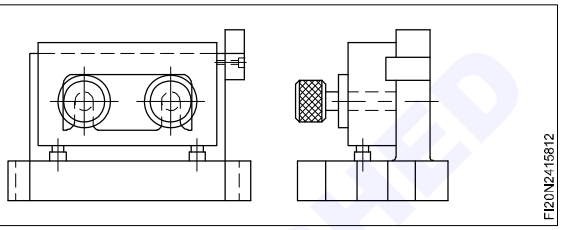
PLATE FIXTURE

FI20N2415811

Angle plate fixture

This fixture is used for machining the part at right angle to the locator. (Fig 2)

Fig 2

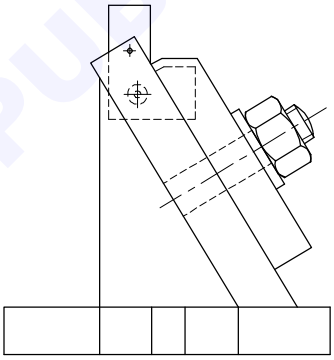


FI20N2415812

Modified angle plate fixture

This fixture is used for machining the part at angles other than 90°. (Fig 3)

Fig 3



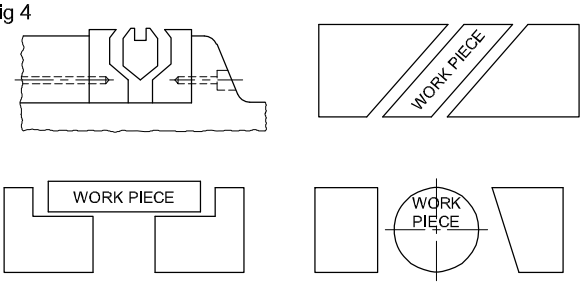
MODIFIED ANGLEPLATE FIXTURE

FI20N2415813

Vice jaw fixture

This fixture is used for machining small parts. The standard vice jaws are replaced with jaws that are made to suit the work. (Fig 4)

Fig 4



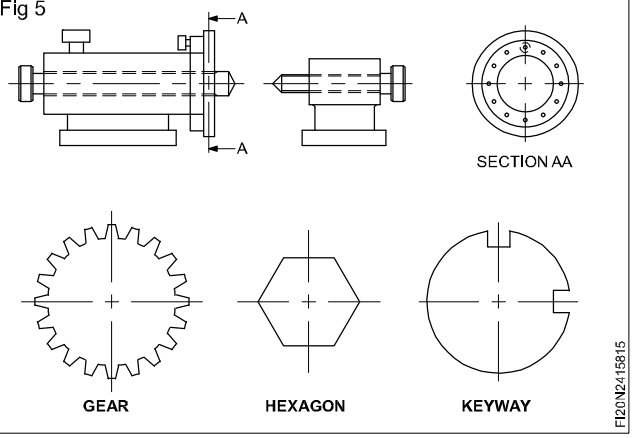
VICE JAW FIXTURES

FI20N2415814

Indexing fixtures

These fixtures are used for parts that require machining on evenly spaced surfaces. (Fig 5)

Fig 5



Use of fixtures

A great deal of importance is placed today on improving productivity in manufacturing processes. Application of jigs and fixtures has contributed a lot towards this direction.

Jigs and fixtures (Figs 6 and 7) are devices used in manufacturing or assembling. They also facilitate in carrying out special operations accurately.

Fig 6

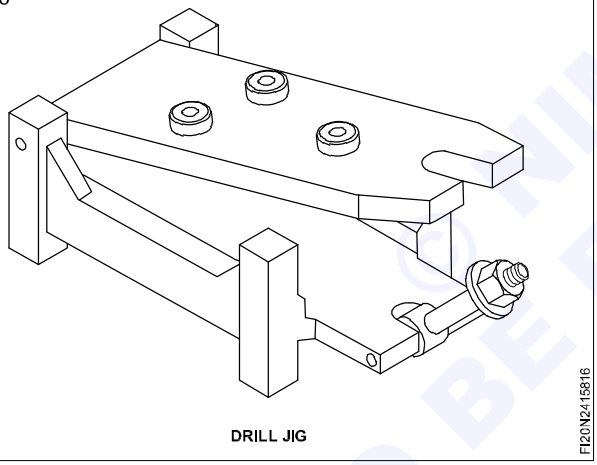
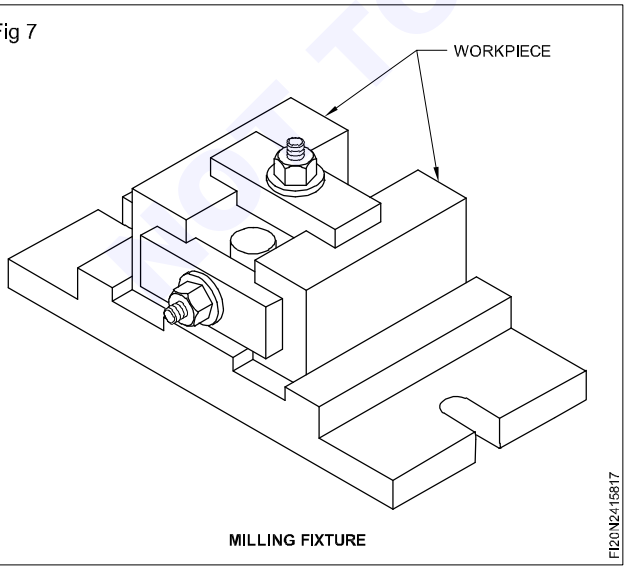
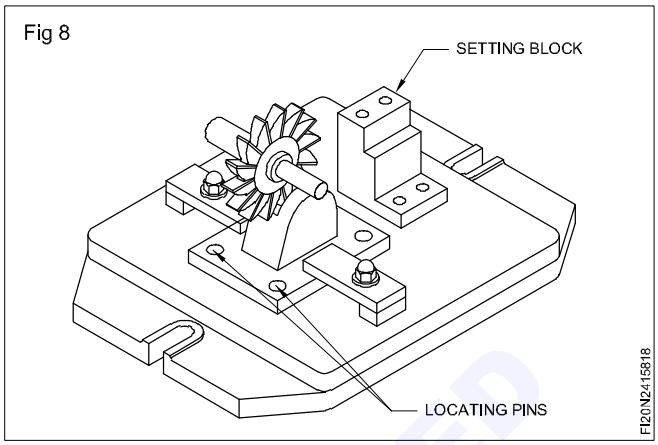


Fig 7



Fixture is a production tool that locates and holds the work-piece. It does not guide the cutting tools, but the tools can be positioned before cutting with the help of setting blocks and feeler gauges etc. (Fig 8)

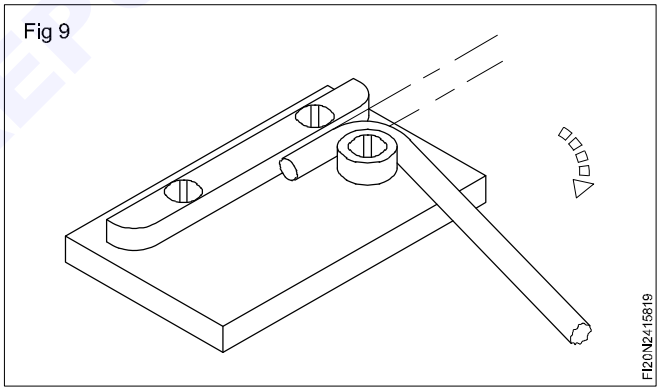
Fig 8



Fixtures of different types are made for:

- milling
- turning
- grinding
- welding
- assembly
- bending etc. (Fig 9)

Fig 9



Constructional features of a fixture

Objective: At the end of this lesson you shall be to

- **brief various constructional features of a fixture**
- **state the functions of setting block and balancing weight in fixture**

common types of fixtures used for the machining operations are:

- milling fixture (Fig 1)
- turning fixture (Fig 2)
- grinding fixture etc.

These fixtures consist of a base plate, standard clamps and locators, setting blocks and balancing weights.

Fig 1

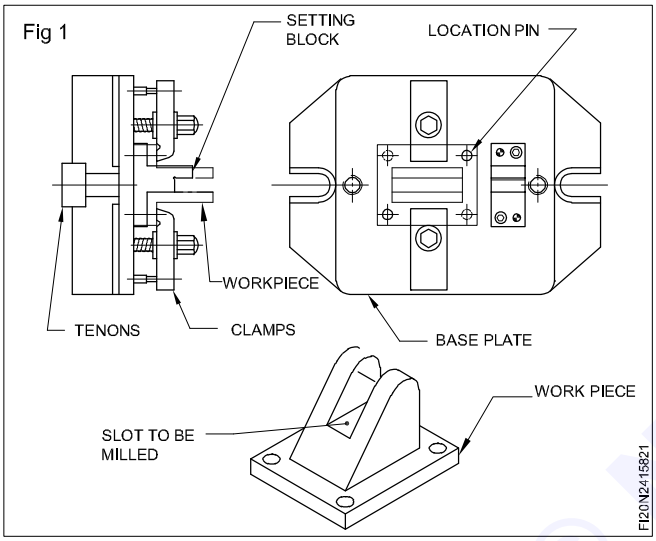
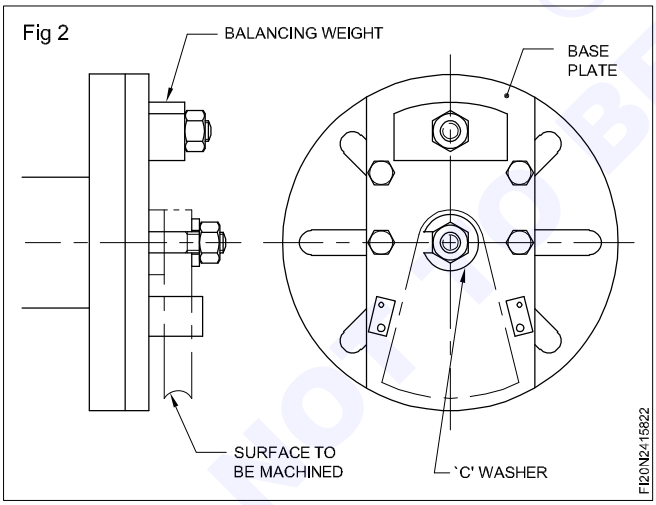


Fig 2



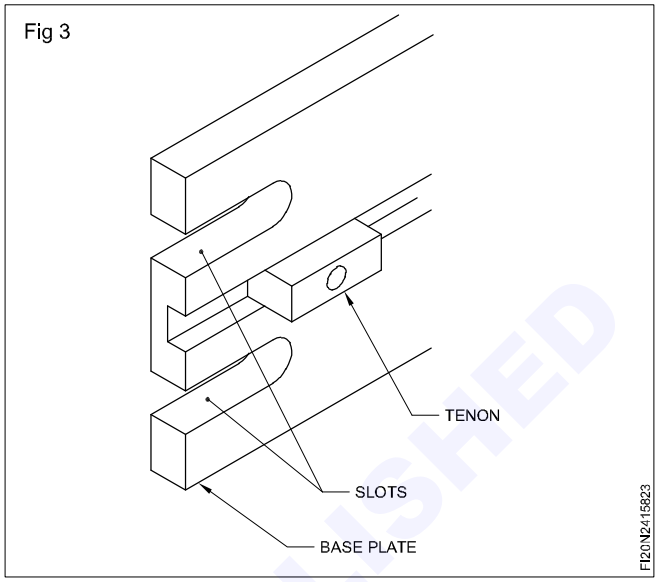
Base plate

The base plate for a milling fixture is provided with tenons at its bottom for proper location of the fixture with the machine table through Tee slots. (Fig 3) Two or four hold-down slots are provided in the base plate for rigid clamping of the fixture with the machine table.

Standard clamps and locators

These are provided for clamping and locating the workpieces with the fixture as in the case of drill jigs.

Fig 3



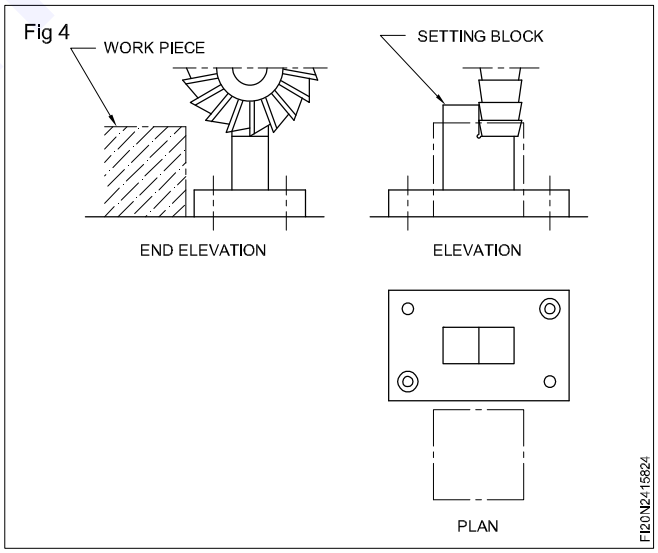
The clamps used in the fixtures are very rigid and sturdy.

The setting blocks

These are used to position the fixture and work relative to the cutter before machining.

A feeler is introduced between the cutter and the setting faces of the block for correct positioning of the cutter with the fixture. (Fig 4)

Fig 4

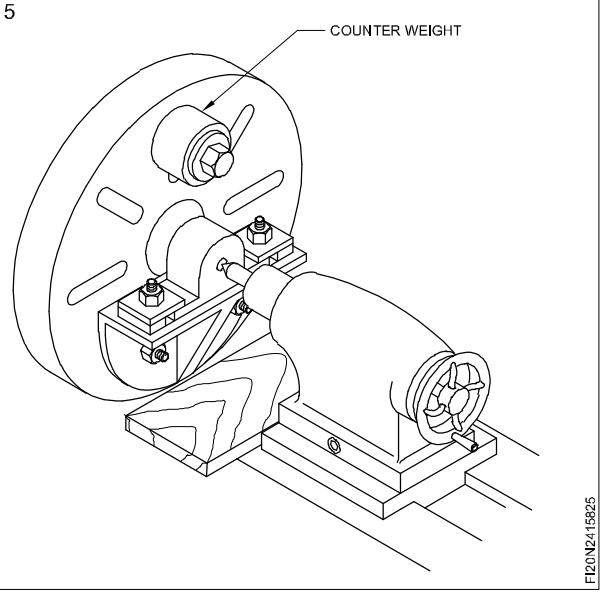


Balancing weight

This is used dynamically balancing the irregular workpiece fixed to the turning or cylindrical grinding fixture.

In the case of a turning fixture, normally the base plate of the fixture is clamped to the face plate. (Fig 5)

Fig 5



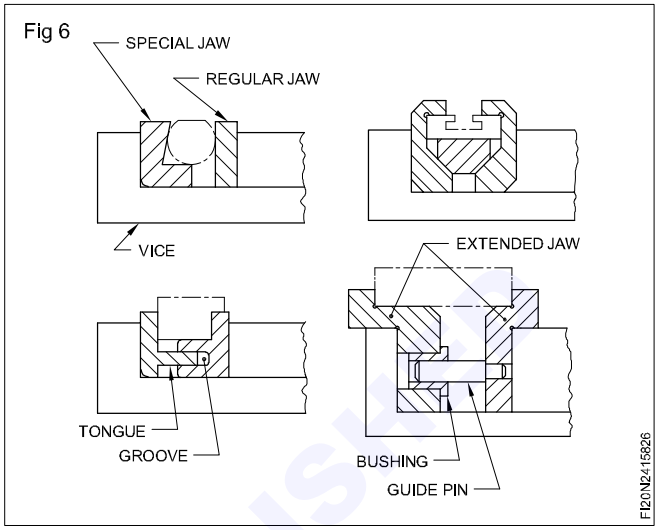
Vice fixture

Standard machine vices, attached with special jaws, provide an easy method of holding parts for machining. (Fig 6)

Other types of tooling used for positioning parts relative to each other for fabricating purposes are also commonly referred to as fixtures. Bending fixtures, assembly fixtures and welding fixtures are examples of this type.

The construction of a fixture depends upon the machining and fabricating methods employed.

Fig 6



Difference between jigs and fixtures

Jigs	Fixtures
jig holds and positions the work piece, guides the cutting tool Jig is not fixed to the machine table Jigs are used in drilling machine for drilling, tapping, counter boring, and countersinking etc.	Fixture only hold and position the work piece, does not guide the cutting tool Fixture is usually fixed to the machine table Fixtures are used in grinding, milling, turning, bending and assembling.

Aluminium and its alloys

Objectives : At the end of this lesson you shall be able to
- **state the properties and uses of aluminium**
- **name the commonly used aluminium alloys and their uses**
- **name the ores from which aluminium is produced, and differentiate aluminium vs steel.**

Aluminium is a non-ferrous metal which is extracted from 'BAUXITE'. Aluminium is white or whitish grey in colour. It has a melting point of 660°C. Aluminium has high electrical and thermal conductivity. It is soft and ductile, and has low tensile strength. Aluminium is very widely used in aircraft industry and fabrication work because of its lightness. Its application in the electrical industry is also on the increase. It is also very much in use in household heating appliances. Some typical aluminium alloys, their composition and applications are given in the table that follows.

Aluminium alloys - Composition - Uses

Composition(%) (Only the percentage of alloying elements is shown. The remaining is aluminium)						Category	Applications
Copper	Silicon	Iron	Manganese	Magnesium	Other elements		
0.1 max.	0.5 max.	0.7 max.	0.1 max.	-	-	Wrought. Not heat treatable.	Fabricated assemblies, Electrical conductors. Food and brewing, processing plants. Architectural decorations.
0.15 max.	0.6 max.	0.75 max.	1.0 max.	4.5 to 5.5	0.5 Chromium	Wrought. Not heat treatable.	High strength ship building and engineering products. Good corrosion resistance.
1.6	10.0	-	-	-	-	Cast, not heat treatable.	General purpose alloy for moderately stressed pressure die-castings.
-	10.0 to 13.0	-	-	-	-	Cast, not h eat treatable.	One of the most widely used alloys. Suitable for sand,gravity and pressure die castings. Excellent foundry characteristics. Used for large marine, automotive and general engineering castings.
4.2	0.7	0.7	0.7	0.7	0.3 Titanium (option)	Wrought. Heat treatable.	Traditional 'Duralumin'. General machining alloy. Widely used for stressed components in aircraft.
-	0.5	-	-	0.6	-	Wrought. Heat treatable.	Corrosion-resistant alloy for lightly stressed components such as glazing bars, window sections and automotive body components.
1.8	2.5	1.0	-	0.2	0.15 Titanium 1.2 nickel	Cast. Heat treatable.	Suitable for sand and gravity die casting. High rigidity with moderate strength and shock resistance. A general purpose alloy
-	-	-	-	10.5	0.2 Titanium	Cast. Heat treatable.	A strong, ductile and highlycorrosion-resistant alloy used for air craft and marine castings, both large and small.

Advantages of using aluminium over steel

Advantages

- lighter
- strength comparable to steel
- corrosion resistance
- good machinability
- can be anodized
- better thermal and electrical conductivity

Disadvantages

- less strength (compared to the higher strength steel alloys)
- not good for threaded fasteners
- more difficult to paint
- weldments require post welding heat treat to recover mechanical properties
- more difficult to weld
- fatigues
- high cost
- lower modulus of elasticity,therefore,increased deformation
- low elongation values

Aluminium and aluminium alloys

Aluminium is one of the most widely used metals in the world. It possesses an exciting range of properties. Moreover,aluminium combines with alloying elements like copper. manganese,silicon,magnesium and zinc,and forms a very useful series of alloys.

Important properties

- Aluminium is a light weight metal. Its density is about 2.7 gm/cm^3. It is about one third as light as steel.
- While pure aluminium has a low strength of 7 kgf/mm^2, the alloys are moderately strong Some alloys have strength as high as 45 kgt/mm^2 in the heat - treated condition.
- The above two properties together provide it with high strength to weight ratio,which makes it suitable for aerospace application.
- Some of the alloys have excellent toughness at low temperatures,making them suitable for cryogenic (below 0° C) application.
- Some alloys have excellent corrosion resistance.
- Aluminium and its alloys have high thermal conductivity.
- Aluminium and its alloys also have high electrical conductivity.

Applications

- Household furniture and utensils.
- Containers,tanks and vessels.
- Automobile structures,bus bodies,road and railway tankers and wagons.
- Buildings and other architectural structures.
- Portable bridges.
- Aircraft,missiles and other aerospace components.
- Radiators and other heat exchangers.
- Electrical conductor cables and bus bars.

Aluminium alloy system

Aluminium alloys are classified on the basis of the principal alloying element present in a particular alloy.

Aluminium vs steel

Steel and aluminium are two of the most widely used materials on the planet.

Aluminium is the second-most abundant metallic element on Earth after silicon, while steel is the world's most popular alloy.

While both metals have countless uses, there are a few key factors that can help you one is best for the job.

Corrosion resistance

Aluminium oxidizes via the same type of chemical reaction that causes iron to rust. But unlike iron oxide, aluminium oxide sticks to the metal, shielding it from decay. As a result, it requires no paint or other coating to keep it from rusting.

Steel or carbon (not stainless) steel, to be specific-typically needs to be painted after being spun in order to protect it from rust and corrosion. Zinc is often used to protect against corrosion through the galvanizing process.

Malleability

While steel is extremely durable and resilient, aluminium is considerably more flexible and elastic.

Aluminium's malleability and smooth fabrication allow it to form deep intricate, and precise spinnings giving handlers significant design freedom. Steel is more rigid and will crack or rip if pushed too far during the spinning process.

Strength

Despite being at risk for corrosion, steel is still harder than aluminium.

While aluminium does increase in strength in colder environments, it is generally more prone to dents and scratches than steel.

Steel is less likely to warp or bend from weight, force, or heat. These resistant properties make it one of the most durable industrial materials.

Weight

Steel's superior strength also comes with a weight/density that is 2.5 times that of aluminium. It weighs approximately 60 percent less than concrete, however, making it easier to transport and use in various construction and fabrication applications.

With that said, shape and structural rigidity can contribute significantly to the strength of a structure, and when those two factors are optimized, aluminium can provide similar reliability to a comparable steel structure at half the weight.

For example, there is a rule of thumb in boat building that aluminium is roughly half the strength of steel at one-third the weight. This means that an aluminium vessel can be built at a given strength that is two-thirds the weight of a comparable steel boat.

Cost

The cost of aluminium and steel is constantly in flux based on global supply and demand, related fuel costs, and the iron and bauxite ore market. Even with that fluctuation, however, steel is typically cheaper than aluminium.

Lead and its alloys

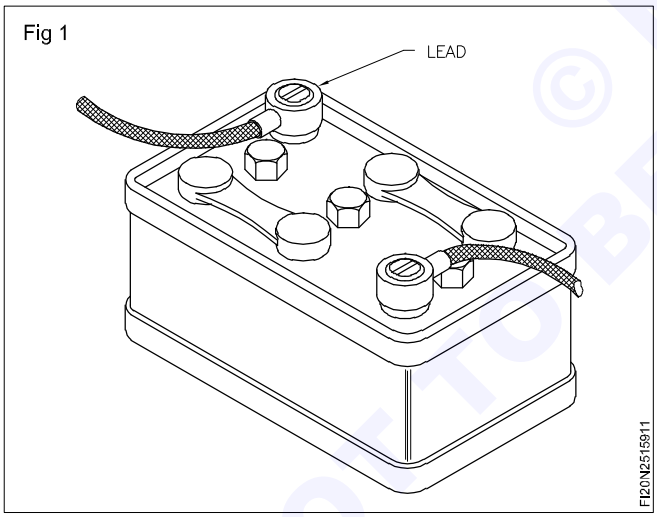
Objectives : At the end of this lesson you shall be able to
- **state the properties of lead**
- **state the various uses of lead**
- **state the uses of babbit metal.**

Lead is a very commonly used non-ferrous metal and has a variety of industrial applications.

Lead is produced from its ore 'GALENA'. Lead is a heavy metal that is silvery in colour when molten. It is soft and malleable and has good resistance to corrosion. It is a good insulator against nuclear radiation. Lead is resistant to many acids like sulphuric acid and hydrochloric acid.

It is used in car batteries, in the preparation of solders etc. It is also used in the preparation of paints.(Fig 1)

Fig 1



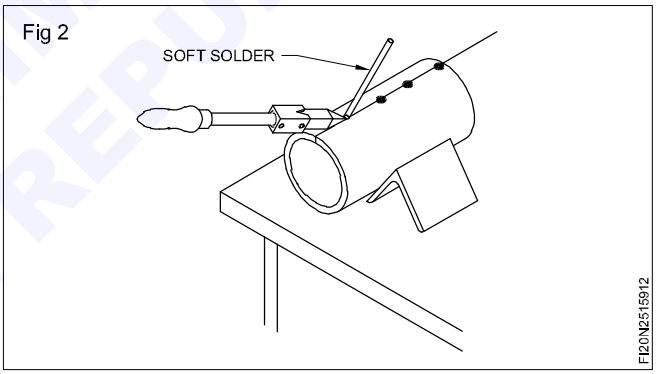
Lead Alloys

Babbit metal

Babbit metal is an alloy of lead, tin, copper and antimony. It is a soft, anti-friction alloy, often used as bearings.

An alloy of lead and tin is used as 'soft solder'.(Fig 2)

Fig 2



Zinc

Objectives : At the end of this lesson you shall be able to
- **state the properties and uses of zinc**
- **state the uses of zinc alloys.**

Zinc is a commonly used metal for coating on steel to prevent corrosion. Examples are steel buckets, galvanized roofing sheets, etc.

Zinc is obtained from the ore-calamine or blende.

Its melting point is 420°C.

It is brittle and softens on heating; it is also corrosion resistant. Due to this reason it is used for battery containers and is coated on roofing sheets etc.

Galvanized iron sheets are coated with zinc.

Tin and its alloys

Objectives : At the end of this lesson you shall be able to
- **state the properties and uses of tin**
- **name the common tin alloys and state their uses.**

Tin

Tin is produced from cassiterite or tinstone. It is silvery white in appearance, and the melting point is 231°C. It is soft and highly corrosion-resistant.

It is mainly used as a coating on steel sheets for the production of food containers. It is also used with other metals, to form alloys.

Eg. Tin with copper to form bronze. Tin with lead to form solder. Tin with copper, lead and antimony to form babbit metal.

Copper and its alloys

Objectives : At the end of this lesson you shall be able to
- **name the commonly used copper alloys**
- **state the properties and uses of copper**
- **state the composition and uses of different types of brasses**
- **state the composition and uses of different types of bronze.**

Metals without iron (Ferrum) are called non-ferrous metals. Eg. Copper, Aluminium, Zinc, Lead and Tin.

Copper

This is extracted from its ores 'MALACHITE' which contains about 55% copper and 'PYRITES' which contains about 32% copper.

Properties

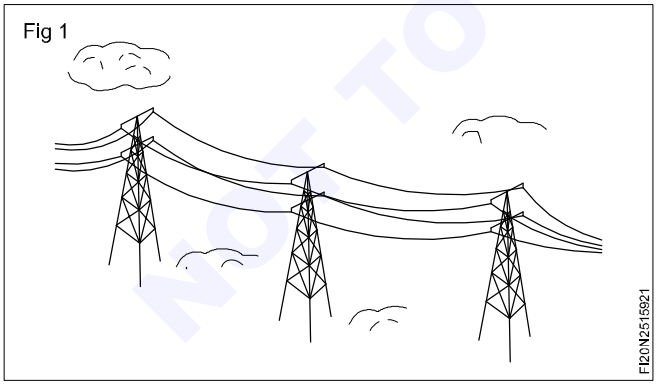
Reddish in colour. Copper is easily distinguishable because of its colour.

The structure when fractured is granular, but when forged or rolled it is fibrous.

It is very malleable and ductile and can be made into sheets or wires.

It is a conductor of electricity. Copper is extensively used as electrical cables and parts of electrical apparatus which conduct electric current. (Fig 1)

Fig 1

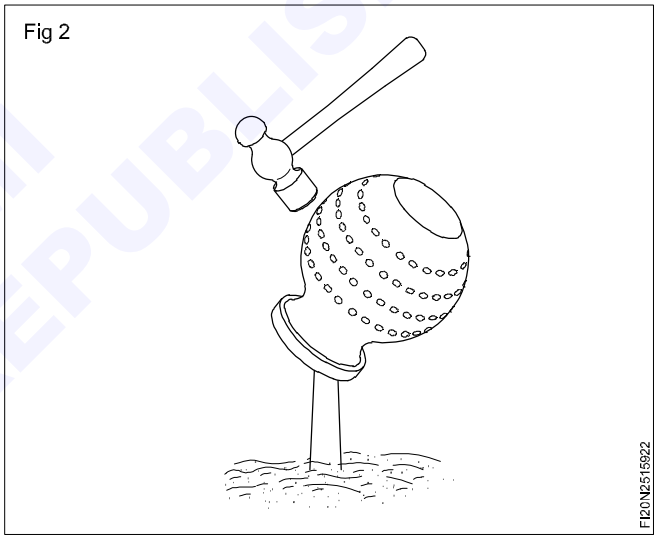


Copper is a good conductor of heat and also highly resistant to corrosion. For this reason it is used for boiler fire boxes, water heating apparatus, water pipes and vessels in brewery and chemical plants. Also used for making soldering iron.

The melting temperature of copper is 1083°C.

The tensile strength of copper can be increased by hammering or rolling. (Fig 2)

Fig 2



Copper alloys

Brass

It is an alloy of copper and zinc. For certain types of brass small quantities of tin or lead are added. The colour of brass depends on the percentage of the alloying elements. The colour is yellow or light yellow, or nearly white. It can be easily machined. Brass is also corrosion-resistant.

Brass is widely used for making motor car radiator core and water taps etc. It is also used in gas welding for hard soldering/brazing. The melting point of brass ranges from 880 to 930°C.

Brasses of different composition are made for various applications. The following table-1 gives the commonly used brass alloy compositions and their application.

Bronze

Bronze is basically an alloy of copper and tin. Sometimes zinc is also added for achieving certain special properties. Its colour ranges from red to yellow. The melting point of bronze is about 1005°C. It is harder than brass. It can be easily machined with sharp tools. The chip produced is

granular. Special bronze alloys are used as brazing rods. Bronze of different compositions are available for various applications. Table-2 gives the type compositions and applications Table 1 - Composition of different types of brass.

Table 1 - Composition of different types of brass

Name	Composition (%)			Applications
	Copper	Zinc	Other elements	
Cartridge brass	70	30	-	Most ductile of the copper/zinc alloys. Widely used in sheet metal pressing for severe deep drawing operations. Originally developed for making cartridge cases, hence its name.
Standard brass	65	35	-	Cheaper than cartridge brass and less ductile. Suitable for most engineering processes.
Basic brass	63	37	-	The cheapest of the cold working brasses. It lacks ductility and is only capable of withstanding simple forming operations.
Muntz metal	60	40	-	Not suitable for cold working, but suitable for hot-working. Relatively cheap due to its high zinc content. It is widely used for extrusion and hot-stamping processes.
Free-cutting brass	58	39	3% lead	Not suitable for cold working but excellent for hot working and high speed machining of low strength components.
Admirality brass	70	29	1% tin	This is virtually cartridge brass plus a little tin to prevent corrosion in the presence of salt water.
Naval brass	62	37	1% tin	This is virtually Muntz metal plus a little tin to prevent corrosion in the presence of salt water.
Gilding metal	9	5	-	Used for jewellery.

Table 2 - Composition of different types of bronze

Name	Composition (%)				Applications
	Copper	Zinc	Phosphorus	Tin	
Low tin bronze	96	-	0.1 to 0.25	3.9 to 3.75	This alloy can be severely cold-worked to harden it so that it can be used for springs where good elastic properties must be combined with corrosion resistance,fatigue-resistance and electrical conductivity. Eg.Contact blades
Drawn phosphor/ bronze	94	-	0.1 to 0.5	5.9 to 5.5	This alloy is used for turned components requiring strength and corrosion resistance, such as valve spindles.
Cast phosphor/ bronze	89.75 to 89.97		0.03 to 0.25	10	Usually cast into rods and tubes for making bearing bushes and worm wheels. It has excellent anti-friction properties.
Admirality gun-metal	88	2	-	10	This alloy is suitable for sand casting where fine-grained, pressure-tight components such as pump and valve bodies are required.
Leaded gun-metal (free cutting)	85	5 (5%lead)	-	5	Also known as 'red brass' this alloy is used for the same purposes as standard, admirality gun-metal. It is rather less strong but has improved toughness and machining properties.
Leaded (plastic) bronze	74	(24%lead)	-	2	This alloy is used for lightly loaded bearings where alignment is difficult. Due to its softness, bearings made from this alloy 'bed in' easily.

Power Transmission Elements

Objectives : At the end of this lesson you shall be able to
- **name the different types of belts**
- **name the different types of belt fasteners.**

Introduction

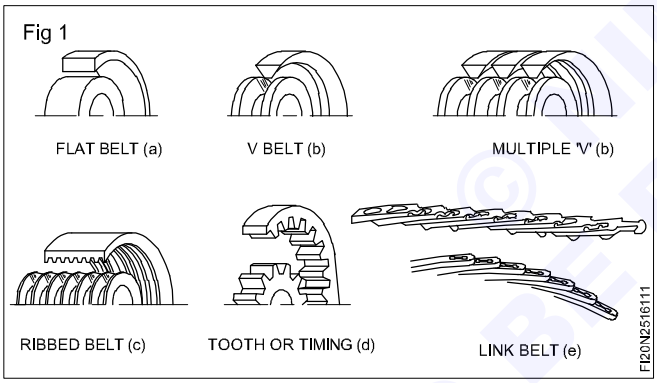
Power transmission is a process of transmit motion from one shaff to another by using some connection between them like belt, rope, chain and gears. Main types of power transmission elements are describe d below

Types of belts

Basically five types of belts are used for the transmission of power.

- Flat belt (Fig 1a)
- V-belt and multiple V-belt (Fig 1b)
- Ribbed belt (Fig 1c)
- Toothed or timing belt (Fig 1d)
- Link belt (Fig 1e)

Fig 1



The choice of a particular belt depends upon speed ratio, centre distance, flexibility, strength, economy and maintenance consideration of the driving system.

V-belts

'V'belt drives are generally used when the distance between the shafts is too short for flat belt drives. Owing to the wedge action between the belt and the sides of the groove

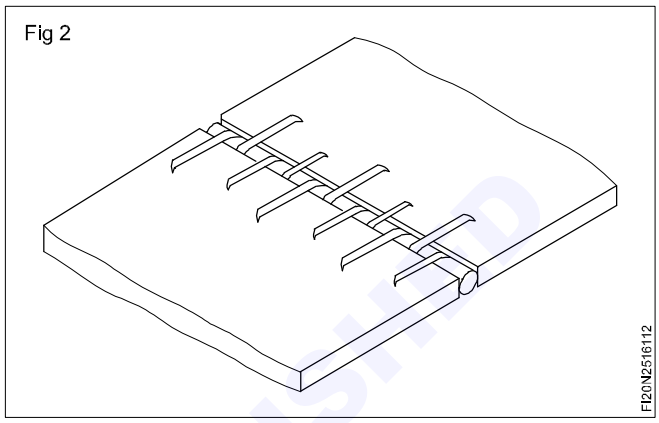
Types of fasteners

The belt fasteners commonly used in addition to the alligator type are as follows.

Wire type belt fastener

Fig 2 shows the wire type fastener generally used on light duty machines.

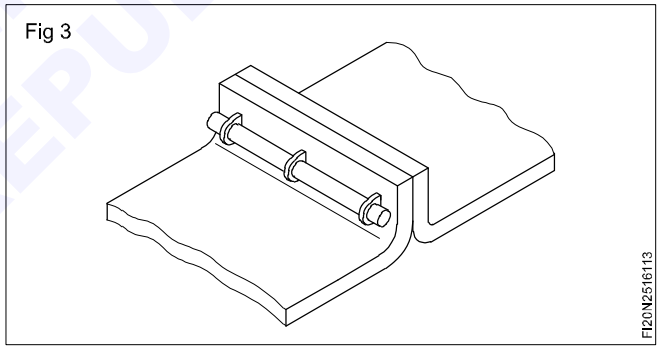
Fig 2



'Lagrelle' type belt fastener

Fig 3 shows a lagrelle type fastener used on heavy duty machines.

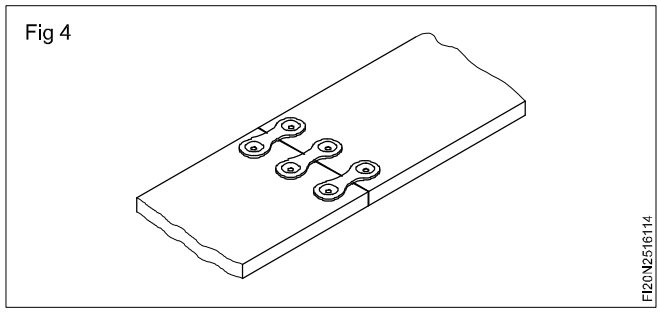
Fig 3



Jackson-type belt fastener

The Jackson-type fastener illustrated in Fig 4 is used on medium duty machines.

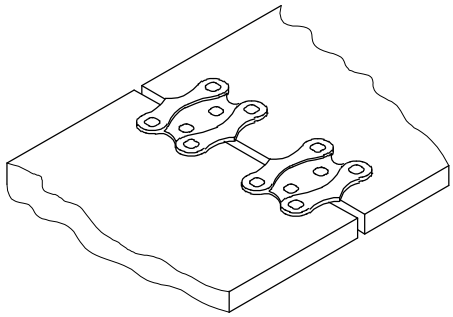
Fig 4



Crescent plate belt fastener

Fig 5 shows a mechanical type belt fastner which is used on medium duty machines.

Fig 5



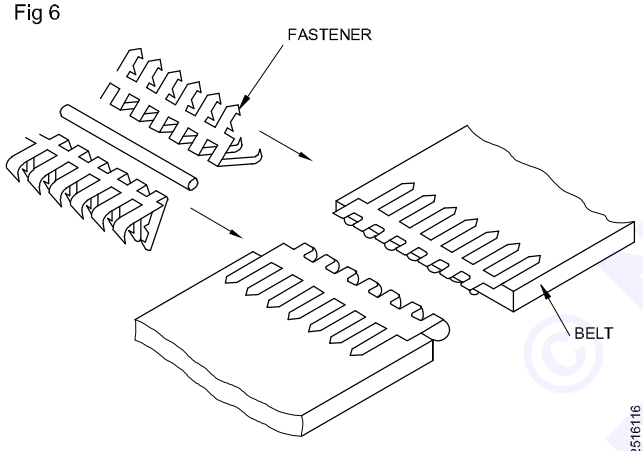
"CRESCENT" - PLATE BELT FASTENER

FI20N2516115

Belt fasteners (Alligator type)

Alligator type fasteners are used in joining belting for industrial purposes. The belt fastener is made of steel sheets conforming to IS:513-1973. The pins shall be made from mild steel wire conforming to IS: 280-1972. Belt fasteners are shown in Fig 6 and the position of the pin in a joint is illustrated in Fig 7.

Fig 6



ALLIGATOR TYPE BELT FASTENER

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Specification

The fastener designation and pin size, thickness of belt and other dimensions are given in the table as per IS: 5593-1980.

Fig 7

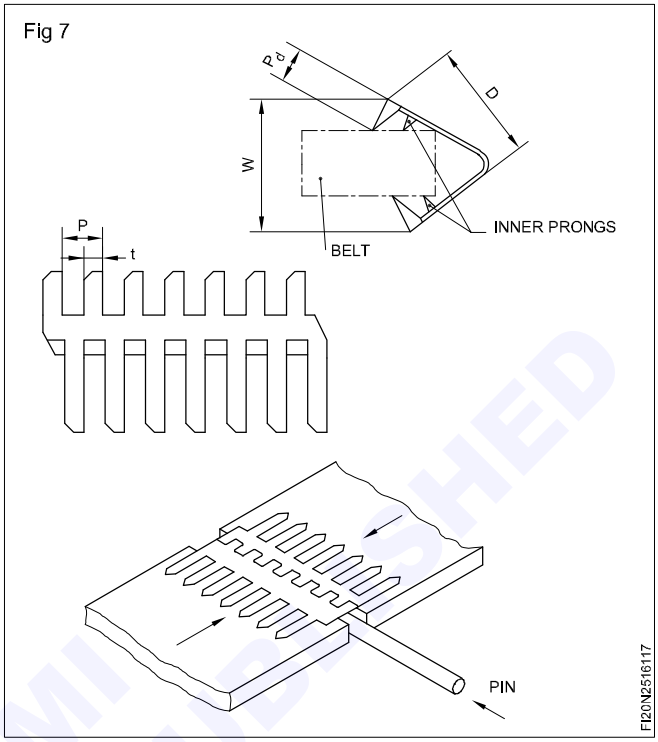

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Table - 1

Fastener Designation	Thickness of belt	Metal thickness (Sheet)	Point depth P_d	Approx overall width W	Approx overall depth t_1 Min D	Width of bar prong P	Pitch of prong
15	3 to 4	1.0	5.0	18	13	2.5	6
20	4 to 5	1.1	6.5	22	17	3	8
25	5 to 5.5	1.2	7.0	25	21	3	8
27	5.5 to 7	1.2	8.0	29	24	3	8
35	7 to 8	1.8	9.5	32	30	4	10
45	8 to 9.5	1.8	11.0	38	31	5	12
55	9.5 to 11	2.0	14.0	48	40	6.5	16
65	11 to 13	2.0	16.0	54	41	6.5	16

Fastener designation	Pin in size mm
15,20,25 27,35 45,55,65	2.64 3.25 4.06

Belts tension

Objectives : At the end of this lesson you shall be able to
- **state the need for tensioning belts**
- **state the methods of adjusting belt tension**
- **state the importance of the arc of contact in a belt drive**
- **state the important factors for improving the efficiency in a belt drive**
- **calculate the deflection force necessary for a belt drive**
- **state the care and maintenance of belts.**

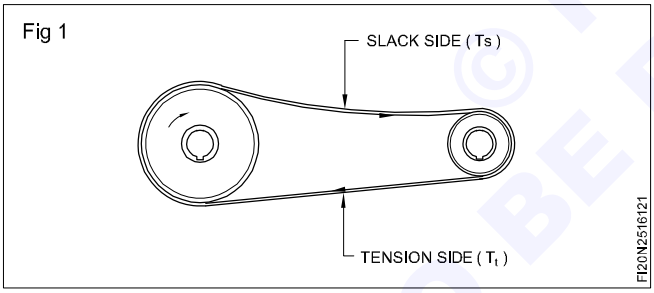
Belt tension

Belts must be tensioned correctly to transfer the torque from the driving pulley to the driven pulley to prevent unnecessary wear.

Too much of belt tension curtails belt and bearing life. As the belts stretch in use, it is necessary to check and adjust the belt drive tension.

When a drive is transmitting power the belt pulls or the belt tensions. There is the tight side tension (Tt) and a slack side tension (Ts). (Fig 1)

Fig 1



Tension ratio

The ratio of the tight side to the slack side tension is commonly referred to as the tension ratio. A higher ratio between the tight side and slack side tension makes the belt loose and slip.

This causes lack of effective pull for transmitting the required power.

Adjustment of tension

When the distance between two pulleys is fixed, the tension of a belt is adjusted by an idler. (Fig 2)

When the distance between two pulleys is not fixed, the tension of the belt is adjusted by the adjustment screw. (Fig 3)

Arc of contact

Tension is necessary to create friction between the pulleys and the belt. Torque transmission depends on the contact area of the belt over the pulleys. (Fig 4)

Fig 2

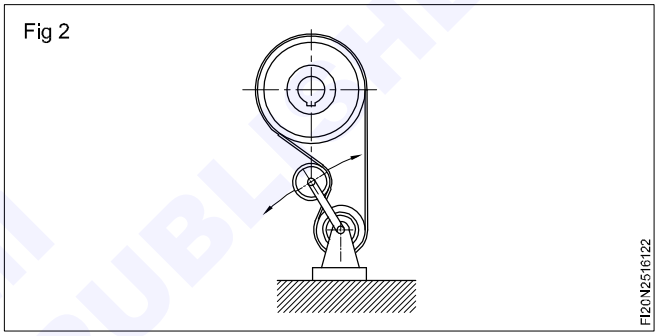


Fig 3

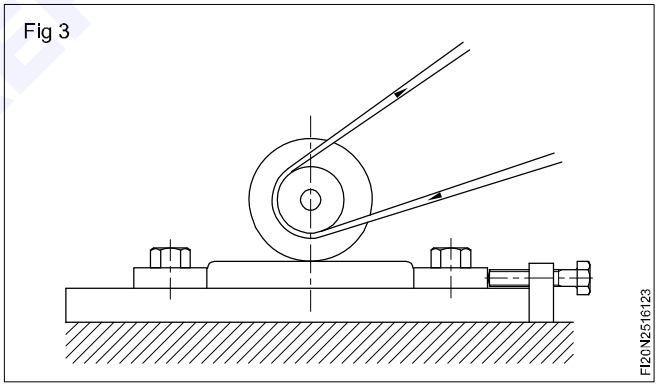
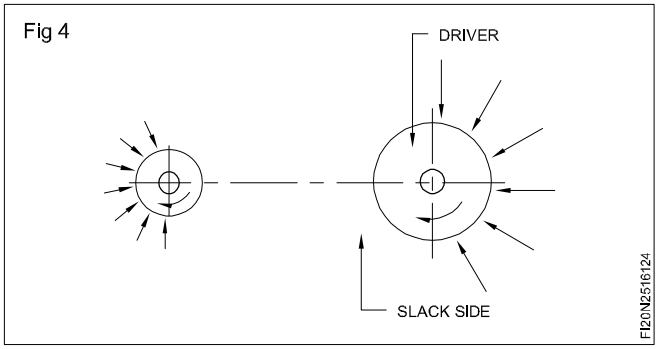
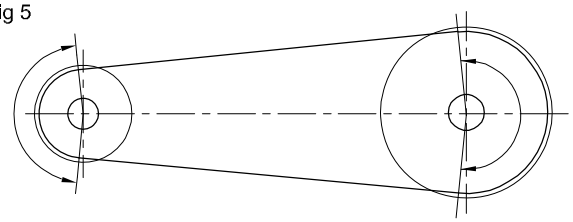


Fig 4



If the wrapping angle is big, the pulley can transmit high torque. (Fig 5)

Fig 5



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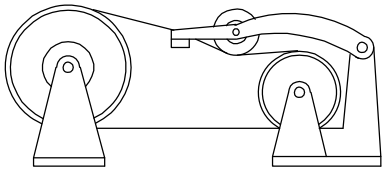
Belt efficiency

To provide maximum arc of contact the following points should be considered.

- Heavy belts of multi ply construction should not be used on small diameter pulleys.
- If the arc of contact is insufficient because of the short centre distance between the pulleys, a jockey pulley should be introduced as near to the small pulley as possible. (Fig 6)

Fig 6



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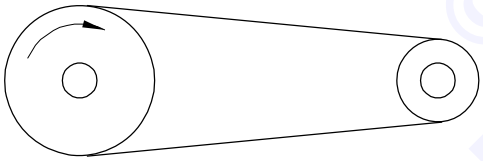
THE USE OF A JOCKEY PULLEY TO MAINTAIN CORRECT BELT TENSION

Excessive tension in the belt reduces the arc of contact, and introduces additional stresses which drastically reduce the life of the belt and bearings. (Fig 7)

Fig 7



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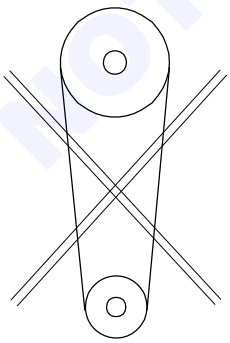
Vertical drives should definitely be avoided because the belt tension necessary to withstand gravitational pull (Fig 8) and accompanying slippage would result in adverse effects.

Fig 8

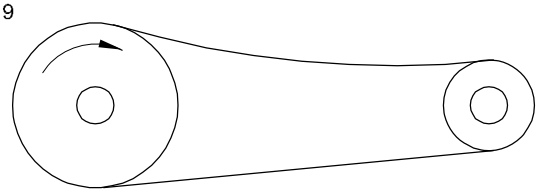


FI20N2516128

THE EFFECT OF GRAVITY ON A VERTICAL BELT

On the open belt drive, the slack side (Fig 9) must be at the top and the centre distance between the pulleys should be the maximum.

Fig 9



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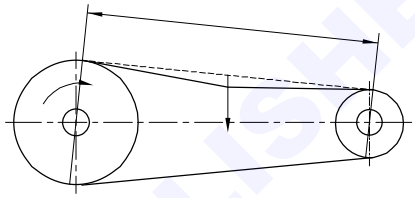
To measure tension of V-belt drives

To determine the force required to deflect one belt per 25 mm span length, apply a force perpendicular to the span at the centre of the belt large enough to deflect one belt to 0.5 mm span from its normal position. (Fig 10)

Fig 10



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- Compare this deflection force with the range of forces given in Table 1.
- If it is less than the minimum recommended deflection force, the belts should be tightened.
- If it is more than the maximum recommended deflection force, the drive is tighter than it need be.

Care and maintenance

- Keep the pulley faces and belts free from foreign material which may cause slips.
- When the 'V' belts begin to show signs of wear they should be replaced. Replace all the belts in a multiple 'V' belt drive rather than a single one.
- Check and adjust drive tension periodically.
- Store belts in a cool, dark and dry place.

The belt tension should be adjusted in such a way that the deflection force is in between the maximum and minimum.

TABLE 1

Recommended deflection force per belt for classical 'V' belts

V-Belt cross-section	Small sheave dia. range cm	Speed ratio range	Recommended deflection force Kg	
			Min.	Max.
A	7.62 - 8.13 8.64 - 9.14 9.65 - 10.67 11.68 - 17.78	2.0 - 4.0	1.08 1.14 1.32 1.59	1.54 1.68 1.91 2.26
B	11.68 12.67 - 13.71 14.22 - 16.25 17.27 - 23.87	2.0 - 4.0	2.00 2.22 2.45 2.81	2.86 3.22 3.53 4.08
C	17.78 19.05 - 20.32 21.59 - 25.4 26.67 - 40.64	2.0 - 4.0	3.4 3.81 4.30 5.00	5.00 5.44 6.36 7.72
D	30.48 - 33.02 34.29 - 39.37 40.64 - 55.88	2.0 - 4.0	7.71 8.6 10.00	10.91 12.27 14.09
E	54.86 - 60.96	2.0 - 4.0	14.54	21.36

Maintenance features of the Vee belt

Trouble	Cause	Remedy recommended
Belt Slips	Less tension. Overload. Oilness in the groove of the pulley or belt.	Increases the tension. Reduce the load. Degrease.
Frequent belt spoilage	Excessive heat. Shock load. Misalignment. Damaged sheave. Foreign particles. Drive overloaded.	Provide ventilation or use neoprane jacket type belt. Avoid shock load as far as possible and increase the belt tension. Align the pulleys. Change the damaged pulley. Provide belt guards. Check that all the belts in the drive have the same tension. If not, provide matching belts.
Belt whips excessively	Centre distance between the pulleys is more. Pulsating load.	Provide an idler. Introduce a fly wheel in the drive system.
Belt squeals.	Drive overloaded. Inadequate arc of contact. High starting torque.	Check that all the belts in the drive are evenly loaded. Provide an idler. Increase the belt tension.

Vee belts and their advantages, disadvantages

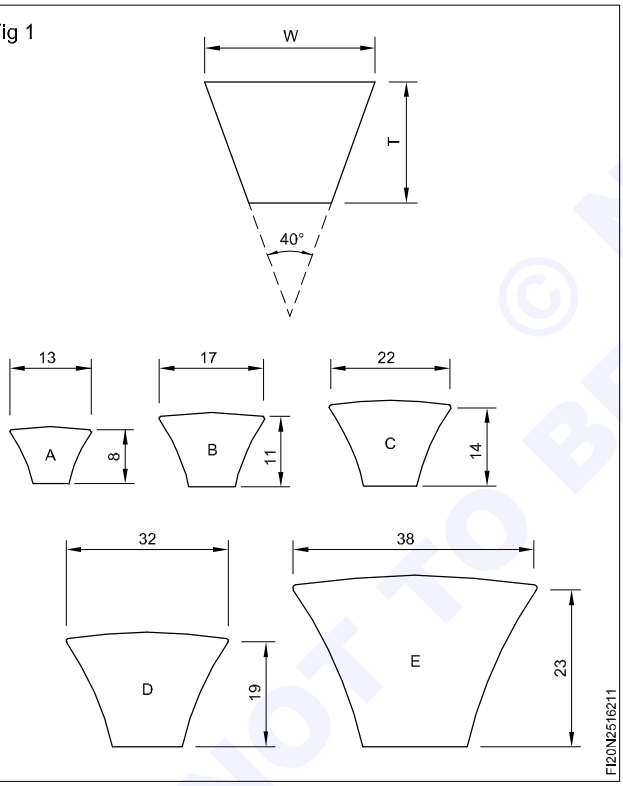
Objectives : At the end of this lesson you shall be able to
- **name of different types of belt**
- **state the advantages of 'V' belt**
- **state the classification of 'V'belt**
- **state the designation of V- belt.**

V- belts

'V' belt drives are generally used when the distance between the shafts is too short for flat belt drives. Owing to the wedge action between the belt and the sides of the groove in the pulley,the V belt is less likely to slip,hence more power can be transmitted.

The endless V belt is shaped roughly like a trapezium in cross- section,and is made of cord and fabric,and is treated with rubber and moulded together in a uniform manner and shape. The cross-sectional symbol of a V - belt is shown in Fig 1.

Fig 1



Advantages of V-belt drive

- It is compact, so installation is possible in limited space.
- It is used when the centre distance between the driver and the driven pulleys is short.
- Less vibration and noise.
- Cushions the motor and bearing against load fluctuation.
- Easy replacement and maintenance.

Classification of 'V'belts

The 'V' belts are classified into 5 groups as per IS.2494-1974 namely A,B,C,D and E. The nominal included angle of the V-belt shall be 40°.

Table 1 given below lists the standard sizes of V-belts from Section A to E.

TABLE - 1

Cross-section Symbol	Nominal Top Width W (mm)	Nominal Thickness (T)
A	13	8
B	17	11
C	22	14
D	32	19
E	38	23

Individual manufacturer's belts may deviate slightly from these dimensions for various constructional reasons. Crowning, if any, in belts should be disregarded for the measurement of thickness.

Designation of V-belt as per IS.2494

The V belts conforming to this standard shall be designated by the cross-section symbol, nominal inside length and the number of IS: standard.

Example

C 3048 IS: 2494

C = V-belt cross-section

3048 = Nominal inside length in mm. in untensioned state.

'V' belts creep, slip

Objectives : At the end of this lesson you shall be able to
- **list the use of commercial 'V' belt**
- **brief the term creep and slip**
- **explain the purpose of belt dressing**
- **calculate length of open belt.**

Use of commercial belt

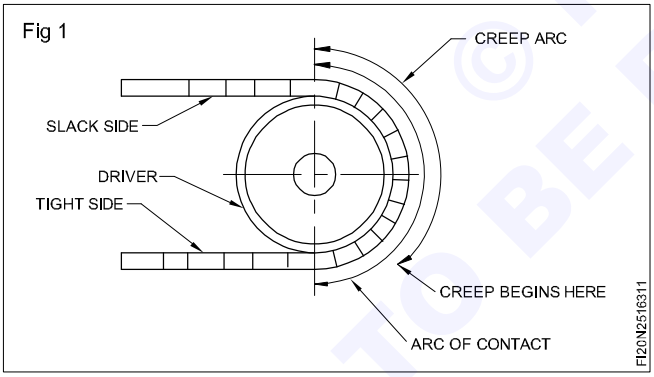
A belt is a loop of flexible material used to link two or more rotating shafts mechanically,most often parallel. Belts may be used as a source of motion, to transmit power efficiently or to track relative movement. Belts are looped over pulleys and may have a twist between the pulleys, and the shafts need not be parallel.

In a two pulley system, the belt can either drive the pulleys normally in one direction (the same if on parallel shafts), or the belt may be crossed, so that the direction of the driven shaft is reversed (the opposite direction to the driver if on parallel shafts). As a source of motion, a conveyor belt is one application where the belt is adapted to carry a load continuously between two points.

Commercial belts are mainly used in home appliances like,grinder,mixie and washing machine etc.

Creep and slip of belt (Fig 1)

Fig 1



As the belt turns on a pulley it tends to strech on the contact area of the driving pulley and shorten on the driven pulley. This localised movement of the belt is a direct result of the elastic stretch and is known as creep, Greater the load more will be the creep. The figure shows the condition of belt as a result of creep.

Slip is the actual difference caused between the surface speed of the belt and pulley. The effect of slip may be reduced by decreasing the pulley ratio and maintaining proper alignment. Creep, being the physical characteristic of the belt, cannot itself be controlled. Slip and creep jointly cause power loss.

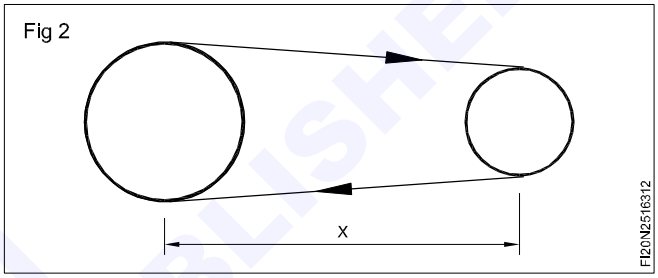
Belt dressing

Due to the continuous rubbing of the belt on the surface of the pulley the belt gets dried up due to friction, and heat is generated. This causes the belt to slip.

To keep the belt supple and free from cracks, belt dressing is applied. Tallow or powdered resin are good dressing materials which are applied on the inner face of the belt. This improves the gripping property of the belt.

Open belting (Fig 2) calculation

Fig 2

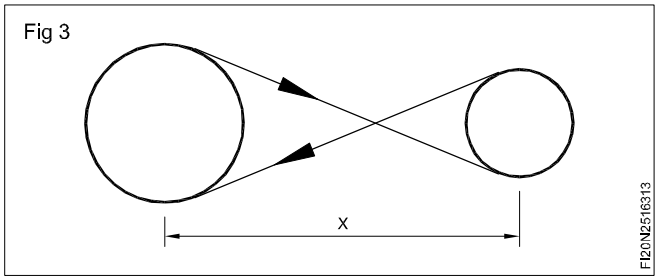


If L = length of open belting
D = dia. of larger pulley
d = diameter of smaller pulley
x = centre distance between the pulleys

$$\text{then, } L = \frac{D + d}{2} \times 3\frac{1}{7} + 2x$$

Cross-belting (Fig 3)

Fig 3



If L_C = length of cross-belting
C = circumference of larger pulley
c = circumference of smaller pulley
R = radius of larger pulley
r = radius of smaller pulley
x = centre distance between the pulleys

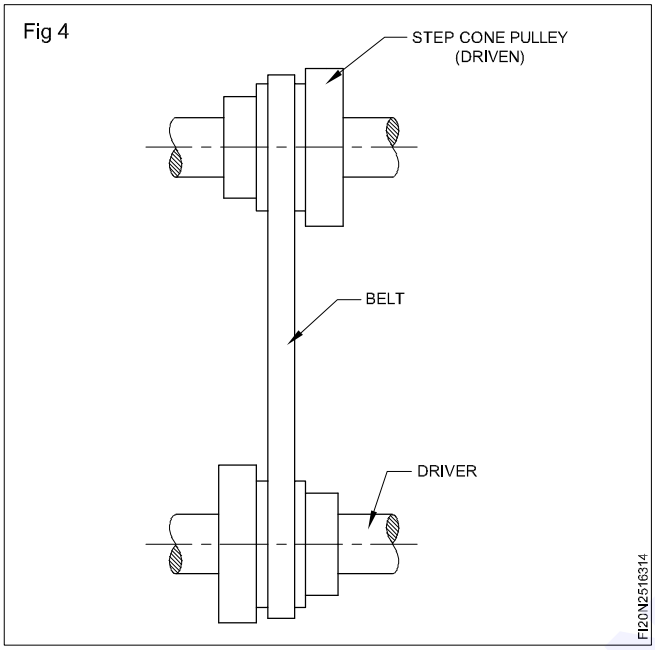
then, $L_c = \frac{C}{2}+\frac{c}{2}+2\sqrt{x^2+(R+r)^2}$

stepped drives (Fig 4)

Stepped drives are used to obtain different speed ratios. Pulleys of different sizes are employed.

Three different speeds can be obtained by changing the belt position from one step to another.

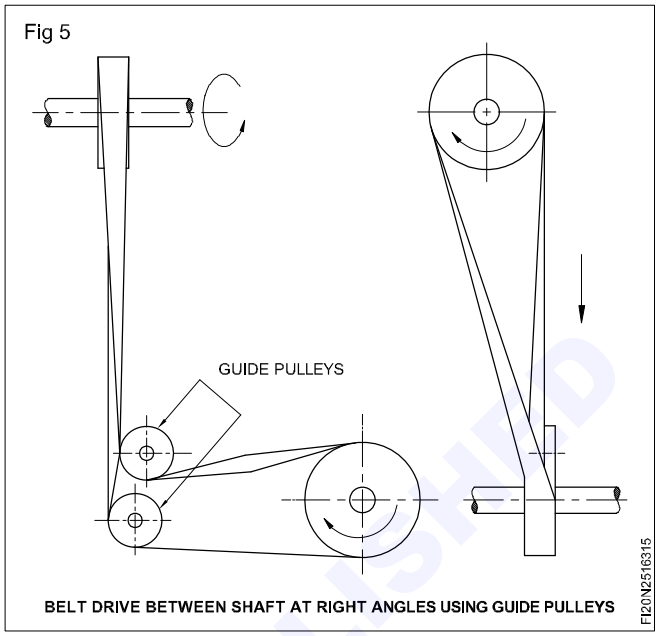
Fig 4



Right angled drive (Fig 5)

This drive is employed between shafts at right angles using tide pulleys. In this the horizontal drive is converted into vertical drive with the help of the guide pulleys.

Fig 5



BELT DRIVE BETWEEN SHAFT AT RIGHT ANGLES USING GUIDE PULLEYS

Couplings - Types of couplings

Objectives : At the end of this lesson you shall be able to
- **state the types of couplings**
- **state the purpose of couplings.**

Introduction

Power is transmitted from one end to the other com monly by means of shafts

If the distance between the two ends is large (say 8- 10 m), it would be inconvenient and expensive to have one such long length of shaft both from manufacturing and transport point of views.

Hence, it is recommended to connect a number of pieces by means of suitable couplings to transmit power from on end to the other.

Types

Shaft couplings may be broadly classified as:

1 Rigid or fast coupling

2 muff coupling

3 Flange coupling

4 Flexible coupling

5 Pin bush coupling

6 Chain coupling

7 Gear coupling

8 Spider coupling

9 Tyre coupling

10 Grid coupling

11 Old ham coupling

12 Fluid coupling

13 Universal coupling

1 Rigid or fast coupling

This type of couplings provide rigid connection between the two shafts without permitting any relative motion between them.

The important types of rigid couplings are

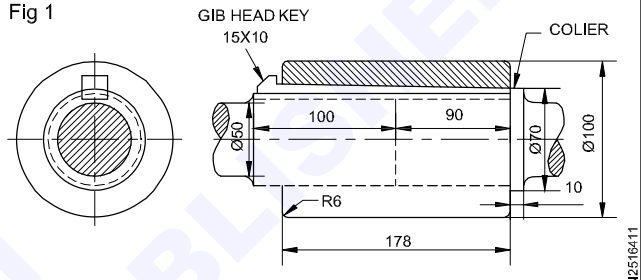
- unprotected type flanged coupling
- protected type flanged coupling
- Solid or forged flanged coupling
- Muff couplings
- Compression coupling

2 Muff coupling

In muff or sleeve coupling shown in fig 1, the ends of the two shafts to be coupled butt against each other and a cast iron muff or sleeve envelops them.

A gib - headed sunk key is provided to hold the sleeve and the shafts together, thus forming a rigid coupling.

Fig 1



MUFF COUPLING

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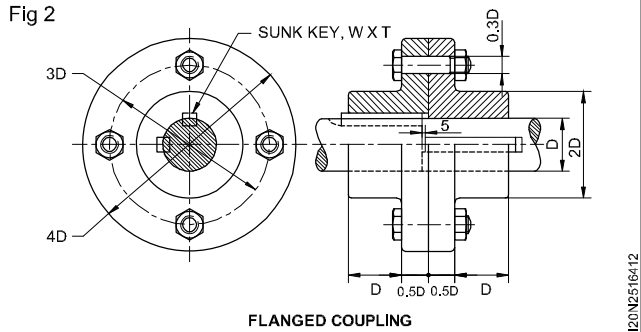
3 Flanged coupling

These are the standard forms of couplings, most extensively used. In a flanged coupling, flanges are either fitted or provided at the ends of shafts. The flanges are fastened together by means of a number of bolts and nuts. The number and size of the bolts depend upon the power to be transmitted and hence, the shaft diameter.

3.1. Flanged coupling with detachable flanges

In this, two flanges are keyed, one at the end of each shaft, by means of sunk keys (Fig 2) For ensuring correct alignment. a cylindrical projection may be provided on one flange which fits into the corresponding recess in the other.

Fig 2



FLANGED COUPLING

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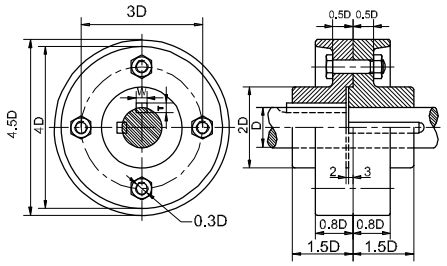
In the design shown in figure, the bolt heads and nuts are exposed and liable to cause injury to the workman. Hence, as a protection, the bolt heads and nuts may be covered by providing an annular projection on each flange. A flanged coupling, using these flanges is called a protected flanged coupling (Fig 3).

Fig 3

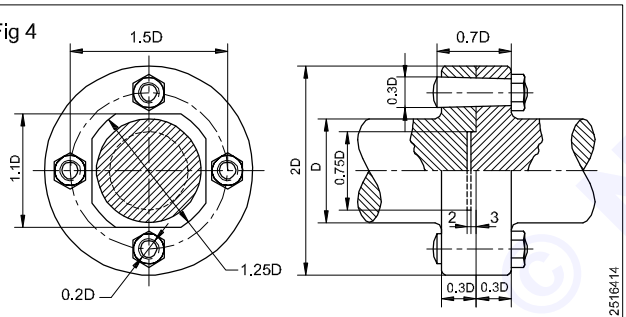


PROJECTIVE FLANGED COUPLING

3.2. Solid flanged coupling

Couplings for marine or automotive propeller shafts demand greater strength and reliability. For these applications, flanges are forged integral with the shafts. The flanges are joined together by means of a number of headless taper bolts (Fig 4)

Fig 4

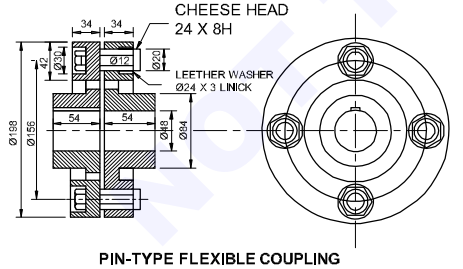


SOLID FLANGED COUPLING

4 Flexible Coupling (Fig 5)

- Flexible couplings are used where slight relative movement is required or the axis of shafts run slightly out of line.

Fig 5



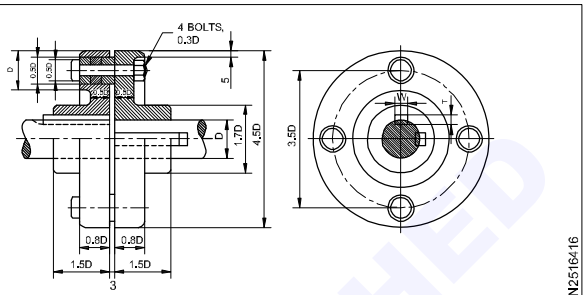
PIN-TYPE FLEXIBLE COUPLING

- Here the motion from one half of the coupling to the other half is imparted with the help of driving pins rigidly bolted to one flange and loosely fitting corresponding holes in the other.
- Brass bush and rubber covering is provided on the driving pins for absorbing shocks and as insulators.

5 Bushed Pin type Flanged Couping (Fig 6)

It is the modified version of a protected flanged coupling. In this, bolts are replaced by bushed pins. The smaller ends of the pins are rigidly fastened by nuts to one of the flanges, while the enlarged ends are covered with flexible material like leather or rubber bushes, in the other flange. The flexible medium takes care of mis - alignment, if any, and acts as a shock absorber. These couplings are used to connect prime mover or an electric motor and a centrifugal pump.

Fig 6

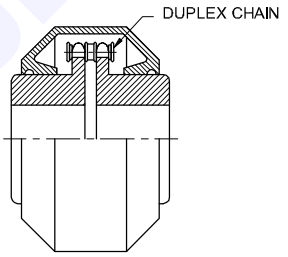


BUSHED PIN TYPE FLANGED COUPLING

6 Chain Coupling (Fig 7)

Flanges replaced a sprocket on each shaft. The coupling is by a duplex chain wrapped over both adjacent coupling.

Fig 7

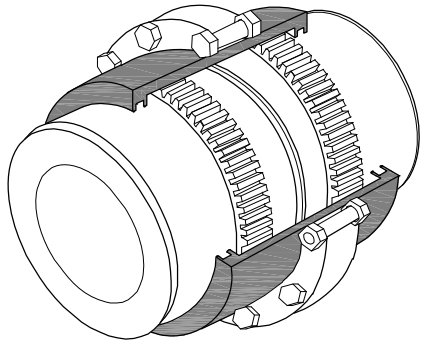


CHAIN COUPLING

7 Gear Coupling (Fig 8)

Both coupling halves have a raised rim machined as an external gear. The sleeve which couples the two shafts comprises two halves bolted together, each half having a machine internal gear. This coupling requires lubrication. The coupling is capable of hgh speeds and high power capacity.

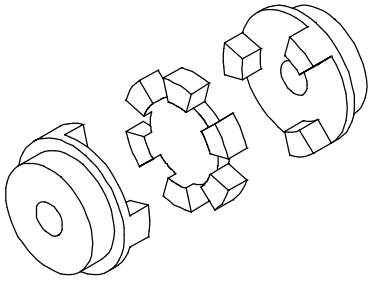
Fig 8



8 Spider (Fig 9)

Both half of the couplings have three shaped lugs. When the coupling halves are fitted together the lugs on one half fit inside the spaces between the lugs on the other side. A rubber insert with six legs fits within the spaces between the lugs. The drive is by the lugs transmitting the torque through the rubber spider spacer. This coupling is only used for low power drives.

Fig 9



SPIDER COUPLING

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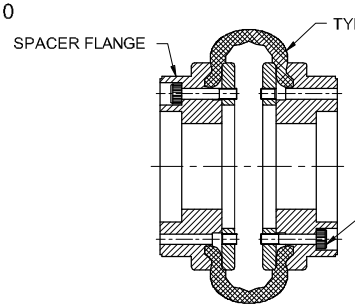
9 Tyre Coupling (Fig 10)

Tyre coupling device is used to reduce vibration in engines and also reduces the torque oscilation. It is available in different versions such as F or H type. And customers can find tyre coupling in various dimensions and in taper lock fitting models. It is applicable in compressors, pumps, blowers. etc.,

Fig 10



TYRE COUPLING

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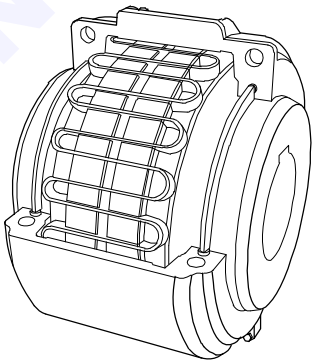
10 **Grid Coupling** (Fig 11)

Metal coupling that provides positive protection against the damaging effects of shock loads and vibration. Both Grid couplings are an excellent choice where torsional flexibility /vibration damping are primary concerns.

Fig 11



FI20N251641B

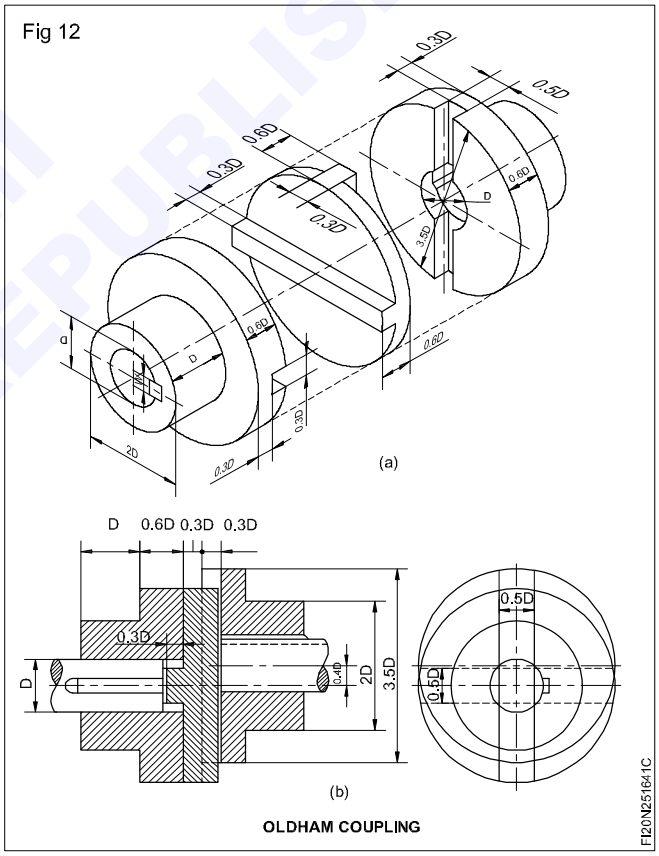
- Easy to assemble/replace
- Part - for - part interchangeable with industry standard grid coupling designs.
- Coupling sizes 2020 through 2140 in - stock in a range of standard bore sizes.
- Shot - peened tapered grid flex element for long llife.

Typical Applications:

- Pumps
- Gear Boxes
- Electric Motors
- Fans/Blowers
- Conveyors
- Compressors

11 Oldham Coupling (Fig12)

Fig 12



OLDHAM COUPLING

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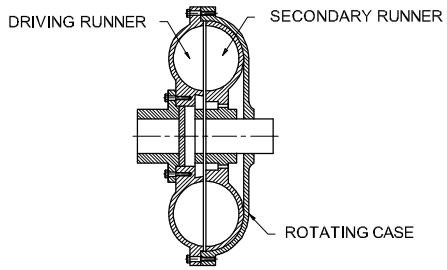
It is used to connect two parallel shafts whose axes are at a small distance apart. Two flanges, each having a rectangular slot,are keyed, one on each shaft. The two flanges are positioned such that, the slot in one is at right angle to the slot in the other.

To make the coupling, a circular disc with two rectangular projections on either side and at right angle to each other, is placed between the two flanges. During motion, the central disc, while turning, slides in the slots of the flanges. Power transmission takes place between the shafts, because of the positive connection between the flanges and the central disc.

12 Fluid Coupling (Fig 13)

Based on both coupling halves having vanes within a housing (case) containing viscous fluid which rotates with the driving shaft. The rotation is transmitted from one side (Driving) to the other (secondary) via the viscous fluid. The coupling provides a soft start.

Fig 13



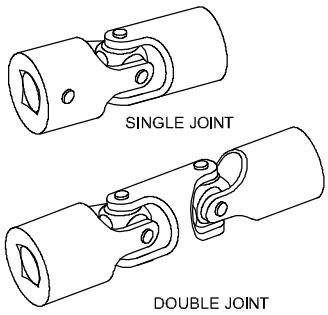
FLUID OUPLING

13 Universal Coupling (Fig 14) (Hooks Coupling)

Coupling which allows large angle between drive halves (20-30°) . Generally based on a yoke mounted on each shaft. Between to yokes in mounted a trunnion cross.

Needle bearings are used at the bearing points between the cross and the yokes. These type or units are used in pairs on carden shafts. Uses widely on rear wheel drive vehicle propshafts.

Fig 14

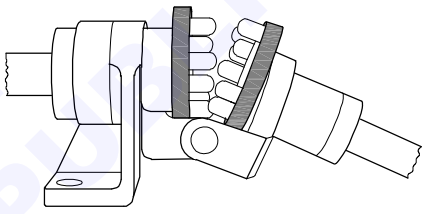


UNIVERSAL COUPLING

14 Universal Coupling - Uni - Joint (Fig 15)

The other name of universal coupling is hook coupling.Simplest type of coupling which allows large angle between drive halves. Each side of coupling includes protruding pins. The halves of the coupling are fastened in a pivotting assembly. At all angles up to about 40° the pins interlock with each other and rotation on one half forces the other half to rotate. Low power use only. Not smooth. Not reliable. Really only suitable for remote manual operations.

Fig 15



COUPLING U-JOINT

Pulleys - types - solid - split and 'V' belt pulleys

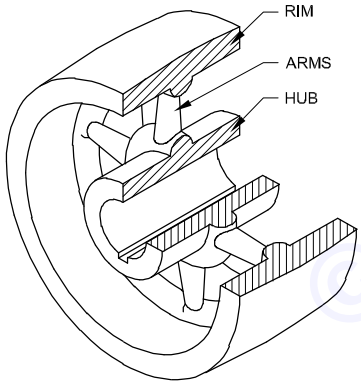
Objectives : At the end of this lesson you shall be able to
- **state the different types of pulleys and their uses**
- **state the purpose of crowning of a pulley**
- **state the importance of wrapping angles in a belt drive**
- **state the maintenance aspects of V belts**
- **state the advantages of a chain drive.**

Pulley for flat belt

Pulleys for flat belts are made from cast iron or mild steel and are available in solid or split form.

The flat pulleys have a wide rim with a crowned surface for retention of the belt. The hub is strongly designed and provides the means of securing the pulley to the shaft. The arms unite the hub and rim into a rigid assembly. The arms of a pulley may be of circular or elliptical cross-section, but larger at the hub than at the rim. (Fig 1)

Fig 1



Crowned face of pulley

The rim of a pulley for flat belt is generally made convex and this is called the crowned face of the pulley. The crown faced pulley will keep the belt centralised even if there is any slight tendency to run off. Shifting the belt from the fast pulley to the 'loose' pulley will be quick and easy. Excessive crowning will be injurious to belting.

'V' groove pulley

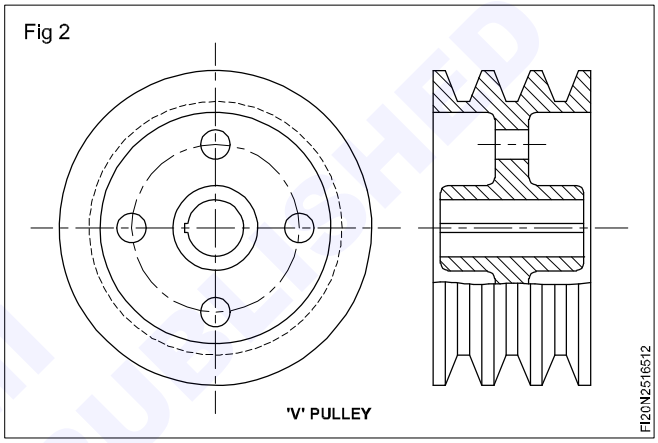
These pulleys have one or more 'V' grooves to carry the V belts. Fig 2 shows a V belt pulley having three V grooves. These pulleys are widely used in transmission of motion in machine tools and are made from cast iron, wrought iron, mild steel or wood.

Fast and loose pulley

Pulleys are usually secured to their shafts by means of a key or grub screw. The function of the pulley keyed to the shaft is to convey rotation from the driving to the driven pulley by means of a belt. This is called a fast pulley.

The loose pulley is not keyed to the shaft and is free to rotate on the shaft.

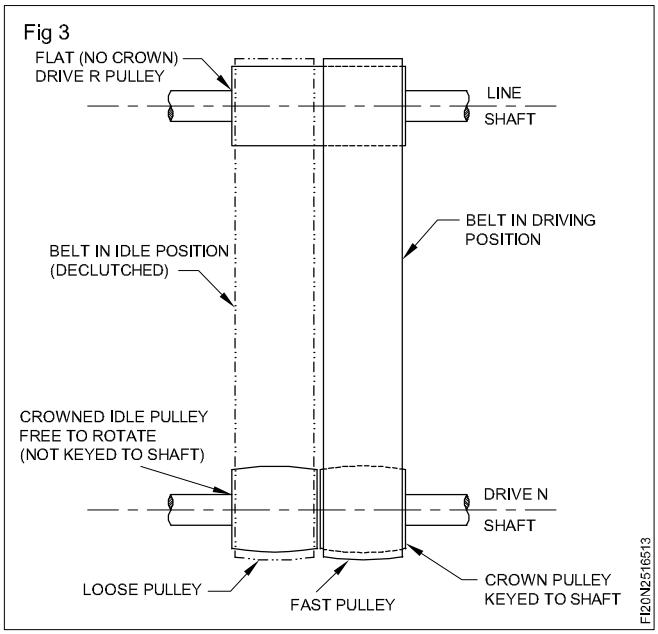
Fig 2



Function

A machine can be easily stopped or started whenever required by the use of a pair of fast and loose pulleys. This pair is mounted on a counter- shaft near the machine to be operated. When the driving belt from the main shaft is on the fast pulley, the countershaft is in motion. If the belt is shifted from the fast pulley on to the loose pulley, the countershaft will stop rotation. Fig 3 shows the position of the fast and loose pulleys in a driving system.

Fig 3



Determining the size of crowning faces of pulley

Objectives: This shall help you to
- **define the importance of crowning**
- **state the specification of standard pulleys.**

Crowning one or several pulleys in belt system is the most common way of tracking a belt. For flat power transmission belts and narrow conveyor belts(up to 8 in.), a radius crown is used. For wider conveyor belts, a trapezoidal crown is typically applied. Note: Never utilize an apex crown!

Radius Crown Specifications for Flat Belt Pulleys

A radius crown represents a great way to track a belt. Dimensionally, it does not take a big crown height in order for the belt to track properly, and exceeding the seemingly small amounts below will actually do more harm than good!

In a system with multiple pulleys, crown the pulleys that turn the same way.

The min. pulley face width

W_p = (belt width W_b x 1.1) + 0.5 in.

The max. belt width

W_b = (pulley face width W_p - 0.5 in) / 1.10

Note:

Fig 1

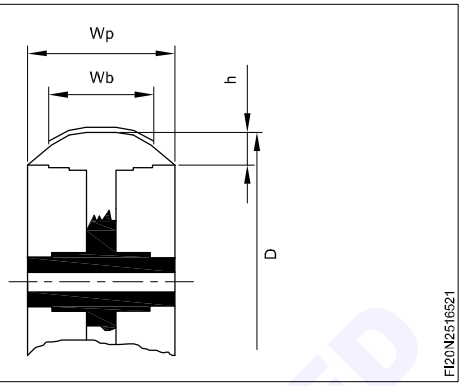
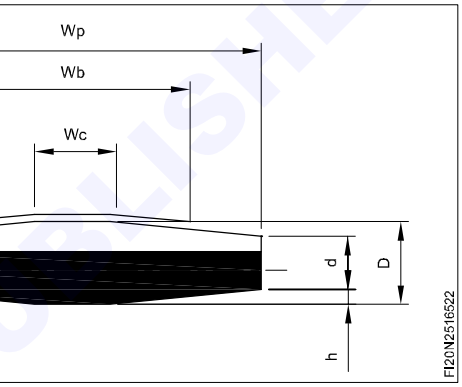


Fig 2



Standard Radius crown heights h						
Pulley Face Width W_P			Pulley Diameter D			
	1 - 6	6 - 12	12 - 18	28 - 40	40 - 60	> 60
in	in	in	in	in	in	in
1 - 5	0.031	0.047	0.051	0.067	0.078	0.098
5 - 10	0.039	0.051	0.059	0.078	0.090	0.110
10 - 16	0.043	0.055	0.063	0.087	0.098	0.118
> 16	0.047	0.059	0.078	0.098	0.118	0.137

Convert to metric units

pulley Diameter D	Crown Height h
1 to 2.75	0.012
2.75 to 4	0.017
4 to 6	0.022
6 to 8	0.026
8 to 11	0.034
11 to 14	0.042
> 14	0.045

The cylindrical part of the pulley W_c is half of the belt width W_b. Also, it is recommended for the pulley width w_b for the pulley crown to function properly. For pulley widths less than 8 in., use a radius crown and refer to the flat belt pulley specifications above.

Belt length

Objective: At the end of this lesson you shall be able to
- **Calculate the length of the belt for open belt drive.**

In belting technology, there are a few special expressions and technical data which need a brief explanation.

Belt length

The length of power transmission flat belts can be expressed in three ways:

- Geometric belt lenght (l_g)
- Effective belt length (l_{eff})
- Shortened belt lenght (l_s)

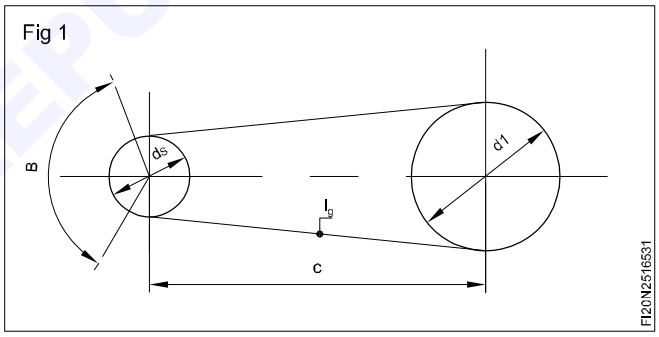
For common two pulley drives, the difference between geometric and effective belt length is negliglble. However, in specific applications, e.g. short centre distance and / or relatively thick belts, limited take -up etc., greater calculation accuracy is necessary.

Please note that the theoretical considerations below are automatically taken into consideration when using the POWER - SeleCalc calculation program.

Geometric belt length (l_g)

The geometric belt length means the inner circumference of an un-tensioned belt drive on the assumption that the belt is infinitely thin. The belt thickness and the position of the neutral layer are not considered.

Fig 1



Exact formula for the calculation of the geometric belt length of a two pulley drive:

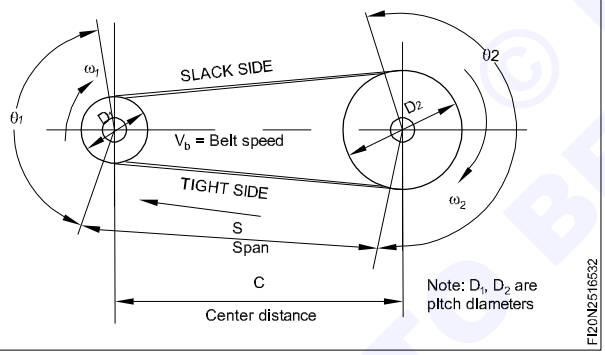
$$lg = 2_c \sin(\frac{\beta}{2}) + \frac{\pi}{2}\left[d_S\ d_l + \frac{(d_{l\_} d_S)(180 - \beta)}{180} \right] (mm)$$

c = center distance (mm)

d_s = diameter of small pulley (mm)

According to SANS 1669 Bag centre	Belt Face 1350	900 1050 1700	1050 1200 1850	1200 1350 2050	1350 1500 2300	1500 1700 2450	1650 1850 2600	1800 2000 2900	2100 2300 3200	2400 2600
Pulley Diameter	Shat Dia Pulley Dia				Resultant tensions (KN)					
200	100/315	21	18	16	13	10	10	9	8	7
250	110/400	30	26	23	19	16	14	13	12	10
315	120/400	45	37	33	27	22	20	19	16	14
400	130/400	60	51	45	37	30	28	26	22	19
500	140/500	80	70	60	50	41	37	35	30	75
630	150/500	100	90	80	66	54	49	45	40	35
800	160/500	119	119	105	86	70	64	60	50	45
1000	170/630	144	144	133	110	88	81	75	65	55
1250	180/630	170	170	165	138	112	100	95	82	70
	190/630	200	200	200	170	138	130	120	100	90

Fig 2 BASIC BELT DRIVE GEOMETRY



d_l = diameter of large pulley (mm)

β = arc of contact on small pulley [°]

$$\beta = 2\arccos\frac{(d_l - d_s)}{2c} = [°]$$

- The belt is placing around the two sheaves while the center distance between them is reduced, then sheaves are moved apart
- Friction causes the belt to grip the driving sheave, increasing the tension in one side, called the “tight side”, of the drive
- The opposite side of the belt is still under tension (at a smaller value) that is called the ‘slack side’.

Clutches and types

Objectives : At the end of this lesson you shall be able to
- **state the function of clutches**
- **name the different types of clutches**
- **state the application of the different types of clutches.**

Power transmission by clutches

The purpose of the clutch is to connect or disconnect the various mechanisms to the power source. Various types of clutches are incorporated in machine tools.

Types of clutches

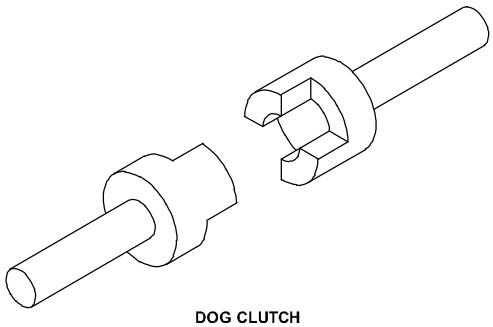
- Dog clutch
- Cone clutch
- Multi-plate clutch
- Electromagnetic multiple disc clutch.
- Air clutch
- Centrifugal clutch

- Overriding clutch
- Single plate clutch

Dog clutch (Fig 1)

The dog clutch provides a positive drive but can only be engaged when two elements of the clutch are stationary or are being gently moved by hand.

Fig 1



DOG CLUTCH

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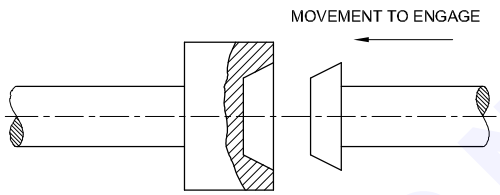
Cone clutch (Fig 2)

The cone clutch can be engaged progressively whilst one or both of the elements are rotating. It can transmit low power.

Fig 2



THE CONE CLUTCH

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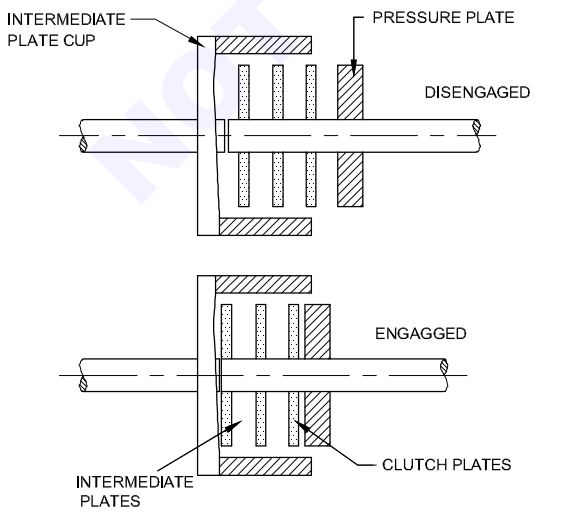
Multi-plate clutch (Fig 3)

The multi-plate clutch is widely used in machine tools to connect the transmission gearbox to the driving motor. It is compact, smooth in operation and very powerful. A brake is frequently built into the clutch so that the transmission gearbox is rapidly brought to rest when the clutch is disengaged.

Fig 3



TRANSMISSION CLUTCHES

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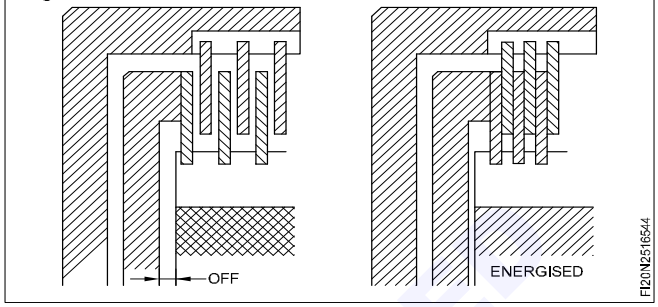
Electromagnetic multiple disc clutch (Fig 4)

This clutch joins the shaft and the gear. It can be operated through a cable from a distance. If direct current is applied, it builds a magnetic field on a magnetic coil. It flows through the discs and firmly pulls and attracts the armature disc. The armature clamps the plates together so that they transmit the drive.

Fig 4



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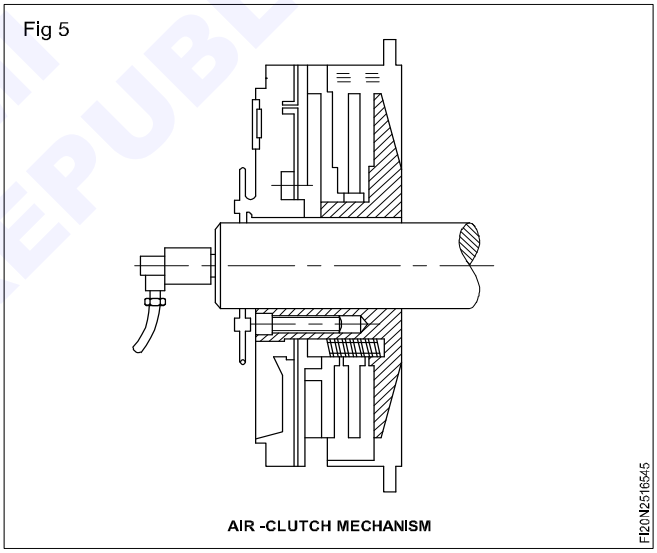
Air clutch (Fig 5)

An air clutch requires no mechanical adjustment since the moving parts automatically take up any wear on the friction surface. Air pressure must be maintained continuously while the clutch is engaged.

Fig 5



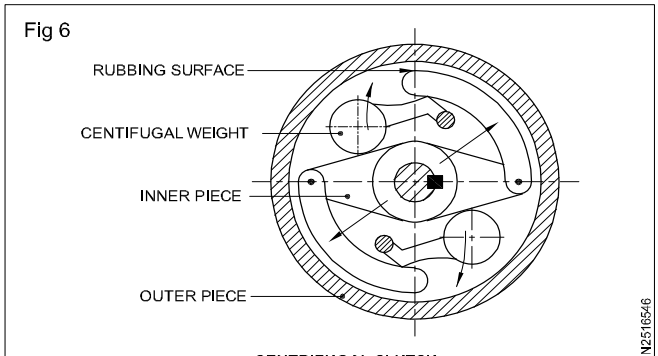
AIR -CLUTCH MECHANISM

FI20N25216545

Centrifugal clutch (Fig 6)

When the inner piece has achieved a sufficiently high speed, the centrifugal weights swivel towards the outside, press the jaws on the outer piece with the friction lining and the clutch is closed. When the speed is reduced, the clutch opens by itself. Eg. moped.

Fig 6



CENTRIFUGAL CLUTCH

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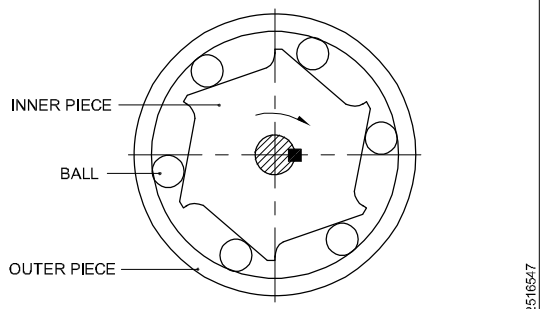
Overriding clutch (Fig 7)

When the inner piece has to be faster the overriding clutch transfers the turning moment by the climbing of balls or the cylindrical rollers. It opens in the opposite case.

Fig 7

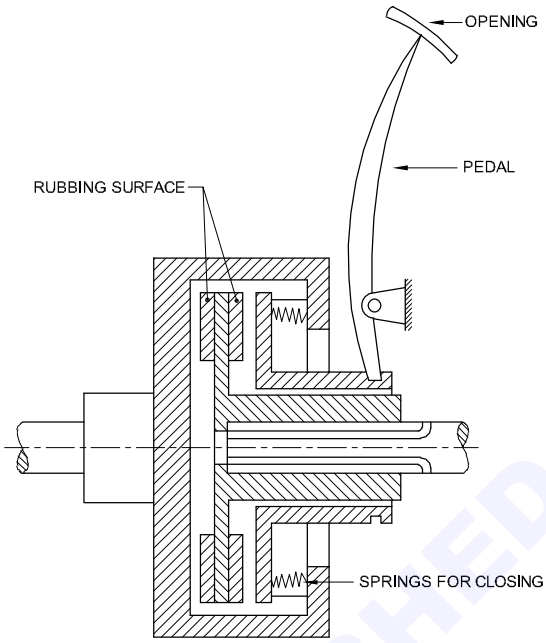


OVER -RIDING CLUTCH

Single plate clutch (Fig 8)

This is used in automobile vehicles. The rubbing surface is covered with friction lining of asbestos/plastic/cotton, with steel wires. The contact force is produced by springs which effect the continuous closing of the clutch. The pedal force acts against the spring force and opens the clutch.

Fig 8



SINGLE PLATE CLUTCH

Chain and wire rope for power transmission

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

- **state the uses of rope drives**
- **list the materials of rope**
- **state the purpose of jackey pulleys**
- **state the uses of chain drive**
- **list the advantages of chain drive.**

Ropes and rope drive

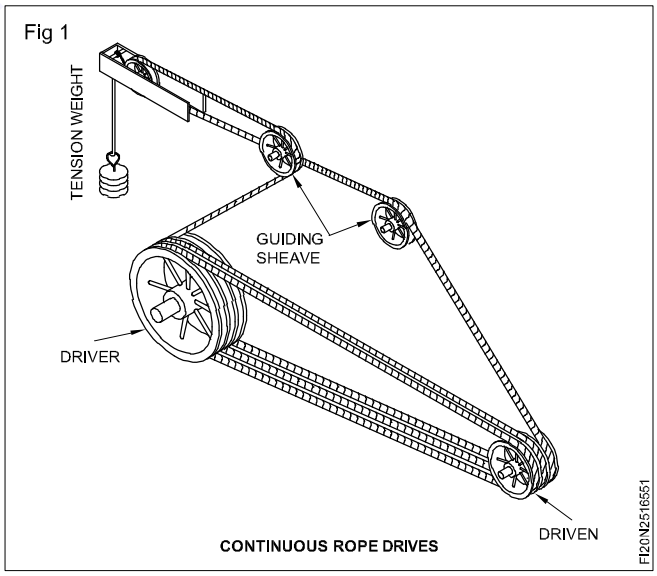
The ropes are made from cotton, hemp, manila, synthetic jute, steel wire, etc.

Rope drives are used for long distance and for large amounts of power transmission. The rope drives are mainly employed in mining and textile industries. Rope drives can be employed when there is a misalignment between the pulleys within limits and in fluctuating temperature and humidity conditions. Fig 1 shows a continuous rope drive in which a single rope passes over the sheaves several times, and the slackness being taken up by a tension carriage.

Wrapping angle of pulley

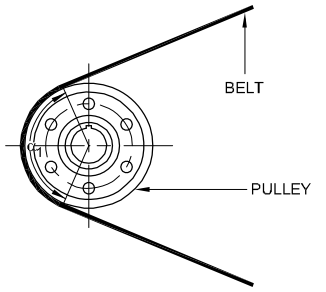
Fig 2 and 3 illustrate the contact area of the belt and wrapping angle. If the wrapping angle is big, the pulley can transmit high torque. If the contact area and wrapping angle is less, it can transmit low torque.

Fig 1



CONTINUOUS ROPE DRIVES

Fig 2



WRAPPING ANGLE IS SMALL (α_1)

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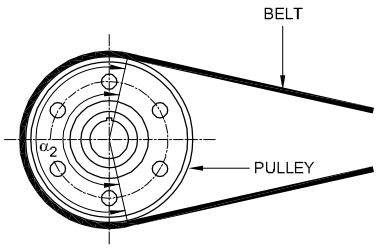
Fig 3



WRAPPING ANGLE IS LARGE (α_2)

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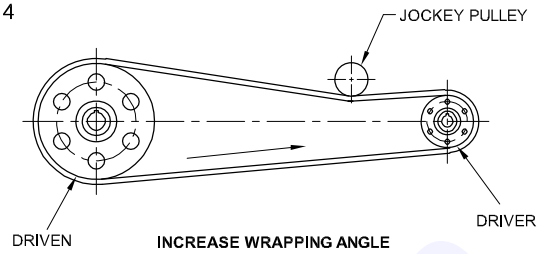
Jockey pulley

The contact surface between the belt and the pulley is increased by providing a jockey pulley which increases the wrapping angle and transmits high torque.

The jockey pulley should be put on the slack side of the belt near the driving pulley. (Fig 4)

Fig 4



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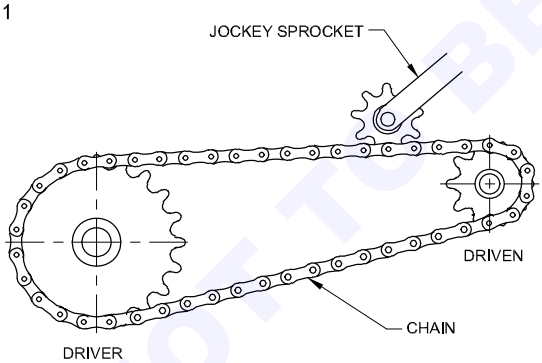
Chains and sprockets

Objectives : At the end of this lesson you shall be able to
- **state the advantages of chains drives**
- **state the use of a jockey sprocket**
- **state the types and specifications of chains**
- **brief the maintenance features of the chain drive.**

Chain drive (Fig 1)

Fig 1



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Chain drives are used for transmission of motion at constant velocity ratio without creep and slippage. Chains are used in conjunction with sprocket pinions and sprocket wheels. Chains and sprockets are available in both british and metric standards. The sprockets are generally keyed to the shafts.

Advantages of a chain drive

- Positive contact between the chain and the drive sprockets eliminates the possibility of slips.
- Has a wide range of driving power.
- Can be used where there is a large distance between the driving and driven shafts.
- Useful for low speed and high torque transmissions.
- Can absorb shocks.
- Chain drives are compact.
- Chain drives withstand heat, dirt and weather exposure when properly lubricated.

Jockey sprocket (Fig 1)

A spring-loaded jockey sprocket can be used to tension a chain which transmits the drive between the sprockets with fixed centres.

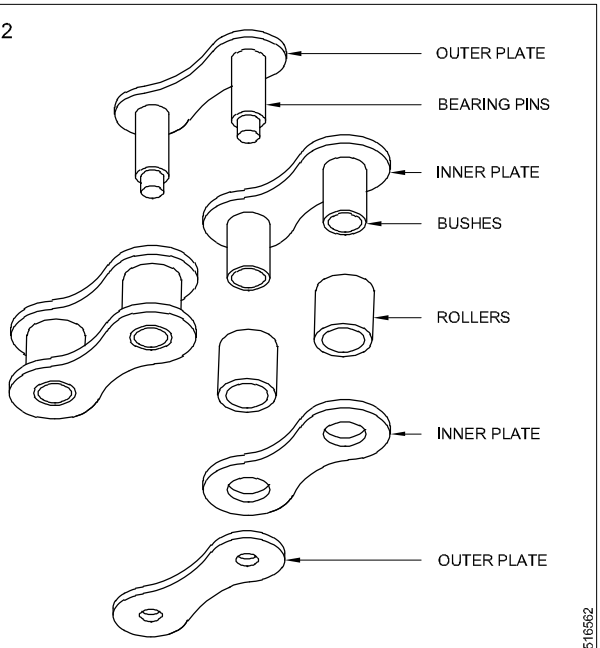
Types of chains

There are many types of chains but follow two types are commonly used.

- Roller chain
- Toothed chain

Roller chain (Fig 2)

Fig 2



COMPONENT PARTS OF A SIMPLE ROLLER CHAIN

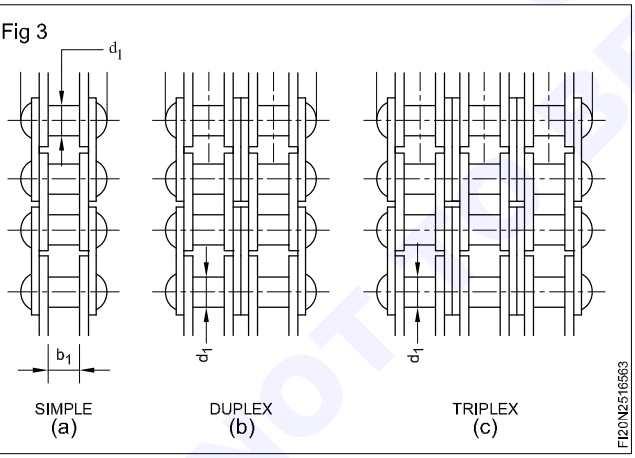
Rollers are housed between the connecting links and rotate freely on the bush. The bush is pressed in the holes of internal link and can rotate about the pin.

a. Single roller type chain is called a Simplex chain. (Fig 3a)

b. Double roller type chain is called a Duplex chain. (Fig 3b)

c. Triple roller type called a Triple chain. (Fig 3c)

Fig 3



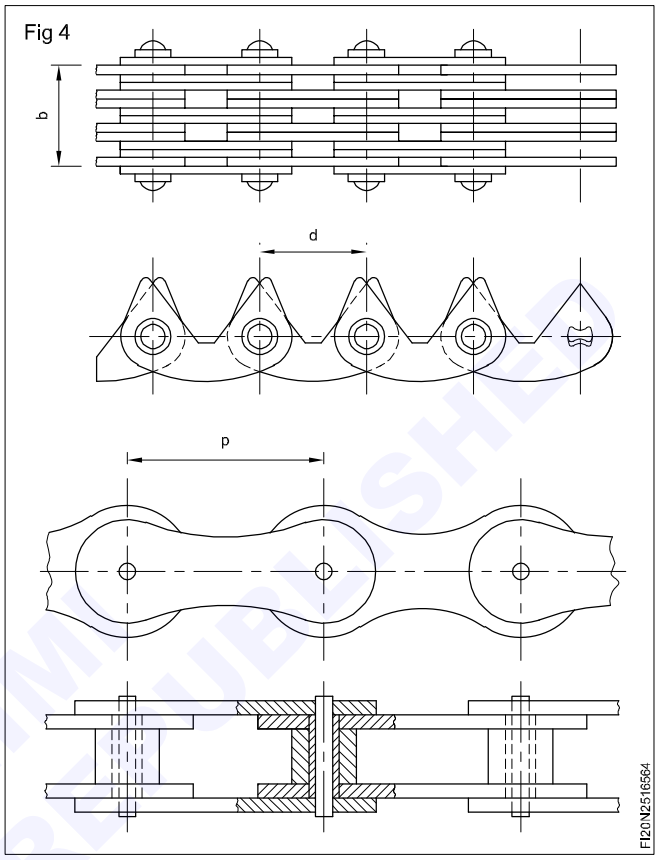
Toothed chain or silent chain

These chains are provided for noiseless and uniform drive. It consist of a row of toothed links connected through bushes.

Chain specification

Chains are specified by the pitch. For roller chains pitch is the distance between the centre-to-centre of adjacent pins. Width refers to normal width of the link measured within the side of the plates. Diameter means the actual outside diameter of the roller. (Fig 4)

Fig 4

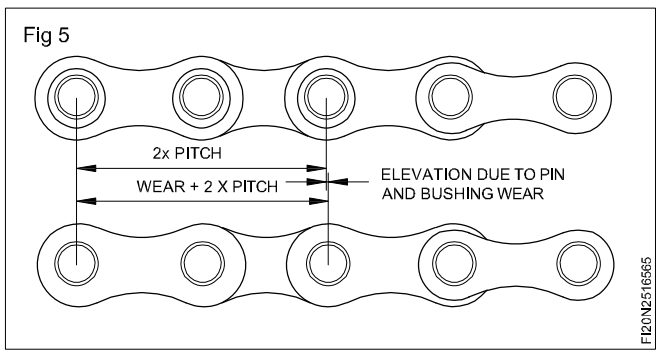


ISI 2403-1975 gives the specifies dimensions for standard chains of different diameters.

Maintenance features for chain drive

- Check alignment periodically and rectify if necessary.
- Inspect the chain for elongation. Excess clearance at point signifies elongation as shown in fig 5. The chain should be replaced as excess elongation spoils the sprocket.

Fig 5



Elements of spur gear

Objectives : At the end of this lesson you shall be able to
- **state the basic elements of a spur gear**
- **calculate spur gear tooth proportions with the given data.**

Spur gear elements

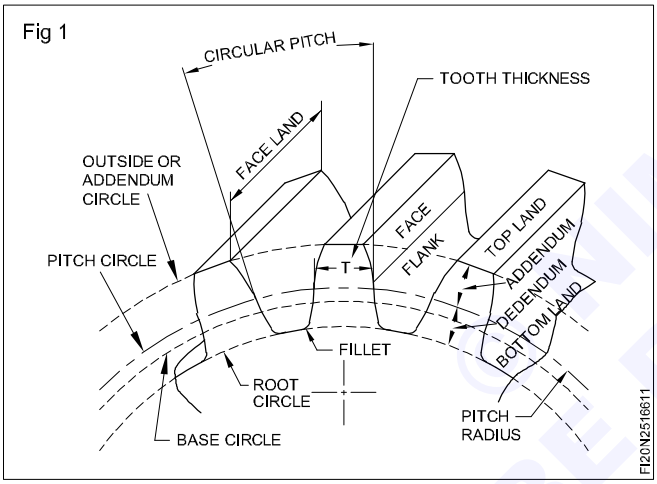
A spur gear is the simplest form of gears. The tooth proportions of the spur gears are expressed in terms of modules.

Module

It is defined as the ratio of the pitch diameter to the number of teeth of a gear. The module is denoted by the letter 'm' and is expressed in millimetres. The module is one of the major determining parameters of a gear.

Basic Elements (Fig 1)

Fig 1



Pitch circle

It is the imaginary circle on which two mating gears seems to be rolling.

The gear calculations are based on this circle.

Circular pitch: 'CP or 'P'

It is the distance from the point of one tooth to the corresponding point of the adjacent tooth measured on pitch circle.

Pitch circle diameter (PCD)

The diameter is called pitch circle diameter (PCI) or simply pitch diameter.

It is denoted by the letter 'd' with proper subscripts *eg.* d1 for pinion and d2 for the matting gear.

Addendum circle

Addendum circle or outside circle bounds the outer edges of the teeth of a gear and its diameter is denoted by 'da'.

Root circle

The root circle or dedendum circle bounds the bottom of the teeth and its diameter is denoted by 'df'.

Base circle ('db')

This is the circle from which the involute tooth profile is developed. Its diameter is denoted by db.

Addendum (ha) (Fig 2)

It is the radial distance between the pitch circle and the addendum circle and is denoted by ha.

Dedendum (hf) (Fig 2)

It is the radial distance between the pitch circle and the root circle, and is denoted by hf.

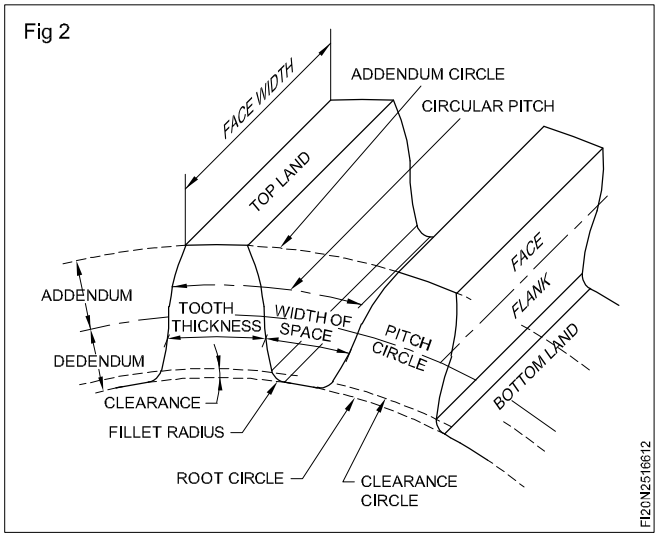
Land (Fig 2)

The land and the bottom land are surfaces at the top of the tooth and the bottom of the tooth space respectively.

Working depth (Fig 2)

This is the distance of engagement of two mating teeth and is equal to the sum of addendums of the mating teeth of the two gears in the case of standard systems and is expressed as '2ha'.

Fig 2



Velocity ratio of gear train

The gear train transmits motion without slip.

Different speeds can be obtained by shifting gear position in the gear- box. Fig 3 shows the feed change by swivelling and sliding the swivel arm in the Norton gearbox of lathes.

Formula for velocity ratio of gear train

$N_1 T_1 = N_2 T_2$

where

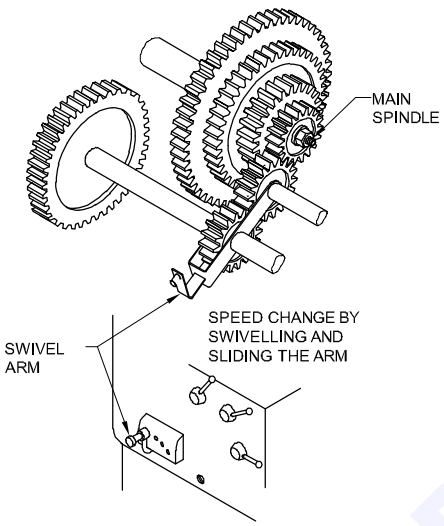
N_1 = RPM of driver gear

T_1 = number of teeth in the driver gear

N_2 = rpm of the follower/driven gear

T_2 = number of teeth in the driven gear.

Fig 3



Types of gears

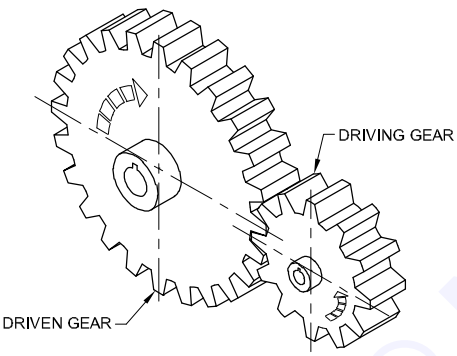
Objectives : At the end of this lesson you shall be able to
- **state the purpose of gears**
- **name the most common forms of gears and state their uses**
- **determine the velocity ratio of a gear train**
- **state the care and maintenance of gears.**

Purpose of gears

Gears are used to transmit torque/motion from the driving shaft to the driven/follower shaft:

- to change the velocity ratio
- to change the direction of rotation. (Fig 1)
- to get a positive drive.

Fig 1



Gears are made from cast iron, steel, non-ferrous, plastic or fibre material.

Types

Spur gear

The teeth are cut parallel to the axis of rotation. The spur gears are used to transmit power between two parallel shafts.

Fig 2 shows two spur gears mating each other and Fig 3 illustrates the application of gears in the centre lathe to transmit motion from the main spindle to the lead screw.

Helical gear

In a helical gear, the teeth are cut at an angle to the axis of rotation. It may be used to transmit power between two parallel shafts. Helical gears run more silently than a spur gear.

Fig 4 shows a set of helical gears mounted on two parallel shafts. These are widely used in automobile vehicles. The application of helical gears in an oil pump is illustrated in Fig 5.

The end thrust is exerted by the driving and driven gears in the case of helical gears and the thrust may be eliminated by using double helical gears. These gears are called herring-bone gears. (Fig 6)

Fig 2

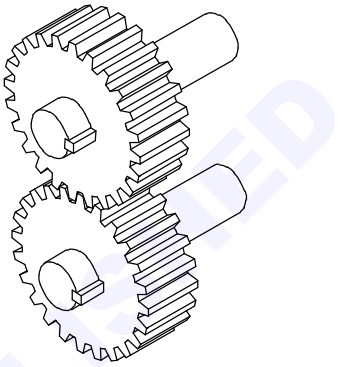


Fig 3

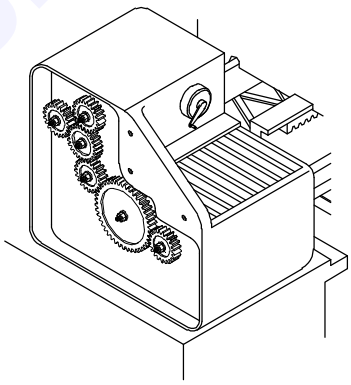


Fig 4

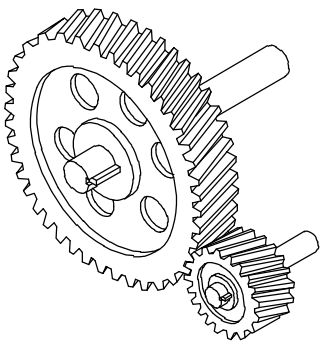
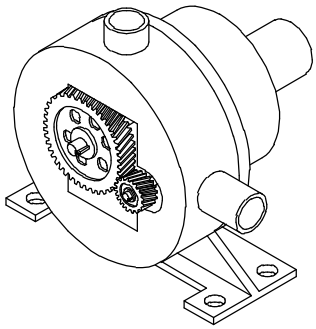


Fig 5



HELICAL GEARS

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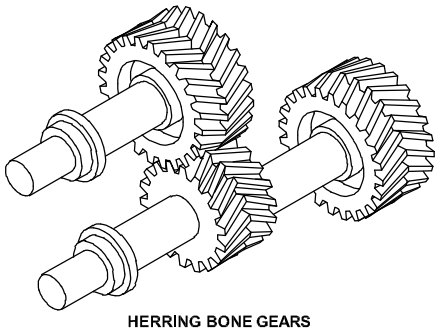
Fig 6



HERRING BONE GEARS

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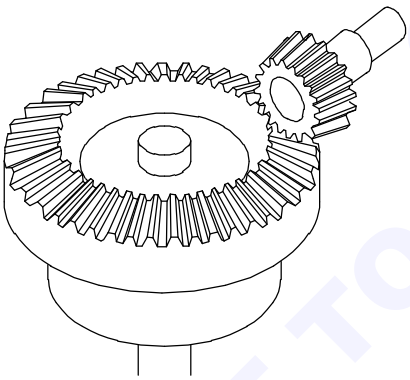
Bevel gear

The bevel gears shown in Fig 7 are used to transmit motion between shafts at various angles to each other. The teeth profile may be straight or spiral.

Fig 7



BEVEL GEAR

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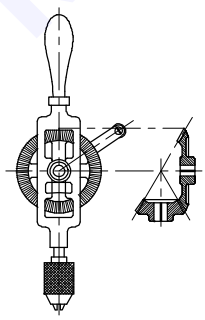
In a hand driller, the bevel gears transmit motion when the shafts are at right angles to each other. (Fig 8)

Fig 8



BEVEL GEAR

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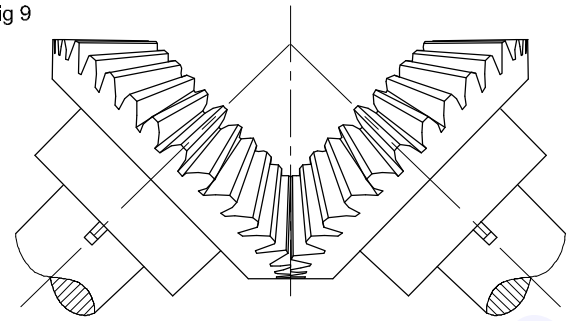
Mitre gears

If two bevel gears are symmetrical to each other and transmit motion at right angles, such gears may be called ‘mitre gears’. (Fig 9)

Fig 9



MITRE GEARING

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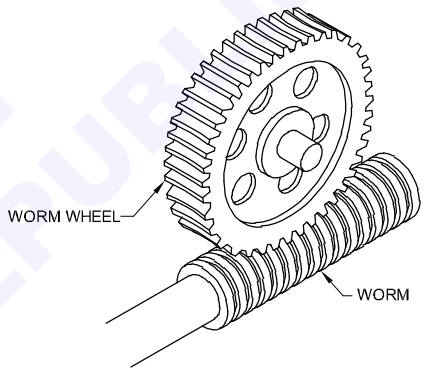
Worm shaft and worm gear

The worm shaft has spiral teeth cut on the shaft and the worm wheel is a special form of gear teeth cut to mesh with the worm shaft. (Fig 10)

Fig 10



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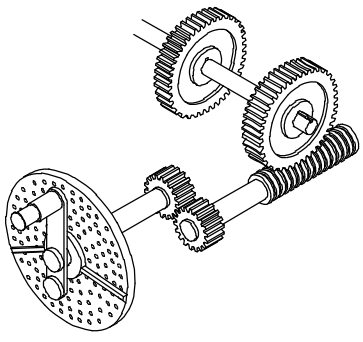
These are widely used for speed reduction purpose.

The application of worm and worm gear in the index-head gear mechanism is shown in Fig 11.

Fig 11



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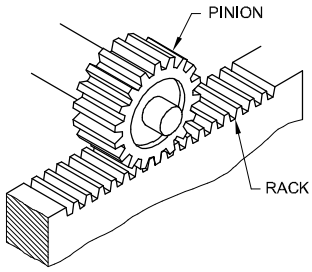
This system transmits motion at right angles to the axis of motion at different planes.

Rack and pinion

The rack and pinion can change rotary into linear movement and vice versa. (Fig 12)

Fig 12



This mechanism is used in drilling machines as illustrated in Fig 13.

Fig 13

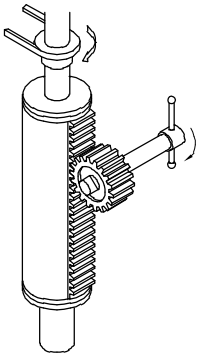
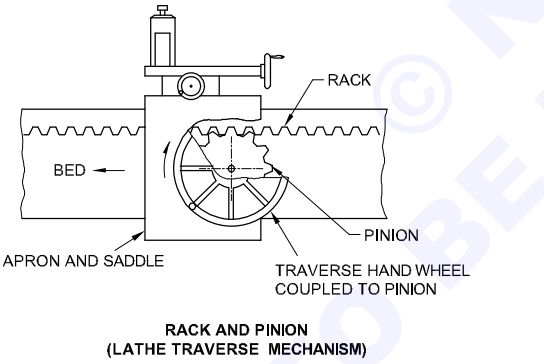


Fig 14 shows the application of the rack and pinion in lathe traverse mechanism.

Fig 14



Hypoid gears

The hypoid gears are used in automotive differential gearboxes. A pair of hypoid gears (illustrated in Fig 15) is similar to the spiral bevel gear but with the shafts offset. The tooth action between each gear is a combination of rolling and sliding action along a straight line. The pitch surfaces are hyperboloids of revolution; as such the gears are called hypoid gears.

Velocity ratio of gear train

The gear train transmits motion without slip.

Different speeds can be obtained byshifting gear position in the gear- box. Fig 16 shows the feed change by swivelling and sliding the swivel arm in the Norton gearbox of lathes.

Fig 15

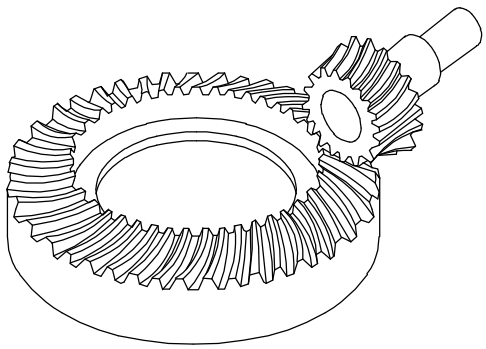
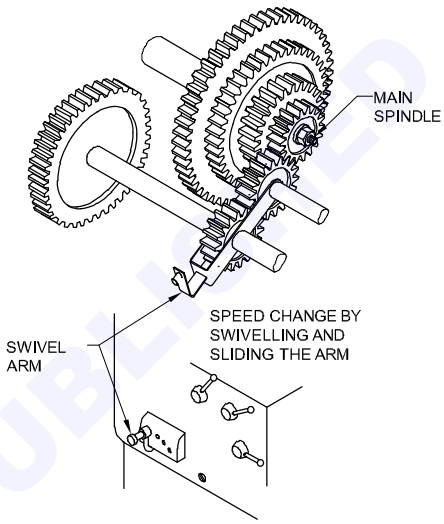


Fig 16



Velocity ratio of worm gear

It is the ratio of number of turns of the worm to 1 turn of the worm wheel.

$$\text{Speed ratio} = \frac{z2}{z1}$$

Where z2 = Number of teeth on the worm wheel.

Z1 = Number of starts on the worm.

Methods of machining worm

- On a centre lathe
- On a worm milling machine
- On a gear hobbing machine

Methods of machining a wormwheel

- On a milling machine
- On a hobbing machine

Repair broken gear tooth (Dovetail blank method)

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

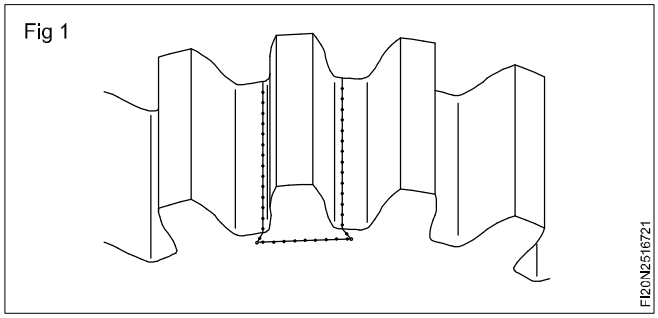
- **repair broken gear tooth by dovetail method.**

Support the gear against a Vee block and clamp it by parallel camp.

Mark the dovetail groove on the gear wheel form both sides using a venier height gauge and vernier bevel protractor.

Punch the marking lines.(Fig 1)

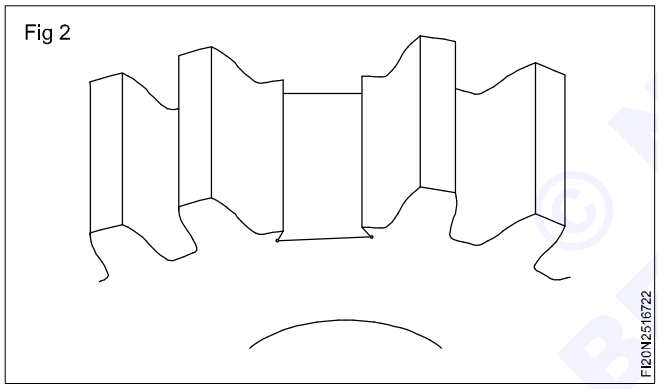
Fig 1



Drill 3mm dia. relief holes one each on the corner of the dovetail.

Remove material from the gear to shape and size of dovetail as per marking. (Fig 2)

Fig 2



File the blank to the profile of the gear tooth as per punch mark.

File the dovetail portion of the blank.

Fit the blank into the dovetail groove of the gear wheel. If necessary,file the blank till it fits in.

Apply Prussian blue on the dovetail groove to check the high spots in the blank piece.

Remove the high spots and make a snug fit in the dovetail groove.

Drill 5.9mm dia. -2 holes up to a depth of 33 mm on the blank and gear wheel in assembled condition.

Ream the holes using a hand reamer.

Dismantle the assembly and remove the chips from the holes of the gear and the blank.

Assemble again and fit the dowel pins in the holes by a slight tapping.

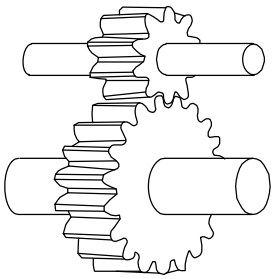
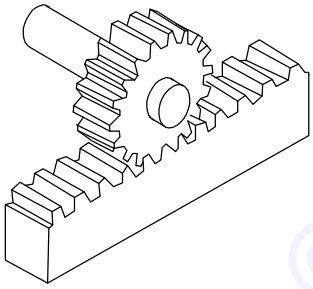
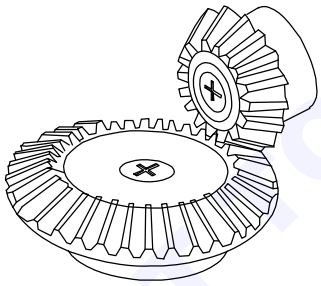
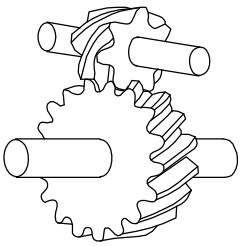
File the profile of the gear tooth to the correct shape.

Use a template to check the profile.

File on the sides of the blank,flush with the gear.

Fixing gear wheel for various purpose drives

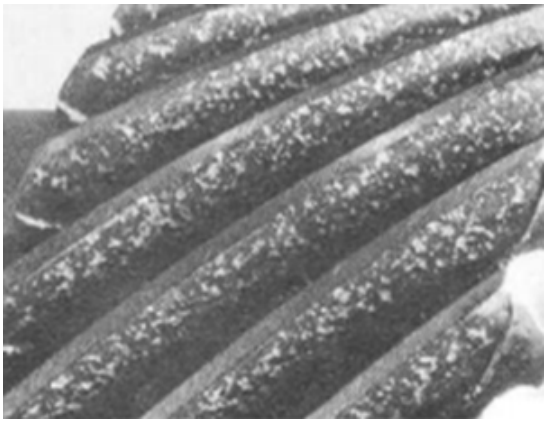
Objectives : At the end of this lesson you shall be able to
- **name the different methods of gear fixing for different drives**
- **list the use of each type gear**
- **state the cause and remedies of gear tooth wear**
- **state the methods of fitting different type gears.**

	**Parallel axes** Transmit power and motion between parallel shafts. Spur gears and helical gears are used. Example: Lathe gear box
	Change the rotary motion into the rectilinear motion and vice versa. A combination of spur gear and rack or a combination of helical gear and helical rack is needed to do work. Example: Dial test indicator
	**Intersersecting axes** Transmit power and motion between intersecting shafts at right (90°) angles. Straight bevel gears or spiral bevel gears are used. Example: Shaping machine table
	**Non parallel, non intersecting axes** Transmit motion and power between nonparallel, nonintersecting shafts that are usually at right angles (90°). Screw gears and worm gear pair are used. Example: Dividing head

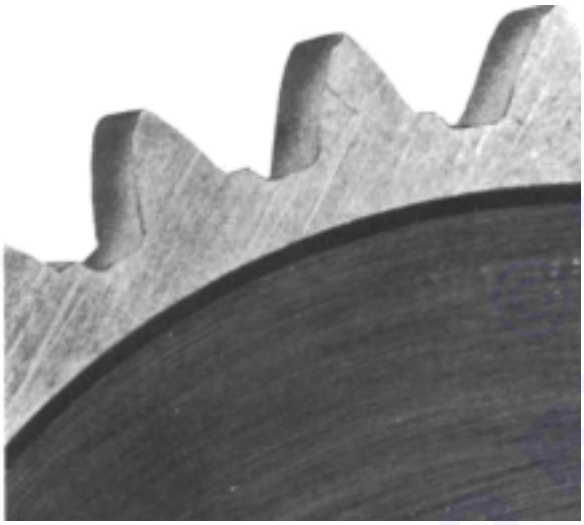
Wear and tear of toothed wheel and their remedies

Wear: A surface phenomenon in which layers of material is removed or "worn away"

Moderate wear



Exessive wear



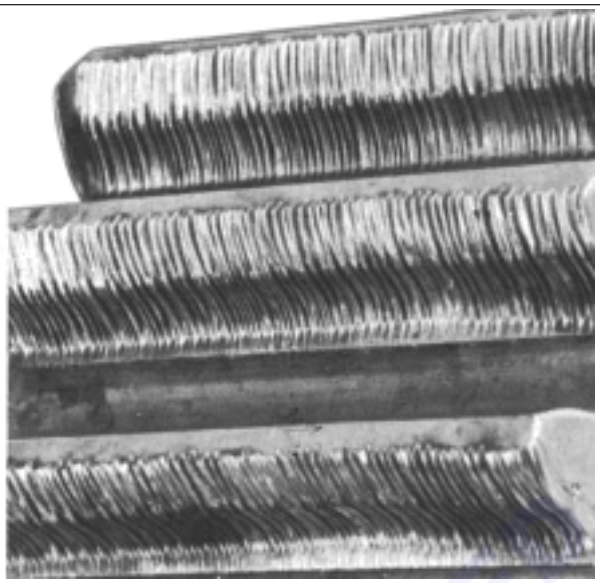
Cause: Wear in progress,in a dequate lubricant film

Remedies: Increasing lubricating film strength, sufficient oil is supplied to working surfaces.

Abrasive wear

Cause: foreign material in the lubrication metallic debris. from the gear.

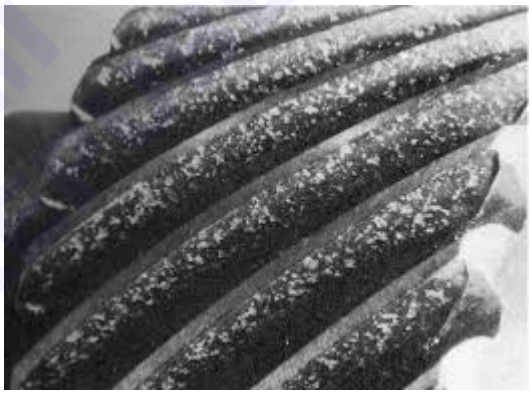
Corrosive wear



Cause: Corrosive elements in oil

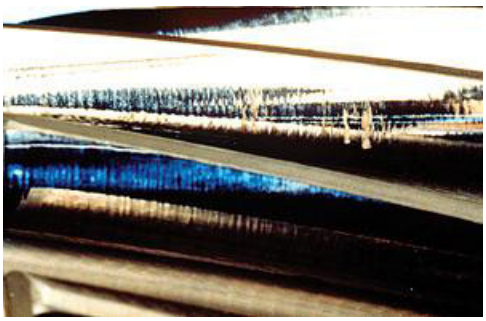
Remedies: Use of filter and use high thick lubricating oil.

Crushing



Causes: Surface irregularities,misalignment of gears.

Remedies: Smooth gear surfaces, reduce dynamic loading limit, keeping the load below the endurance limit.

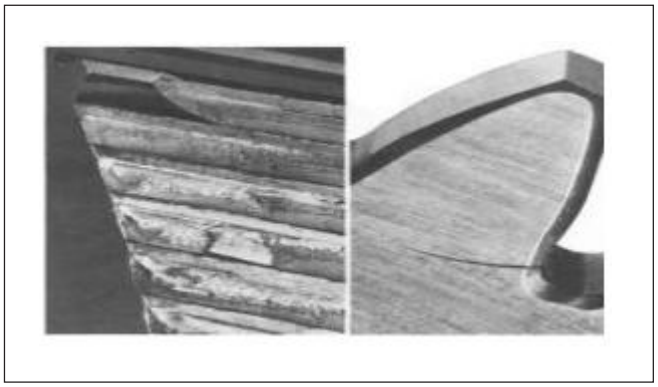


Fracture: Fracture is caused by breakage of whole tooth

Fatigue breakage

Cause: Extreme tooth loads, notches

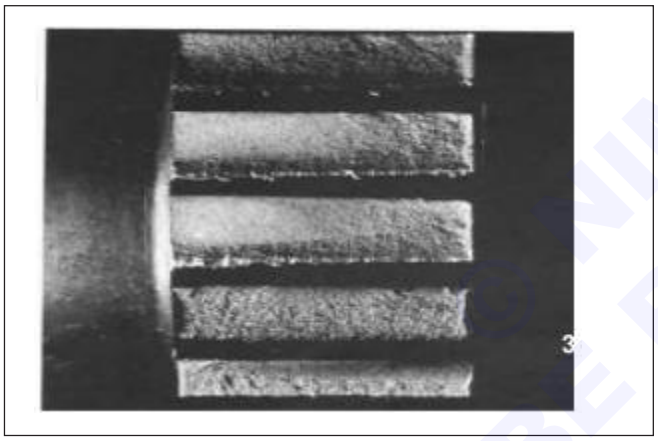
Remedy: Higher strength material,load in with endurance limit



Overload

Cause: Overload which exceeds tensile strength

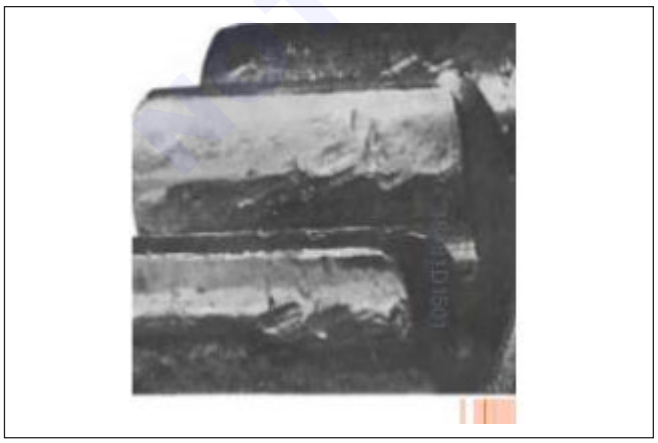
Remedy: Torque limiting overload protectiondevices



Plastic flow: Cold working of tooth surfaces caused by high contact stress.

Cold flow

Causes: Rolling and peening action of much under heavy loads.



Rippling

Cause: Cyclic loads under high contact stresses.

Remedy: Case hardening of tooth surface.

Method of fitting spiral gear, helical gear, bevel gear and worm gear

Worm and worm wheel

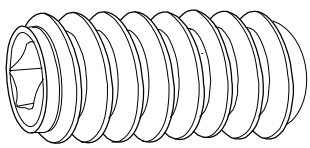
The mounting of worm gears is critical to their implementation. Multiple points of contact are necessary between the drive and gear, so high work loads do not overwork the same lead angle, which could lead to gear failure. Enveloped worm gear sets are normally assembled in the same housing, to ensure proper mating and due to the sets' small footprint.

Consider the gear center, bore diameter and shaft diameter. The gear center can be a bored hole or an integral shaft. The bore diameter is the diameter of the center hole. The shaft diameter is the diameter of the shaft for gears with an integral shaft. Worms and worm gears can be mounted on a hub or shaft. A hub is a cylindrical projection on one or both sides of a worm or worm gear, often for the provision of a screw or other shaft attachment mechanism.Hubless gears are typically attached via press fit, adhesive or internal keyway.

Shaft mounting choices include the following:

Keyway: One or more square cutouts exist in the gear bore for exact mounting on the shaft.

Fig 1



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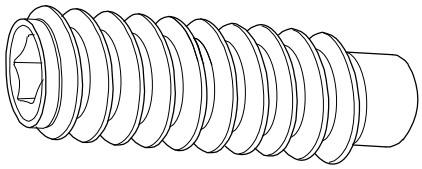
Set screw: The gear is attached to the shaft by screws through the hub.

Fig 2



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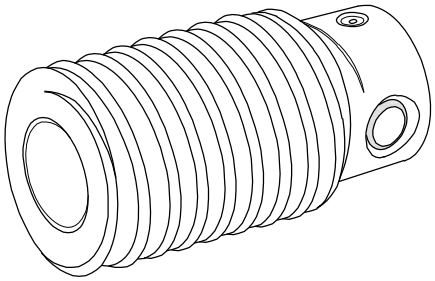
Simple bore: A straight bore designed for adhesive attachment.

Fig 3



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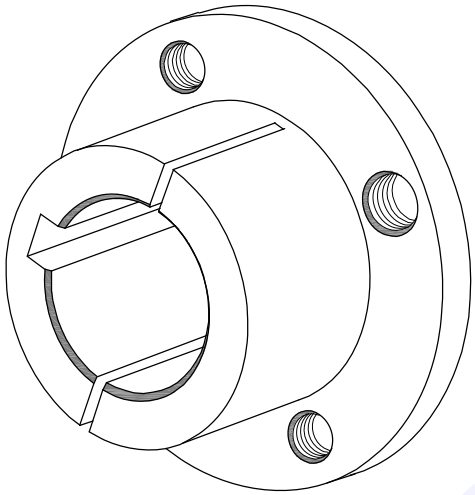
Split: The hub is split into several pieces that are tightened down by a separate clamp to grip the shaft.

Fig 4



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Helical gear

Consider the gear center, bore diameter and shaft diameter.The gear center can be a bored hole or an integral shaft. The bore diameter is the diameter of the center hole. The shaft diameter is the diameter of the shaft for gears with an integral shaft. Helical gears can be mounted on a hub or shaft. A hub is a cylindrical projection on one or both sides of a helical gear, often for the provision of a screw or other shaft attachment mechanism. Hubless gears are typically attached via press fit, adhesive or internal keyway

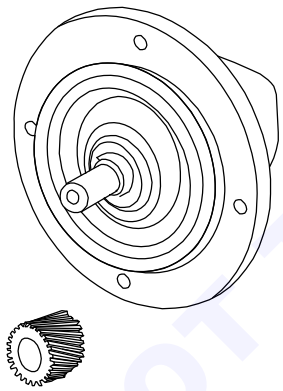
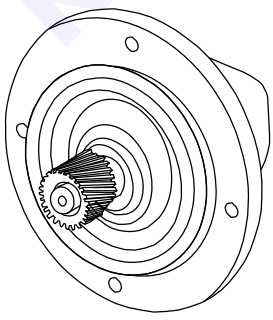
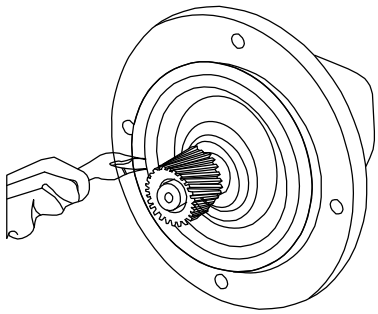
Illustration	Procedure
	• Prepare the input side. • **Important:** The round chamfer on the bore of the pinion must lie in the direction of the shaft shouder.
	Mount the pinion onto the shaft.

Illustration	Procedure
	Fit the retaining ring using the pliers.

Bevel gear

Bevel gears are **gears** where the axes of the two shafts intersect and the tooth-bearing faces of the **gears** themselves are conically shaped. **Bevel gears** are most often **mounted** on shafts that are 90 degrees apart, but can be designed to work at other angles as well.

Several parameters contribute to proper assembly to operate the gear box smoothly and efficiently.The most important are

- Back lash Fig 1
- Mounting distance Fig 2

Fig 5

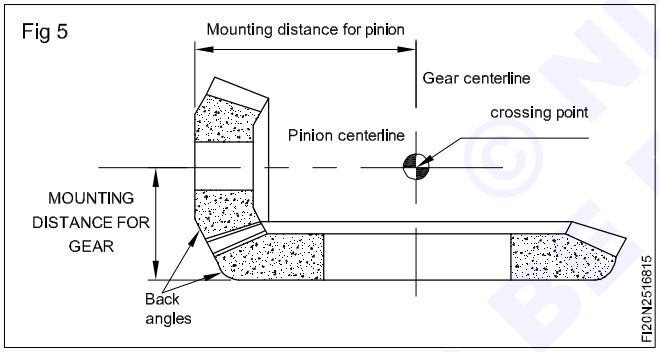
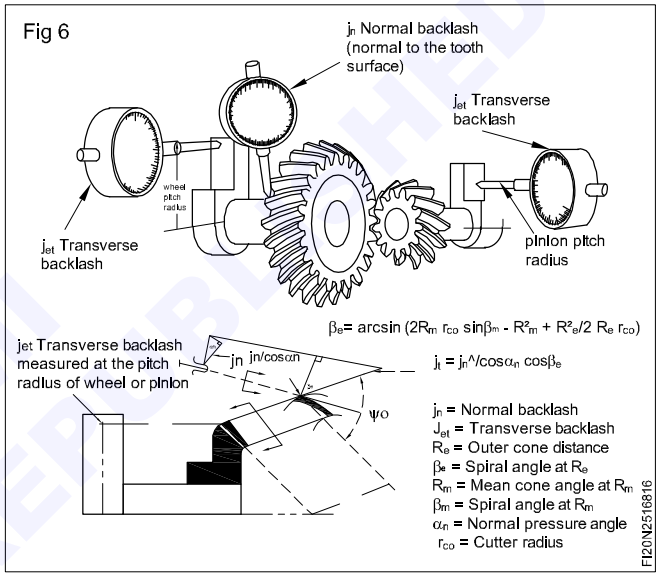


Fig 6



Application of Pneumatics

Objectives : At the end of this lesson you shall be able to
- **define pneumatics**
- **state the application of Pneumatics**
- **list the advantages and limitation of pneumatics.**

Overview of Pneumatic

original world PNEUMA is taken from Greek language which means breathing.

Pneumatic system gets compressed air as an energy input then converts it into a suitable work and after that exhaust back to the atmosphere. This process of intake and exhaust is compared with breathing.

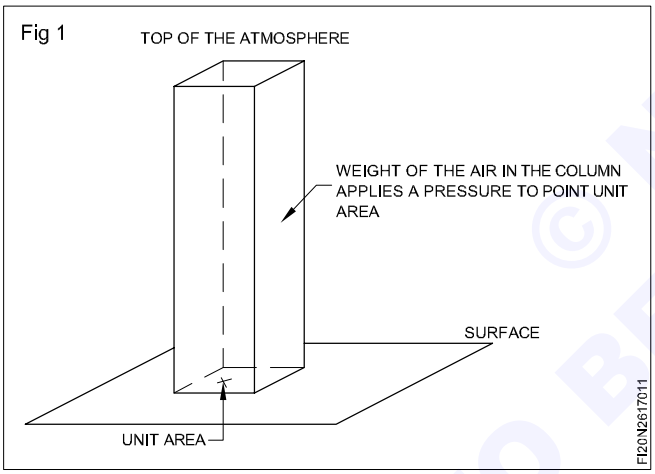
Definition: It is the science under which you study properties and application of air.

Common terms used in pneumatics

Pressure

Pressure is defined as the load acting upon unit area.(Fig1)

Fig 1



Pressure = Force/Area

In pneumatic system three terms related to pressure are commonly used.

Atmospheric Pressure

It is pressure caused by weight of column of atmospheric air acting on the surface

Gauge Pressure

It is pressure value read through an instrument called Pressure Gauge. It indicates pressure value above the atmospheric pressure.

Absolute Pressure

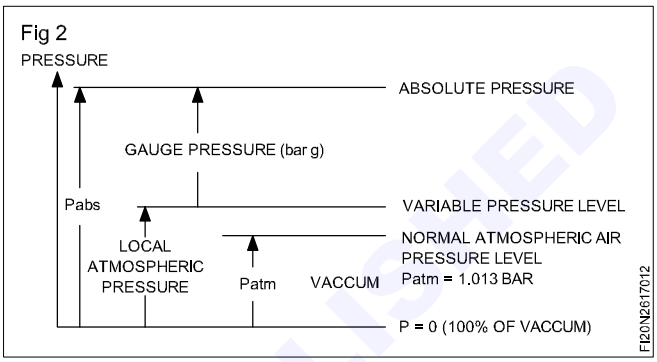
It is the pressure value measured with respect to perfect vacuum.

Absolute pressure = Atmospheric pressure + gauge pressure

Abs Pr = Atm Pr + Gg Pr

Fig 2 shows the relation between Absolute pressure, Gauge pressure and Atmospheric pressure.

Fig 2



Units of Pressure: Pressure is measured in Pascal (P_a)in SI unit. 1 pascal = 1 newton per meter square. one pascal is the pressure exerted by a force of magnitude one newton perpendicularly upon an area of one square metre...

Example: Pressure = Bar = 1 Kg/Cm^2 (aprox.)

Bar is a metric unit of pressure euqal to 100,000 pa (pascal) standard atmosphric pressure at sea level is 1013.25 milli bar or 101.35 kilo pascal

1 Bar = 1 Kg / Cm^2

Force

Force is the product of pressure and cross section area upon which force is acting.

Force = Pressure x Area (F = P x A)

Unit of Force: Force is measured in Newton in SI unit

1 newton = 1 kg m /s^2

Flow rate

Flow rate is the volume of air flowing per unit time.

Units of Flow Rate: Flow rate is measured in lpm (Litre/ Minute) or M^3/ Hour.

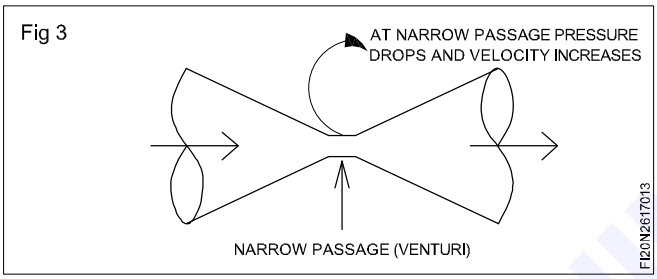
Example: Flow Rate = 10 Litre/ Minute

Or Flow Rate = 50 M^3/ Hour

Properties of Air

- Atmospheirc air posses certain properties as follows:
- Air is a mixture of gasses. (Nitrogen - 78%,Oxygen-21%,Other gases,Water vapour- 1% by Volume)
- It contains dust particles and water vapour.
- Air is compressible means it's volume can be reduced.
- Air does not burn itself.
- Volume of air increases with increase in temperature.
- Moisture or water vapour carrying capacity increases with increase in temperature of air or volume of air.
- Pressure of air increases with reduction of volume.
- Air temperature increases with increase in pressure.
- When air passes through narrow passage pressure drops velocity increases. (Refer Fig 3)

Fig 3



Applications: Pneumatic is widely used in many industrial automation applications where fast movements of lesser loads are required.

Pneumatics is used to move load with less efforts,general applications are:

- Push - Pull
- Lift - Drop
- Clamp - Unclamp
- Tilt

Boyle's Law

Robert Boyle (1627-1691), an English scientist,was among the first to experiment with the pressure volume relatioship of gas at constant temperature.

Statement: If a given mass of a gas is compressed or expanded at a constant temperature,then the absolute pressure is inversely proportional to the volume.

Pressure $\propto \frac{1}{Volume}$ when temperature = constant

or pV = constant, $p_1 v_1 = p_2 V_2$

Advantages of Pneumatics

Pneumatics is popular in industrial applications as Low Cost Automation because of following advantages:

- Air is available at free of cost.
- Air is available in unlimited quantity every where.
- Air can compressed,pressurised and can be transported through pipes.
- Air can be exhausted to the environment without any harmful effects.
- Action is fast.
- Speed control is possible.
- System is overload safe.
- Air does not ignite.
- Simple in design and construction.
- Long life and low maintanance
- Components are simple in design and hence cheaper.

Limitations

- Pneumatic system has certain limitations as follows:
- Pneumatic system is economical up to a limit of
- 3000 kgf force.
- Pneumatics needed fine quality equipment to remove dust and moisture.(Air filters & demoisture)
- Air exhaust is noisy
- Uniform speed is not possible.
- Special lubrication technique is required to avoid friction between internal components.
- In case of leakage pneumatic system becomes costly.
- Compressing air beyond 7 bar is costiler.

Introduction of Hydraulic system

Objectives: At the end of this lesson you shall be able to
- **define hydraulic system**
- **define Pascal's law**
- **state the Bernoulli's principle.**

Any working or control system that uses liquid as the transmitting fluid is known as hydraulic system.

The word hydraulic is derived from Greek words "hydra" meaning water and "aulic" meaning pipe.

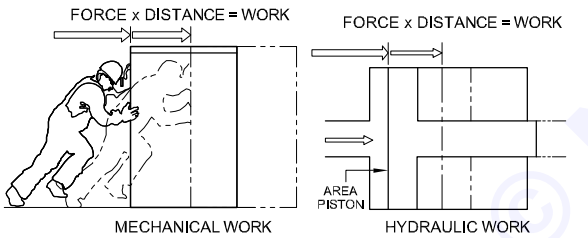
Some common examples of hydraulic system include automobile braking, power steering, elevators, earth moving equipments, jacks, presses, riveting machines, tool feeding mechanisms etc. The liquid used in hydraulics is generally viscous petroleum oils.

The following paragraphs gives basic physical properties and laws that govern liquids, relevant to hydraulic systems.

"Work" is defined as the product of force and the distance in which the object has moved in the direction of force.

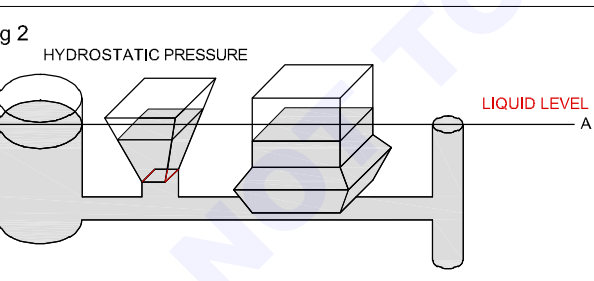
Fig 1 shows the comparison between the work done in a mechanical and hydraulic system.

Fig 1 COMPARISON BETWEEN HYDRAULIC AND MECHANICAL WORK



The Fig 2 shows that different shaped and sized containers inter-connected by a pipe, the level of the liquid remains same. This is because of the internal pressure of the liquid. At any point the liquid attains certain pressure proportional to the height of the liquid above.

Fig 2



Therefore the higher pressure in any of the container will force the liquid to flow to the next container until the pressure on both the sides are equalised.

Through the line 'A' the pressure in all the open containers remain the same, since height of liquid columns are same.

Pascal's Law

It states that the pressure exerted on a liquid is transmitted equally in all the directions. Fig 3 clearly explains this law followed by Fig 4.

Fig 3

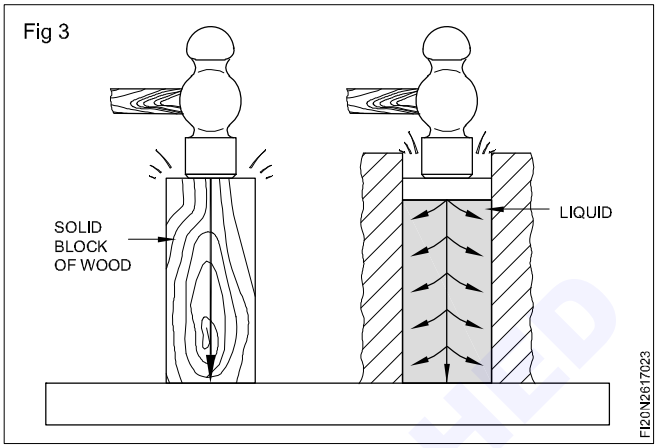
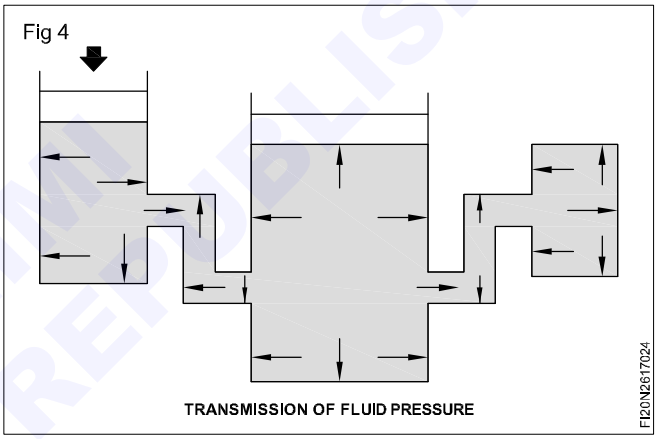
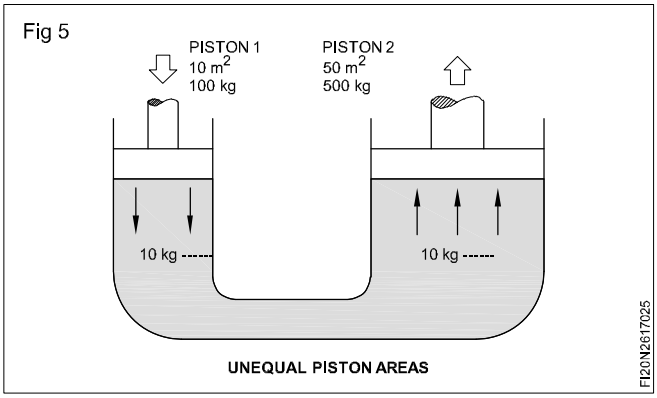


Fig 4



Thus if small amount of pressure is exerted on a smaller piston as shown in Fig 5, the higher force can be attained at the larger piston, since the pressure is equally applied on larger area.

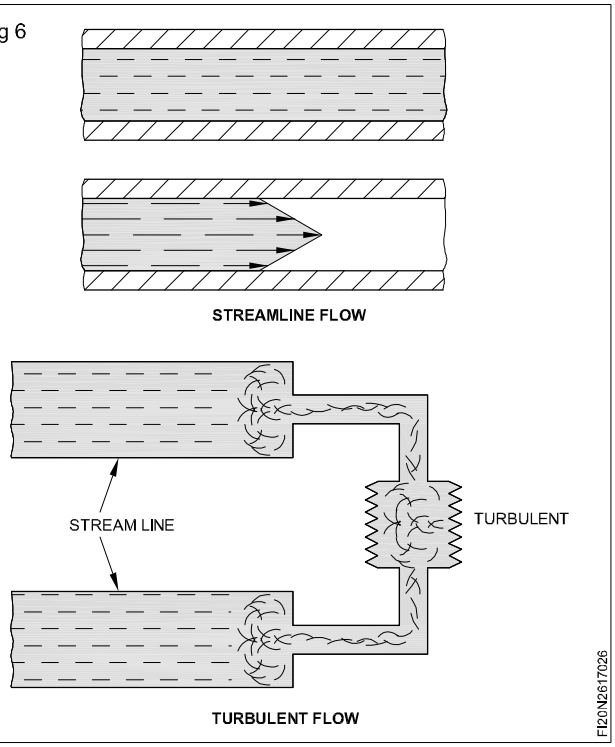
Fig 5



Cavitation

The inter-locked air bubbles and pockets in the hydraulic pipe lines and components is called cavitation. In cavitation the static pressure falls below vapour pressure. The vapour formation condenses resulting in pressure jerks and noise, and heating-up the oil resulting in a turbulent flow. Therefore resulting flow of oil should be a stream line or laminar in the pipe lines (Fig 6).

Fig 6

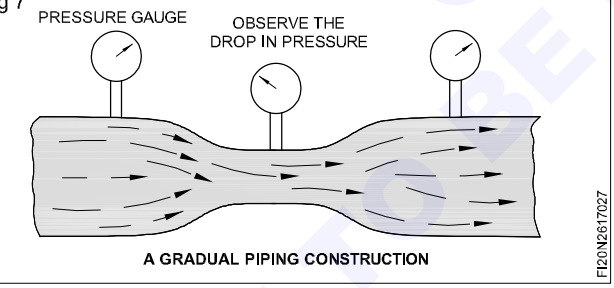


Bernoulli's principle

Kinetic energy is the energy present in oil by virtue of its motion. Potential energy is due to the pressure. The total energy is the sum of these two energies.

The bernoulli's principle states that the total energy of fluid always remains constant. During the course of flow of liquid, the flow increases and pressure decreases when a restriction is encountered. If the flow decreases, liquid pressure increases. Fig 7 Depicts this principle clearly.

Fig 7



Effect of heat

Since the liquids (oil) full in containers cannot expand or be compressed on heat, it exerts pressure on the container thus developing unwanted stresses.

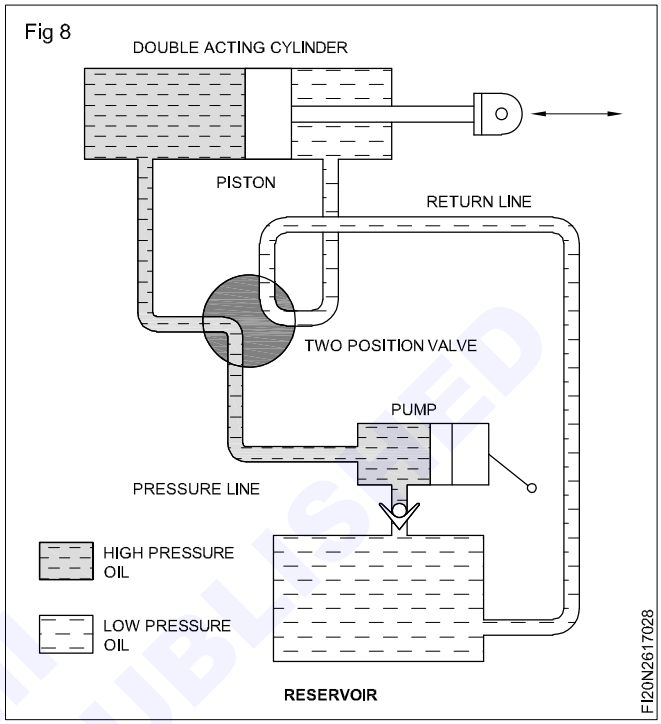
Heat also thins out the oil. The low viscous oil may leak through seals and packings. Heat also causes the deterioration of oil. Hence a suitable cooling system must be provided.

The basic hydraulic system consists of the following elements:

- A reservoir to store the hydraulic fluid
- A pump to provide fluid pressure to the system
- A control valve to direct the flow of fluid
- An actuating unit, such as a cylinder
- A suitable hydraulic fluid
- Piping or tubing to circulate the fluid through the system.

But the following components make up actual hydraulic power system (Fig 8) for a safe and greater range of work.

Fig 8



- A reservoir to store the hydraulic fluid
- A pump to provide fluid pressure to the system
- A filter to remove dust, chips and other foreign particles from the fluid
- A pressure-regulating valve, which keeps the fluid pressure in the main part of the system at the proper level
- An accumulator, which acts as a cushion and prevents large variations in fluid pressure that occurring in the system
- Check valves, which permit fluid flow only in the desired directions.
- A hand pump for operating the system manually if necessary
- A pressure gauge, which indicates the amount of fluid pressure in the system
- A relief valve, which prevents the system pressure from rising too high, if the pressure-regulating valve fails

Advantages of Hydraulics

- Liquids are incompressible and capable of moving much higher loads providing much higher force.
- No need to bleed off " pressurized air to release pressure on the load.
- Highly responsive compared to pneumatics
- Supply more power than pneumatics
- Also provides Lubrication & cooling.

Comparison between Pneumatics and Hydraulics

Pneumatics	Hydraulics
Confined pressurized system that use moving/air or other gases	Confinded pressurized systems that use moving Liquids
Because gases can be compressed, there is a delay in the movement, the force	Liquids are not very compressible, there is no delay in the movement
Need for air compressor	Hydraulic Fluid-liquid inside system.
Examples:	Cylinder-container holding liquid
Precision drills used by dentists	piston-plunger moving inside cylinder
Pneumatic brakes (air brakes) used by buses, trucks, trains	Pumps-moves liquid in specific direction (usually against gravity)
tampers used to pack down dirt and gravel	Valves-controls the flow of direction (allows flow in one direction)
lungs	Examples:
nail gun	Dump truck lift
dentist chair	Hydraulic lift to lift cars
most industrial pneumatic application uses pressure of 550 to 690 kpa	Jaws of lift
	blood in body Used in cars
	Hydraulic application commonly use from 6.9 to 34.5 mpa.Special high pressure application may exceed 69 mpa.

Air compressor parts and function

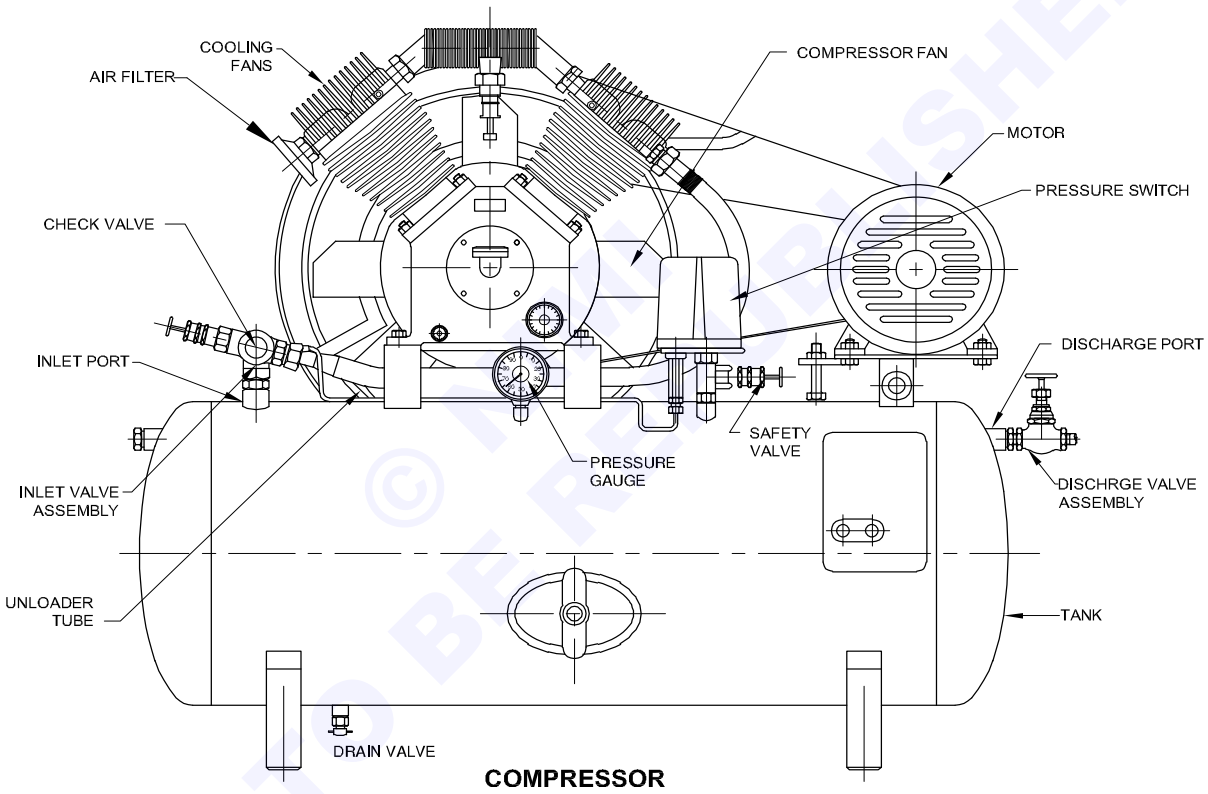
Objectives : At the end of this lesson you shall be able to
- **state construction of compressor**
- **explain parts of compressor**
- **describe the working principle of air compressor.**

Air compressor parts and functions

Air compressors are a type of machine tool and they work great with other power tools too. It basically provides other tools the ability to function and the power to do household as well as industrial improvement projects and installations. In order for tools to function at their best, air compressor must be working in its optimum power and efficiency and that means that the parts of an air compressor must be working 100% of the time to make sure the work is done.

Parts of an air compressor (Fig 1)

Fig 1



COMPRESSOR

The following are the main parts of an air compressor.

Motor

An air compressor needs an electric motor to power up the machine. The motor basically drives two belts a pulley which allows the transfer of power from the motor to the pump pistons and this is done through a flywheel and a crankshaft. One important thing need to install will be a magnetic starter to prevent the motor form overload.

Tank

This is the compressor part that stores the air being compressed. It is biggest part of the air compressor and it can range from 1-10 gallons or even more for bigger construction needs. The tank generally made of steel.

Pressure switch

The pressure switch automatically shuts down the motor when the receiver reaches the factory-set limit. Once the pressure level drops to a pre-set level then the pressure switch restarts the motor therefore resuming the pumping of air by the compressor. We can also call this as an emergency switch that regulates how much pressure in the tank can take.

Drain valve

The main purpose of the drain valve is exactly what its name impiles. It drains the oil,dirt, moisture, and other debris that might be trapped inside the tank. Simple maintenance of air compressors entails draining a tank from impurities and debris from use. Moisture and oil are the most common reasons for rust to develop inside the tank when not drained.

Pressure gauge

This gauge measures compressed air pressure in the tank of the air compressor. It lets the user know that there is a problem if the measurement is higher than the regulated normal limit and serves as a warning to inspect the air compressor or stop the compression before the gauge reaches even higher pressure. On the contrary if the reading is very low from the normal allowed measurement, it also indicates a problem with the compressor such as a leak in the tank. This should also be checked right away to avoid any more complications and accidents.

Inlet port

This port is used to guide the inlet air towards the compressor inlet valve.

Inlet valve assembly

Inlet valve assembly compromises valve plate, and valve spring. Inlet valve controls the flow of air towards the cylinder of compressor. It is opening downwards to allow the air inside when the piston moves downwards. Valve plate is used to hold the inlet valve in proper position.

Cooling fins

Cooling fins are the extended part provided from the cylinder body to assure heat transfer from cylinder to surrounding.Generally these are made of aluminum.

Discharge Port

It is the opening provided at the top of compressor cylinder to guide discharge air towards the discharge line.

Discharge valve assembly

It comprises discharge valve plate, valve plate and valve spring. Valve plate helps to hold the discharge valve in proper position. Valve is aimed for discharge the high pressure air when the piston reaches its top.

Air filter

Air filter is very important part in an air compressor. It helps to prevent the dirt and dust to enter inside the compressor cylinder. Filter is provided in the suction end of the compressor.

Safety valve

A safety valve is provided on the air storage tank or air outlet line ro prevent the danger occurred when the air pressure reaches beyond the capability of storage tank capacity.

Regulator

Generally an air regulator is provided in the discharge tube to regulate the high pressure air flow.

Check valve/Non return valve (NRV) and unloader tube

An one way check valve is provided in the bypass line in between air receiver tank and compressor head. It will open and admit the high pressure air towards the receiver tank while unloading is going on during the starting time. An unloader tube is connected at the inlet port of the check valve and the valve only opens in one direction (ie from compressor top to receiver air flow). During this time the high pressure air is unloaded towards tank through unloader tube.

Compressor fan

A compressor fan is connected at one end of the crank shaft to provide sufficient cooling air to compressor. It will prevent overheating of compressor.

Air compressor working principle

Working principle (Fig 1)

Air compressors collect and store air in a pressurized tank, and use pistons and valves to achieve the appropriate pressure levels within and air storages tank that is attached to the motorized unit. There are a few different types of piston compressors that can deliver even air pressures to the user.

Automotive compressors are combustion engine compressors that use the up-and-down stroke of the piston to allow air in and pressurize the air with in the storage tank. Other piston compressors utilize a diaphragm, oil-free piston. These pull air in, and pressurize it by not allowing air to escape during the collection period.

Now the air compressor is capable of building extreme pressure in storage tanks capable of storing enormous amounts of pressurized gases for industrial use.

Air dryer

A compressed air dryer is used for removing water vapor from compressed air.

Compressed air dryers commonly found in a wide range of industrial commercial facilities.

Usage

Drying air for use in commercial or industrial processes that demand dry air:

Telecom industry (pressurizes its underground cables to repel moisture and avoid shorts).

Painting.

Pneumatic tools.

Textile manufacturing.

Pneumatic control systems.

Feed air for zeolite type oxygen and nitrogen generators.

Dental office air.

Truck and train air brake systems.

The process of air compression concentrates atmospheric contaminants, including water vapor. This raises the dew point of the compressed air relative to free atmospheric air and leads to condensation within pipes as the compressed air cools downstream of the compressor.

Excessive water in compressed air, in either the liquid or vapour phase, can cause a variety of operational problems for users of compressed air. These include freezing of

outdoor air lines, corrosion in piping and equipment , malfunctioning of pneumatic process control instrument, fouling of processes and products and more

There are various types of compressed air dryers. Their performance characteristics are typically defined by the dew point.

- Refrigerated dryers
- Deliquescent dryers
- Desiccant dryer
- Memberane dryers

Refrigerated dryer

Refrigeration dryers employ two heat exchangers, one for air-to-air one for air-to-refrigeration. These dryers are used in refrigeration compressors.

Deliquescent dryer

A deliquescent dryer typically consists of a pressure vessel filled with a hygroscopic medium that absorbs water vapor. The medium gradually dissolves-or deliquesces-to form a solution at the base of the pressure vessel. The liquid must be regularly drained from the vessel and new medium must be added.

Deliquescent dryers are used for removing water vapour from compressed air, natural gas, and waste gases.

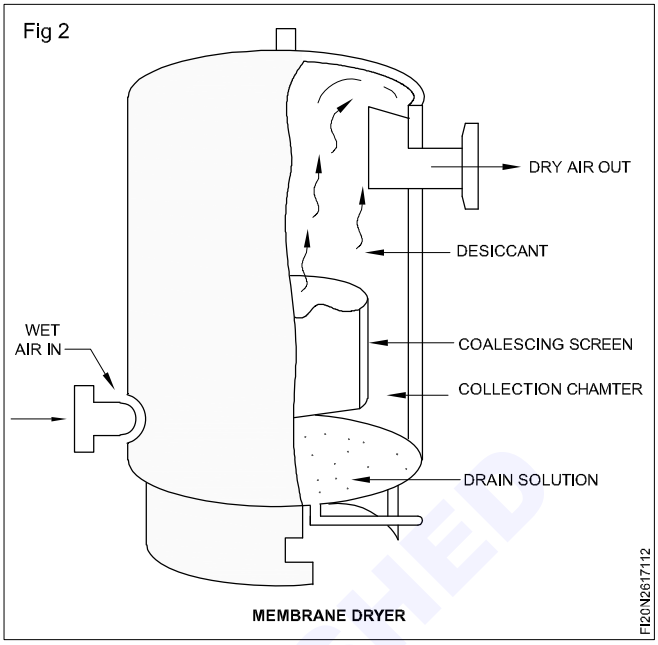
Desiccant dryer

The term “desiccant dryer” refers to a abroad class of dryers. Other terms commonly used are regenerative dryer and twin tower dryer,and to a lesser extent absorption dryer.

The compressed air is passed through a pressure vessel with two “towers” filed with a media such as activated alumina, silica gel, molecular sieve or other desiccant material. This desiccant material attracts the water from the compressed air via adsorption.

Membrane dryer (Fig 2)

Fig 2

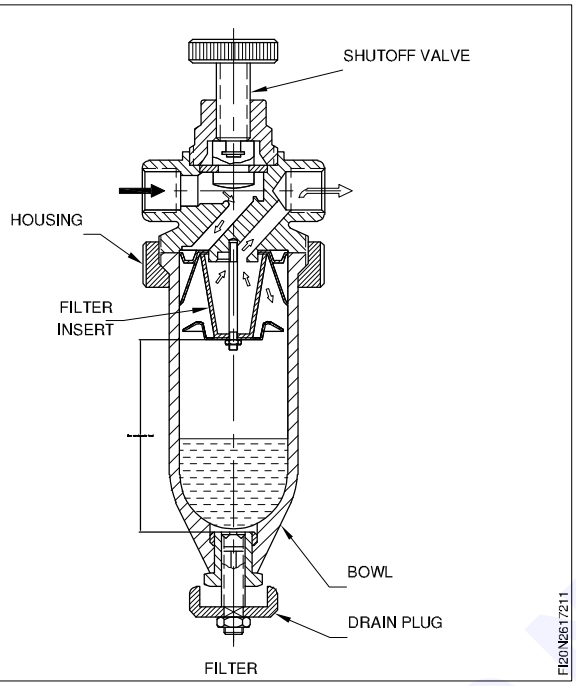


Membrane dryer refers to a dehumidification membrane that removes water vapor from compressed air. Typically, the compressed air is first filtered with a high-quality coalescing filter. This filter removes liquid water, oil and particulate from the the compressed air. The water vapor-laden air then passes through the center bore of hollow fibers in the membrance bundle. At the same time, a small portion of the dry air product is redirected along the outside surface of the fibers to seep out the water vapor which has permeated the membrane. The moisture-laden sweep gas is then vented to the atmosphere, and clean, dry air is supplied to the application. The membrane air dryers are designed to operate continuously, 24 hours per day, 7 day per week. Membrane air dryers are quiet, reliable and require no electricity to operate.

FRL unit (Filter, regulator, lubricator)

Objectives : At the end of this lesson you shall be able to
- **defind FRL unit**
- **state the types of FRL**
- **state the specifications of FRL.**

Fig 1



Fitter,regulator,lubricator (FRL) assemblies are pre-packaged or modular assemblies of air filters,pressure regulators,and gauges. Air leaving a compressor is hot,dirty,and wet and can cause damage to equipment and tools if it is not filtered.

The filter cleans compressed air by trapping solid particles and separating liquids,such as oil and water,that are trapped in the compressed air. Filters are installed in the air line upstream of regulators,lubricators,and all pneumatically-powered tools and equipment. They remove contaminants from pneumatic systems,preventing damage to equipment and reducing production losses due to contaminant-related downtime.

Pressure regulators control fluid pressure in compressed air systems. Regulators are also known as pressure reducing valves(PRVS). Pressure regulators maintain a constant output pressure regardless of input pressure variations and demands made on the system by downstream components.

Lubricators add controlled quantities of oil into the compressed air system to reduce the friction between moving components within air tools and other equipment that are powered by the system. Adding lubrication oil to the system also clears compressor oils that travel through the system in vapor form. To prevent build-up of oil within system components,mineral oils are added to the system to flush away the deposits.

Downstream equipment flow and pressure requirements determine the correct regulator and lubricator for the application. Manufactures offer flow characteristics charts on their products to help chose the correct combination of regulators and lubricators.

Types

There are several choices for regulator type.

- **General-purpose regulators** are designed for typical industrial use;they generally operate only above atmospheric pressure.
- **High- pressure regulators** are rated for inlet pressures higher than general purpose,typically over 1,000 psi.
- **Low- pressure regulators** have special design characteristics for precise control of pressures typically below 15-20 psi.
- **Differential** or **bias regulators** maintain a pressure differential between two locations in the system.
- **Pressure- reducing valves** provide a sub-circuit with a supply of fluid at a pressure that is less than the pressure in the main circuit.

Specifications

Performance specifications:

- **Regulating (adjustment) range** - Dictates the limits of adjustment control
- **Maximum flow (gas or air)** - Unnecessary to specify if primary application is liquid
- **Maximum pressure rating**- Refers to the pressure rating for the valve or inlet pressure for the regulator
- **Filter minimum particle size rating** - Applies to filter,regulator,and lubricator (FRL) assemblies. It is the smallest size particle that will be entrapped by the filter. This rating is an indication of the largest opening in the filter element.

Other important specifications include:

- Regulator type
- Medium
- Adjustement control
- Connectors or pipe size
- Body material
- Environmental parameters

Applications of pneumatics

Objectives : At the end of this lesson you shall be able to
- **state the application of pneumatic cylinders**
- **state various areas of automation**
- **describe the hazards and safety precautions in pneumatic system.**

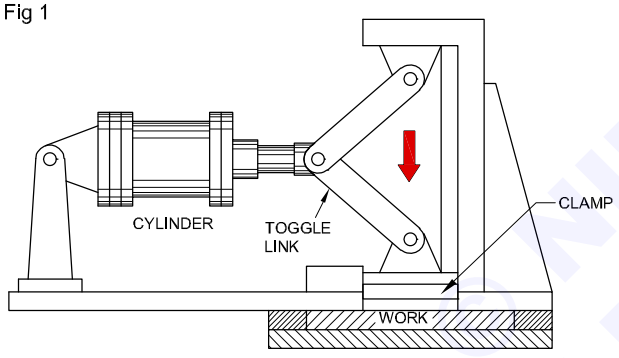
Application

In any control system or automation,penumatics can be economically applied. Besides,in other inaccessible areas like furnaces Pharmaceutical industry Food Processing and nuclear/reactors,compressed air is the only choice to operate the control sytem.

Air cylinders are widely used in pneumatic systems,since the liner motion is the most common requirement of the sytem.But rotaing actuators (motors)find their application in hand tools like portable drilling machine. As a general practice pneumatics is efficiently used in speed control rather than power requirements.

In the Fig 1 the piston moves the toggle link. The free ends of the toggle link moves down to clamp the work.

Fig 1



TOGGLE LEVER SYSTEM FOR WORK CLAMPING

The Fig 2 Shows feed unit. For a slot milling machine. The pedal operates valve 1. 1 clamps the jobs on the table. The piston rod at the end of its travel operated the valve 2. 1 and make the cylinder to move forward, in turn operating the valve 3.1. The valve operates the cylinder 3 to enact the feed to the work.

In Fig 3, the movement of the piston rod to the right tils the pivoted link to the left. By this movement the load is swing to the left hand side.

Fig 3

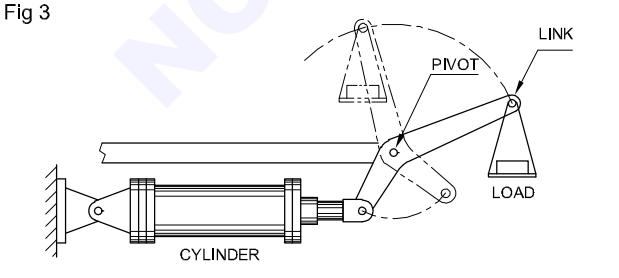
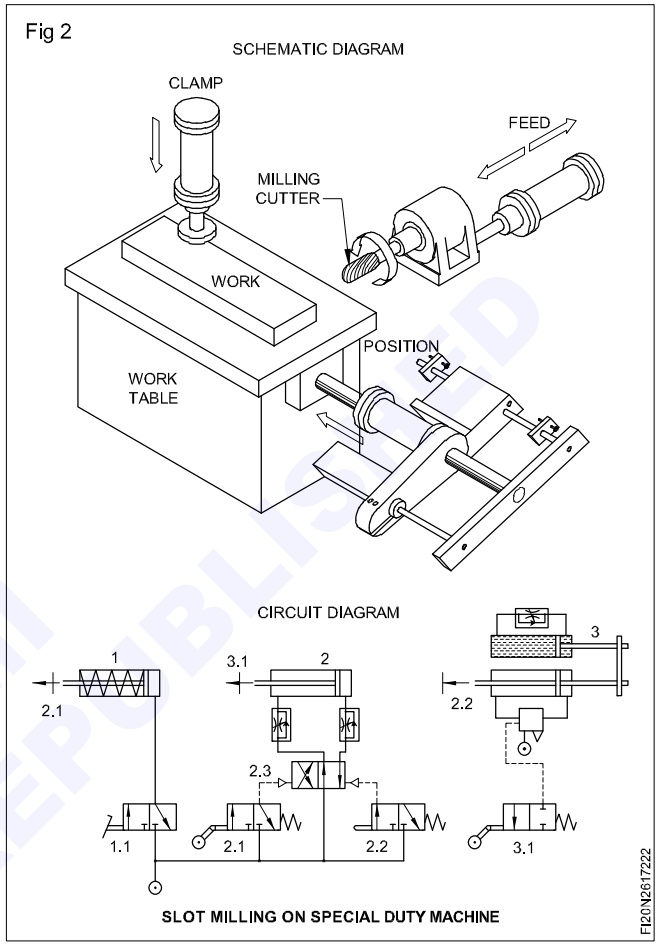


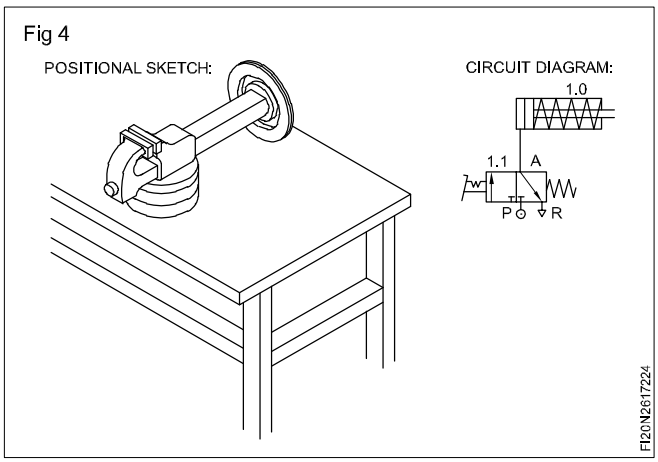
Fig 2



SLOT MILLING ON SPECIAL DUTY MACHINE

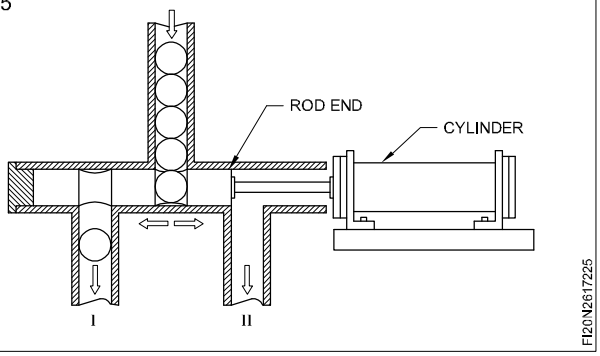
The operation of vice is shown in Fig 4. The 3/2 way valve extends and retreats the single acting cylinder attached to the movable vice.

Fig 4



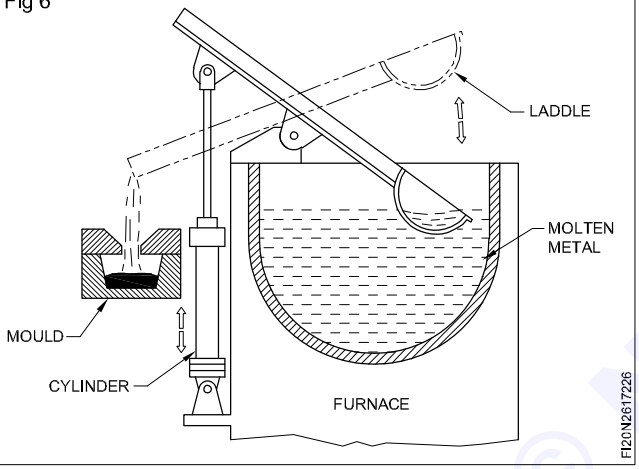
In Fig 5 the ball falling by gravity is distributed in two passages I & II, by means of the cylinder action.

Fig 5



In Fig. 6 the vertical movement of the piston rod lifts or lowers the laddle of molten metal to pour it into the mould.

Fig 6



Hazards & Safety precautions in pneumatic system

Whenever you are working with Pneumatic system you must take following safety precautions:

- Take precaution against corrosion in pneumatics components.
- Do not use compressed air to clean body parts.
- Never use kerosene to clean pneumatic system.
- Compressed air does not lignite but can explode due to pressure.
- Pneumatic system operates at high speed, most of the accidents happen due to crushing, hence takecare when handling.
- Do not put hands in the path of operating components.
- Avoid contact of plastic pipes with sharp edges.
- Close main valve to unpressurise pneumatic system prior to maintenance work.
- Loose connection may cause withdrawal of pneumatic hose, that whips due air flow. This whipping action may cause injury.

Pneumatics actuators

Objectives : At the end of this lesson you shall be able to
- **define pneumatic actuators**
- **state the types of pneumatics actuators**
- **to calculate cylinder forces**
- **define stroke length.**

Pneumatics actuators

pneumatic actuators are the devices used for converting pressure energy of compressed air into the mechanical energy to perform useful work. In other words, Actuators are used to perform the task of exerting the required force at the end of the stroke or used to create displacement by the movement of the piston. The pressurised air from the compressor is supplied to reservoir. The pressurised air from storage is supplied to pneumatic actuator to do work.

The air cylinder is a simple and efficient device for providing linear thrust or straight line motions with a rapid speed of response. Friction losses are low, seldom exceeds 5% with a cylinder in good condition, and cylinders are particularly suitable for single purpose applications and / or where rapid movement is required. They are also suitable for use under conditions which preclude the employment of hydraulic cylinders that is at high ambient temperature of up to 200 °C to 250 °C

Their chief limitation is that the elastic nature of the compressed air makes them unsuitable for powering movement where absolutely steady forces or motions are required applied against a fluctuating load, or where extreme accuracy of feed is necessary. The air cylinder is also inherently

Limited thrust output by the relatively low supply pressure so that production of high output forces can only by achieved by a large size of the cylinders.

1.2. Types of Pneumatics Actuators

Pneumatic cylinders can be used to make linear, rotary and oscillatory motion. There are three types of pneumatic actuator: they are

1 Linear Actuator or Pneumatic cylinders

2 Rotary Actuator or Air motors

3 Limited angle Actuators

Calculation of cylinder forces - metric based products

General Formula

The cylinder output forces are derived from the following formula:

$$F = \frac{PxA}{10}$$

Where F = Force in N

P = Pressure at the cylinder in Bar

A = Effective area of cylinder piston in square mm.

Prior to selecting the cylinder bore size, properly size the piston rod for tension (pull) or compression (push) loading. (see the piston Rod Selection Chart)

If the piston rod is in compression, use the 'Push Force' table below, as follows:

1 Identify the operating pressure closest to that required.

2 In the same column, identify the force required to move the load (always round up).

3 In the same row, look over to the cylinder bore required.

If the cylinder envelope dimensions are too large for the application, increase the operating pressure, if possible, & repeat the exercise.

If the piston rod is in tension,use the 'Deduction for Pull Force' table. The procedure is the same but due to the reduced area caused by the piston rod, the force available on the 'pull' stroke will be smaller. To determine the pull force:

1 Follow the procedure for 'push' force as described previously.

2 using the 'Deduction for Pull Force' table, identify the force indicated according to the rod & pressure selected.

3 Deduct this from the original 'push' force. The resultant is the net force available to move the load.

If this force is not large enough, repeat the process & increase the system operating pressure or cylinder diameter if possible.

Deduction for pull force

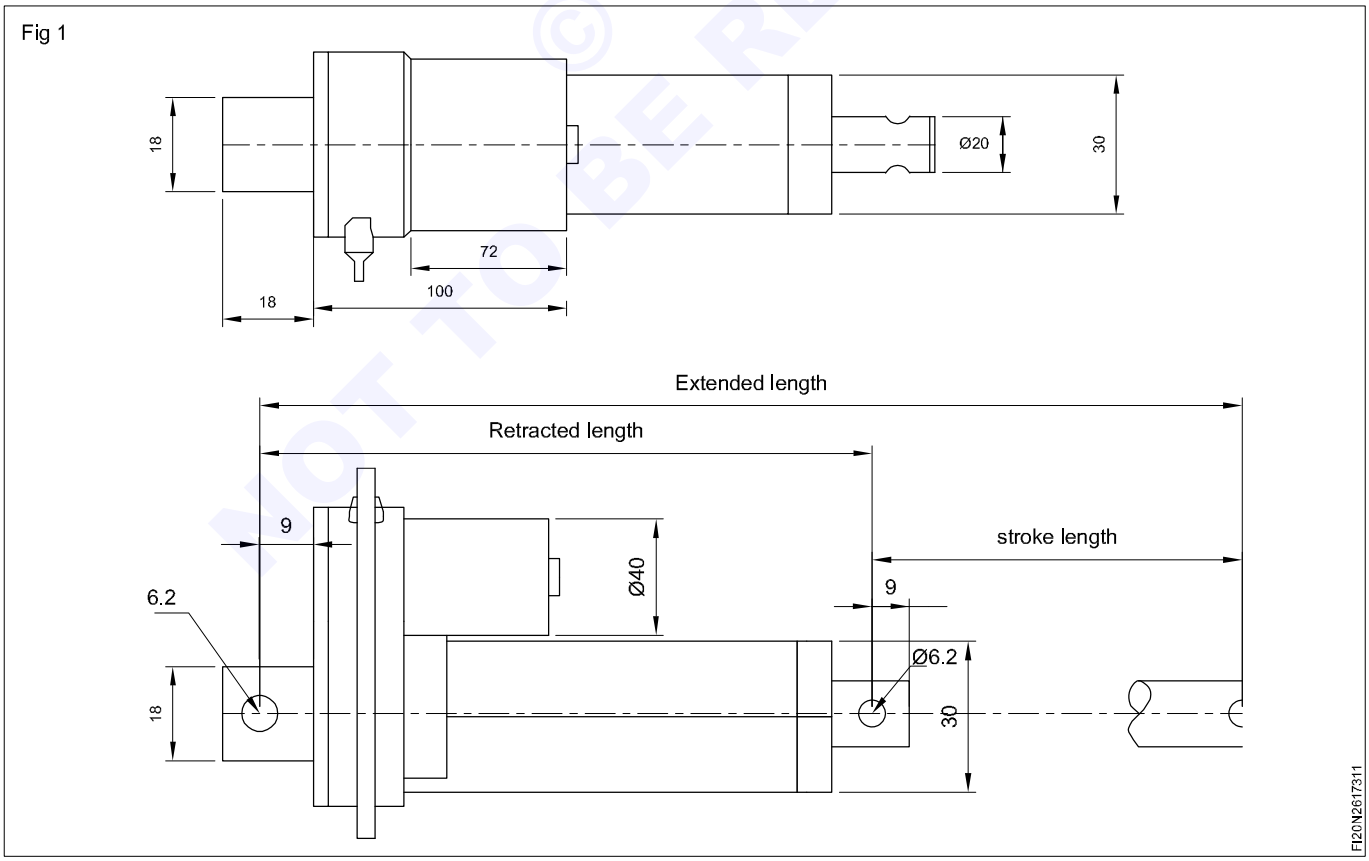
Piston rod size (mm)	Piston rod Area (mm^2)	Reduction in Force (N) at various Pressures in Bar			
		1	5	7	10
4	13	1	6	9	13
6	28	3	14	20	28
8	50	5	25	35	50
10	79	8	39	55	79
12	113	11	57	79	113
16	201	20	101	141	201
20	314	31	157	220	314
25	491	49	245	344	491
32	804	80	402	563	804
40	1257	126	628	880	1257

Stroke is the distance travelled by an **actuator** in motion. This is a measurement of the capability of a linear **actuator**. ... **Stroke** helps determine key factors such as the weight capacity of the actuator, how much time will it take, the speed of the motion, and the force that can be generated. (Fig 1)

Push Force

Cylinder Bore size (mm)	Piston Area Area (mm^2)	Reduction in Force (N) at various Pressures in Bar			
		1	5	7	10
6	28	3	14	20	28
8	50	5	25	35	50
10	79	8	39	55	79
12	113	11	57	79	113
14	154	15	77	108	154
16	201	20	101	141	201
20	314	31	157	220	314
25	491	49	245	344	491
32	804	80	402	563	804
40	1257	126	628	880	1257
50	1963	196	982	1374	1963
63	3117	312	1559	2182	3117
80	5027	503	2513	3519	5027
100	7854	785	3927	5498	7854
125	12272	1227	6136	8590	12272
160	20106	2011	10053	14074	20106
200	31416	3142	15708	21991	31416

Fig 1



Single acting cylinder and its application

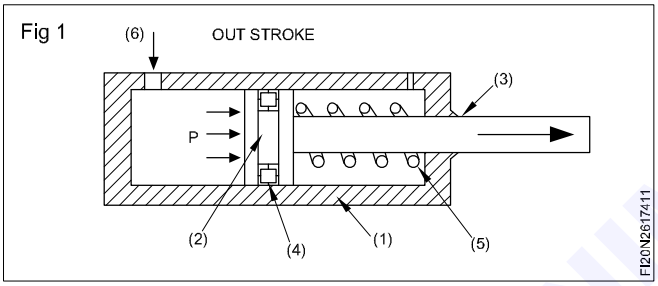
Objectives : At the end of this lesson you shall be able to
- **identify internal parts of single acting cylinder**
- **explain working principle of single acting cylinder**
- **explain working of 3/2 way valve**
- **interprete circuit to control single acting cylinder.**

Single acting cylinder

It is an actuator which moves load along the straight line. It can apply pneumatic force only in one direction therefore called single acting. Movement in opposite direction is caused by external force like spring or own weight of the load.

Construction: Construction of single acting cylinder is shown in the Fig 1.

Fig 1



Main parts of single acting cylinder are listed as follows:

1 Cylinder

2 Piston

3 Piston rod

4 Seal

5 Spring

6 Inlet Port

Working principle of single acting cylinder

Initially piston remains at the innermost position in the cylinder due to spring force (Fig 1)

When compressed air is supplied through inlet port, pressure acts on cross section of the piston.

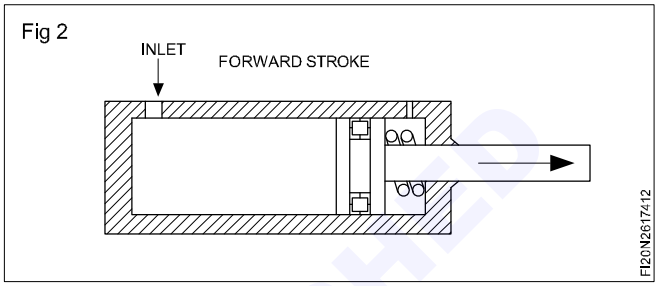
Product of pressure and piston cross section area gives rise to a force which acts opposite to the spring force. If pneumatic force is greater than the spring force then spring gets compressed and piston starts moving.

Seal prevents air leak across the piston.

Continuous flow of air causes continuous motion of piston.Load is attached to piston through piston rod; therefore load also moves with piston.

Piston and load move till piston reaches to other end. At the end there is no further space for piston to move, hence piston and load movement stops. (Fig 2)

Fig 2

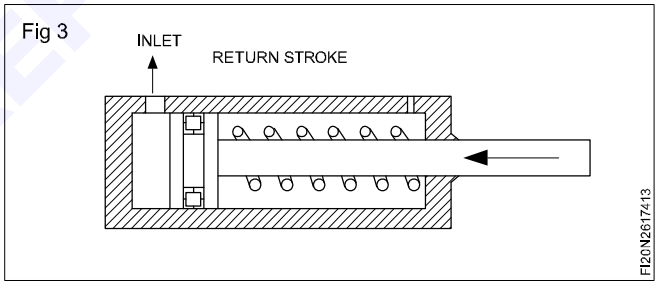


This piston movement is called forward stroke.

In forward stroke pistion rod comes out of the cylinder. If we denote piston by A, then forward stroke is denoted by A

If pressure acting on piston is released, pneumatic force acting opposite to spring becomes weak, therefore spring pushes piston back. (Fig 3)

Fig 3



This stroke is called return stroke.

In return stroke piston rod goes inside the cylinder. Return stroke is denoted by A^-.

Direction control of single acting cylinder

To control single acting cylinder or in other words to push and pull load by single acting cylinder you always need 3 port 2 position direction control valve as main control element.

Construction of 3 port 2 position valve

Construction is shown in the Fig 4.

It consists of following parts:

1 Valve body

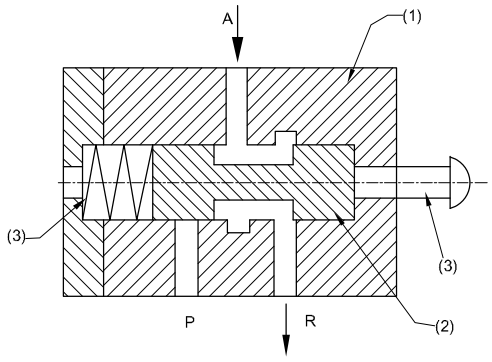
2 Spool

3 Actuation mechanism: Push button & Spring

4 Air flow path

5 Ports (P,A,R)

Fig 4



Valve body provides cavity whch accommodates spool, internal passage for air flow and actuation mechanism.

Spool is a piston shaped element which when shifts changes air flow path.

Actuation mechanism provides facility to shift the spool.

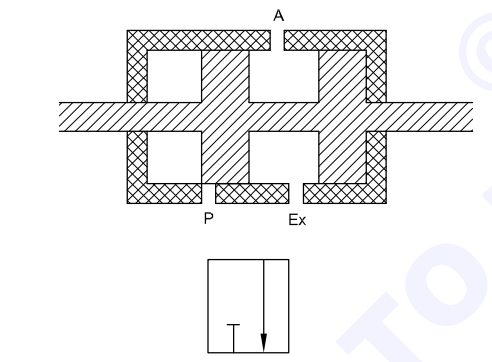
Port is a point where you can connect air pipe with the help of connector.

Working principle of 3 port 2 position valve:

3 port 2 position valve gives two status or positions of air flow.

Input port is blocked and output is connected to exhaust. In this status compressed air does not flow through the valve. Also output port is connected to exhaust port so that output line remains at atmospheric pressure. (Fig 5)

Fig 5



Input port is connected to output port and exhaust port is blocked. In this status compressed air flow through the valve and push the piston. (Fig 6)

Fig 7 shows the circuit to operat single acting cylinder.

When compressor is switched on compressed air is available up to input port “1” (Fig 8)

When push button is pressed,direction of air changes due to valve shift. Piston moves forward. (Fig 9)

Push button is when released piston returns back. (Fig 8)

Fig 6

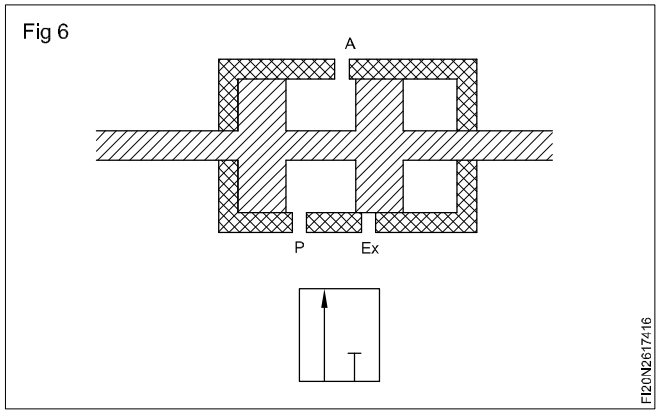


Fig 7

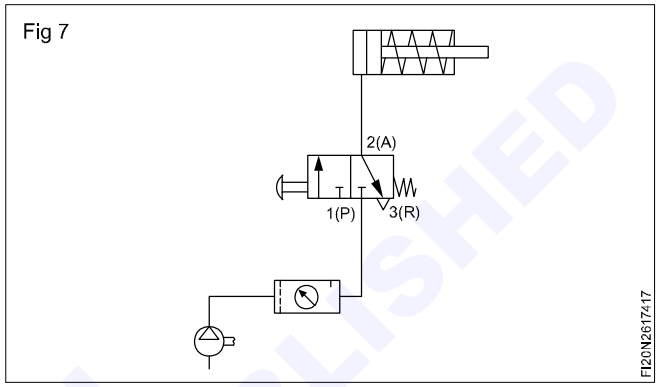


Fig 8

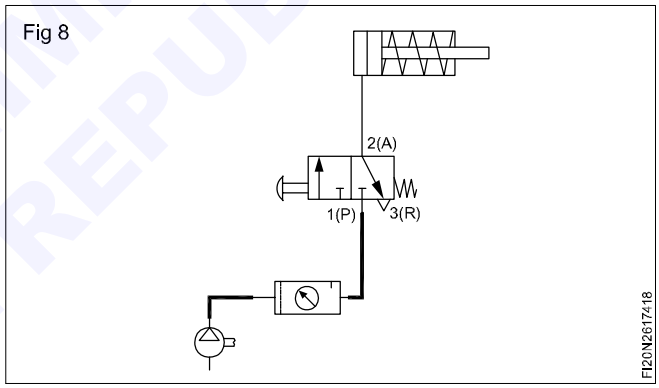
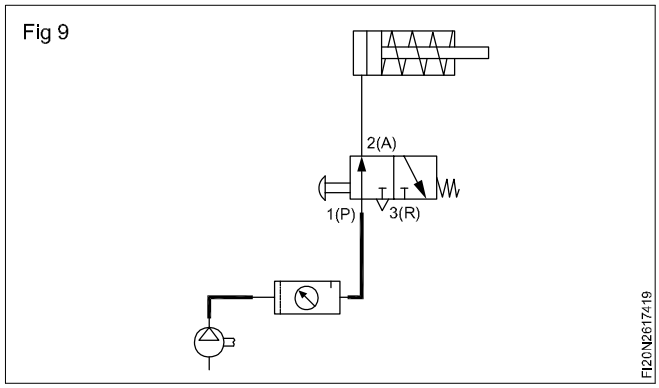


Fig 9

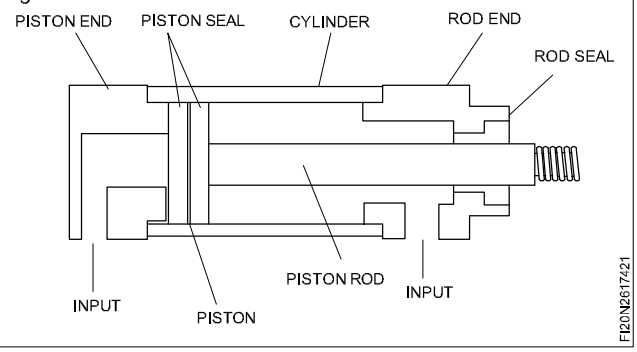


Double acting cylinder and its application

Objectives: At the end of this lesson you shall be able to
- **explain working principle of Double Acting Cylinder**
- **explain operation of 5/2 way valve**
- **use 5/2 way valve to operate double acting cylinder.**

Double acting cylinder is an actuator which can push and pull the load using compressed air. It has two ports for air sypply. Fig 1 shows the construction of double acting cylinder.

Fig 1

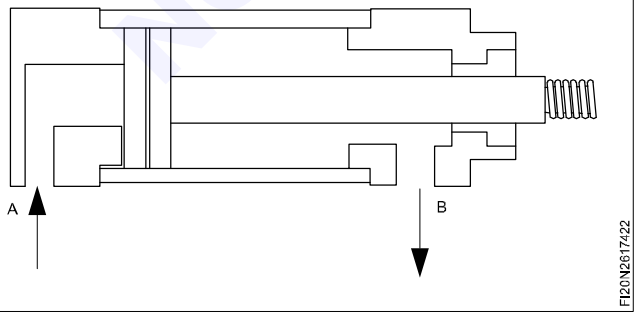


Input Ports: For air supply

- Piston: Element which moves to and fro inside the cylinder.
- Cylinder: It confines air for the piston movement.
- Piston rod: A rod which connects piston and a load.
- Piston Seal: Seal which prevent leakage across the piston.
- Rod Seal: Seal which prevents air leakage from cylinder to the atmosphere.
- Piston End: Part of the cylinder consisting air passage and connected to the piston side.
- Rod End: Part of the cylinder consisting air passage and connected to the piston side.

  When air is supplied through port A, force is exerted on the piston so that it moves in forward direction. This movement is called forward stroke. During forward stroke air already present at the rod side exhausts through port B. (Fig 2)

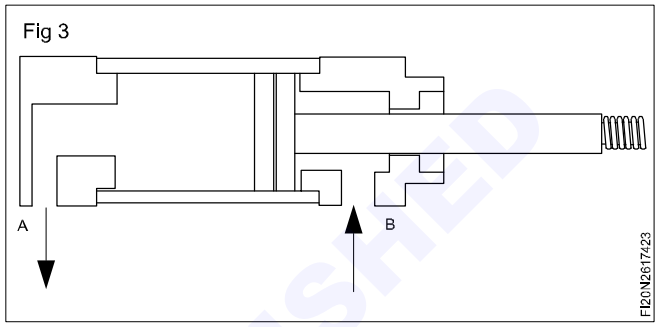
Fig 2



Piston movement will stop if air does not exhaust.

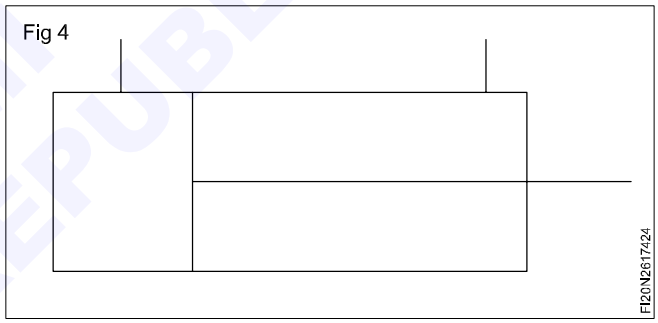
When air is supplied through port B, air already present exhausts through port A and piston retracts. (Fig 3)

Fig 3



Symbol of double acting cylinder is shown in fig 4

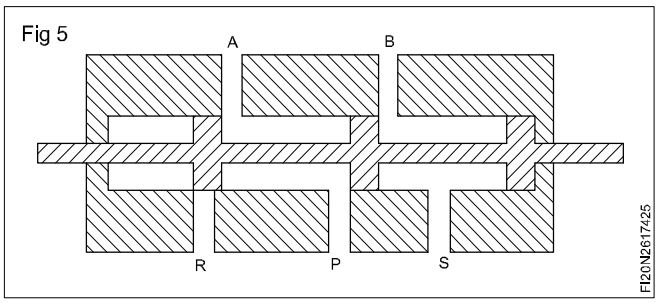
Fig 4



5 port 2 position valve

To operate double acting cylinder it is needed to change the direction of air between ports A & B. Therefore a valve is required whcih has two output ports. 5 port 2 position valve has two output ports. Construction is shown in fig 5.

Fig 5



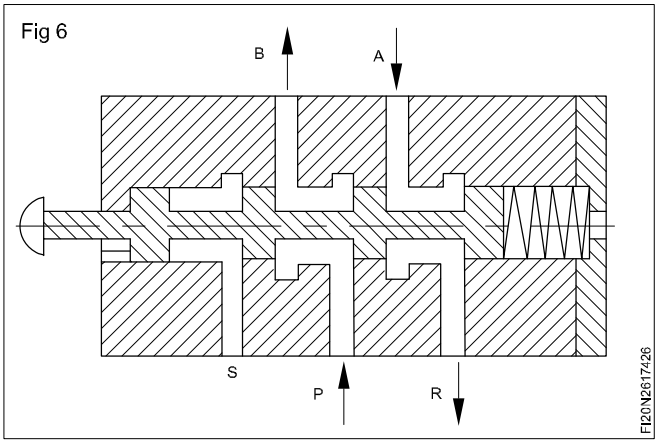
- Valve body: It provide cavity to move spool and ports.
- Spool: It is an element which change flow path when moves inside the valve body.
- Input port: Connection point where air enters into valve. It is denoted by 'P' or number '1'.

- Output port: Connection points from where air comes out of valve. Output ports are denoted by ‘A” & ‘B’ or number ‘2’ & ‘4’ respectively.
- Exhaust port: Connection points from where air exhausts.Exhaust ports are denoted by ‘R’ & ‘S’ or number ‘3’ & ‘5’ respectively.

Position refers to status of direction of air flow path in the valve.

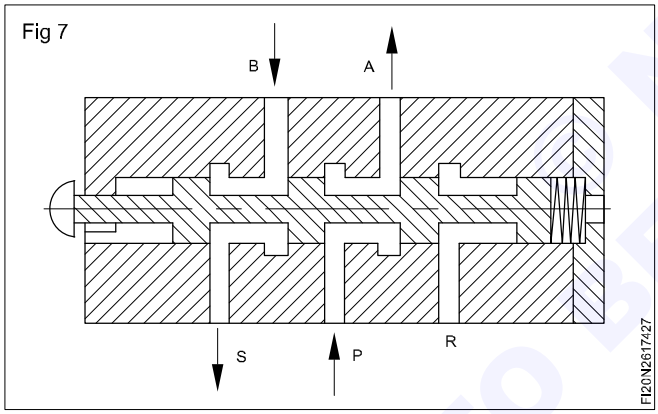
In one position port ‘P’ is connected to ‘B’ and port ‘A’ exhausts through ‘R, but exhaust port ‘S’ closed. (Fig 6)

Fig 6



In other position port ‘P’ is connected to ‘A’ and port ‘B’ exhausts through ‘S’ but exhaust port ‘R’ is closed. (Fig7)

Fig 7



Symbol of 5 port 2 position valve is shown in fig 8

Fig 9 Shows circuit to operate double acting cylinder. initially in normal position (Spring operated position), supply direction is from 1 (p) to 2 (B) and 4 (A) to (R) so that piston is always in retracted position unless actuated. (Fig 9)

Fig 8

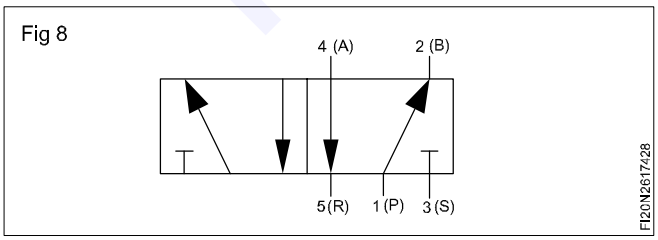
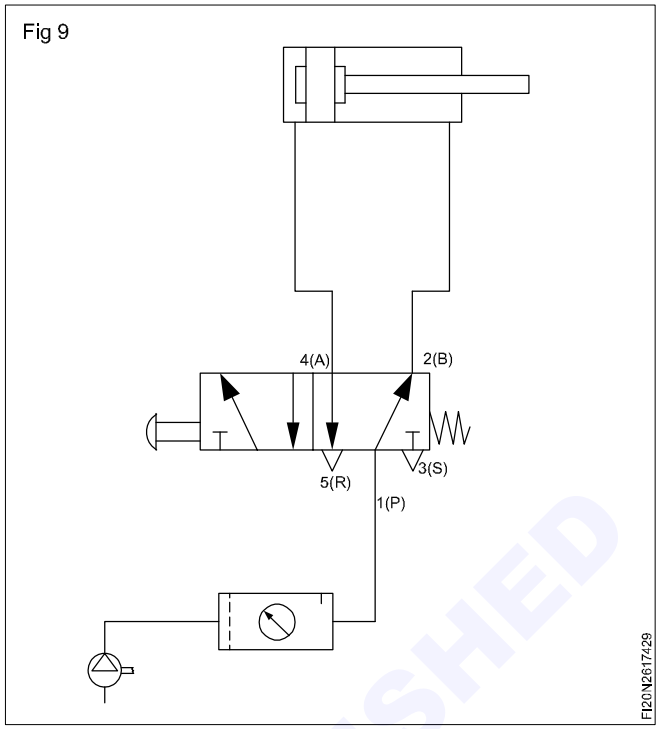
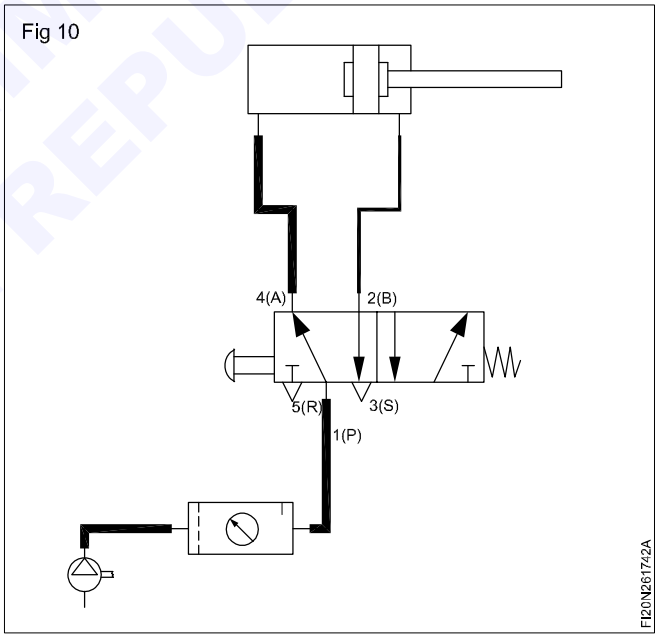


Fig 9



When push button is operated air flow path changes inside the valve so that supply direction is 1 (P) to 4 (A) and 2 (B) to 3 (S), thus gauses piston moves forward. (Fig 10)

Fig 10



Pneumatic valves

Objectives: At the end of this lesson you shall be able to
- **state the directional control valve**
- **list the classification or directional control valve**
- **state the sealing action in valves**
- **explain the different types of directional control valve.**

Valves are the devices used to control, regulate commence, terminate or change direction of flow and pressure of fluid used in the system.

Valves in pneumatics are grouped according to their function. They are

- Directional control valves
- Non-return valves
- Pressure control valves
- Flow control valves.

These valves will be discussed in the following lessons.

Directional control valve

Directional control valves are used to control the (1) direction of flow of the fluid, (2) commencement and termination of the flow of fluid. Direction control valve finds its place in the circuit immediately before the cylinder/air motor.

Classification of directional control valve

Directional control valves can be classified according to the following features by virtue of construction and function

- According to the internal design
- According to the number of ports and position
- According to the valve actuating mechanism.

According to the internal design

The design of the valve even though not affecting the function, plays an important role in terms of

- Life of valve
- Actuating force
- Means of actuation
- Means of connection.

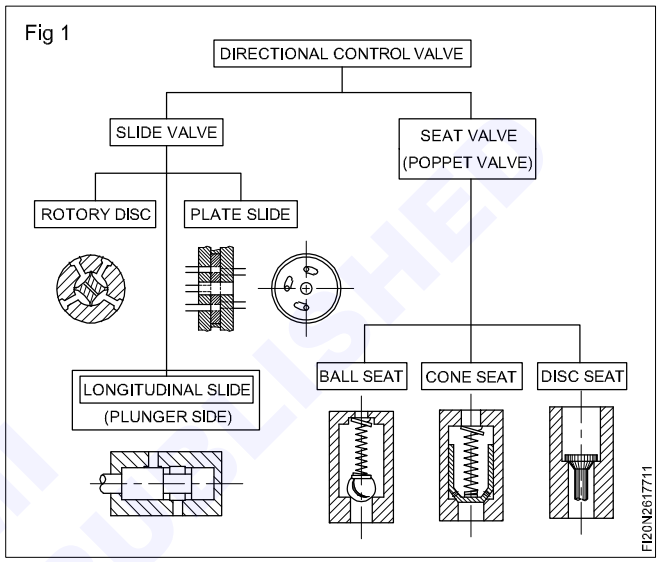
Directional control valves are classified in two major group as shown in Fig 1

Slide valves

Slide valves are called so, because the opening and closing takes place by sliding of one of its member. Further in slide valve we have

- Rotary disc valve
- Longitudinal slide or spool valve
- Plate slide valve

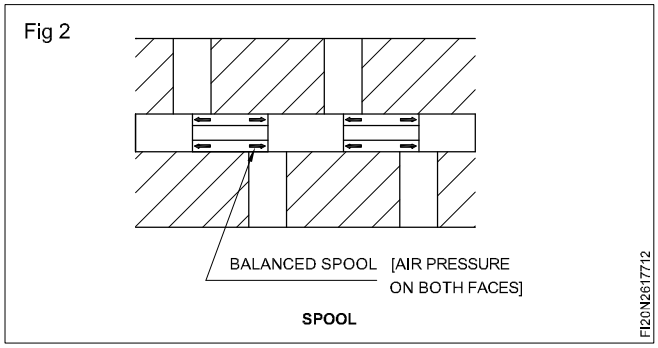
Fig 1



Slide valves are used extensively in pneumatics because of its advantages like.

- Balanced spool (Fig 2)
- Less force required to actuate

Fig 2



However they have their disadvantages also

- A fine finish and accuracy are required for sliding parts
- Sensitive towards dirt in the air
- Length of actuation is more
- Wear and tear is more
- Life is less.

Seat valves

Seat valves are also called as poppet valves. The valve is opened or closed by the lift of seating element.

These valves are further grouped as

- Ball seat valve
- Cone or taper seat valve
- Disc seat valve.

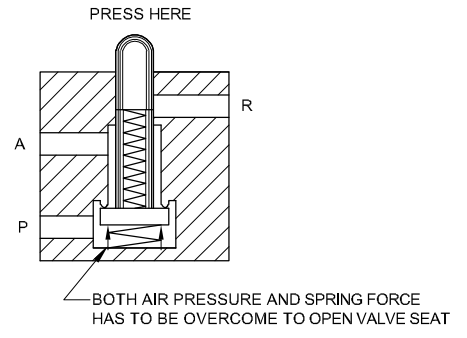
Seat valve are superior in terms of the following

- Wear and tear is minimum
- Actuating length or lift is very less
- Provides leakproof arrangement
- Long life
- Insensitive to dust/dirt

However these valve also have a few disadvantages

- Force, required to operate is more
- Balancing of force not adequate. (Fig 3)

Fig 3



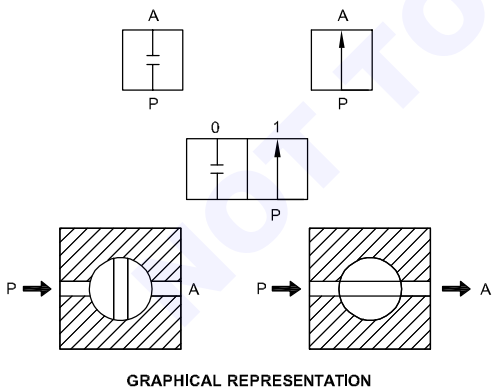
Valve classification according to the number of ports and position

A directional control valve has a number of ports through which air enters and exits.

It also takes various position according to flow path of air.

The valve shown has inlet(P) and outlet(A) position .(Fig 4)

Fig 4

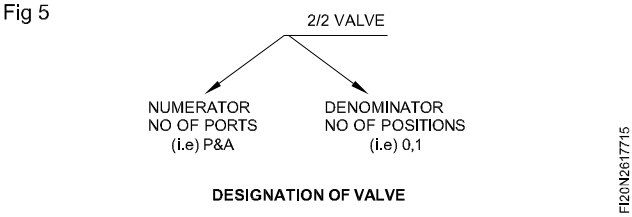


It also has two positions.

Initial position - No flow. Final position - Full flow. This is graphically represented as one square for each operating position.

Inside this square the path of flow of air is indicated by arrow marks. The valve shown in the Figs 4 & 5 is designated a 2/2 valve.

Fig 5



The ports are named as follows:

P - Pressure port

This is to indicate the entry of the compressed air from the compressor into the valve. (which is represented by a square)

A,B,C - working parts

These ports supply air to the cylinder and receive air from cylinder.

R,S,T = Exhaust parts

These are the ports from where used air is exhausted.

X, Y, Z - Control or signal ports.

These ports are used as signal input and signal outputs.

The positions of valves are named as 0, 1 and 2 or 1, 2 according to the type of actuation.

Valve classification according to the type of actuation

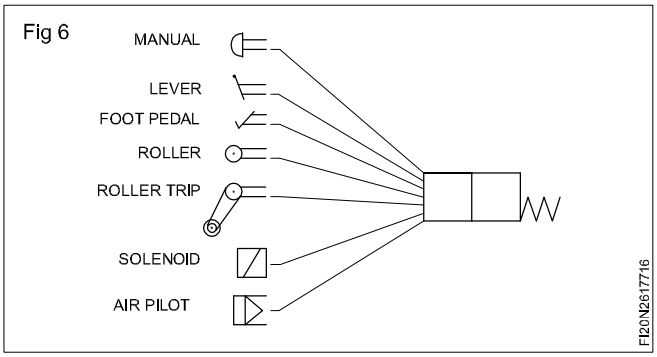
The valves have more than one marking position. For the position to change, an external force is required. The method of actuating the valve plays a very significant role to suit the purpose for which the valve is employed. This also determines the level of automation of the circuit. The actuation is grouped into 2 major groups as

- Spring return valve
- Detent valve

Spring return

In this mechanism the valve always assumes a particular position because of the spring. When operated it changes ts position. Actuation of other end may be of the following types. (Fig 6)

Fig 6

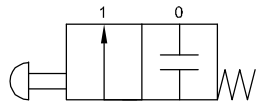


- Manual type
- Lever type
- Pedal type
- Roller type

- Roller trip type
- Solenoid
- Pilot operated

Initial position of a spring return valve is always named as '0' and other position as 1. (Fig 7)

Fig 7



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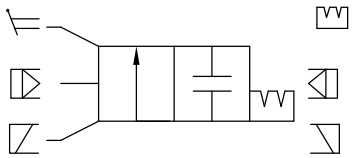
Detent valve

In this mechanism the change of position of the valve is retained (by latch), unless it is actuated, again. This type of valve is called a detent valve.

Under this category we have (Fig 8)

Fig 8



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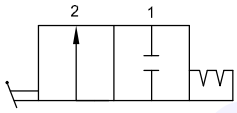
- Lever operated
- Impulse operated
- Solenoid operated

The return is also effected by any of the above mechanism.

The positions of these detent valves are indicated as 1 and 2 since it does not have a normal position, that is generally denoted by '0'. (Fig 9)

Fig 9



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According to the proximity of actuation mechanism from control again actuations can be

- Direct or
- Remote

Direct actuations are hand lever,pedal,rolleretc. (Fig 10)

Remote control is by air, air impulse solenoid et (Fig 11)

Fig 10

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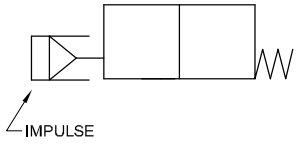
Fig 11



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Various types of directional control valve

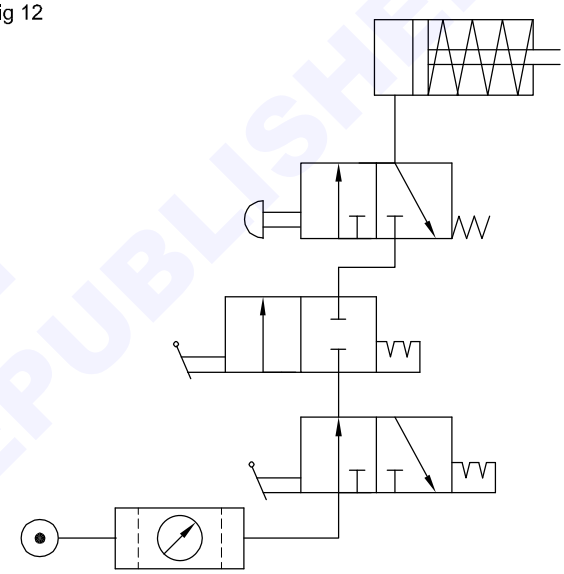
Here we discuss various types of valves according to their function. The type of actuation and constructions are not considered.

2/2 directional control valve

This has 2 ports and 2 positions

This valve normally is used for termination and commencement of air flow. This valve ideally serves as a cut-off valve in circuit. For emergency situations a cut-off valve shown in the circuit diagram, (Fig.12) can stop the cylinder movement, suddenly by cut-off the air supply. The various 2/2 valves according to the internal design are shown in Fig13 in both normal and operated conditions. These valves can be normally closed type or opened type. (Fig 14)

Fig 12



CUT OFF VALVE

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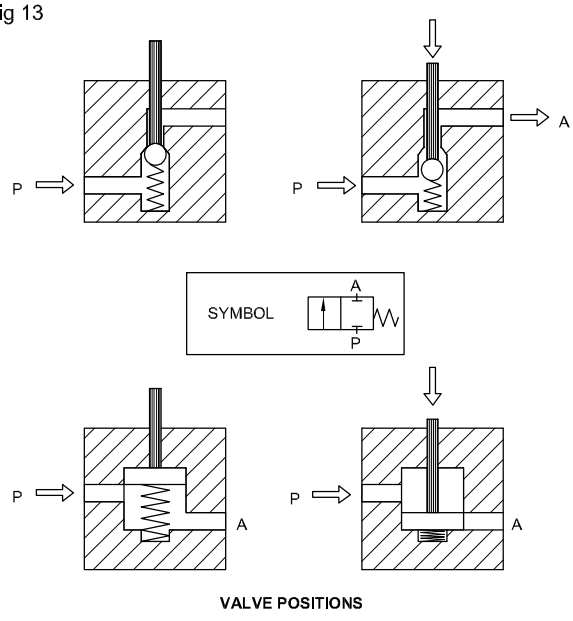
Fig 13



VALVE POSITIONS

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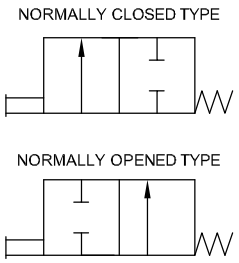
Fig 14



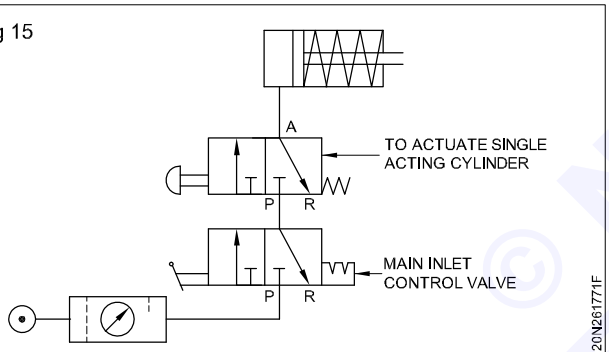
3/2 directional control valve

The main advantage of the 3/2 valve is that it gives vent for the used air through the exhaust port. It has 3 ports P, A and R. This facilitates to generate a signal and also to cancel the signal in the valve as shown in the Fig 15 initial position P is blocked, A is connected to R. In the actuated position P gets connected to A, R gets blocked.

A 3/2 valve is ideally suited for an application of inlet valve, and also for actuating a single acting cylinder (Fig 15).

This valve is also very ideal for remote control of main direction control valves as impulse and pilot type. The construction of various 3/2 valves in normal and actuated conditions are shown in Fig 15.

Fig 15



3/2 valves are available as both normally opened type or closed type, which can be selected according to the requirement of the circuit. (Fig 16)

4/2 directional valve

The main application of a 4/2 valve is in actuation of a double acting cylinder. This valve has 4 ports namely

P - Pressure port

A & B - Working port

R - Exhaust port

In normal position (Fig 17) P is connected to A and B is connected to R and vice-versa in the other position.

The application of a 4/2 valve to actuate of double acting cylinder is shown in Fig 18.

Fig 16

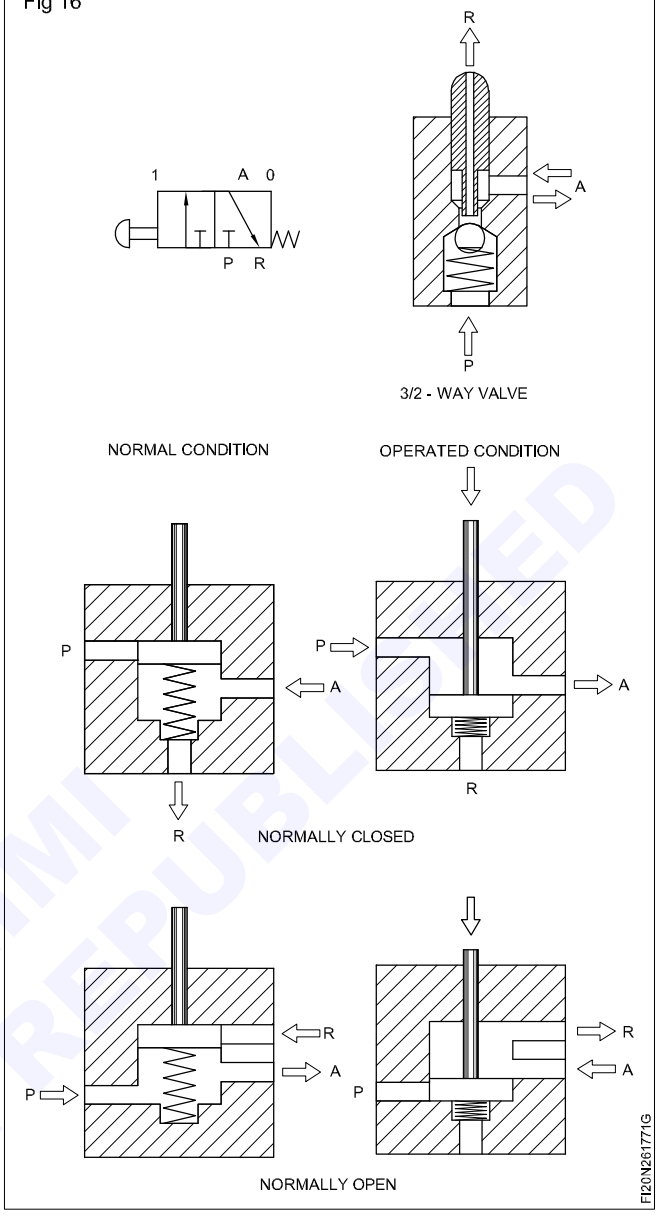


Fig 17

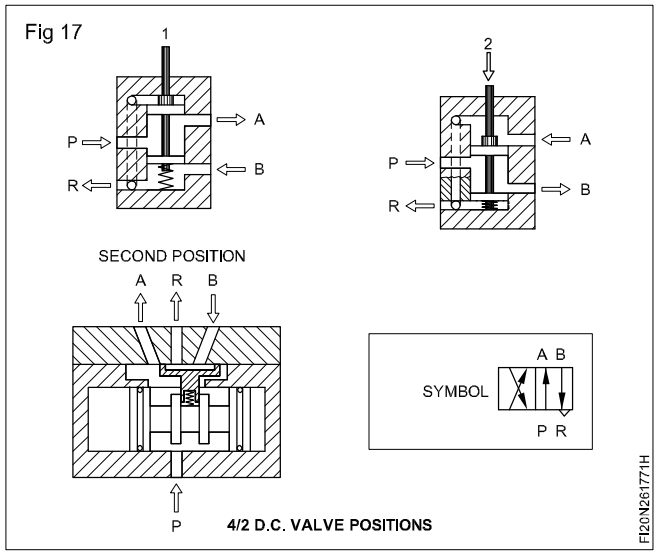
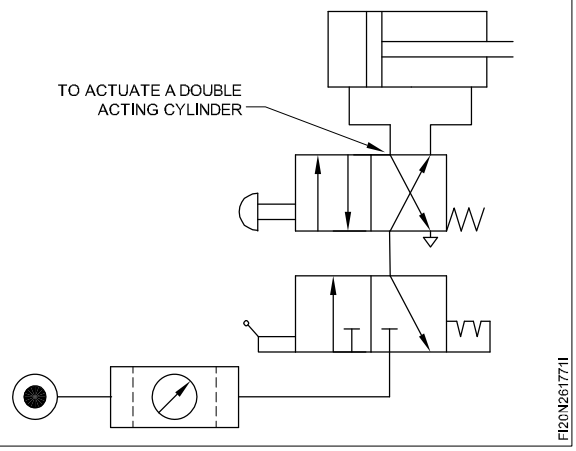


Fig 18



5/2 directional control valve

A 5/2 directional control valve functions similar to that of a 4/2 valve, to actuate a double acting cylinder. 5/2 valve has the advantage of having separate exhaust paths for forward and retraction motion, thereby the motion can be controlled independently. 5/2 valve also has advantage in its simple manufacturing process. 5/2 valve has 5 ports

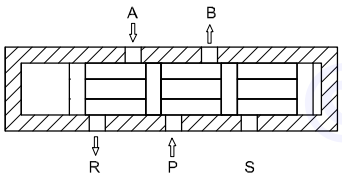
P - Pressure port

A & B - Working ports

R & S - Exhaust ports.

The construction of a 5/2 valve is shown in Fig 19

Fig 19



Sealing action in valves

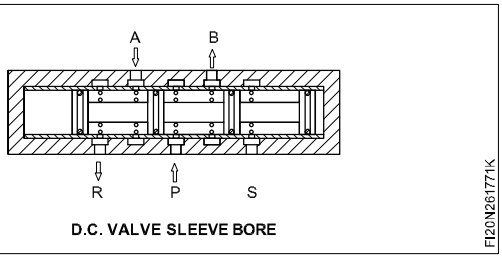
The body of the valve and the seat or the spool should have minimum leakage between them. This is a very important criteria in the design of valves.

The sealing is done by the following methods.

In spool valves

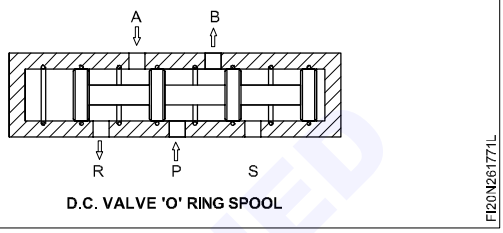
- The bore of the body and spool are matched by super finishing to have a minimum working clearance (Fig 19) and a metal to metal sealing.
- A separate sleeve (Fig 20) is inserted into the body of the valve. The sleeve ID and the spool have a close tolerance, with (Fig 21) 'O' rings on the spool creating a leak proof working.

Fig 20



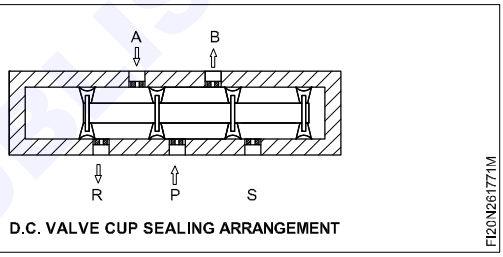
- 'O' ring mounted on the bore of the body (Fig 21) also helps in sealing.

Fig 21



- Cup seats mounted on the spool also helps in having a leak proof (Fig 22) spool movement.

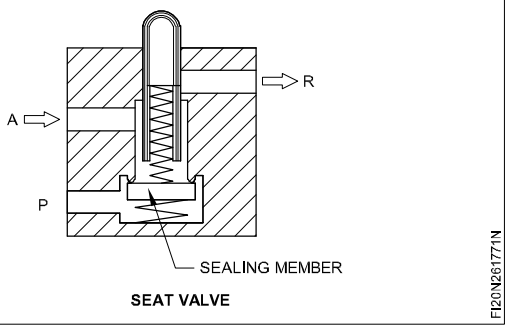
Fig 22



Sealing in seat valve

In seat valves the seat or the disc is usually made of non-metallic substance line rubber nylon etc, so as to have perfect sealing of the ports. These valves have better sealing compared to slide valves. Hence seat valves are more reliable. (Fig 23)

Fig 23



Pneumatic symbols

Objectives: At the end of this lesson you shall be able to
- **identify components using ISO 1219 symbol**
- **interprete symbol of direction control valve symbol.**

Symbol: It is a representation of pneumatic component. Commonly pneumatic symbols are drawn as pe IS 1219 standards.

> **Symbol does not indicate size of the Component.**
>
> **It does not indicate orientation or arrangement of inner components.**

Symbols uses common geometrical shape which is to catagorise the type of component. The shape used in general are:

Square: It represents a valve.

Circle: It represents compressor,pneumatic motor and gauge.

Line: it represents piping.

Dimond: It represents filter, dryer, lubricator.

Cylinder: It represents receiver.

Rectangle: It represents cylinders.

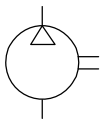
Dotted box: It represents an assembly of various components.

Triangle: It represents pneumatic energy i.e service air.

Symbol with circle:

Unidirectronial (Fig 1)

Fig 1



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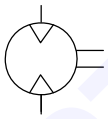
pneumatic Motor (Fig 2) Bidirectional

Fig 2



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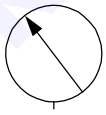
Pressure Gauge (Fig 3)

Fig 3



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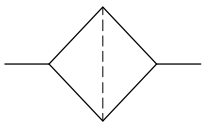
Symbol with diamond shape

Filter (Fig 4)

Fig 4



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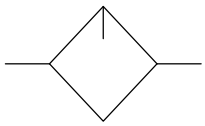
Lubricator (Fig 5)

Fig 5



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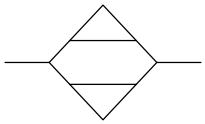
Dryer (Fig 6)

Fig 6



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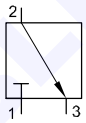
Symbol with square

As explained earlier square means valve. Look at the fig 7 given below.

Fig 7

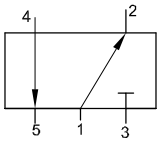


FI20N2617727

In this figure three extended lines 1,2,& 3 are shown which shows that the port, means where you connect pipes. Arrow inside the square shows the path of air flow inside the valve. The figure shows port 1 is closed but port 2 & 3 are connected internally.

In figure 8 there are 5 ports namely 1,2,3,4 & 5 where you can connect pipes. The figure shows that ports 1 & 2 are connected such a way that flow direction is from 1 to 2, similarly ports 4 & 5 are connected in such a way that flow direction is 4 to 5. But port 3 is closed.

Fig 8



FI20N2617728

The port numbering has certain meaning as follows:

Input port: Port where incoming compressed air is connected. It is always "1" and also represented by port "p".

Output port: From where air comes out of the valve is always even number "2" and "4". Output ports are also represented by port "A" & "B".

Exhaust port: From where air is vented to the atmosphere is always odd number "3" and "5". Output ports are also representd by port "R" & "S".

Types of Valves

There are three types of valves used in pneumatic system.

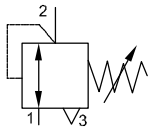
Pressure Valve: Used to control pressure there by force in the pneumatics. It is always represented by single square.

Direction control valve: Used to control the direction of movement of load connected to piston rod; like forward or reverse, clockwise or counter clockwise. It is always represented by combination of minimum two squares.

Flow control valve: Used to control speed of load, in this case square is not used.

Pressure Regulator: Symbol of pressure regulator is shown in Fig 9

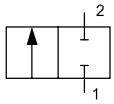
Fig 9



FI20N261729

Direction control valves: Look at the symbol shown in Fig 10

Fig 10



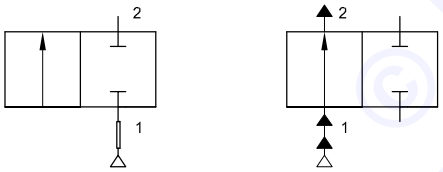
FI20N261772A

In this symbol there are two squares drawn side by side. A square indicates position, thus right square indicate one position and left square other position.

Position refers to status. In the right position port 1&2 are closed, but in the left position both ports are connected.

Let us compare the two positions as shown in Fig 11.

Fig 11

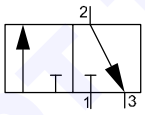


FI20N261772B

In this valve there are 2 ports and 2 positions, hence called two port two position valve or simply 2/2 way valve.

3/2 Way valve: By name it is clear this valve is having 3 ports and 2 position. Symbol is shown Fig 12

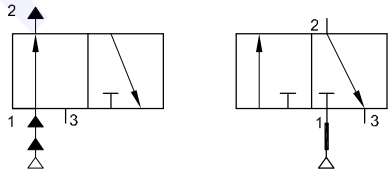
Fig 12



FI20N261772C

Compare the two positions as shown in fig 13

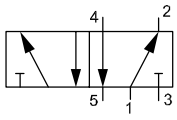
Fig 13



FI20N261772D

5/2 Way valve: By name it is clear this valve is having 5 ports and 2 position. Symbol is shown in Fig 14

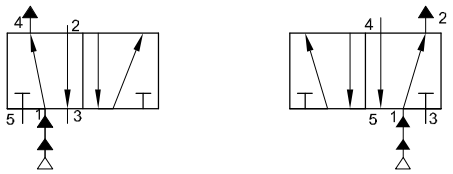
Fig 14



FI20N261772E

Compare the two positions as shown in Fig 15

Fig 15



FI20N261772F

Actuation Type

It is a device which indicates how to operate the valve There are several types available but our scope is limited to following types.

- Manual Type
- Mechanical Type
- Pilot Type
- Solenoid Type

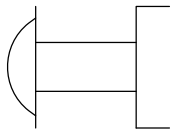
Manual Type

This mechanism is operated by a person, like

- Push Button
- Lever
- Foot pedal

Push Button: It is a button type device when pressed by operator valve actuates (Fig 16)

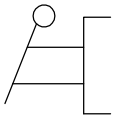
Fig 16



FI20N261772G

Lever: It is a handle type device when pressed by operator valve actuates (Fig 17)

Fig 17

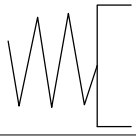


FI20N261772H

Mechanical Type: Valve is operated by some mechanical force.

Spring: Common compression spring which actuates valve on de-compression (Fig 18)

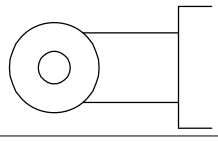
Fig 18



FI20N261772I

Roller: It is like a lever with small wheel type device when pressed by some object valve actuates (Fig 19)

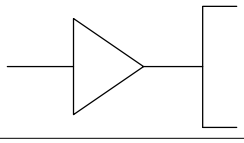
Fig 19



FI20N261772J

Pilot: It is air operated type (Fig 20)

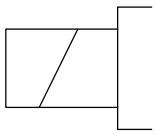
Fig 20



FI20N261772K

Solenoid: IT is electrical operated type (Fig 21)

Fig 21



FI20N261772L

Identifying the direction control valve

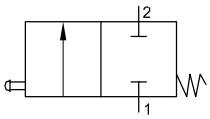
To identify direction control valve follow the procedure given below.

- Identify number of ports.
- Identify number of positions.
- Identify actuation mechanism.
- Observe air flow path in the symbol, in each position.

Observe the symbol given in Fig 22

In the fig 22

Fig 22



FI20N261772M

- No of ports: Two (1 & 2)
- No of positions: Two; (2 Squares)
- Actuation methods: Push Button (at left side), spring (at right side)

Write this information in the format given:

--------Port-------- Postion--------operated-------return

So you get:

2 port 2 position push button operated spring return Direction control valve. Whenever you observe spring in the symbol it means "Normal" position exists. Normal position refers to predominant unactuated condition.

In the symbol shown in Fig 22, right side positon is achieved due to spring when there is no force applied on push button, means right side position is the normal position.

It is important to note that whether input port (1 or p) is open or closed in normal position.

If input port is closed, we say normally closed valve.

If input is connected to output port (2,4 or A, B then we say normally open valve:

In the symbol shown above, in normal position input port is closed therefore valve is normally closed valve.

We can rewrite complete designation of the valve as follows:

2 port 2 position push button operated spring return normally closed Direction Control Valve.

Lets try to identify valves given in the next pages. (Fig 23 to Fig 59)

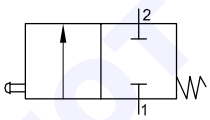
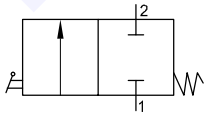
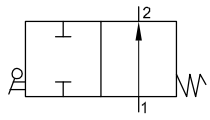
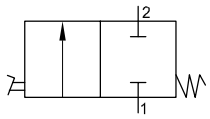
Symbol	Designation
Fig 23  FI20N261772N	2 port 2 position push button operated spring return normally closed Direction Control Valve.
Fig 24  FI20N261772O	2 port 2 position lever operated spring return normally closed Direction Control Valve.
Fig 25  FI20N261772P	2 port 2 position lever operated spring return normally open Direction Control Valve.

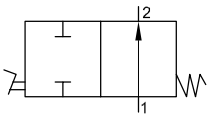
Fig 26



FI20N261772Q

2 port 2 position foot pedal operated spring return normally closed Direction Control Valve.

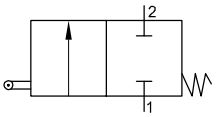
Fig 27



FI20N261772R

2 port 2 position foot pedal operated spring return normally open Direction Control Valve.

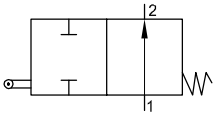
Fig 28



FI20N261772S

2 port 2 position roller operated spring return normally closed Direction Control Valve.

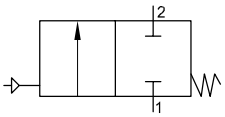
Fig 29



FI20N261772T

2 port 2 position roller operated spring return normally open Direction Control Valve.

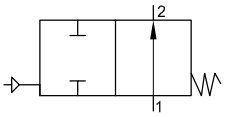
Fig 30



FI20N261772U

2 port 2 position pilot operated spring return normally close Direction Control Valve.

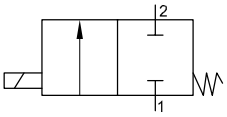
Fig 31



FI20N261772V

2 port 2 position pilot operated spring return normally closed Direction control Valve.

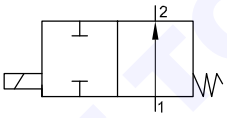
Fig 32



FI20N261772W

2 port 2 position Solenoid operated spring return normally closed Direction Control Valve.

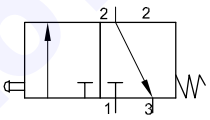
Fig 33



FI20N261772X

2 port 2 position Solenoid operated spring return normally open Direction Control Valve.

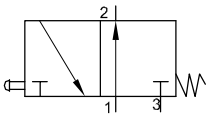
Fig 34



FI20N261772Y

3 port 2 position push button operated spring return normally closed Direction Control Valve.

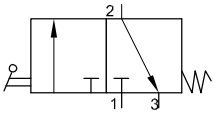
Fig 35



FI20N261772Z

3 port 2 position push button operated spring return normally open Direction Control Valve.

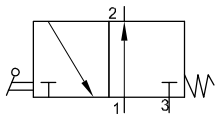
Fig 36



FI20N261772Z1

3 port 2 position lever operated spring return normally closed Direction Control Valve.

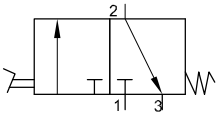
Fig 37



FI20N26177222

3 port 2 position lever operated spring return normally open Direction Control Valve.

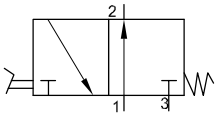
Fig 38



FI20N26177223

3 port 2 position foot pedal operated spring return normally close Direction Control Valve.

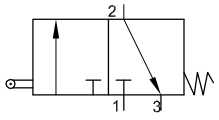
Fig 39



FI20N26177224

3 port 2 position foot pedal operated spring return normally open Direction Control Valve.

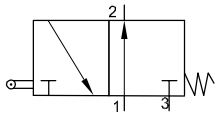
Fig 40



FI20N26177225

3 port 2 position roller operated spring return normally close Direction Control Valve.

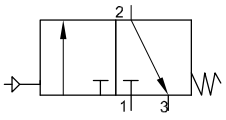
Fig 41



FI20N26177226

3 port 2 position roller operated spring return normally open Direction control Valve.

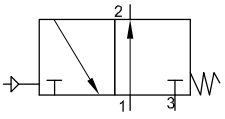
Fig 42



FI20N26177227

3 port 2 position pilot operated spring return normally close Direction Control Valve.

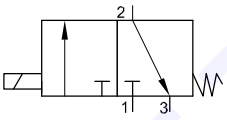
Fig 43



FI20N26177228

3 port 2 position pilot operated spring return normally open Direction Control Valve.

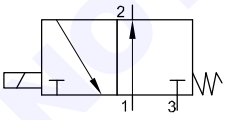
Fig 44



FI20N26177229

3 port 2 position solenoid operated spring return normally close Direction Control Valve.

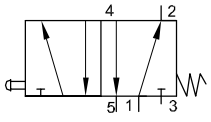
Fig 45



FI20N2617722A

3 port 2 position solenoid operated spring return normally open Direction Control Valve.

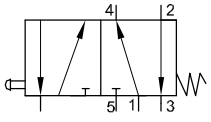
Fig 46



FI20N26177225

5 port 2 position push button operated spring return Direction Control Valve,normally 1 is connected to 2.

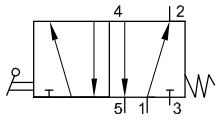
Fig 47



FI20N2617722C

5 port 2 position push button operated spring return Direction Control Valve, normally 1 is connected to 4.

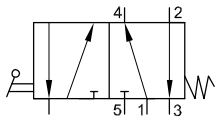
Fig 48



FI20N2617722D

5 port 2 position lever operated spring return Direction control valve,normally 1 is connected to 2.

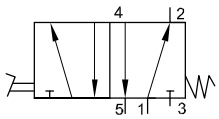
Fig 49



FI20N2617722E

5 port 2 position lever operated spring return Direction Control Valve normally 1 is connected to 4.

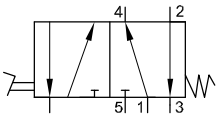
Fig 50



FI20N2617722F

5 port 2 position foot pedal operated spring return Direction Control Valve normally 1 is connected to 2.

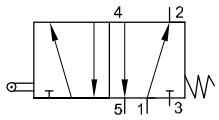
Fig 51



FI20N2617722G

5 port 2 position foot pedal operated spring return Direction Control Valve normally 1 is connected to 4.

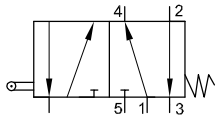
Fig 52



FI20N2617722H

5 port 2 positionr roller operated spring return Direction Control Valve normally 1 is connected to 2.

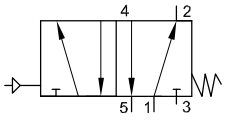
Fig 53



FI20N2617722I

5 port 2 position roller operated spring return Direction Control Valve normally 1 is connected to 4.

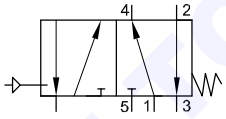
Fig 54



FI20N2617722J

5 port 2 position pilot operated spring return Direction Control Valve normally 1 is connected to 2.

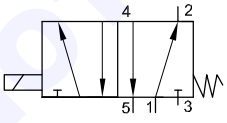
Fig 55



FI20N2617722K

5 port 2 position pilot operated spring return Direction Control Valve normally 1 is connected to 4.

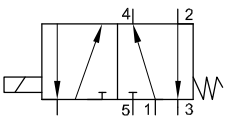
Fig 56



FI20N2617722L

5 port 2 position solenoid operated spring return Direction Control Valve,normally 1 is connected to 2.

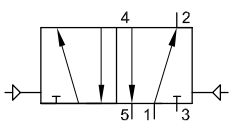
Fig 57



FI20N2617722M

5 port 2 position Solenoid operated spring return Direction Control Valve, normally 1 is connected to 4

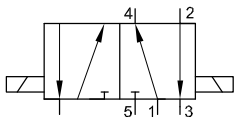
Fig 58



FI20N2617722N

5 port 2 position double pilot operated Direction Control Valve.

Fig 59



FI20N261772ZO

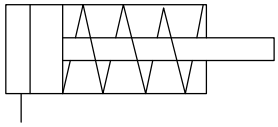
5 port 2 position double solenoid operated Direction Control Valve.

Symbol with Rectangle

In general rectangle is used to represent linear actuator like single acting cylinder and double acting cylinder.

Single acting cylinder (Fig 60)

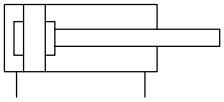
Fig 60



FI20N2617722P

Double acting cylinder (Fig 61)

Fig 61



FI20N2617722Q

Symbol with cylinder:

In general cylindrical shape is used to represent air receiver or air storing device (Fig 62).

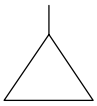
Fig 62

FI20N2617722R

Symbol with triangle:

In general triangular shape is used to represent air source (Fig 63).

Fig 63



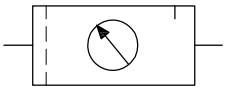
FI20N2617722S

Symbol with dotted box:

Symbol shown in dotted box represents assembly of components like FRL, Time delay valve.

FRL: It is an assembly of Filter, regulator and lubricator. (Fig 64).

Fig 64

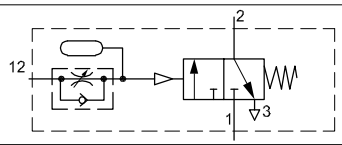


FI20N2617722T

Time delay valve

It is an assembly of flow control valve, 3/2 way valve and an air receiver (Fig 65.)

Fig 65



FI20N2617722U

Other Symbols

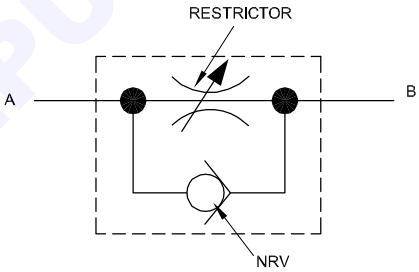
Non return valve (Fig 66)

Fig 66

FI20N2617722V

Flow control valve (Fig 67)

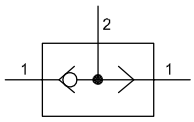
Fig 67



FI20N2617722W

Shuttle valve (Fig 68)

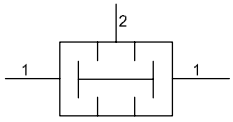
Fig 68



FI20N2617722X

AND valve (Twin pressure valve) (Fig 69).

Fig 69



FI20N2617722Y

Non-return valve/check valve

Objectives : At the end of this lesson you shall be able to
- **name the parts of a non-return valve**
- **state the working principle of a non-return valve**
- **differentiate between swing and ball type check valves.**

Non-return valve

Water supply piping systems use several mechanical devices to control and regulate the fluids and gases flowing through them.

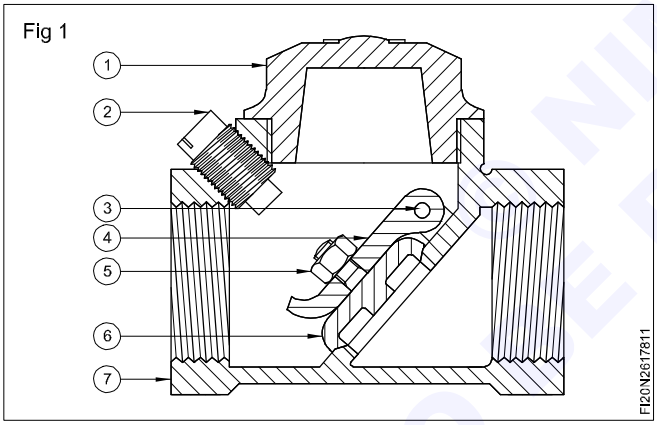
The non-return valve allows one-way flow in water supply or drainage lines. It is also called a check valve. Valves are made of cast iron, brass, bronze or plastic.

Sometimes two or more different kinds of material are used on a single valve. There are many types of check valves available in the market.

The swing check valve consists of the following parts. (Fig 1)

1 Cap

Fig 1



2 Stop plug

3 Hinge pin

4 Hinge

5 Disc hinge nut

6 Disc

7 Body

In the swing check valve, the flow of a fluid or gas in one direction lifts the disc and allows one-way flow only. The return of the disc to its seating position prevents the flow in the reverse direction.(Figs 2 & 3)

Fig 2

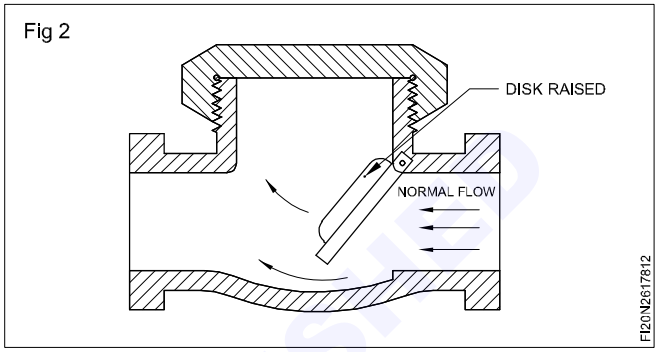
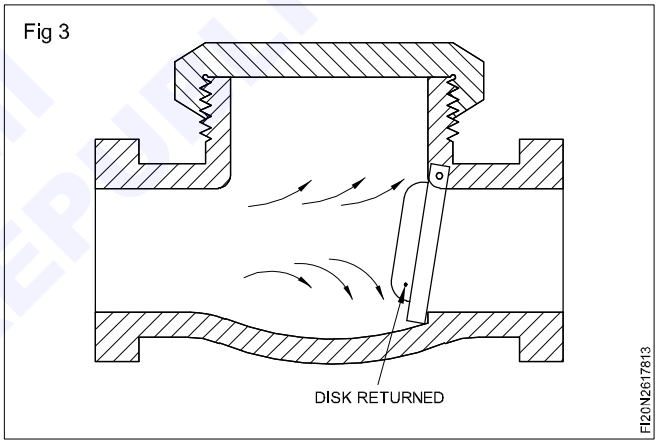
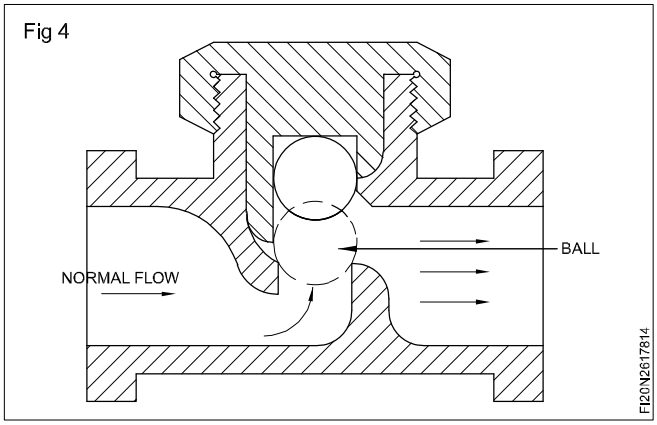


Fig 3



In the ball-type check valve, the flow of a fluid or gas in one direction lifts the ball; when the pressure is released the ball falls against its seating and prevents flow in the reverse direction. (Fig 4)

Fig 4



Flow control valve

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

- **explain the flow control valve**
- **state the difference between variable and one way flow control valve**
- **interpret and draw meter - in speed control hydraulic control**
- **explain meter - out speed control method**
- **explain bleed - off speed control circuit and its function.**

The purpose of flow control in a hydraulic system is to regulate speed of a cylinder or the R.P.M. of a motor. Since both values are dependent on the flow rate,however constant pumps supply a uniform flow rate.

Reduction in the flow rate is achieved according to the following principle

A reduction in the flow cross - section in the flow control valve causes an increase in pressure ahead of this. This pressure causes the pressure relief valve to open and flow rate is divided. This divison of the flow rate causes enough flow volume required for the r.p.m. or speed to flow to the actuator and the excess delivery to be discharged via pressure relief valve.

Flow control valve is a orifice or restrictor in hydraulic system.

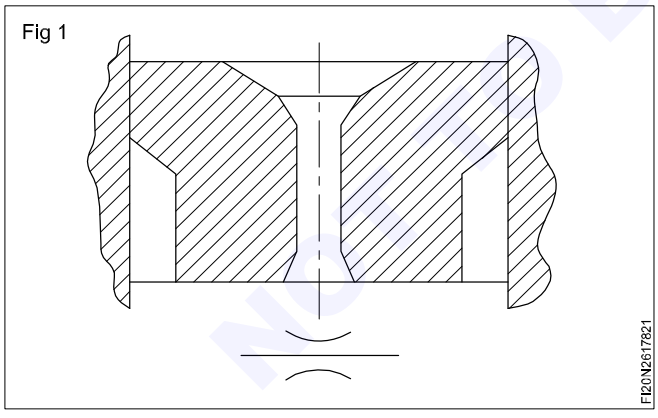
Orifices

- A simple orifice is the most elementary method for controlling flow.
- The orifice is always placed in series with the pump.
- A fixed orifice can be a drilled hole in a fitting, but variable orifice is a calibrated needle valve.

Fixed orifice (Fixed flow control valve)

Fixed orifice is a simple small opening in line which is not variable. (Fig 1)

Fig 1



Variable flow control valve

Throttle and orifice valves are used to achieve a certain pressure drop. This is done by creating a specific flow resistance.

If needle of flow control valve moves closer to the seat then opening is less and flow also reduced. (Fig2)

When needle move away from valve seat (Fig 3) opening increases and flow also increases.

Fig 2

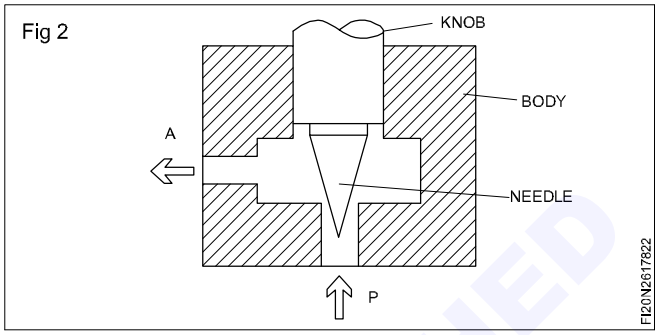
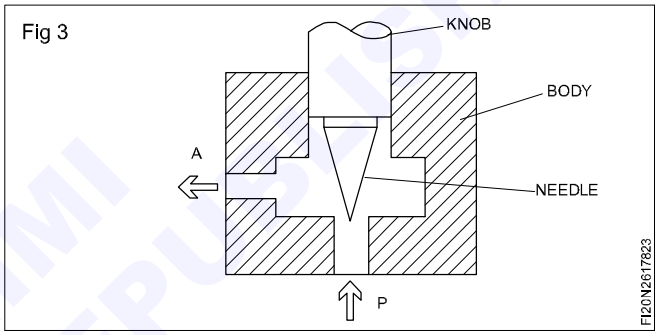
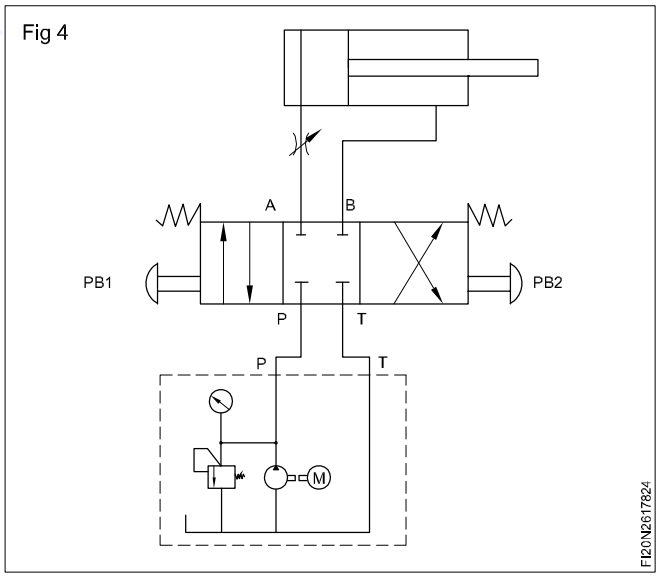


Fig 3



One advantage of this design is that it is simple and inexpensive. Hyadraulic circuit diagram with variable flow control valve is given below in fig 4

Fig 4

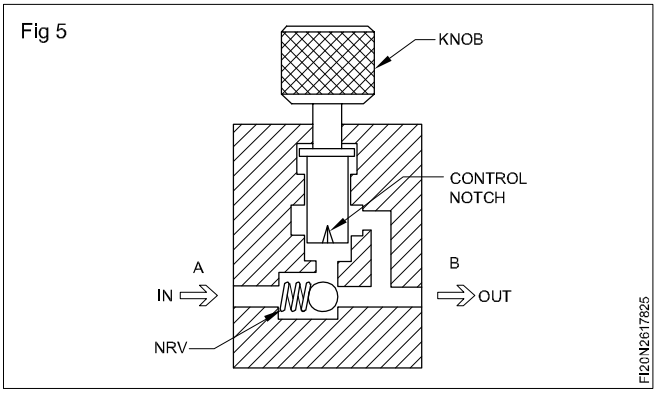


One - way flow control valve

The one - way flow control valve is a combination of an orifice or throttle valve and a non - return valve. The restrictor controls the flow rate in a single direction dependent on flow. In the opposite direction, the full cross - sectional flow is released and the return flow is at full, pump delivery.

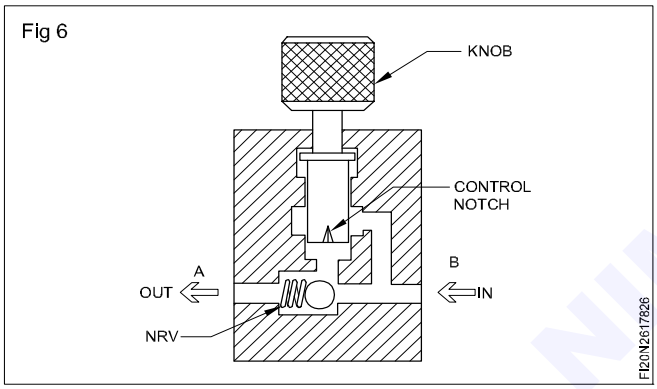
The flow is throttled in the flow direction from A to B. So less flow is going inside the actuator and speed of actuator is reduced. (Fig 5)

Fig 5



Flow is not restricted in the opposite direction from B to A because the non - return valve is lifted from its valve seat and the full cross - section flow is released. (Fig 6)

Fig 6



With adjustable one - way flow control valves, the throttling point can either be enlarged or reduced.

Speed - control Methods

Three methods are generally used to control the speed of actuator

- Meter - in speed control
- Meter - out speed control
- Bleed off speed control

Meter - in speed control

Fig 8 provides a schematic drawing of a meter - In flow control circuit restriction fluid as it enters an actuator port. Meter -in circuits work well with hydraulic fluids, but can give erratic action with air. Meter - in flow controls only work on resistive loads because a running - away load can move the actuator faster than the circuit can fill it with fluid.

The method in which the flow of oil is reduced which is going inside the actuator is known as meter - in speed control method.

In Fig 7 pump running in unload condition due to open centre valve. Notice that the check valves in the flow controls force fluid through the orifices as it enters the cylinder and lets fluid by pass them as it leaves.

Fig 7

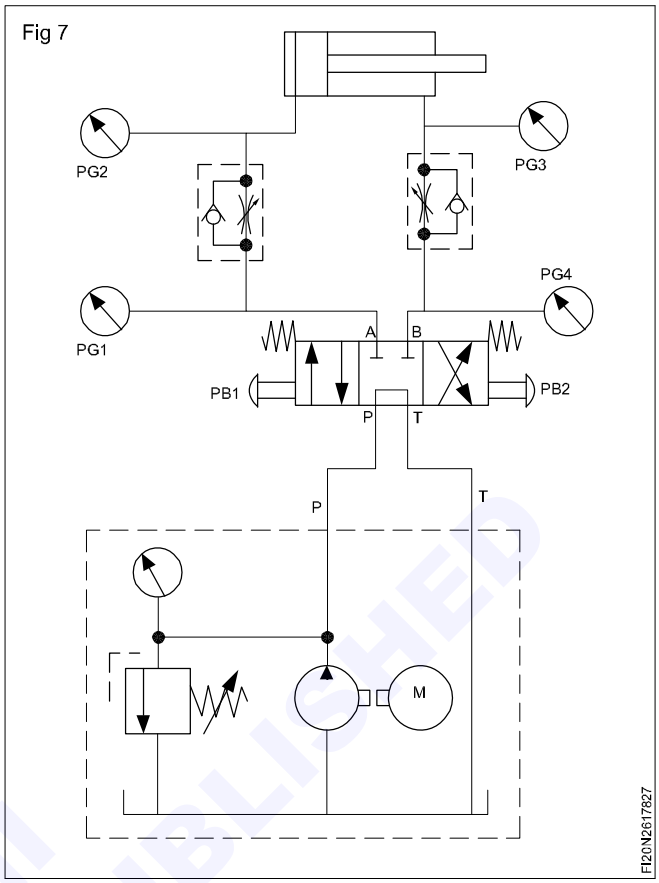
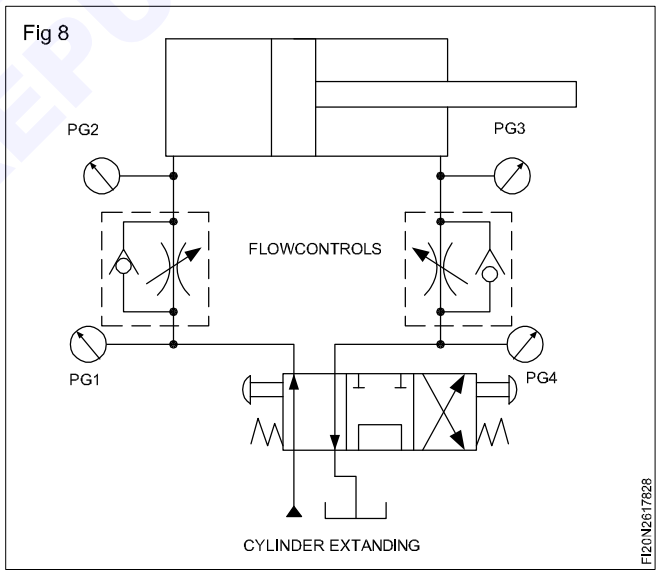


Fig 8



It is obvious that if the cylinder had an external foce pulling on it, it would extend rapidly. Because fluid enters the cap end at a reduced flow rate, a vacuum void would form there until the pump had time to fill it.

- For any normal application meter - in speed control method is preferable.
- It gives finer & smooth speed control

Meter - out speed control

Fig 10 shows a schematic drawing of a meter - out flow control circuit that restricts fluid as it leaves an actuator port. Meter - out circuits work well with both hydraulic

and pneumatic actuators. Cylinder - mounting attitude is not important because outlet flow is restricted and an actuator cannot run away. Meter - out flow controls work on resistive loads or running away loads.

Speed control by regulating flow coming out of actuator is called Meter out method.

Below circuit in Figure 9 is shown at rest with the pump running. Notice how check valves in the flow controls allow fluid to by pass the orifices and freely enter the cylinder. As fluid leaves the cylinder, it is forced through the orifices at a set rate. Only PG3 pressure gauge will show the pressure because the load on the cylinder rod is inducing pressure at the valve's blocked port**.**

Fig 9

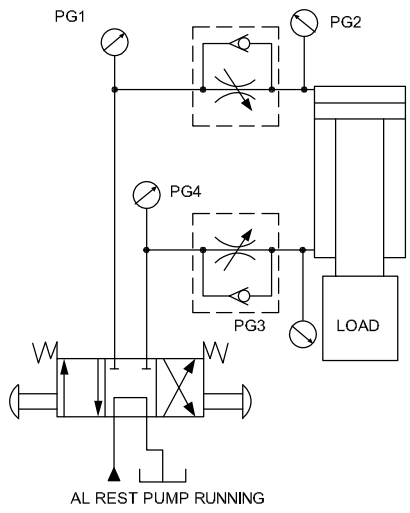
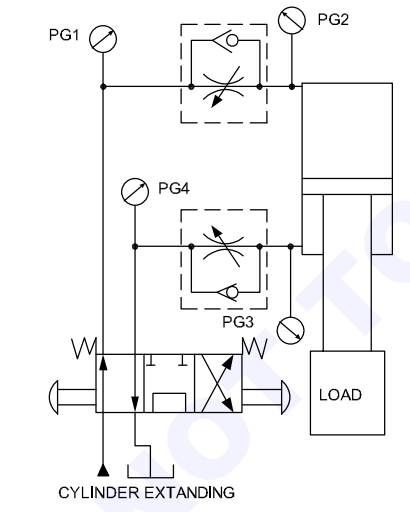


Fig 10



- If nature of load on actuator is pulling type or pushing type then meter - out speed control is preferable method to use.
- This circuit maintains a constant back pressure during rod extension if the load drops quickly or reverses.

The below circuit shows conditions when the cylinder is extending. The directional control valve shifts to straight arrows and pump flow by passes the upper flow contorl to go to the cylinder cap end. Fluid leaving the cylinder rod end is held back before it goes to tank even with an external load trying to move it. The cylinder extends at a reduced speed in hydraulic circuits until it meets a resistance.

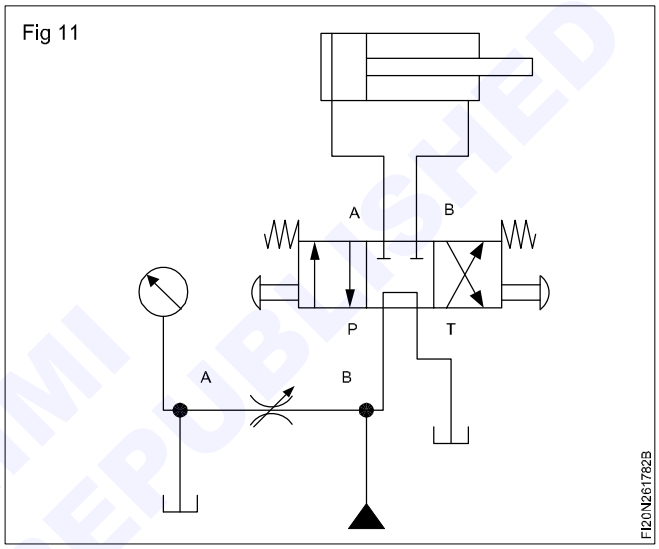
Bleed - off speed control

Bleed - off flow control circuits are found only in hydraulic systems and normally only in those with fixed - volume pumps.

Speed control by metering part of the pump flow to tank is known as bleed off flow contol (Fig 11)

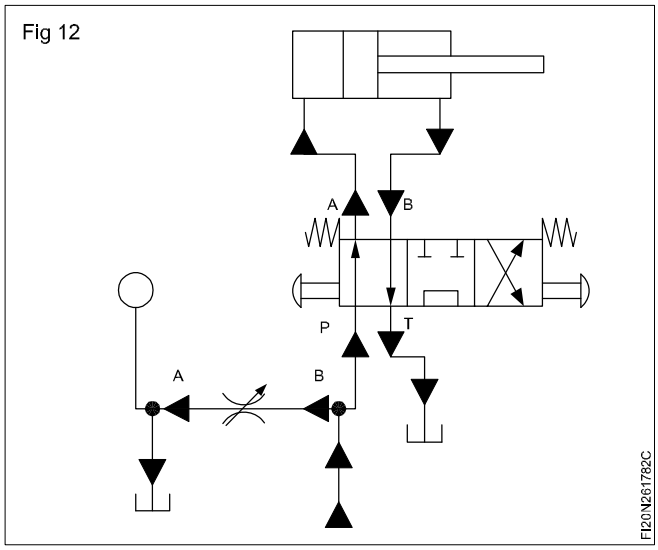
Fig 11 shows a bleed - off circuit at rest with the pump running. One port of flow control valve (Needle valve) is connected to P port or any output (A or B port) and another port of flow control valve is connected to T port.

Fig 11



When the directional valve in Fig 12 shifts or actuated in parallel port position then all pump flow passes from P port to A port through direction control valve.

Fig 12



On the way to the actuator, part of the flow is bled off to tank, so the actuator forward speed is decreased as per setting of bleed off flow control valve.

This circuit is more efficient than meter - in or meter -out, as pump output is only high enough to overcome resistance, but part of pump output is wasted.

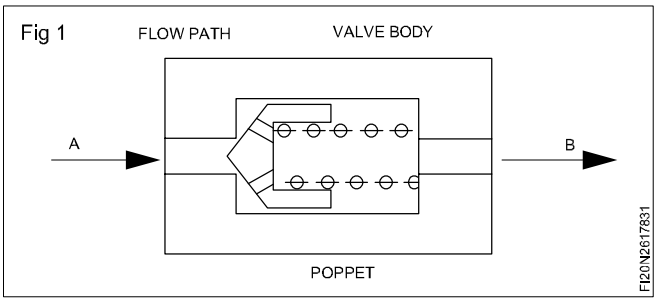
Shuttle valve and application to control single acting cylinder

Objectives : At the end of this lesson you shall be able to
- **explain working principle of non return valve (NRV) and shuttle valve**
- **state use of shuttle valve in pneumatic applications**
- **draw circuit to operate single acting cylinder using two 3/2 way valves and shuttle valve.**

Working principle of Non Return Valve:

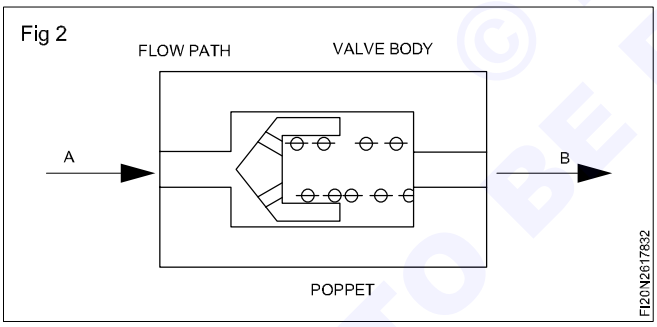
This valve allow air flow in one direction but does not allow air to flow in opposite direction. Non return valve is also known as check valve.

Fig 1 shows the construction of non return valve.

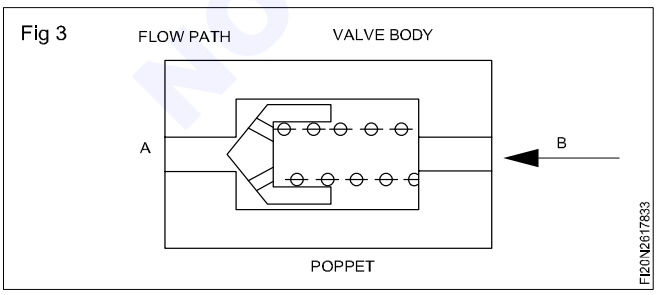


It consists of a valve body having flow path and accommodates poppet and spring. Spring exerts very small force on poppet so that it is closing the path and poppet does not dislocate even if NRV is connected vertically or at an angular position.

When air flows from port A to B, pneumatic force acts on poppet and spring gets compressed. It causes poppet to shift right side and air flow freely in A to B direction (Fig 2)



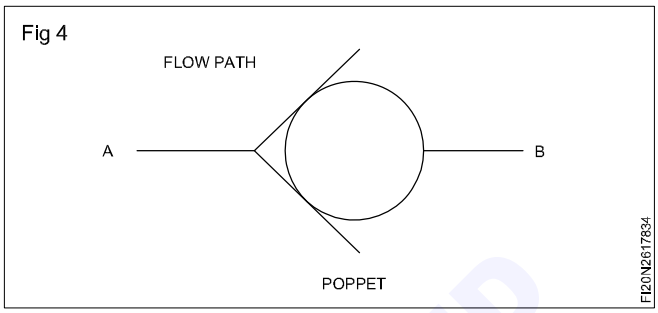
When flow direction is reversed (fig 3) means directed from port B, air pressure acts on poppet which further blocks flow path tightly thus no flow from port A.

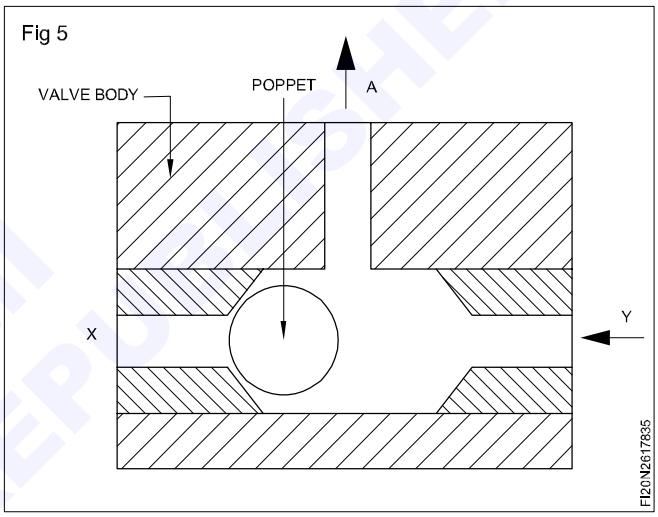


Symbol of NRV is shown if fig 4

Working principle of Shuttle Valve

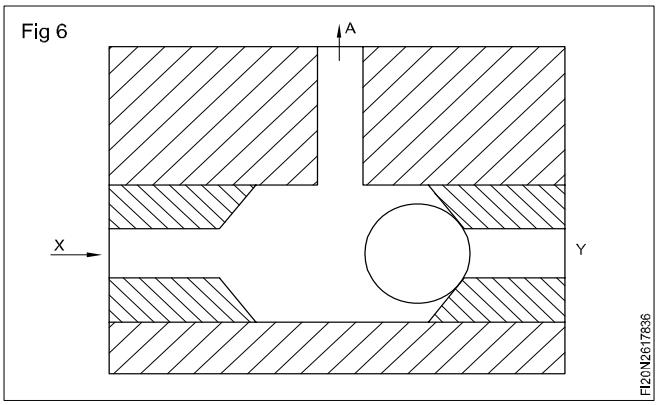
Shuttle valve is a combination of two NRV placed face to face, but having common poppet as shown in the Fig 5.





If air is supplied through port Y as shown in fig 5, poppet shifts and block port x, thus air flow from Y to A.

If air is supplied through port X as shown in fig 6 poppet shifts and block port Y, thus air flow from X to A



You can conclude that if air is supplied either from X or Y, poppet shuttles between the ports and you get the output from A. Symbol of shuttle valve is shown in fig 7.

Application

If we use two 3/2 way valves and connect their outputs fo ports x & y then on actuation of any of the valves we get output from A.

Fig 7

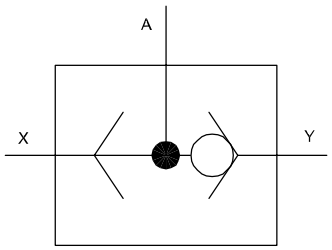
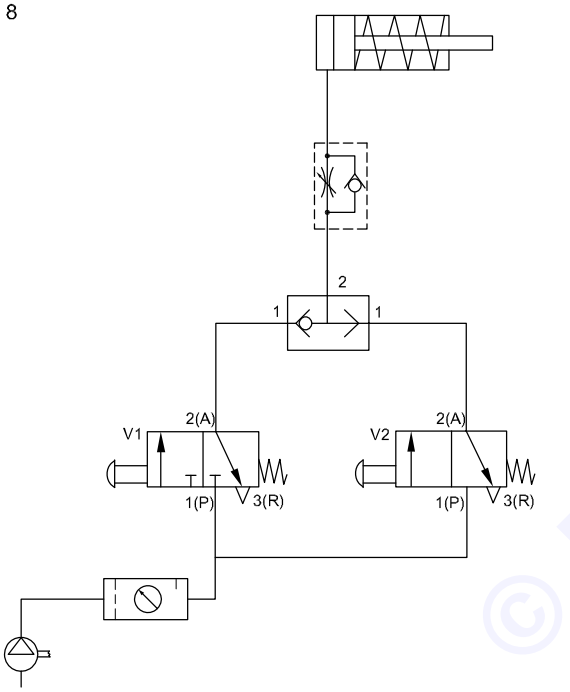


Fig 8 shows the application of shuttle valve in pneumatic circuit to operte single acting cylinder from two different locations.

Fig 8



When you operate valve V1 air flows through shuttle valve to cylinder and piston moves forward. (Fig 9)

As soon as valve is released cylinder side air exhausts through valve V1 and piston retracts.

When Valve V2 is operated air flows through shuttle valve to cylinder and piston moves forward. (Fig 10)

As soon as valve is released cylinder side air through valve V2 and piston retracts.

If you operate both valves V1 & V2 simultaneously, poppet shifts due to flow from either of the valves and air flow to cylinder, thus piston moves forward. (Fig 11)

Fig 9

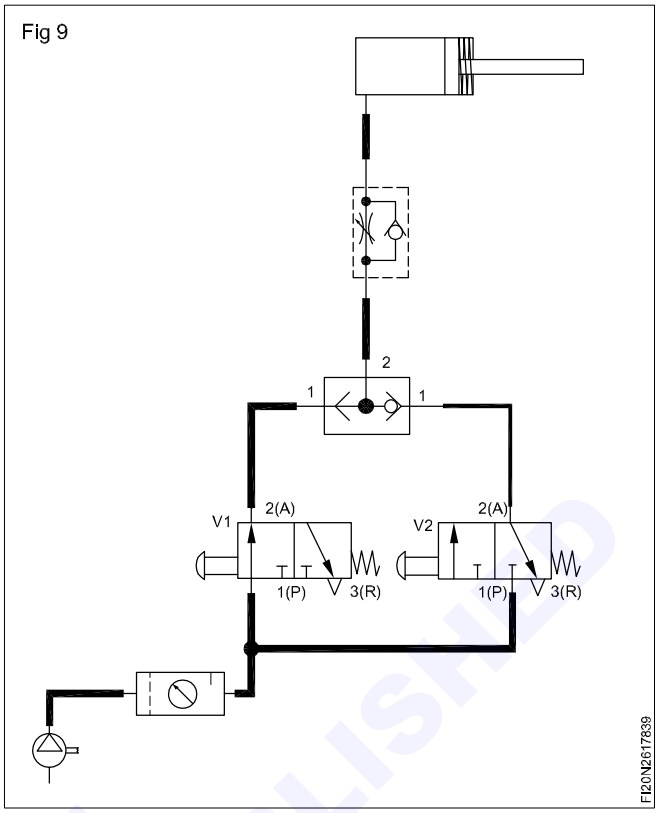
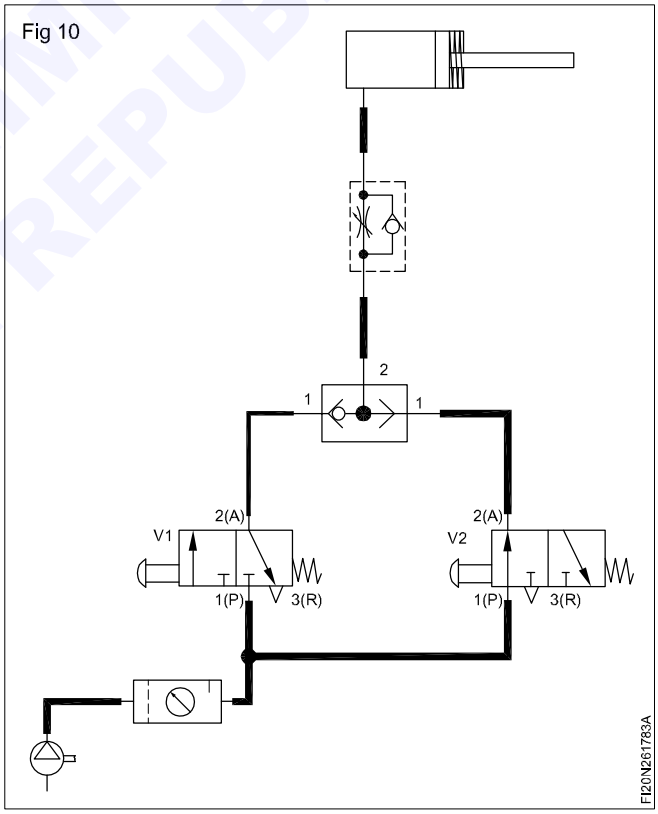


Fig 10



As soon as both valves are released cylinder side all exhausts through either of the valves and piston retracts. (Fig 12)

Fig 11

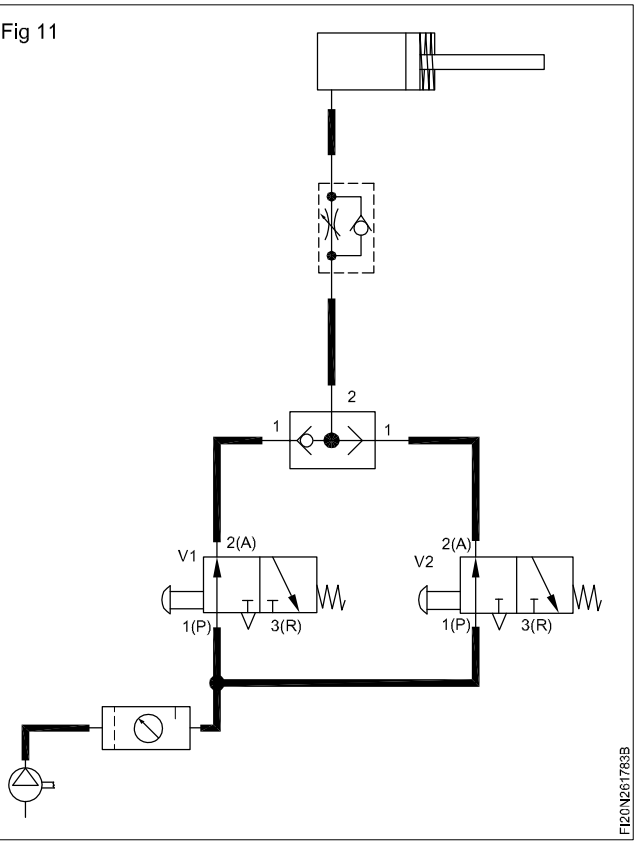
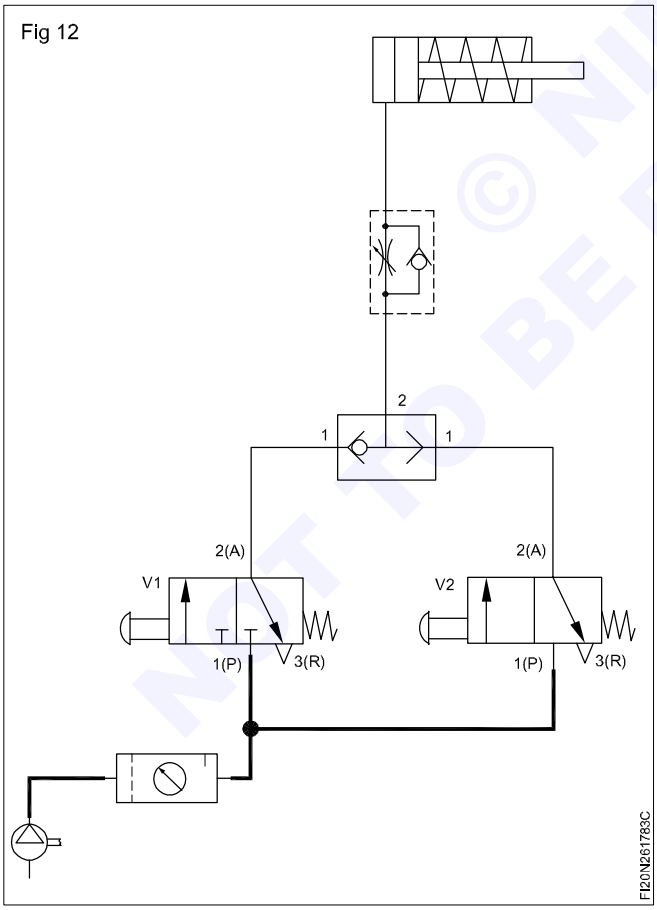


Fig 12



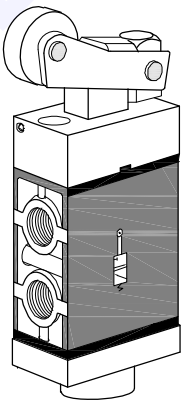
Roller valve

Pneumatic roller lever valves, used for mechanical position sensing in machine automation systems. The linear horizontal movement of a machine part of passing material, for example on a conveyor line, moving over the roller operates the valve. The wheel rotates in the direction of the moving part which reduces friction, this minimises wear and tear of both the pneumatic roller lever valve and the travelling part, for this reason, a preferred method of mechanical sensing.

Pneumatic roller lever valves, constructed from a die - cast zinc aluminium alloy that is machined and lacquered offering strength and reliablility, an overall excellent quality product. We offer 2 or 3- way normally closed, or a 5 way roller lever valve in either poppet or spool designs. Choose from a standard pneumatic roller lever valve or a compact design should space be limited. An air pilot assisted version can be ordered, used when less force is available to actuate the lever for lighter operation.

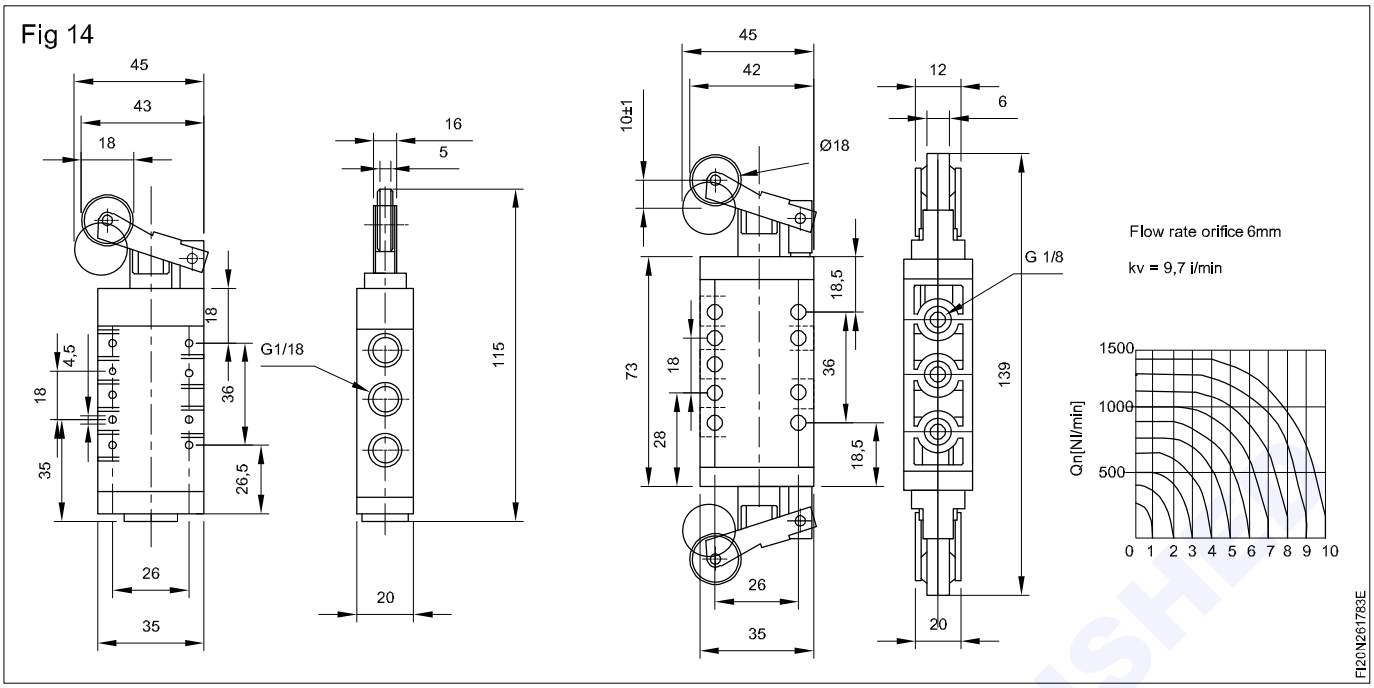
Order one- way or two - way roller levers with spring return, air pilot return or double rollers. A double roller lever is used on machine carriages to reverse the direction of travel. Port sizes are G 1/8 as standard.

Fig 13



ROLLER LEVER VALVE

Dimensional drawings



Pressure control valve

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

- **differentiate pressure relief valve, pressure reducing valve, pressure regulator and explain their function**
- **interprete counter balancing and sequencing.**

To control and regulae the pressure various pressure valve are used in hydraulics systems, like:

Classification of Pressure control valve

- Pressure relief valve.
- Pressure reducing valve
- Pressure regulator.

Pressure relief valve

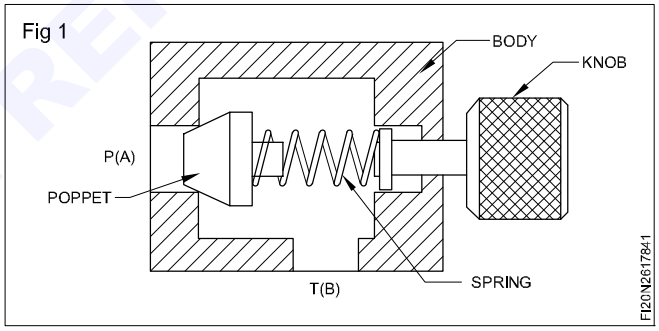
The pressure in the system is set and restricted by pressure relief valve. Pressure relief valve also help to remove excess among of oil from system to tank to overcome excess pressure.

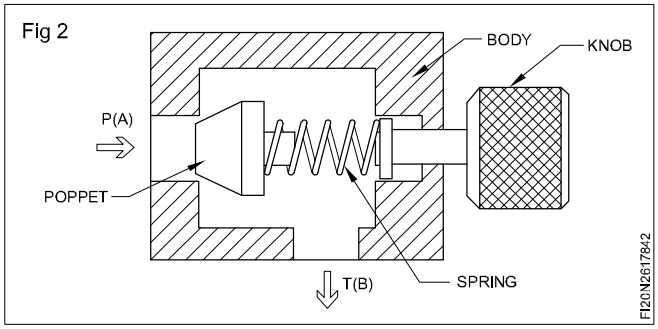
In this design incorporating a poppet valve, a seal is pressed against the inlet port P by a spring when the valve is in its normal position. The input pressure (P) acts on the surface of the sealing element generates the force.

$$F = p_1 A_1$$

The Spring force by which the sealing element is pressed onto the seat is adjustable

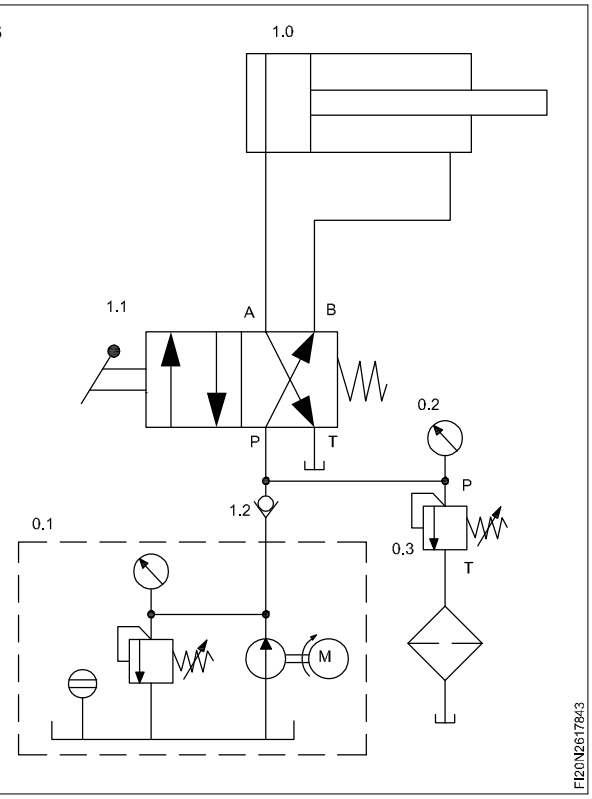
If the force generated by the input pressure exceeds the spring force, teh valve starts to open. This causes a partial flow of the liquid to the tank. If the input pressure continues to increase, the valve opens until the complete pump delivery flows to the tank.





The resistances at the outlet (tank line. filter) must be added to the force of the spring in the pressure relief valve. Application of PRV is shown in the Fig 3

Fig 3

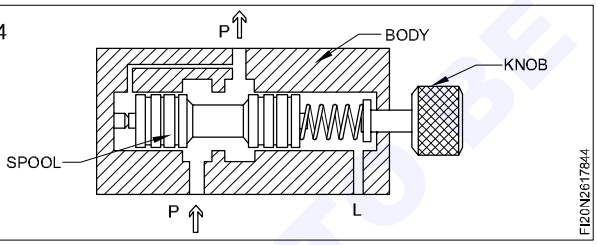


Pressure reducing valve (2 - way valve)

Pressure regulators reduce the inlet pressure to an adjustable outlet pressure. It is appropriate to use these in hydraulic system only if different pressures are required.

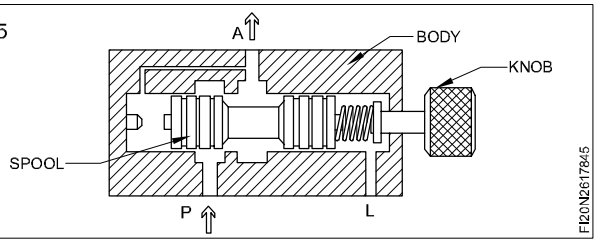
This valve is normally open. The outlet pressure (A) acts via a pilot on the left - hand surface of the pilot piston against an adjustable spring force. (Fig 4)

Fig 4



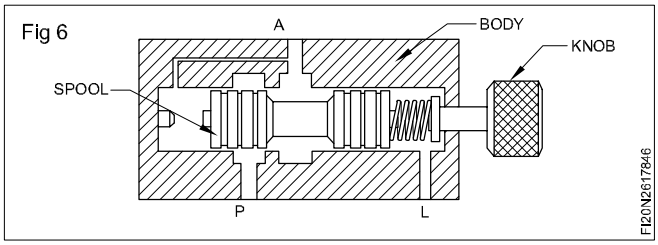
When the pressure rises at outlet A, the force at the left hand surface of the pilot piston becomes increases, the piston is displaced to the right and the throttle gap becomes narrower. This causes a pressure drop. In the case of slide valves, it is also possible to design the control edges in such way that the opening gap increases only slowly. This gives greater control precision. (Fig 5)

Fig 5



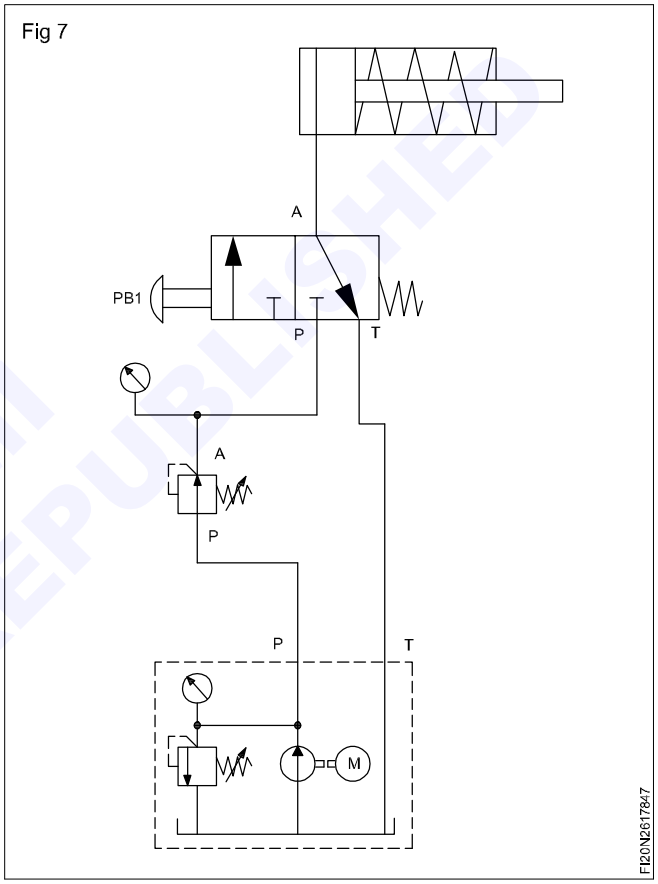
When the preset maximum pressure is reached, the throttle point closes completely. (Fig 6)

Fig 6



The pressure at the outlet A of the pressure regulator is less than the system pressure at P and constant. The piston rod of the cylinder is now in its forward end position. Application of pressure reducing valve is shown in the Fig7

Fig 7

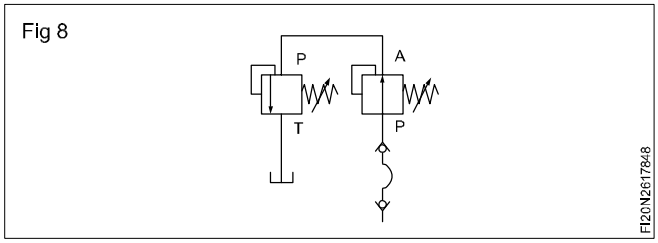


Pressure regulator (3- way Valve)

When the 2 - way pressure regulator close fully, then any impact vibration in cylinder will responsible to increase the output pressure above the set value which is not desirable. One method of rectifying this would be to install a pressure relief valve at the output.

The 3-way pressure regulator can be regarded as a combination of a 2- way pressure regulator (PR) and a pressure relief valve (PRV) (Fig 8)

Fig 8



When the pressure at A raises the result of external conditions, this pressure acts via a pilot line on the left hand piston surface of the pilot piston against an adjustable spring force. Every pressure increase causes the throttle gap to become narrower, resulting in a pressure drop. (Figs 9 & 10)

Fig 9

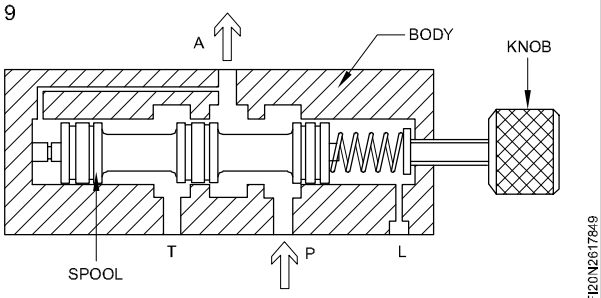
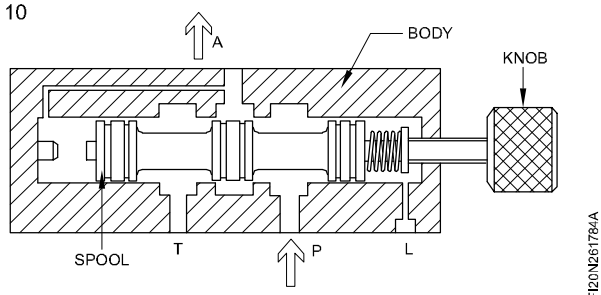
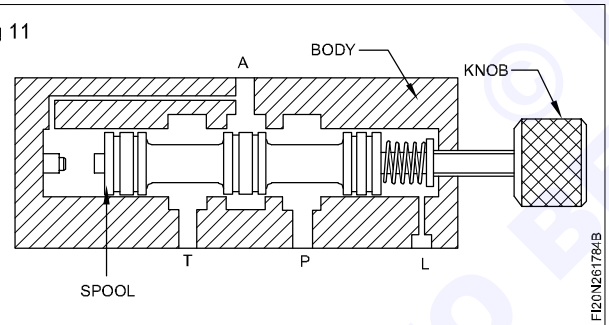


Fig 10



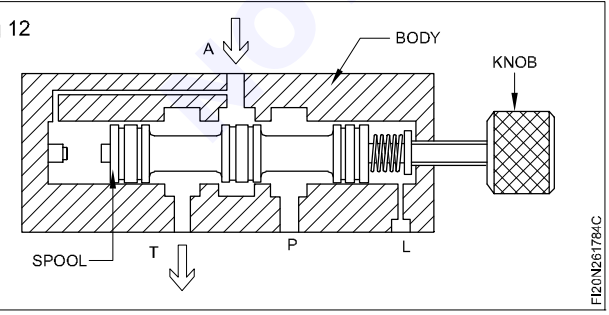
When the maximum preset pressure is reached, the throttle point closes completely. (Fig 11)

Fig 11



If the pressure rises above the preset value as the result of an external load at outlet A, the valve opens to allow from A to the tank port T (pressure - limiter - function). (Fig 12)

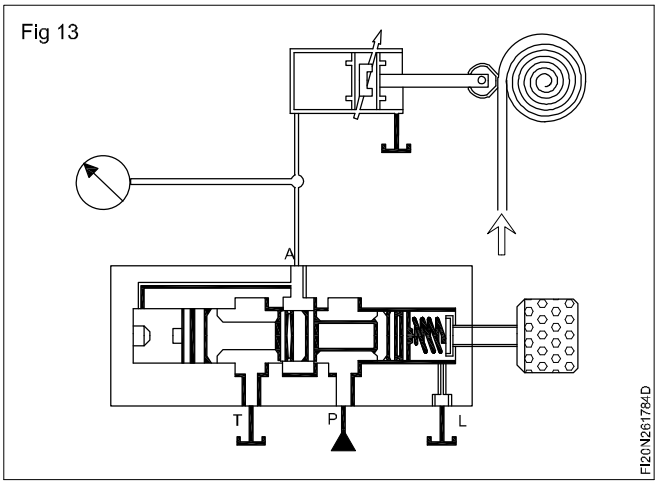
Fig 12



Example of pressure regulator is shown in the fig 13

Pressure regulator help to maintain constant pressure in line and also safe the sytem from excess pressure, so you able to get approximate constant pressure in line.

Fig 13



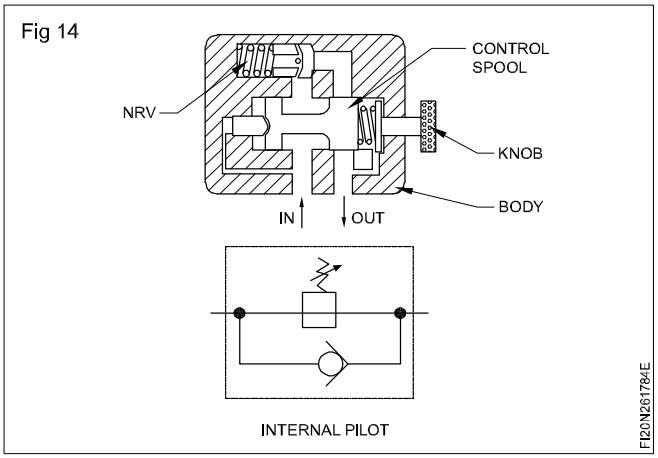
Counter Balancing

Cylinders with external forces such as weight from a platen, machine members, or tooling acting against them will over r**un** when oil flowing out of them is not restricted. A meter - out flow control circuit is one way to control over running loads but it has one main drawback. A flow control's speed is fixed except for manual adjustment. Because flow is fixed, the actuator will continue at the same speed, even when working flow to it increases or decreases.

The valve which is used to create a back pressure against pushing or pulling types of load to maintain normal speed of cylinder is known as counterbalance valve.

A counterbalance valve keeps an actuator from running away regardless of flow changes because it responds to pressure signals, not flow. A counter balance valve is almost the same as a sequence valve. The figure of counter balance valve and symbols are shown in Fig 14

Fig 14

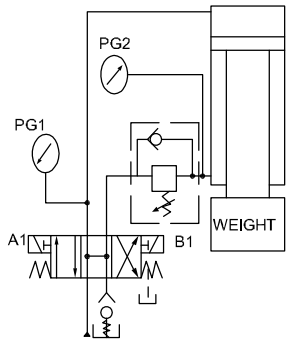


A counterbalance valve usually has a bypass check valve for reverse flow because its most common use is in controlling actuators with running away or overruning loads.

Fig 15 shows a vertically oriented cylinder with rod facing down and a load trying to extend it . To keep the cylinder from running away, the counterbalance valve must resist the load - induced pressure from the weight. The load -

induced pressure can be calculated and the counterbalance valve could be preset at 100 to 150 psi higher on a test stand.

Fig 15



In the centre position of directional control valve ports A and B are connected to tank in the center condition. There is no chance of extra pressure buildup in the pilot line while the circuit is at rest. If ports A or B? were blocked, pressure could not build and counterbalance valve will not open, not allowing the cylinder to drift.

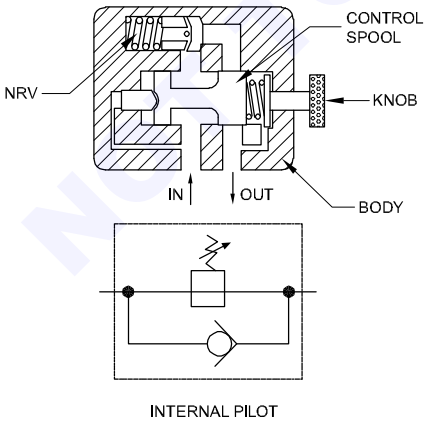
Press PB1 oil flows to the cylinder cap end. As pressure builds there, pressure also increases in the rod end. When pressure at the cylinder rod end reaches 100 to 150 psi above the load- induced pressure, the cylinder starts to extend as fast as the pump fils the cap end. When flow increases, cylinder speed increases and when flow decreases, cylinder speed increases and when flow decreases, cylinder speed decreases. Back pressure at the cylinder rod end is present during the entire extend stroke.

When PB2 is operated oil flows to rod end via check valve thus by passing the counterbalance hence piston retracts.

Sequencing

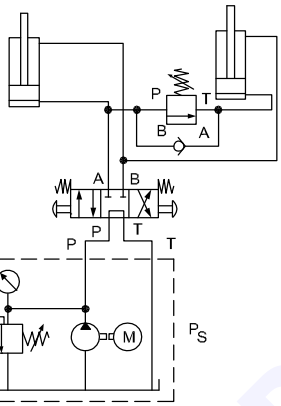
To operation of number of hydraulic actuators in desired steps sequencing is done. A sequence valve is the simplest mechanism to achieve desired steps. Fig 16 shows the sectional view and symbol of sequencing valve.

Fig 16



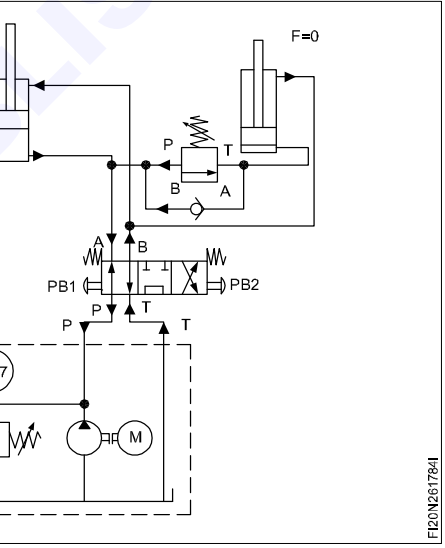
A balanced spool held in place by an adjustable - force spring blocks fluid at the hydraulic sequence valve's inlet. When pressure at the inlet reaches the spring setting, pressure in the internal pilot line pushes the spool up to allow enough flow to the outlet. A by pass check valve allows reverse flow without pressure sequencing. In this circuit 4/3 way valve is in neutral position Fig 17 so the pump flow is flowing into tank without any resistance.

Fig 17



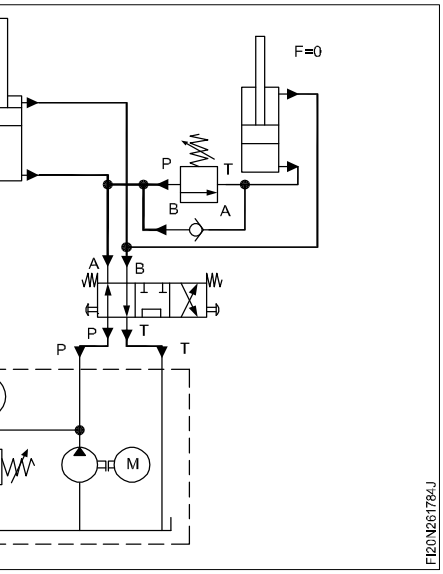
In the actuated condition (Fig 18) the loaded cylcinder will complete it's stroke first then after no load cylinder start moving. This is the sequencing of actuation for cylinder with the help of pressure sequence valve.

Fig 18



In other actuated condition (Fig 19) cross connection of port in direction control valve, loaded piston will return back at faster speed as compare to the no load piston.

Fig 19



Electro- pneumatics

Objectives : At the end of this lesson you shall be able to
- **explain about the electro pneumatic control system**
- **list the basic electrical devices**
- **explain the operation of switches**
- **describe the purpose and constructional details of solenoid valves.**
- **explain purpose and operation of relay.**

Introduction

Electro pneumatic control consists of electrical control systems operating pneumatic power system. In this solenoid valves, are used as interface between the electrical and pneumatic system. Devices like switches are used as feedback elements.

In electro pneumatics, the signal medium is the electrical signal either AC or DC source is used. Working medium is compressed air. Operating voltages from around 12v to 220 v are used. The final control valve is actuated by solenoid activation.

In electro pneumatic controls, mainly three important steps are involved.

Signal input devices

Signal generation such as switches and contactor, various types of contact and proximity sensors.

Signal processing

Use of combination of contactors of relay or using programmable logic controllers.

Signal outputs

Outputs obtained after processing are used for activation of solenoids, indicators or audible alarms.

Basic electrical devices

Basic electrical devices commonly used in the control of fluid power systems are

Manually actuated push button switches

Limit switches

Pressure switches

Solenoids

Relays

Temperature switches

Push button switches

A push button is a switch used to close or open an electric control circuit. They are primarily used for starting and stopping of operation of machinery. They also provide manual over ride when the emergency arises. Push button switches are actuated by pushing the actuator into the housing. This causes set of contacts to open or close.

Push buttons are of two types

Momentary push button

Maintained contact or detent push button

Momentary push buttons return to their unactuated position when they are released. Maintained (or mechanically latched) push buttons has a latching mechanism to hold it in the selected position.

The contact of the push buttons, distinguished according to their functions.

- Normally open (NO) type
- Normally closed (NC) type
- Change over (CO) type.

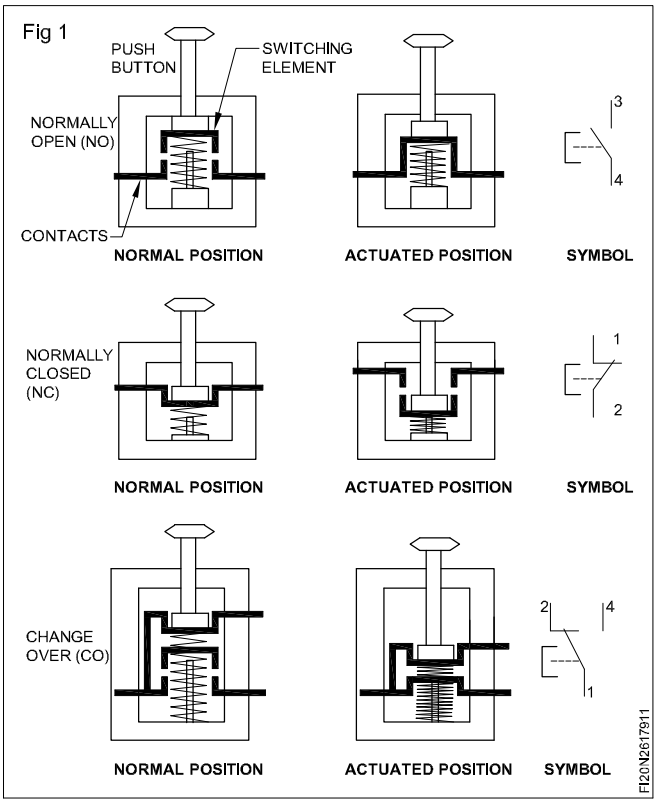
The cross section of various types of push buttons in the normal and actuated positions and their symbols are given in the fig 1. In the NO type, the contacts are open in the normal position, inhibiting the energy flow through them. But in the actuated position, the contacts are closed, permitting the energy flow through them. In the NC type, the contacts are closed in the normal position, permitting the energy flow through them. And, the contacts are open in the actuated position, inhibiting the energy flow through them. A changeover contact is a combination of NO and NC contacts.

Type of devices	Terminal numbers	
	Normally closed contacts	Normally open contacts
Push buttons and relays	1 and 2	3 and 4

Limit switches

Any switch that is actuated due to the position of a fluid power component (usually a piston rod or hydraulic motor shaft or the position of load is termed as limit switch. The actuation of a limit switch provides an electrical signal that causes an appropriate system response.

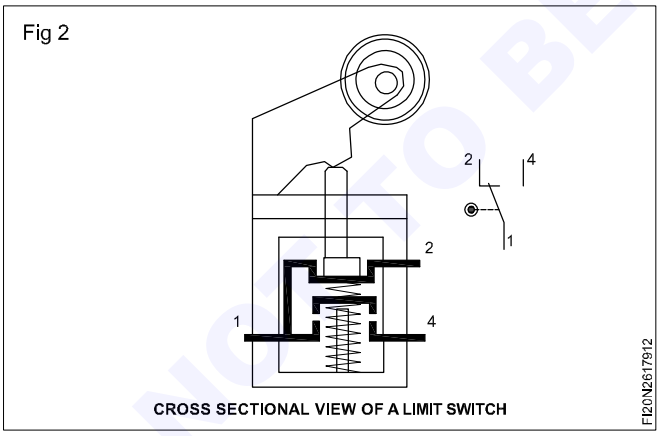
Limit switches perform the same function as push button switches. Push buttons are manually actuated whereas limit switches are mechanically actuated.



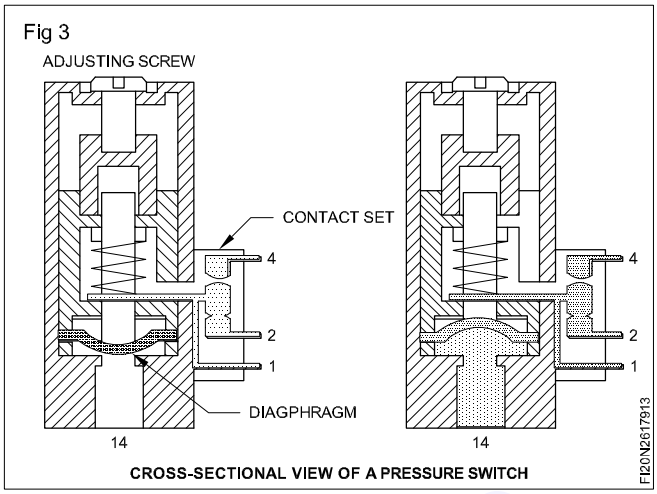
There are two types classification of limit switches depending upon method of actuation of contacts

- Lever actuated contacts
- Spring loaded contacts

In lever type limit switches, the contacts are operated slowly. In spring type limit switches, the contacts are operated rapidly. Figure 2 shows a simplified cross sectional view of a limit switch and its symbol.



A **pressure switch** is a pneumatic - electric signal converter. Pressure switches are used to sense a change in pressure, and opens or closes an electrical switch when a predetermined pressure is reached. Bellow or diaphragm is used to sense the change of pressure. Bellows or diaphragm is used to expand or contact in response to increase or decrease of pressure. Figure. 3 shows a diaphragm type of pressure switch. When the pressure is applied at the inlet and when the pre-set pressure is reached, the diaphragm expands and pushes the spring loaded plunger to make/break contact.



Temperature switch

Temperature switches automatically senses a change in temperature and opens or closes an electrical switch when a predetermined temperature is reached. This switch can be wired either normally open or normally closed.

Temperature switches can be used to protect a fluid power system from serious damage when a component such as a pump or strainer or cooler begins to malfunction.

Solenoids

Electrically actuated directional control valves form interface between the two parts of an electro pneumatic control. The most important tasks of electrically actuated DCVs include.

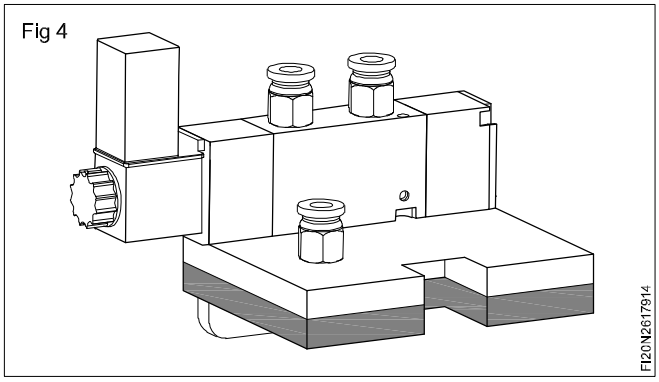
Switching supply air ON or OFF

Extension and retraction of cylinder drives.

Electrically actuated directional control valves are switched with the aid of solenoids. A solenoid is like a coil of the relay. When it is energized, it will switch on the valve, similar to turning on the hand lever of a normal valve.

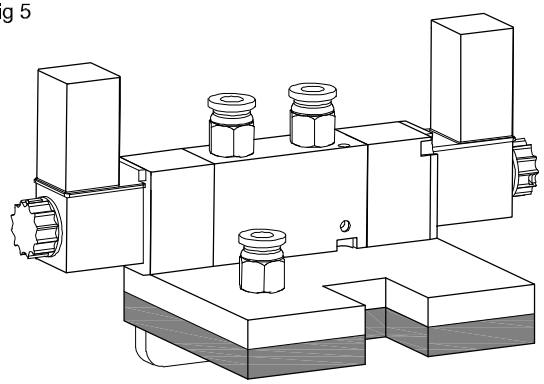
They can be divided into two groups

- Spring return valves (single solenoid valve) only remain in the actuated position as long as current flows through the solenoid (fig 4)



- Double solenoid valves (double solenoid valve) retain the last switched position even when no current flows through the solenoid (fig 5)

Fig 5



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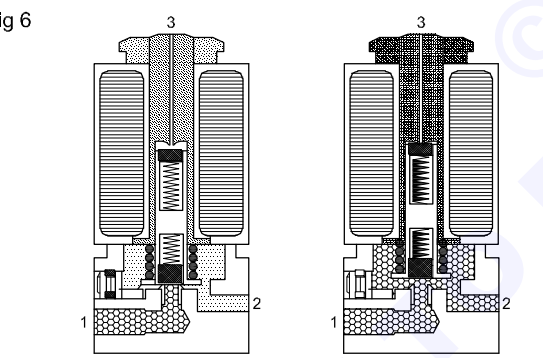
In the initial position, all solenoids of an electrically actuated DCVs are de - energized and the solenoids are inactive. A double valve has no clear initial position, as it does not have a return spring. The possible voltage levels for solenoids are 12V Dc, 12V Ac, 12V 50/60 Hz, 24V 50/ 60 Hz, 110/120V 50/60 Hz,220/230V 50/60 Hz

3/2 way signal solenoid valve, spring rectors : The cross sectional view of 3/2 way single solenoid valve in the normal and actuated positions are shown in fig 6. In the normal position, port 1 is blocked and port 2 is connected to port 3 via back slot (details shown in the circle) when the rated voltage is applied to coil, armature is pulled towards the centre of the coil and in the process the armature is lifted away from the valve seat. The compressed air now flows from port 1 to port 2, and ports 3 is blocked. When the voltage to the coil is removed, the valve returns to the normal position. Fig 7 shows 2/2 solenoid operated valve.

Fig 6



CROSS SECTIONAL VIEW OF A 3/2 SINGLE SOLENOID VALVE

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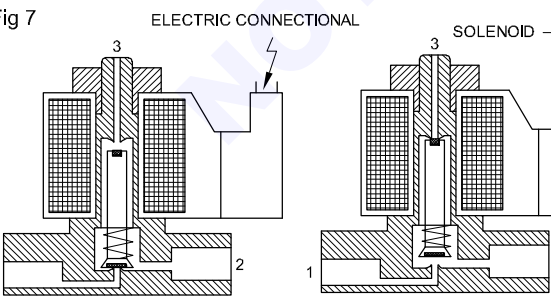
Fig 7



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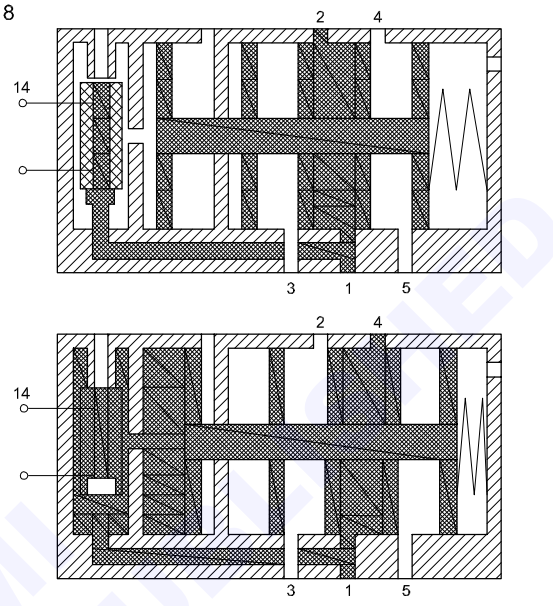
5/2 way single solenoid valve, spring return

The cross section view of 5/2 way single solenoid in the normal and actuated positions are shown in figure 8. In normal position, port 1 is connected to port 2, port 4 is connected to port 5, and port 3 is blocked. When the rated voltage is applied to coil 14, the valve is actuated through an internal pilot valve. In actuated position, port 1 is connected to port 4, port 2 is connected to port 3, and port 5 is blocked. The valve returns to the normal position when the voltage to the armature coil is removed. This type of valves is normally used as final valve to control double acting cylinders.

Fig 8



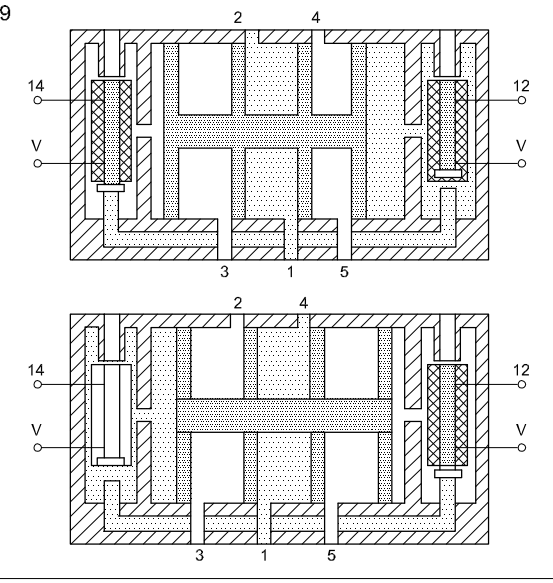
CROSS SECTIONAL VIEW OF A 5/2 WAY SOLENOID OPERATED VALVE

FI20N2617918

5/2 way single double solenoid valve

The cross section view of 5/2 way double solenoid in the normal and actuated positions are shown in the fig 9 when the rated voltage is applied to coil 14, the valve is actuated to a one switch in position with port 1 connected to port 4, port 2 connected to port 3, and port 5 blocked. When the rated voltage is applied to the coil 12, the valve is actuated to the other switching position with port 1 connected to port 2, port 4 connected to port 5 and port 3 blocked.

Fig 9

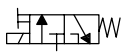
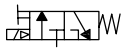


FI20N2617919

The symbols for the various solenoid/pilot actuated valves are given in table 1

Fig 10

TABLE 1

SYMBOL	DETAILS
	3/2 WAY SINGLE SOLENOID VALVE (SPRING RETURN)
	3/2 WAY PILOT OPERATED SINGLE SOLENOID VALVE (SPRING RETURN)
	5/2 WAY SINGLE SOLENOID VALVE (SPRING RETURN)
	5/2 WAY DOUBLE SOLENOID VALVE
	5/2 WAY PILOT OPERATED DOUBLE SOLENOID VALVE (SPRING RETURN)

VARIOUS SYMBOLS FOR DCVs

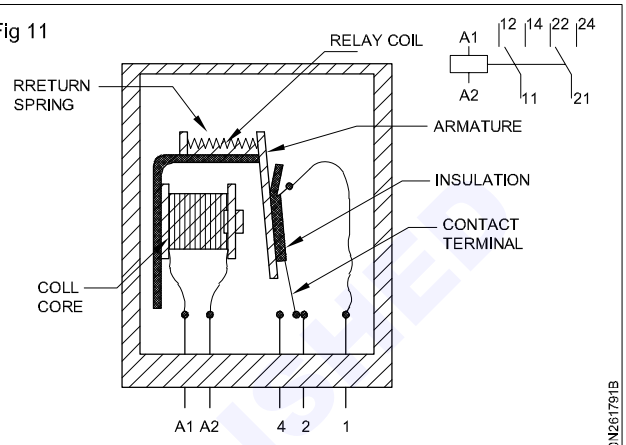
FI20N261791A

Relay

A relay is an electro magnetically actuated switch. It is a simple electrical device used for signal processing. Relays are designed to withstand heavy power surges and harsh environment conditions. When a voltage is applied to the solenoid coil, an electro magnet field results. This causes the armature to be attracted to the coil core. The armature actuates the relay contacts, either closing or opening them, depending on the design. A return spring returns the armature to its initial position when the current to the coil is interrupted. Cross sectional view of a relay is shown in fig 11.

A large number of control can be incorporated in relays in contrast to the case of a push button station. Relays are usually designated as K1, K2, and K3 etc. Relays also possess interlocking capability that is an important safety feature in control circuits. Interlocking avoids simultaneous switching of certain coils.

Fig 11



CROSS SECTIONAL VIEW OF A RELAY

FI20N261791B

Symbols for hydraulic components

Objectives : At the end of this lesson you shall be able to
- **read and interpret the circuit symbol**
- **state the uses of symbol in hydraulic components.**

In a hydraulic circuit symbols are used to represent individual component to impart representation of hydraulics system in diagrams. A symbol identifies a component and its function. These symbols are as per ISO 1219 standards.

Pump and motor

Hydraulic pump and motor are represented by means of a circle. Triangle within the circle represent the direction of flow and position of triangle differentiates between the symbol of pump or motor.

If triangle is filled darkened means it is meant for hydraulics fluid but if triangle is not filled means it is for gaseous pressure media or Pneumatic energy. (Figs 1 & 2)

Fig 1

HYDRAULIC ENERGY

FI20N26180I1

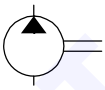
Fig 2

PNEUMATIC ENERGY

FI20N26180I2

Symbols of pump and motor (Figs 3 to 9)

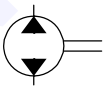
Fig 3



UNIDIRECTIONAL FIXED DISPLACEMENT PUMP

FI20N26180I3

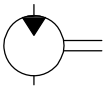
Fig 4



BIDIRECTIONAL FIXED DISPLACEMENT PUMP

FI20N26180I4

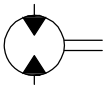
Fig 5



UNIDIRECTIONAL HYDRAULIC MOTOR

FI20N26180I5

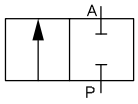
Fig 6



BIDIRECTIONAL HYDRAULIC MOTOR

FI20N26180I6

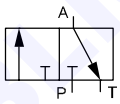
Fig 7



2/2-WAY VALVE

FI20N26180I7

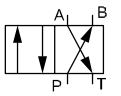
Fig 8



3/2-WAY VALVE

FI20N26180I8

Fig 9



4/2-WAY VALVE

FI20N26180I9

Direction control valve

Direction control valves are represented by several connected squares.

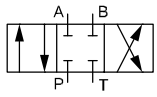
- The number of squares indicates the number of switching positions.
- Arrows in the squares indicate the direction of flow.
- Lines indicate how the ports are interconnected in the different switching position.

Port designation

P	Pressure port
T	Tank port
A	Service port (output port)
B	Service port (output port)
L	Leakage port

Symbols of Direction control valve (Figs 10 to 11)

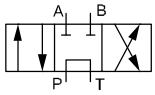
Fig 10



4/3-WAY CLOSE CENTRE VALVE

FI20N261801A

Fig 11



4/3-WAY OPEN CENTRE VALVE

FI20N261801B

Port should always be represented in the neutral position of valve.

The neutral position is a position which automatically come in valve due to spring force when no any command is available in valve, it is also the initial position unless otherwise actuated.

Actuating mechanism of Valve

The switching position of direction control valve can be changed by various actuation methods.

Different mechanisms of actuation of valve are shown in fig.12 to fig.19.

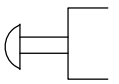
Mechanical actuation

Fig 12

GENERAL MANUAL OPERATED

FI20N261801C

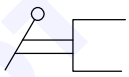
Fig 13



PUSH BUTTON

FI20N261801D

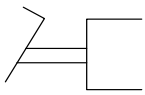
Fig 14



LEVER

FI20N261801E

Fig 15

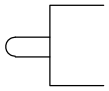


PEDAL

FI20N261801F

Manual actuation

Fig 16



PUSH PIN

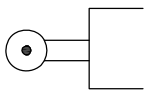
FI20N261801G

Fig 17

SPRING

FI20N261801H

Fig 18

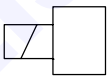


ROLLER

FI20N261801I

Electrical actuation

Fig 19



SOLENOID

FI20N261801J

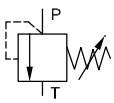
Pressure control valve

Pressure control valve are represented by a single squares. Arrow within the square indicate the direction of fluid flow.

The position of arrow within the square indicates whether the valve is normally open or normally closed.

Symbols of pressure control valve(Fig.20 to Fig.22)

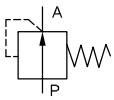
Fig 20



PRESSURE RELIEF VALVE

FI20N261801K

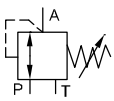
Fig 21



PRESSURE REDUCING VALVE

FI20N261801L

Fig 22



PRESSURE REGULATOR

FI20N261801M

Function

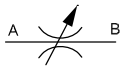
Flow control valve(Fig.23 to Fig.25)

Fig 23

FIXED FLOW CONTROL VALVE

FI20N261801N

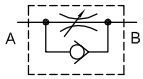
Fig 24



VARIABLE FLOW CONTROL VALVE

FI20N261801O

Fig 25



ONE WAY FLOW CONTROL VALVE

FI20N261801P

Non-return valves

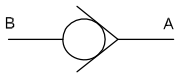
The symbol of non-return valve is a ball which is pressed against a sealing seat. (Fig. 26 to Fig.28)

Fig 26

SPRING LOADED NRV

FI20N261801Q

Fig 27



UNLOADED NRV

FI20N261801R

Fig 28

SHUT-OFF VALVE

FI20N261801S

Cylinder

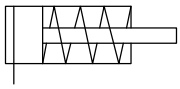
Single acting cylinders have one port and double acting cylinder have two ports.(Fig.29 to Fig.31)

Fig 29

SINGLE ACTING CYLINDER

FI20N261801T

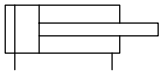
Fig 30



SINGLE ACTING CYLINDER WITH SPRING

FI20N261801U

Fig 31



DOUBLE ACTING CYLINDER

FI20N261801V

Measuring devices

Measuring devices are shown in the Fig.32 to Fig.36.

Fig 32

PRESSURE GAUGE

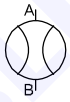
FI20N261801W

Fig 33

TEMPERATURE GAUGE

FI20N261801X

Fig 34



FLOW METER GAUGE

FI20N261801Y

Fig 35

LEVEL GAUGE

FI20N2618017

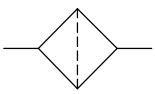
Fig 36

DIFFERENTIAL PRESSURE GAUGE

FI20N2618017I

Other symbols(Fig.37 to Fig.39)

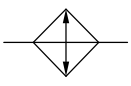
Fig 37



FILTER OR STRAINER

FI20N2618017Z

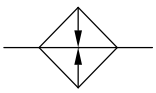
Fig 38



COOLER

FI20N2618017Z

Fig 39



HEATER

FI20N2618017Z

Symbols using Line (Fig 40 to Fig 46)

Fig 40

WORKING LINE

FI20N26180IZ5

Fig 41

DRAIN OR BLEED LINE

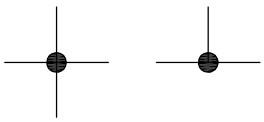
FI20N26180IZ6

Fig 42

FLEXIBLE PIPE FLEXIBLE HOSE

FI20N26180IZ7

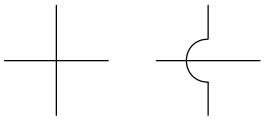
Fig 43



PIPELINE JUNCTION

FI20N26180IZ8

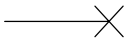
Fig 44



CROSSED PIPELINES

FI20N26180IZ9

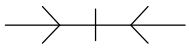
Fig 45



PLUGGED ON EQUIPMENT OR LINES

FI20N26180IZA

Fig 46



QUICK-ACTING COUPLING

FI20N26180IZB

Hydraulic oil Functions and properties

The primary function of a hydraulic fluid is to convey power. In use, however, there are other important functions of hydraulic fluid such as protection of the hydraulic machine components. The table below lists the major functions of a hydraulic fluid and the properties of a fluid that affect its ability to perform that function:

Function	Property
Medium for power transfer and control	Non compressible (high bulk modulus) Fast air release Low foaming tendency Low volatility
Medium for heat transfer	Good thermal capacity and conductivity
Sealing Medium	Adequate viscosity and viscosity index Shear stability
Lubricant	Viscosity for flim maintenance Low temperature fluidity Thermal and oxidative stability Hydrolytic stability / water tolerance Cleanliness and filterability Demulsibility Antiwear characteristics Corrosion control
Pump efficiency	Proper viscosity to minimize internal leakage High viscosity index

Special function	Fire resistance Friction modifications Radiation resistance
Environmental impact	Low toxicity when new or decomposed Biodegradability
Functioning life	Material compatibility

Types of Hydraulic fluids

According to ISO there are three different types of fluids according to their source of availability and purpose of use.

Mineral- Oil based Hydraulic fluids

As these have a mineral oil base, so they are named as Mineral- Oil-Based Hydraulic fluids. This kind of fluids will have high performance at lower cost. These mineral oils are further classified as HH, HL and HM fluids.

Type HH fluids are refined mineral oil fluids which do not have any additives. These fluids are able to transfer power but have less properties of lubrication and unable to withstand high temperature. These types of fluid have a limited usage in industries. Some of the uses are manually used jacks and pumps, low pressure hydraulic system etc.

The HL fluids are refined mineral oils which contain oxidants and rust inhibitors which help the system to be protected from chemical attack and water contamination. These fluids are mainly used in piston pump applications.

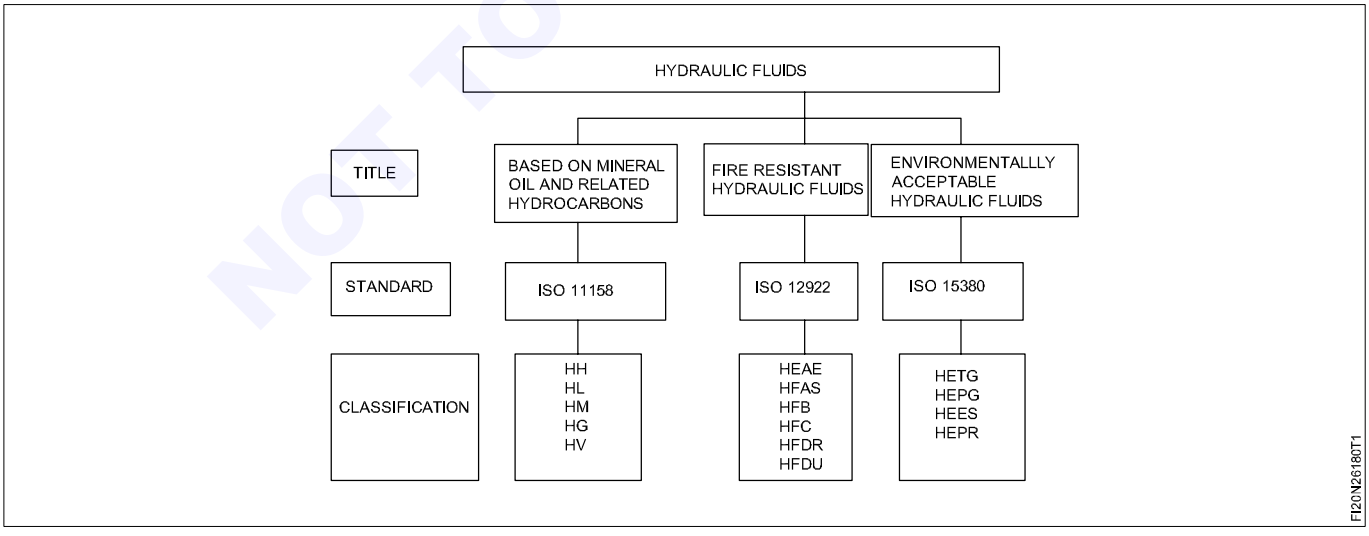
HM is a version of HL- type fluids which have improved anti- wear additives. These fluids use phosphorus, zinc and sulphur components to get their anti-wear properties. These are the fluids mainly used in the high pressure hydraulic system.

Fire Resistant Fluids

These fluids generate less heat when burnt than those of mineral oil based fluids. As the name suggests these fluids are mainly used in industries where there are chances of the hazards, such as foundries, military, die-casting and basic metal industry. These fluids are made of lower BTU (British Thermal Unit) compared to those of mineral oil based fluids, such as water-glycol, phosphate ester and polyol esters. ISO have classified these fluids as HFAE (soluble oils), HFAS (high water-based fluids),HFB(invert emulsions), HFC(water glycols), HFDR(phosphate ester) and HRDU (polyol esters).

Environmental Acceptable Hydraulic Fluids (EAHF)

These fluids are basically used in the application where there is a risk of leakage or spills into the environment, which may cause some damage to the environment. These fluids are not harmful to the aquatic creatures and they are biodegradable. These fluids are used in forestry, lawn equipment, off - shore drilling, dams and maritime industries. The ISO have classified these fluids as HETG (based on natural vegetable oils), HEES (based on synthetic esters), HEPG (polyglycol fluids) and HEPR (polyalphaolefin types).



Controlling of Contamination

While the fluid is at operating temperature, completely drain the system. paying attention to the reservoir, all lines, cylinders, accumulators, filter housings or any area of fluid accumulation. Also, replace the filters.

With a lint-free rag, clean the reservoir of all sludge and deposits. Make sure the entire reservoir is free of any soft or loosened paint.

Flush the system with a lower viscosity fluid that is similar to the fluid to be used. A Reynolds number between 2,000 and 4,000 should be selected to achieve enough turbulence to remove particles from the lines. Stroke valves frequently to ensure they are thoroughly flushed. The fluid should be filtered and the flushing should continue until reaching one level beyond the system's target cleanliness levels. For example,if the target is ISO 15/13/11, continue to flush the system until ISO 14/12/10 is reached.

Drain the flushing fluid as hot and as quickly as possible. Replace the filters and inspect/ clean the reservoir again.

Fill the system to approximately 75 percent with the fluid to be used. Bleed/vent the pump.If the pump has a pressure relief or bypass, it should be wide open. Run the pump for 15 seconds, then stop and let it sit for 45 seconds. Repeat this procedure a few times to prime the pump.

Run the pump for a minute with the bypass or pressure relief open. Stop the pump and let it sit for a minute. Close the bypass and permit the pump to operate loaded for no more than five minutes. Allow the relief valve to lift to confirm that it is flushed as well. Do not operate the actuators at this time. Stop the pump and let the system sit for about five minutes.

Start the pump and operate the actuators one at a time, allowing fluid to return to the reservoir before moving to the next actuator. After operating the final actuator, shut down the system. Keep an eye on the fluid level in the reservoir. If the level drops below 25 percent, add fluid and fill to 50 percent.

Refill the reservoir to 75 percent and run the system in five- minute intervals. At each shutdown, bleed the air from the system. Pay close attention to the system sounds to determine if the pump is cavitating.

Run the system for 30 minutes to bring it to normal operating temperature. shutdown the system and replace the filters. Inspect the reservoir for obvious signs of cross-contamination. If any indication of cross-contamination is present, drain and flush the system again.

After six hours of operation, shut down the system, replace the filters and sample and test the fluid.

The sampling frequency should be increased until you are confident that the system fluid is stable.

Contamination of oil and its control

Contamination in hydraulic systems can be classified into particle contaminants (Metal particles from wear,dirt ingression) or chemical contaminants (water, air ,heat, etc). Examples of damage from contamination are: accelerated component wear, orifice blockage, formation of rust or other oxidation, depletion of additives, formation of other chemicals, oil degradation.

Types of contamination

Particle contaminants

Particle sizes are generally measured in micrometers or microns. Some examples of microns: Grain of salt 100 microns, human hair 70 microns, lower limit of visibility 40 micron, milled flour 25 micron, average bacteria 2 micron. Note that most damage-causing particles in hydraulic or lubrication systems are smaller than 14 μm micrometers, so they cannot be seen.

Chemical contaminants

Water

The most common chemical contaminant in hydraulic systems is water. The presence of water in hydraulic oil can have wide- ranging effects on system components because of its effect on the physical and chemical properties of hydraulic oil. Rust in tanks, reduced lubrication characteristics resulting in accelerated metal surface wear are some of the most obvious physical results of excessive water, however the effects could be as diverse as the jamming of components due to ice crystals at low temperatures. Chemical effects include additive depletion or deposition, oxidation, unwanted reactions which can result in the formation of acids, alcohols or sludges. Oil becomes cloudy when it's contaminated with water above its saturation level. The saturation level is the amount of water that can dissolve in the oil's molecular chemistry and is typically 200 to 300 ppm at 20° C for mineral hydraulic oil. SKF state that hydraulic oil containing just 0.1% water by volume cuts bearing life in half, while 1% reduces bearing life by 75%

Air

Air in hydraulic system can exist in either a dissolved or entrained (undissolved, or free) state. Dissolved air may not pose a problem, providing it stays in solution. When a liquid contains undissolved air, problems can occur as it passes through system components. There can be pressure changes that compress the air and produce a large amount of heat in small air bubbles. This compressibility of air means that control of the system is lost. Air bubbles and frothing in the oil reservoir can cause major damage to pumps or it can also cause oil to "boil" out of the tank.

Heat

Excessive heat in hydraulic systems can also result in additive depletion or chemical changes to the oil.

Hydraulics filter

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

- **explain hydraulic filters**
- **list the types of filters**
- **state the difference between mechanical, absorbent, adsorbent and magnetic filter.**

Filter

Filter is a device which removes solid contaminants from the fluid.

Hydraulic filters are available in several shapes, sizes, micron ratings and construction materials. Hydraulic filters provide in built protection and minimize hydraulic system breakdowns that are quite often caused by contamination.

The life of a filter in a hydraulic system depends primarily on the system pressure, level of contamination and nature of contaminants.

Filters is a very important components used in hydraulic system for the reliable functioning and long service life of the components.

Filter and Strainer are the two terms commonly used.

Use of Hydraulic Filters

One of the main cause of failure or poor functioning of a hydraulic system is contamination of hydraulic oil or fluid. Hydraulic filters are used for handling and removing contamination from hydraulic oil.

Contaminants of hydraulic fluid are broadly defined as any substance that impairs the proper functioning of the fluid.

Contaminants are classified as

- Solids
- Liquids
- Gaseous
- Bacteria
- Organic

Types of Filters

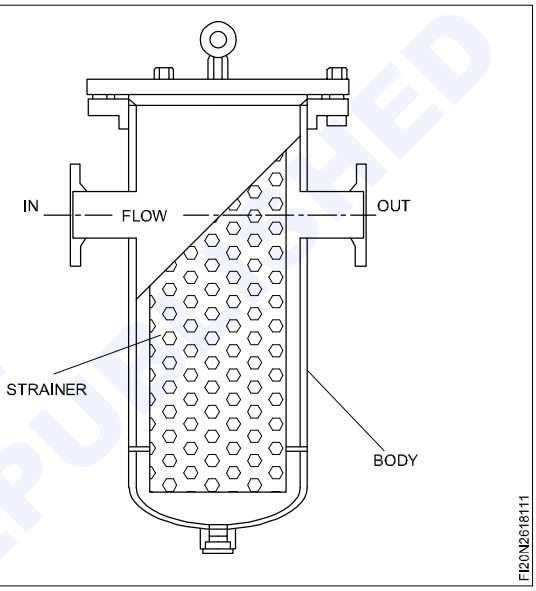
There are four types of filters generally used in hydraulic system.

- Mechanical filter
- Absorbent filter
- Adsorbent filter
- Magnetic filters

Mechanical filter

Mechanical filters contain closely woven metal screens or discs. They generally remove only fairly coarse particles. Mechanical filter is known as strainer in hydraulic system. These filters are located in the suction line of the pump, hydraulic oil is drawn from the reservoir through the filter. (Fig.1)

Fig 1



Grade of Mechanical filter: 60-100μm

μ**m** is the micron which is 1/1000 part of 1 mm.(ie)

1μm = .001 mm

Absorbent filter

Absorbent filters, such as cotton, wood pulp, yarn, cloth, or resin, remove much smaller particles; some remove water and water-soluble contaminants. The elements often are treated to make them sticky to attract the contaminants found in hydraulic oil.

These filters are installed in the pressure line of a hydraulics system at the pressure port of the pump.

Since this filter is subjected to the maximum operating pressure, it must be of robust design. (Fig.2)

Adsorbent filter

A filter used for trapping various sizes of particulate matter. Adsorbent filters consist of clay, chemically treated paper and desiccant. (Fig.3)

Fig 2

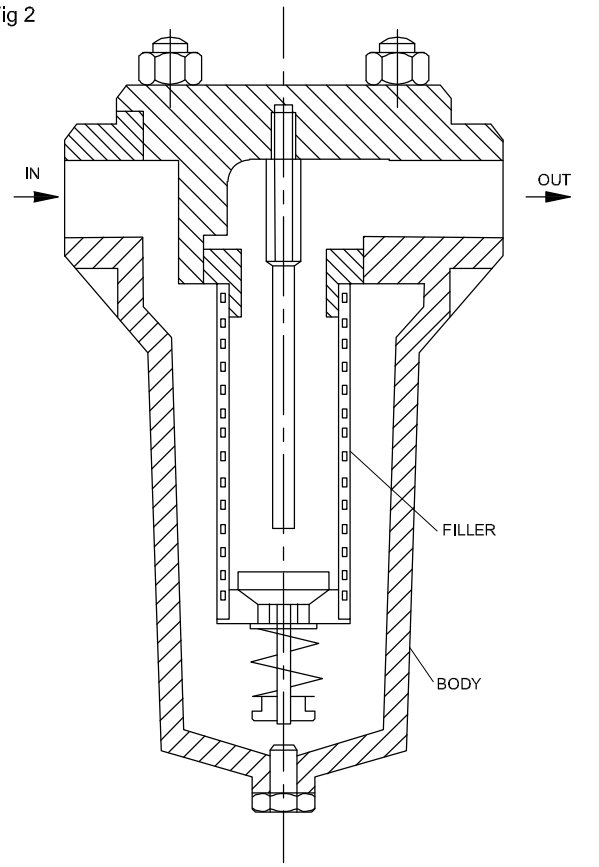
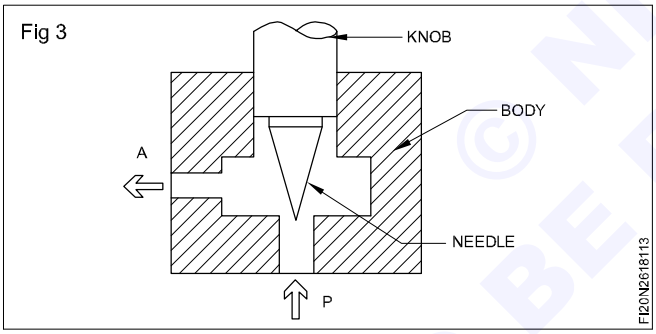


Fig 3



Magnetic filter

Magnetic filters are basically used to remove the ferrous material from oil along with contaminants.

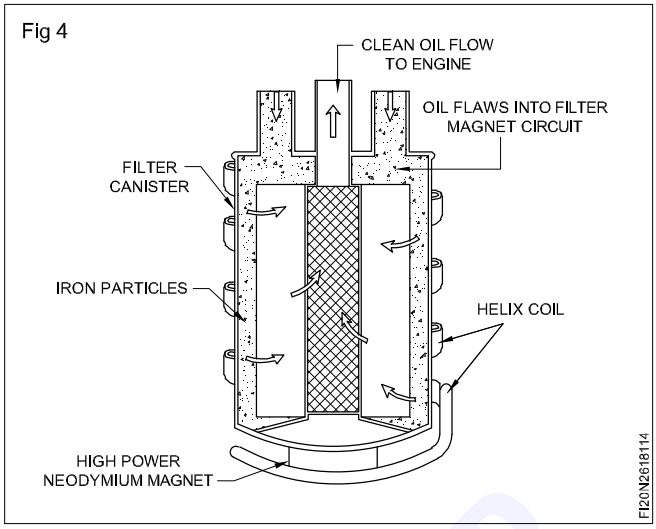
Magnet are geometrically arranged outside or inside the filter which produce a strong magnetic field that help to arrest the ferrous particles from oil.

In most of magnetic filter permanent magnet is used to create magnetic field.

These filters are commonly used in the automotive industry but are also utilized in a number of low-pressure industrial applications.

Filter is wrapped by magnetic ring which transmit a magnetic field through the steel filter bowl in order to trap ferromagnetic debris it is held tightly against the internal surface of the bowl which we can easily separate during servicing. (Fig.4)

Fig 4



Generally filter can be classified on the basis of their location in hydraulic system:

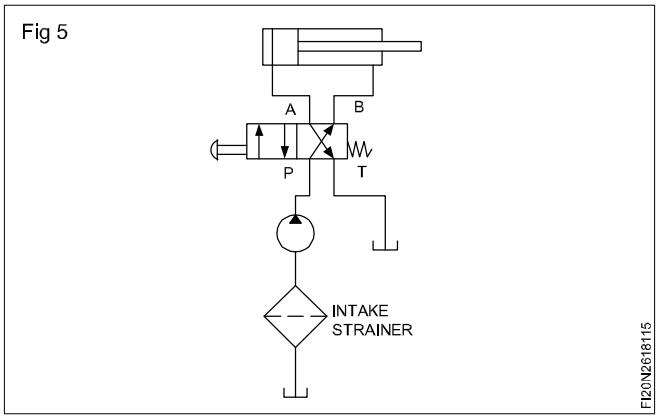
- Suction stainer
- Pressure line filter
- Return line filter
- Off line filter

Filter types on the basis of location

Suction stainer

Suction filters serve to protect the pump from fluid contamination. They are located in the upstream of pump's inlet port. Inlet strainers are submersed in fluid in the tank. Suction filters have relatively coarse elements, due to cavitations limitations of pumps.(Fig.5)

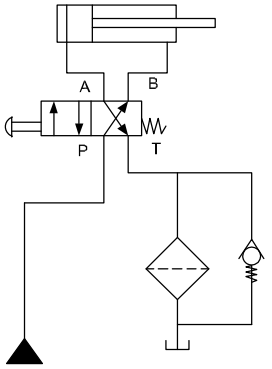
Fig 5



Return line filter

Return line filters may be the best choice if the pump is particularly sensitive to contamination. In most systems, the return filter is the last component through which fluid passes before entering the reservoir. Therefore, it captures wear debris from all of the system's working components and any particles that enter through worn cylinder rod seals before such contaminant can enter the reservoir and be pumped back into the system. Because this filter is located immediately upstream from the reservoir, its pressure rating and cost can be relatively low. (Fig.6)

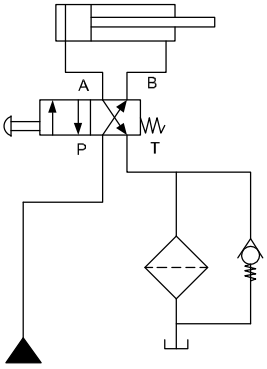
Fig 6



Pressure line filter

Pressure filters are located downstream from the system pump. They are designed to handle the system pressure and are sized for the specific flow rate in the pressure line where they are located. Pressure filters are especially suited for protecting sensitive components, such as servo valves, because pressure filters are located just downstream from the pump, they also help to protect the entire system from any pump-generated contamination. (Fig.7)

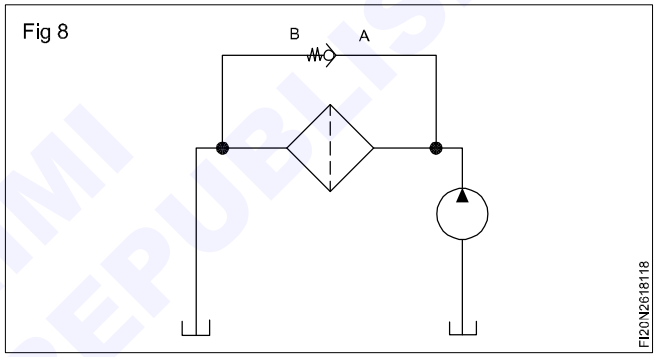
Fig 7



Off line filter

An off-line filtration circuit includes its own pump and electric motor, a filter and the appropriate connecting hardware. These components are installed off-line as a small subsystem separate from the working lines, or they may be included in a fluid-cooling loop. Fluid is pumped continuously out of the reservoir, through the off-line filter and back to the reservoir (Fig 8).

Fig 8



Hazard and safety precautions in hydraulic system

Objectives : At the end of this lesson you shall be able to
- **state the safety precaution while working with hydraulic fluids**
- **describe related hazards of hydraulic fluid.**

Safety precautions

There are numerous hazards involved, like skin irritation, fires, explosions, environmental damage and a slippery workplace. But hydraulic fluids are required for many machines to function. Therefore it is necessary to follow certain precautions while using these fluids. With proper knowledge of these hazards, working with hydraulic fluid can be safe.

- In order to avoid skin irritations, it is necessary to wash contaminated skin immediately. It is also necessary to keep your clothing clean.
- Wearing masks and gloves while using hydraulic fluids is also helpful.
- To avoid environmental dangers,there is biodegradable hydraulic fluid option,though it is more expensive.
- To avoid fires,materials and fluids soaked in hydraulic fluid should be stored in sealed metal containers and disposed of at proper places.
- To check for leaks, use cardboard.
- Never use hands or fingers to search for hydraulic leaks.
- Maintain a clean work area free of slipping hazards.
- Use chemical resistant gloves, splash goggles and a chemical resistant apron to avoid prolonged or repeated skin or eye contact.
- Never begin work on a hydraulic system until fully trained.

Related hazards

Health problems while using hydraulic fluids

People can become exposed to the chemicals in hydraulic fluids. The exposure to chemicals may be due to inhalation, ingestion or touch. There are instances of people suffering from skin irritation or weakness in hands while handling hydraulic fluids. There are also cases of intestinal bleeding, pneumonia or death through hydraulic fluid ingestion though no serious hazards are reported with hydraulic fluid inhalation.

Similar to ingestion, fluids can be accidentally injected into the skin as well. This takes place when the high pressure hydraulic system hose is disconnected and toxic fluids are leaked and injected into the skin. If there is a small leak in the hydraulic pipe and someone runs there hand along it, at 2000 psi, they can easily incur an injection of hydraulic fluid and may not even be aware that it happened until gangrene begins to set in.

Fire dangers associated with hydraulic fluids

When working with hydraulic fluid, there is every chance that the hydraulic fluid gets heated to high temperatures. And it is evident that most petroleum - based hydraulic fluids will burn and thereby create explosions and burns.

Environmental problems related to hydraulic fluids

Another hazard of hydraulic fluid is that when the hydraulic hose or pipe leaks, the chemicals of the fluids can either stay on top of the soil or sink into the ground. If the chemicals get mixed in a water body, they will sink to the bottom. In fact in such cases the chemicals can stay there for more than a year. Aquatic life can absorb the toxic hydraulic fluid, leading to illness or death to the animal or anything higher on the food chain. For example, a hawk that eats a fish that has been contaminated by hydraulic fluid that was mixed in water could become ill as well.

Fluid texture problems

Although the slimy texture of hydraulic fluids may not seem like a danger or a problem, a spill can cause a person to slip and fall. Also when there is fluid on the hands of a person, it can cause him to slip while climbing on a machine. It can also cause the operator to lose steering control.

Injuries from loose hydraulic hoses

Due to high pressure with in a hydraulic system, the impact force of a disconnected and flailing hydraulic hose can cause abrasions, temporary unconsciousness, bruise, fractures and laserations. Proper maintenance and good pre - shift equipment inspections can minimise these hazards

Hydraulic pumps

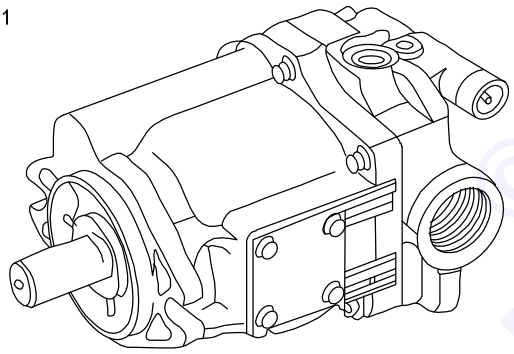
Objectives : At the end of this lesson you shall be able to
- **define hydraulic pump**
- **differentiate between positive and non-positive displacement pump**
- **explain working of gear pump**
- **explain the working of vane pump**
- **explain the working of piston pump.**

Hydraulic Reservoir and Accessories

Hydraulic reservoirs are storage tanks that hold liquids or gases used for fluid power applications. They are usually rectangular and cylindrilal shaped. The purpose of the hydraulic reservoir is to hold a volume of fluid, transfer heat from the system allow solid contaminants to settle and fecilitate the release of air and moisture from the fluid.

A hydraulic pump fig 1 is a device which converts mechanical force and motion into hydraulic energy. Many different sources provide mechanical power to the pump. They are electric motors, air motors, engines and manual operation.

Fig 1



Classification of pumps

Pumps are classified as either non-positive or positive displacement. This describes the fundamental division of pumps.

Non-positive displacement pumps

- The non-positive displacement type pump gives continuous discharge.
- The non-positive displacement pump does not provide a good seal against slippage, causing pump output to vary as the system pressure changes.
- The volume of fluid delivered during each cycle will depend on resistance to flow in the system.
- Centrifugal pumps are the Non-positive displacement pumps.(Fig 2)

Positive displacement pumps (Fig 3)

- A positive displacement pump provides positive internal seal against slippage.

Fig 2

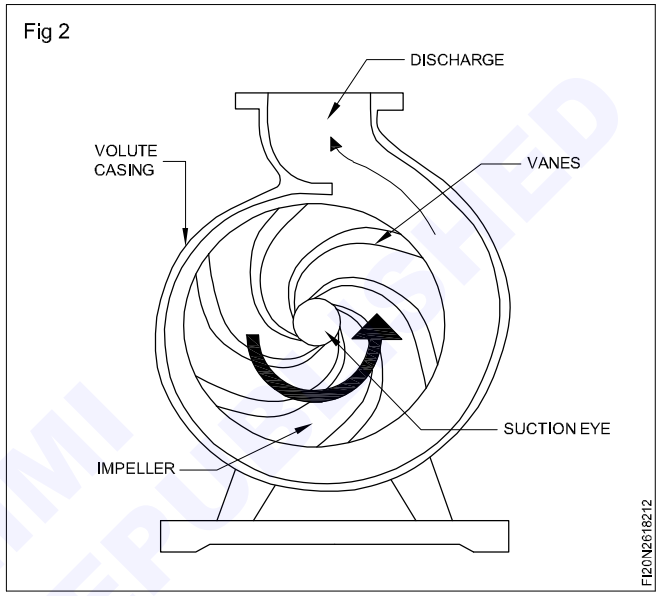
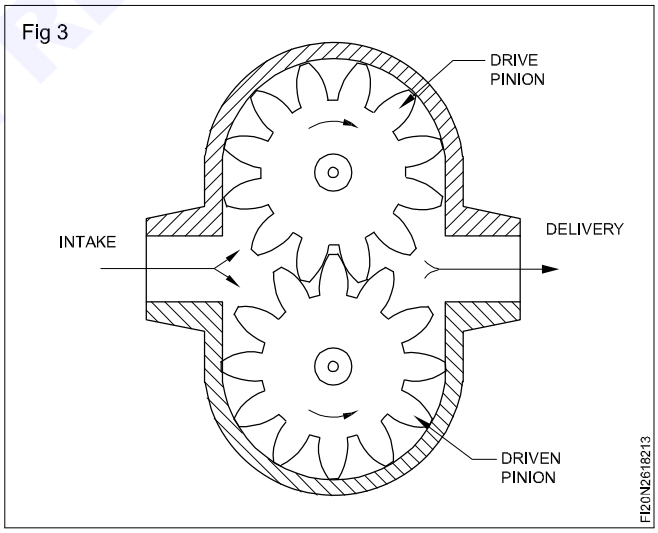


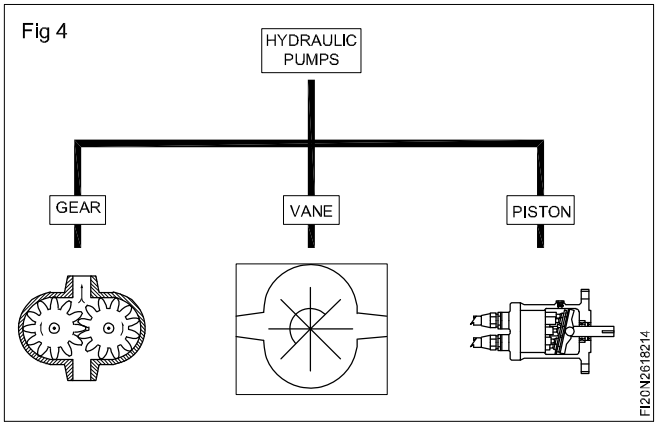
Fig 3



- This type of pump is capable of delivering a definite volume of fluid for each cycle of pump operation.
- Closing the outlet of a positive displacement pump causes an instantaneous increase of pressure. This increase in pressure can stall the equipment or break up of components.
- Gear pump is an example of positive displacement pump.

Types of Hydraulic pumps(Fig 4)

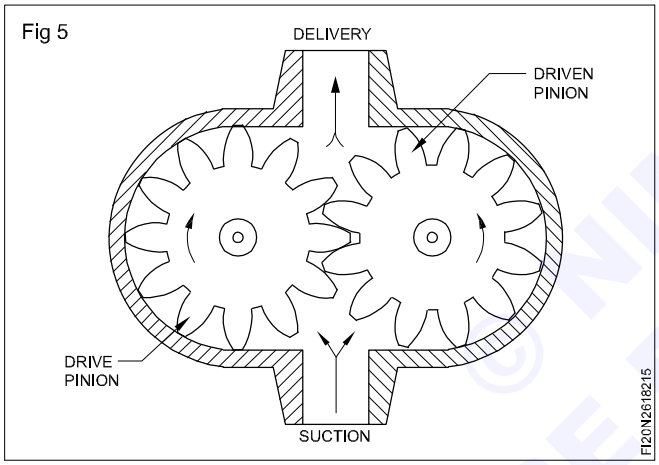
Fig 4



External Gear pump

External gear pump is the most common type rotary pump. In this pump the drive gear is turned by a drive shaft, which engages the power source. The inlet port is connected to the supply line and the outlet is connected to the pressure line. (Fig 5)

Fig 5



As gears rotate the volume of area on the inlet increases, thereby decreasing the pressure and making it possible for the atmospheric pressure exerted on the surface of the liquid in the reservoir to push the liquid into the inlet port. This causes liquid to be trapped in the gear space as the gears rotate and to be carried from the inlet port to the discharge port.

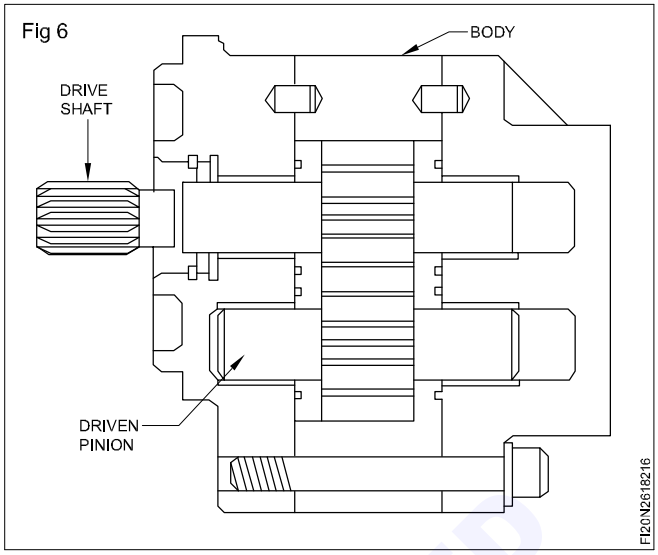
This action produces flow of liquid into the system.

A tighter seal against slippage can be accomplished by a metallic contact between the teeth ensures the seal against slippage. (Fig 6)

Important parameters

- Displacements volume 0.2 to 200 Cm^3/rev
- Suitable for pressure up to 300 bar
- Fixed displacement only
- Generally noisy
- Compact and low weight
- Low cost

Fig 6



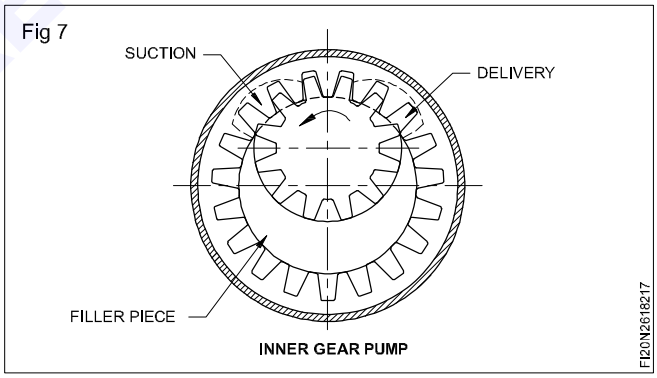
Gear pump applications

Gear pump is generally used to transfer lubricating oil in industrial & automobile application. Some time it is also used in some hydraulics power application.

Internal gear pump

Two gears are available in internal gear pump. The spur gear is mounted inside a large ring gear (outer gear). The smaller spur gear is in mesh with one side of the larger gear and kept apart by a crescent-shaped separator on the other side. The crescent-shaped separator isolates the inlet port from the outlet port. In the internal gear pump, both gears rotate in the same direction. (Fig 7)

Fig 7



As the gear teeth un-mesh, a partial vacuum is created on the inlet side. Atmospheric pressure forces liquid into the space created, and with the rotation of the gears, liquid is carried around the periphery of the gears and the crescent-shaped separator until it reaches the outlet port. A continuous flow of liquid is pushed out through the outlet port.

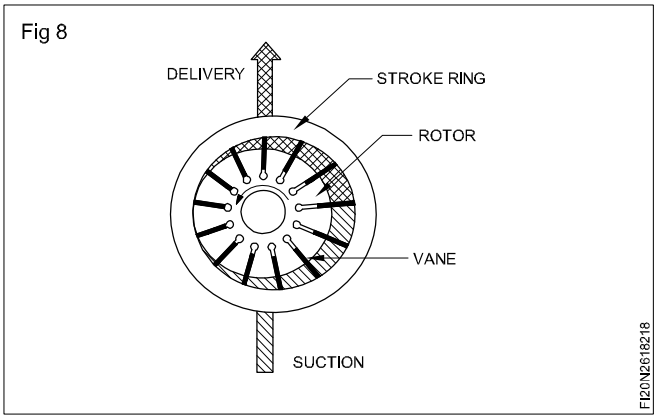
Important parameters

- Internal gear pumps are suitable for pressure up to 3500 psi.
- Working a wide viscosity range up to 2200 cSt, depending on flow rate.
- Generally quiet.
- Internal gear pumps have a high efficiency even at low fluid viscosity.

Vane Pump

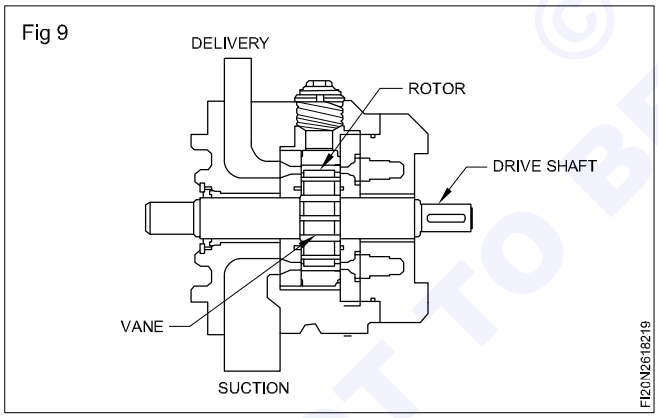
Vane pump is very common type of pump. The vanes pump having slots in the rotor. When the rotor spins, centrifugal force pushes the vanes out to touch the casing, where they trap and propel fluid. Springs are use to push the vanes outward. When the vanes reach the delivery side they are pushed back into the rotor by the casing. Fluid escapes through a channel or groove of the casing. In this vane pump there is considerable unbalanced force is acting on the drive shaft because high-pressure area is available on outlet side. (Fig 8)

Fig 8



The inlet port is located in that part of the pump where the chambers expand in size so a partial vacuum is formed to allow liquid to flow into the pump. The liquid is trapped between the vanes and is carried to the outlet side of the pump. The chambers at the outlet side contract in size, and this action forces liquid through the outlet port into the system. (Fig 9)

Fig 9



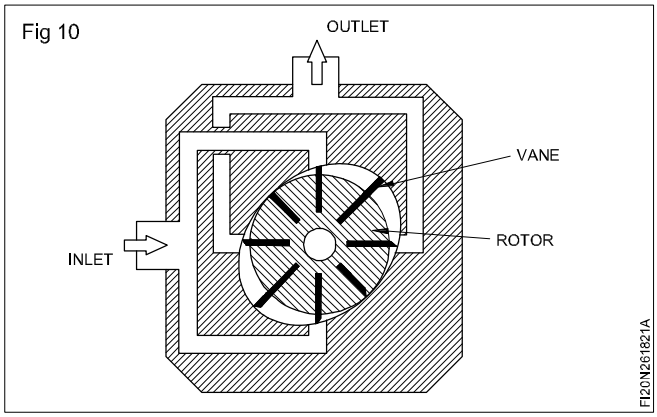
Balance Vane pump

This design results in two pressure cycles per revolution. The two outlet ports are spaced 180° apart so that the pressure forces on the rotor are balanced. These pumps can develop much higher pressures at high rotational speeds. (Fig 10)

Vane pump characteristics

- Typical use for higher flow application.
- Typical pressures upto 160 bar
- Simple multiple assemblies

Fig 10



- Range of pump controls
- Low noise

Vane pump applications

Vane pump is used for higher discharge & low pressure application. It is used to transfer lubricating oil in industry & also used in medium machine tools and presses.

Piston pump

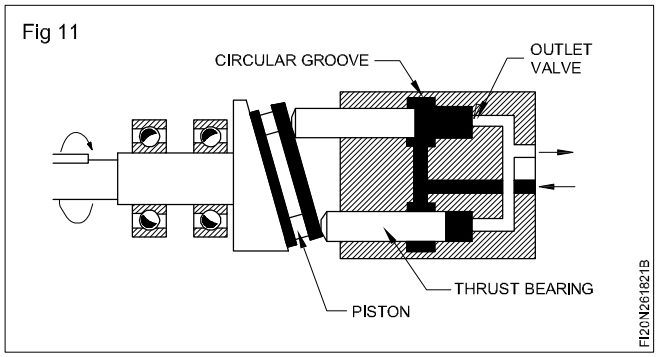
Piston pump is a common pump used for high pressure application. Following three types of pump are come in this category:-

- Axial piston pump
- Bent axis piston pump
- Radial piston pump

Axial piston pump

In the axial piston pump the block and the piston rotates on a shaft in such a way that the piston reciprocates in their cylinders bores, axially. This motion is called axial motion. The pumping action is made possible by a universal joint or a link and a swash plate. (Fig 11)

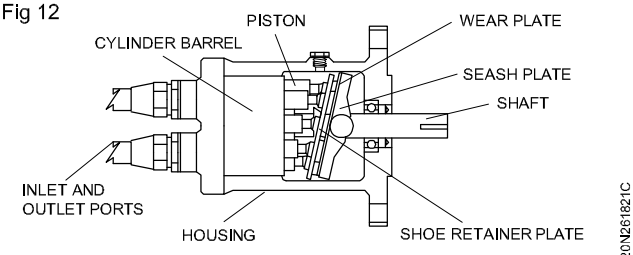
Fig 11



The main parts of the pump are the drive shaft, pistons, cylinder block, and the swash plate. Atmospheric pressure forces liquid in one port; and it is forced out the other port by the reciprocating action of the pistons.

A fill port is located in the top of the cylinder housing. The opening is normally plugged but it can be opened for testing pressure in the housing or case. If a new or repaired pump is installed, this plug must be removed and the housing filled with the recommended fluid. (Fig 12)

Fig 12



As the drive shaft rotates, it rotates the cylinder block and the pistons. The offset position of swash plate in pump block causes the pistons to move back and forth in the cylinder block. The shaft, pistons and cylinder block rotate together.

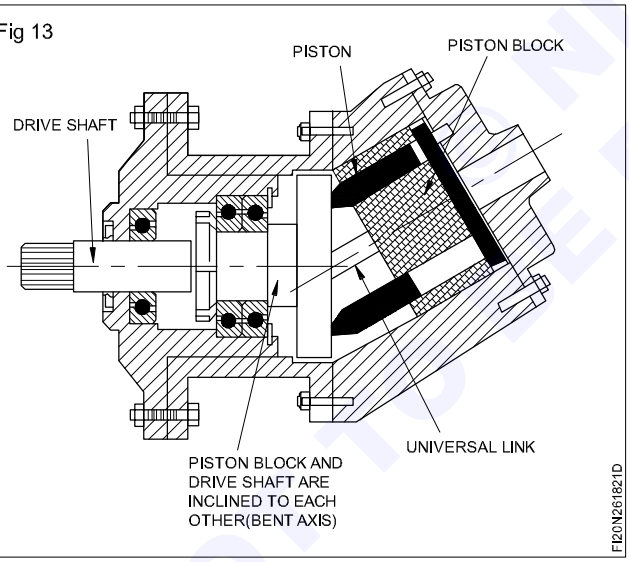
As the pistons reciprocate in the cylinder block, liquid enters through one port and is forced out through the other. This action provides a steady, non-pulsating flow of liquid.

Pumping action depends upon tilt angle of the swash plate. If there is no tilt; there is no pumping action.

Bent axis piston pump

Like the swash plate pump, this pump is also of the axial piston type. There are several pistons those are parallel to each other and reciprocate axially in a piston-block. However unlike the swash plate pump, the drive shaft is inclined at an angle to the piston-block and hence the termed bent axis (Fig 13).

Fig 13



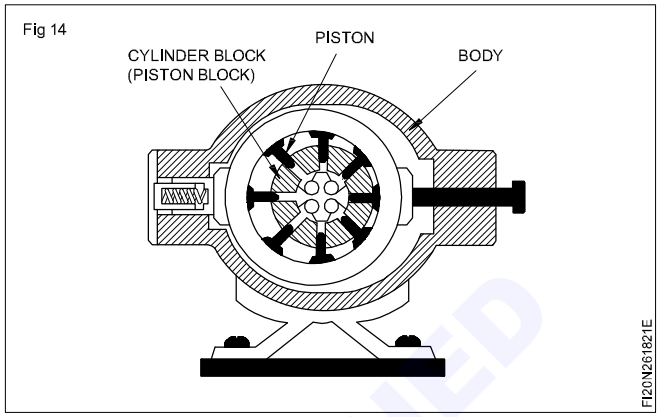
There are several piston housing within slots in the piston-block and they are connected to the drive shaft-flange. A universal link key the piston-block to the drive shaft to maintain alignment and to assure that they rotate together.

As the drive shaft rotates, it transmits drive to the pistons and piston-block. At the suction side, along the direction of rotation between the piston-block and drive shaft-flange distance increases and the piston are pulled out, thus resulting induction. Alternately, the pistons are pushed in as they pass along the discharge port, thus resulting in discharge. This reciprocating of the piston as the drive shaft rotates result in the pumping of the liquid.

Radial piston pump

A typical picture of a radial piston pump is illustrated. The pump has several pistons those are uniformly spaced and housed radially in a cylinder block (Piston-block). The pistons reciprocate in radial direction to the cylinder-block axis and hence the term radial piston pump.(Fig14)

Fig 14



The drive shaft transmits drive torque to the piston-block by means of a cross-disc coupling. The piston-block rotates around a pintle, which has ducts routed to inlet and outlet connections behind the pump. There are several piston arranged radially inside slots in the piston-block, which against a stroke ring through slipper pads. The piston is connected to the slipper pad by means of a ball and socket joint and the slipper pad is guided in the stoke ring by means of two overlapping rings. The stoke ring is eccentrically located with respect to the piston-block.

When the piston block is rotated, the pistons are forced against the stoke ring by centrifugal force and hydrostatic pressure. Sometime springs are also used for this purpose. Since the stoke ring is eccentric to the piston-block, in one half of the rotation the piston move away from the piston-block. Thus liquid is drawn through inlet port in the pintle into slots in the piston-block. In the other half of the rotation, the piston move into the piston-block, thus forcefully discharge liquid trapped in the slots, into outlet ports in the pintle. If the eccentricity increases the stoke length also increases and it amounts to twice the eccentricity.

Important parameters

Piston pump applications:

Piston pump are commonly used for high pressure and low discharge application.

- Displacements to 750 cm^3/r
- Pressure capabilities to 350/400 bar
- High noise level
- Sensitive to poor inlet conditions & contamination
- High overall efficiency
- Good life expectancy
- Large, bulky units
- High cost.

Piston pump applications

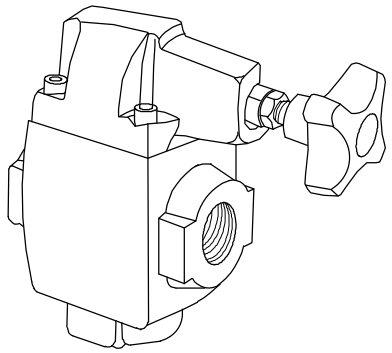
Piston pump are commonly used for high pressure and low discharge application.

Pressure relief valve

Objectives: At the end of this lesson you shall be able to
- **identify different parts of a pressure relief valve**
- **explain the functional features of a different parts of a pressure relief valve**
- **explain the constructional features of a pressure relief valve.**

The general outlook of a pressure relief valve is shown in (Fig 1). Knob is the main controlling element from outside.

Fig 1

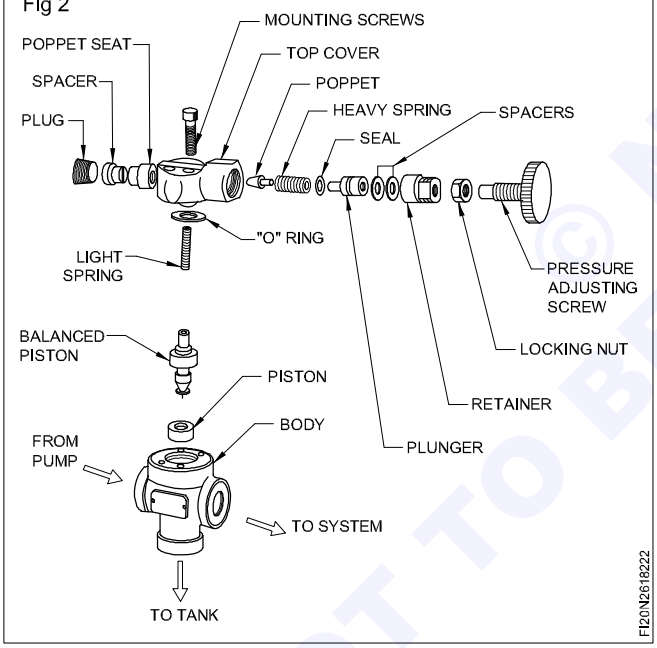


PILOT OPERATED PRESSURE - RELIEF VALVE

FI20N2618221

The following are main parts (Fig 2) of a pilot operated relief valve:

Fig 2



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Body	Poppet
Top cover	Poppet seat
Piston	Heavy spring
Light spring	Adjusting screw
Piston seat	

Body

Body of the valve is a fine grade cast iron. The inside of the casting is accurately machined to accommodate piston, piston seat and tight spring. Body is fixed with top cover by screws. Ports for inlet outlet and drain connections are provided in the body, as threaded holes. The body accommodates the main relieving mechanism.

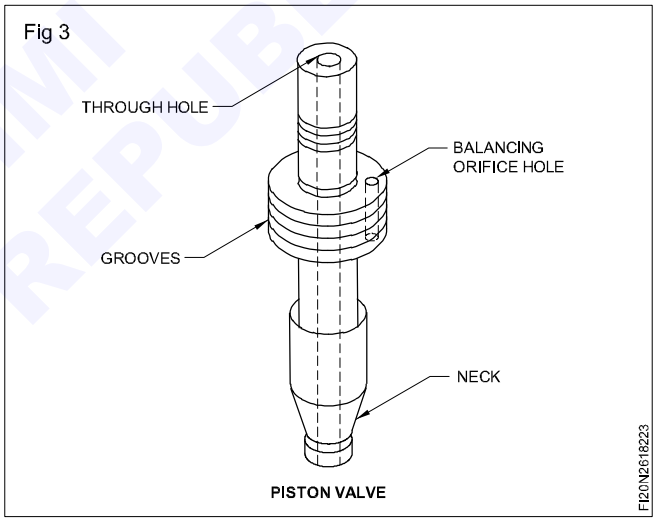
Top cover

The top cover is also a fine grade casting. It is machined inside to accommodate - poppet, heavy spring, adjusting screws, seals and vent plug. The top cover is fixed with the body by means of screws. The top cover houses the pilot operating mechanism, by means of the stated elements.

Piston

It is the main relieving valve element in the body. It is made of wear resistant steel, hardened and ground. The sliding portions of the valve are provided with shallow grooves. These groove retain oil, to give oil film for lubrication. There is a through hole at the centre of the valve piston. (Fig 3) There is an orifice hole on a flat side of large diameter. The purpose of through hole is to relieve oil at the time of cracking. The orifice hole fill up the area above piston from the inlet pressure area to balance the piston.

Fig 3



PISTON VALVE

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The bottom of the valve is tapered to have a cone seating in closed condition. Piston is accommodated in the body.

Light spring

The purpose of light spring is to retain the piston down against the seat in a balanced condition. It is accommodated in between the large diameter of the piston and body portion around the upper stem of the piston. This spring is not adjustable one, for its tension.

Piston seat

It is a liner bush tightly fixed in the body. It is made of wear-resistant steel, hardened and ground. The inner side of the bush has a taper to seat the tapered portion of the piston valve.

Poppet

Poppet is a conical member housed in the top cover. Poppet serves as a pilot valve. It is held in position by a

heavy spring. It is also made of a wear resistant steel with a fine conical ground surface.

This conical seat will have perfect sealing against oil from pilot port. Poppet is retained by a heavy spring.

Poppet seat

It is a seat for the poppet valve. It has got a conical seat within to match the tapered surface of a poppet. It is a hardened ground and rigidly fixed inside the top-cover by press-fit.

Heavy spring

This spring has to seat the poppet in the pilot port.

This spring is housed in between a plunger and maximum diameter of the poppet. When the force exerted by the oil at pilot port is more, the heavy spring lift off the poppet, to relive oil. The tension of spring is adjustable by means of knob.

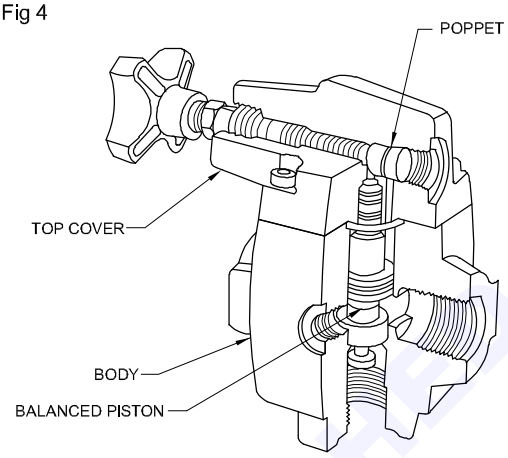
Adjusting screw

Adjustable screw is a fine pitched screw along with knob accommodated in the top cover. The matching thread for this screw is provided by the retainer rigidly fixed in the body, by a locking nut. Spacers are used in initial setting to adjust the tension of spring.

Leakage between the cast bodies and screw end are prevented by suitable seals made of heat and oil resistant rubber. Plug is used to dummy the port.

The complete assembly of all parts in a pilot operated relief valve is shown in Fig 4 by a cross-sectional view.

Fig 4



CROSS - SECTION VIEW OF A PILOT OPERATED PRESSURE RELIEF VALVE

Tube and pipe assembly

Objective: At the end of this lesson you shall be able to
- **state the various types of tubes and pipes fitting in an hydraulic system.**

Tubings in hydraulic system

In any hydraulic system the fluid should pass from one element to the other without breaking. For this purpose tubing is employed. Tubes act as a leakproof carrier for hydraulic fluid from and to the various elements used in the hydraulic circuits.

These pipes/tubes should be capable of withstanding pressure and also temperature. Thus the pipes also act as a area where the fluid dissipates the heat.

Normally the term tube and pipe is always leading to a confusion. What is the exact definition of a tube?

Difference between a tube and pipe

The difference between a pipe and tube is very narrow. Tube walls are usually thin contrary to the pipe walls which are thicker.

Tube generally is seamless in its design, whereas pipe may beveled.

Tubes, because of its thin wall cannot be threaded, whereas pipes can be threaded without affecting the strength.

Both tube and pipe are available in steel, but tubes are available in copper, brass, steel and also in plastic.

Bending of tubes are relatively easier compared to pipes, so tube have better flexibility over the pipes.

A main difference of the tube to a pipe is the inner wall of a tube is smooth, so as to provide a smooth flow of liquid resulting in a LAMINAR flow, which usually is a turbulent flow in a pipe, having not such a smoother inner side.

But generally even now in workplaces, both pipes and tubes are mentioned not precisely.

Tube material

Tubes are usually specified by their outside diameter and the length. Usually the length is made to customer requirement by cutting the tubes. Tubes are available in various materials such as copper, brass, aluminium, carbon steel and stainless steel. All tubes are usually seamless drawn tubes.

Classification of pipe fitting in hydraulics

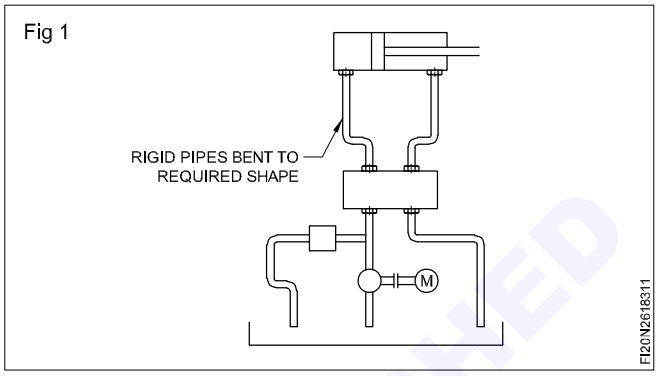
Tube/pipe fitting in hydraulics is usually classified as

- Rigid connections
- Flexible connection.

Rigid connections

Rigid tubing in done using metallic tubes. The tube is bent to the required length and shape and the various elements of the circuit is connected. (Fig. 1)

Fig 1



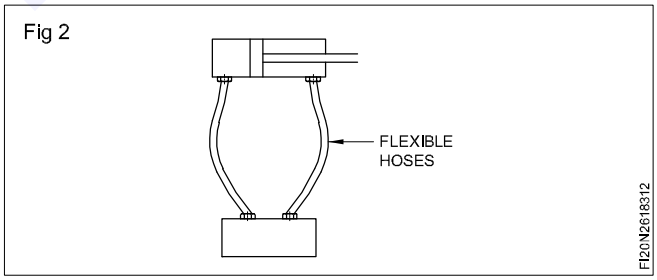
This type of connection is done where the circuit only built will not have any change in design or change in the position of the elements in future.

If there is a change then the existing pipes have to be disconnected and new pipes have to be bent fresh.

Flexible connection

This is a system in which the elements are connected with flexible tubes normally called as hoses. Flexible hoses are made of synthetic rubber tube reinforced with one or two braids of high tensile steel wire or with synthetic yarn suitably covered with weather resistant rubber. (Fig. 2)

Fig 2



Flexible hoses are very good in taking up pulsating pressure which is dampened by the hose itself. In case of rigid pipe this would have resulted in vibration ultimately causing breakage or loosening of connector.

Advantages of using hoses

- Insulates against shock noise and vibration
- Connects stationary parts
- Makes connection easier in congested space
- Makes good temporary connections
- Provides connections and disconnections which are to be frequently changed.

Types of flexible hoses

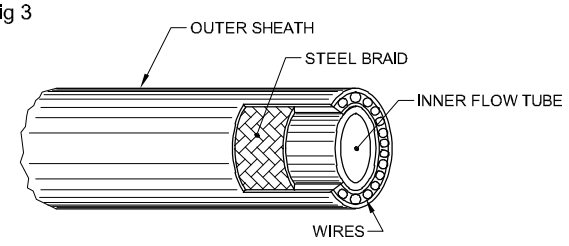
Flexible hoses again are available to cater various pressures and temperature ranges.

Hoses are usually classified according to the:

Type of construction

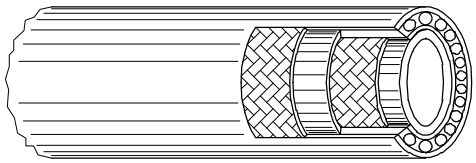
(a) Wire braided-single (Figs. 3 & 4) or double braid

Fig 3



SINGLE BRAIDED HOSE

Fig 4



DOUBLE BRAIDED HOSE

(b) Synthetic yarn braid (Cotton, fibre, asbestos etc).

Normally the flexibility of synthetic yarn braided hoses are more flexible but the operating pressure is a limitation.

Whereas wire braided hoses because of steel wire used is good in withstanding high pressures up to 300 cm^2 but is not as flexible as synthetic yarn braided hose.

Pressure and temperature withstanding capacity

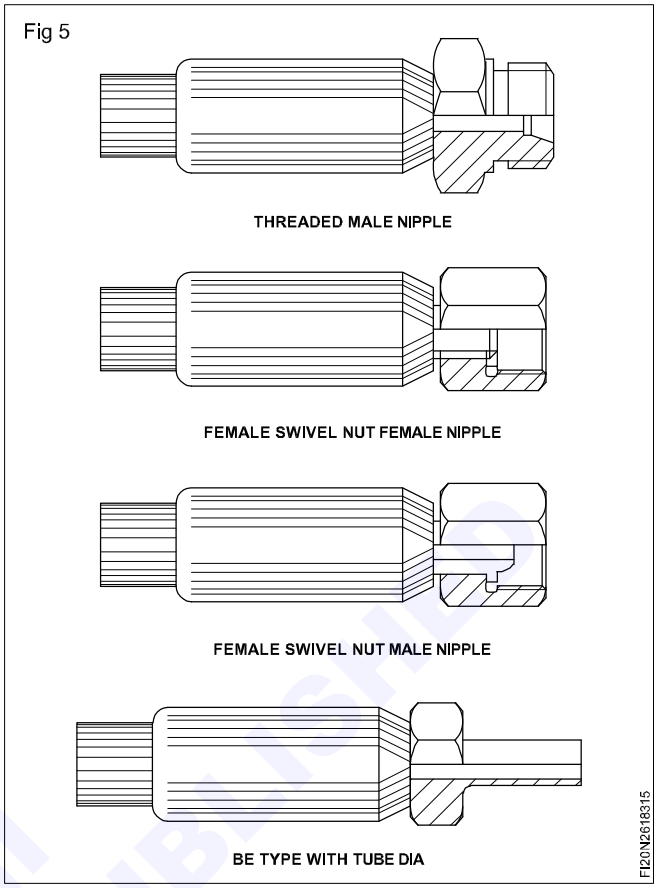
Hoses are used in hydraulic circuits and are subjected to pressure from the oil flowing through it. So hoses are classified according to its pressure withstanding capacity also this is given by the specification standard SAEJ517 as SAE100R1, SAE100R2 etc.

The number R1, R2 indicates the withstanding capacity in pressure and temperature and the construction. This has to be noted while selecting the hoses keeping in mind the maximum pressure produced in the circuit under construction. For actual valves of pressure and temperature the manufacturers catalogue has to be referred.

Type of pipe end fitting

Since hoses are used in various applications and has to mounted to suit a variety of connectors, it is also available with various end fitting. There are many type of end fitting available as required by customer. Some of them shown in the Fig. 5.

Fig 5



Specification of hoses

Flexible hoses are specified according to the following informations,

- Internal diameter
- Length between the two end connectors
- Pressure and temp withstanding capacity
- Type of end fitting.

All these can be readily referred from manufacturers catalogue for the specific application. An example is given below.

dia.10 x 1000 x SAE100R2 x both ends female nuts.

Connectors

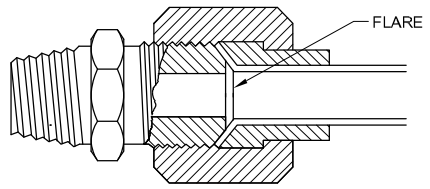
Connectors are the elements which connects the tube ends to the body of the various hydraulic elements. Connectors also serve various other purposes like change in size of tube, change in direction of flow, restriction of flow etc. Connectors can be grouped according to various parameters.

- According to the type of sealing design.
- According to the shape, size and purpose used for.

According to the type of sealing design

Flared fitting (Fig 6)

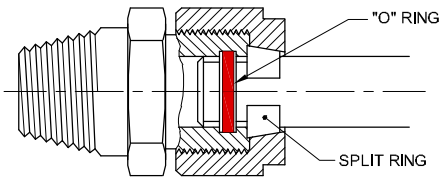
Fig 6



In this, the pipe is flared and fitted to the suitable connector.

'O' ring compression fitting (Fig 7)

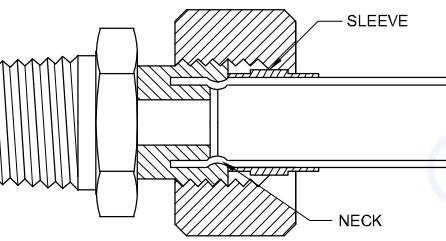
Fig 7



In this type of `O' ring seals the pipe outside diameter. The split ring clamps the pipe in position.

Sleeve compression fitting (Fig 8)

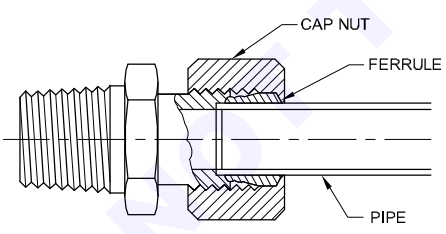
Fig 8



In this the pipe is formed the neck seals the path for oil along with the sleeve.

Ferrule compression fitting (Fig 9)

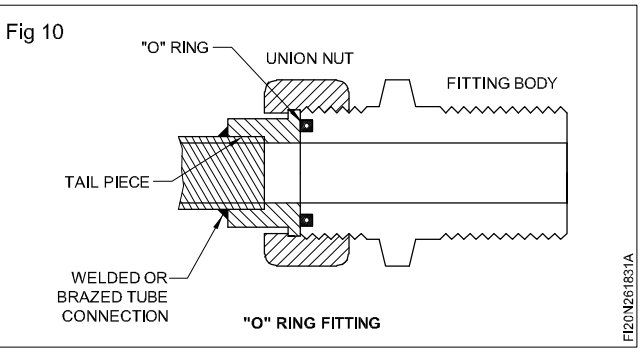
Fig 9



In this, the ferrule is of a special design, ferrule bites into the tube to form a permanent seal.

O' ring fitting (Fig 10)

Fig 10



The pipe is welded with a ring with a flat face, this face seals against a 'O' ring.

Various fitting have been illustrated, each of these fittings have the corresponding connectors. The connection will be perfect only when the connection is made according to the manufacturers instructions.

The selection of the right type of connector depend upon various factors like

- Working pressure of system
- Frequency of assembly and disassembly
- Vibration or shock level in circuit
- Working area.

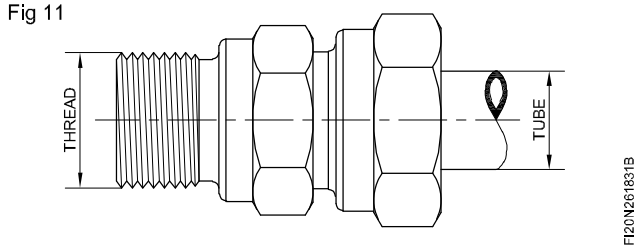
According to the size, shape and purpose of use

Connectors are used to connect either a tube to the body of a hydraulic element or a tube end to another tube end.

To connect a hydraulic element to a tube end

The connector shown (Fig 11) has threads which is screwed on to the body of the hydraulic element. On the other side a tube is fixed with proper sealing. This sealing is done by various methods as discussed in the previous exercise.

Fig 11



These connectors are available in various size according to the pipe it has to accommodate. The chart shows the pipe size and the threads on the connector.

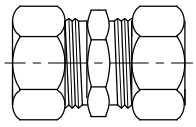
Pipe outsidedia	British standard pipe thread (BSP)	Metric Fine thread
6	R 1/4"	M22 x 1.5
8	R 1/4"	M14 x 1.5
10	R 3/8"	M16 x 1.5
12	R 3/8"	M18 x 1.5
14	R 1/2"	M20 x 1.5
16	R 1/2"	M22 x 1.5
20	R 3/4"	M27 x 2
25	R 1	M33 x 2
30	R 11/4"	M42 x 2
38	R 11/2"	M48 x 2

The various types of connectors in this category to take care of the flow direction of fluid as follows

Straight connector (Fig 12)

To connect tube perpendicular to the body.

Fig 12



STRAIGHT CONNECTOR

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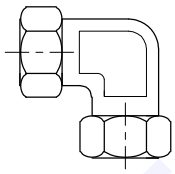
Elbow connector (Fig 13)

To connect the tube end parallel to the body of the hydraulic elements.

Fig 13



ELBOW CONNECTOR

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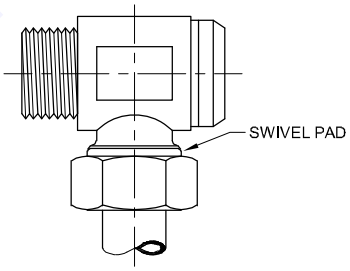
Banjo connector (Fig 14)

Banjo connector is similar to a elbow, but has the flexibility to turn 360 degree with the port axis. This helps in easy positioning of the pipe, with hydraulic elements.

Fig 14



BANJO CONNECTOR

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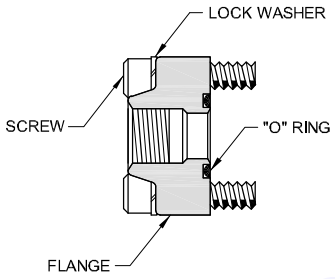
Flange connection (Fig 15)

Big size valves do not have threaded ports. They only have a hole as a port. In these case a flange is mounted on the body and the connector is mounted on the flange. This is also called as flush mounting.

Fig 15



FLANGE CONNECTION

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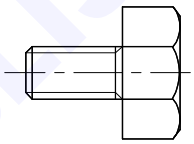
Plug (Fig 16)

A plug is used to block any port of the hydraulic element.

To connect a tube end to another tube end

Fig 16



PLUG

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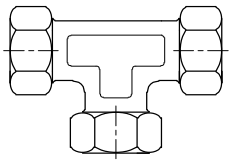
'T' connector (Fig 17)

Used to connect three pipe ends at a junction.

Fig 17



TEE CONNECTOR

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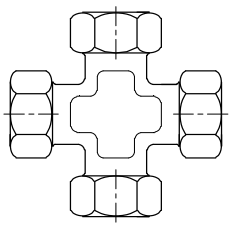
4 way connector (Fig 18)

Connect 4 pipe ends at a junction.

Fig 18



4 WAY CONNECTOR

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Reducer (Fig 19)

Connect two pipe ends of different size.

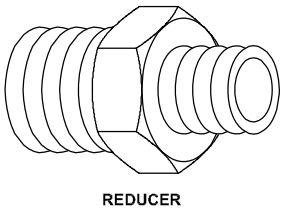
Do's and don'ts in tube/hose fitting:

Life of tube/hose fitting depends very much on how the fitting has been designed and installed.

In case of the rigid connections the following has to be observed:

Tubes should be bent such that the bend has no flats or wrinkle at the bent corners. (Fig 20)

Fig 19



REDUCER

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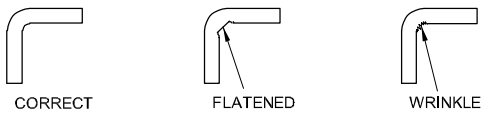
Fig 20



TUBE BEND

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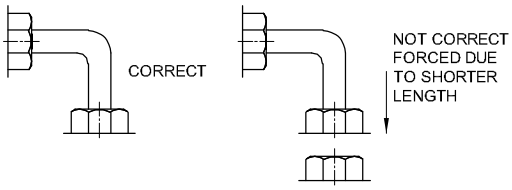
Tubes should be installed and removed without springing, bending or damaging the tubing. (Fig 21)

Fig 21



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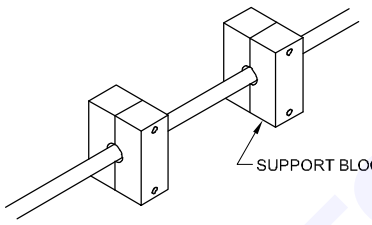
Support for tubes along the length if more than 1 meter long. (Fig 22)

Fig 22



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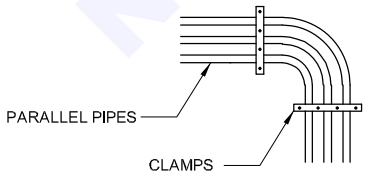
- Use minimum number of connectors.
- Use minimum number of bends in tubing.
- Design pipe lines in a neat and straight way to make fixing and maintenance easy. (Fig 23)

Fig 23



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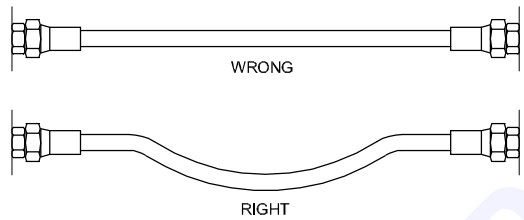
- Use tubes and connectors according to the working pressure of the circuitry.
- Make sure tubes are kept clean and clear from chips dust etc. that enables to deduct apparent oil leakages.

Points to note while using flexible hose connections

- Flexible hoses are costly. Use of them has to be justified.
- Remember that the hose will change in length from +2% to +4% when pressurised. Provide slack or bend in the hose to compensate for any change in length which might occur. (Figs 24 and 26)

Fig 24



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- If high operating pressures are applied to a twisted hose, the hose may fail or the attaching nut becomes loose.

Fig 25

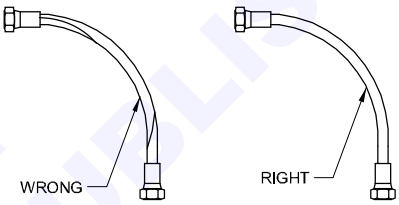

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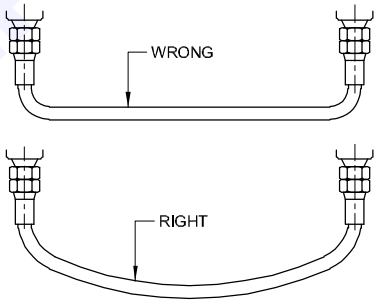
Fig 26



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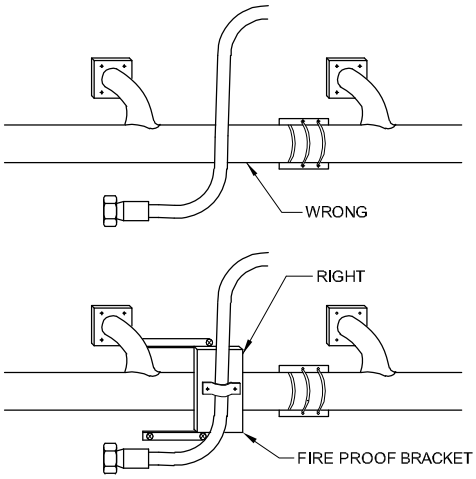
- Keep the bend radii of the hose as large as possible to avoid collapsing of line and restriction of flow. (Figs 26 and Fig 25)

Fig 27



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- When hose lines pass close to a hot exhaust manifold protect the hose with a fire proof boot or metal baffle. (Fig 27)
- Use elbows and adapters to ensure easier, cleaner installation for quick inspection and maintenance. (Fig 29)

Fig 28

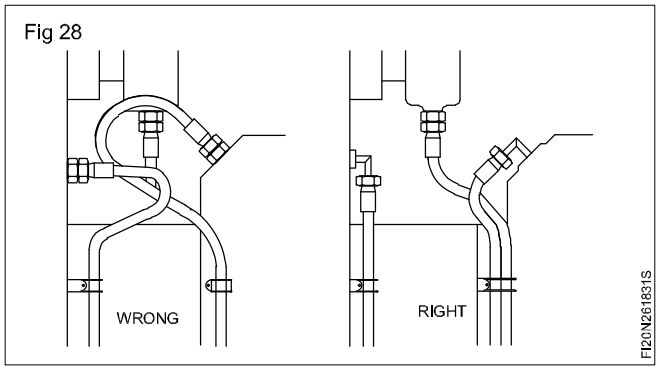
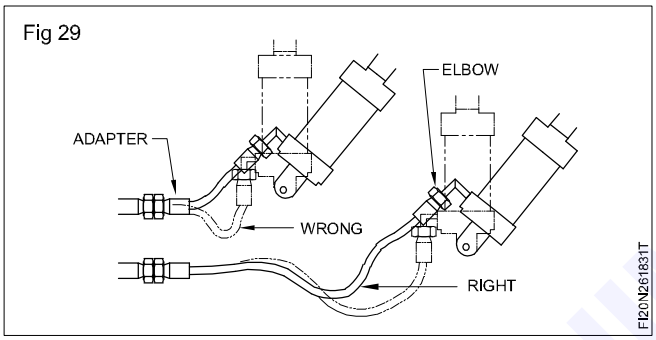
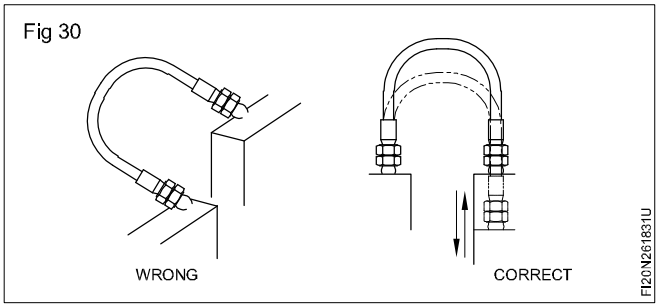


Fig 29



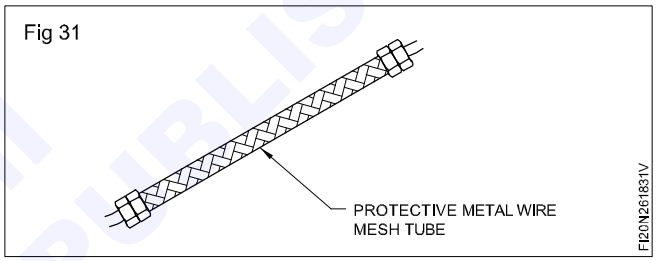
- When a hose assembly is to be subjected to considerable flexing or vibration remember that the metal hose fittings are not part of the flexible portion. (Figs 28, 29, 30)

Fig 30



- Hose must be bent in the same plane as the motion of the part to which the hose is connected. (Figs 28, 29 and 30)
- Use metal wire mesh to cover the tube in areas where the hoses may come in contact with hot chips etc. (Fig 31)

Fig 31



Hydraulic cylinders (linear actuators)

Objectives: At the end of this lesson you shall be able to
- **state the basic principle of hydraulic cylinder**
- **explain the construction of hydraulic cylinders**
- **state the sealing arrangement in a hydraulic cylinder**
- **name the parts of the hydraulic cylinder**
- **specify the hydraulic cylinder**
- **state the application of hydraulic cylinders**
- **calculate speed and force of a cylinder.**

Linear actuator

A hydraulic linear actuator is basically a cylinder, used to convert the hydraulic pressure and flow into a linear mechanical motion or force. Cylinder can be coupled with different types of mechanical linkages to produce enhanced or restricted movements in the combination of linear and rotary motions. Likewise with the arrangements, force can be multiplied or reduced.

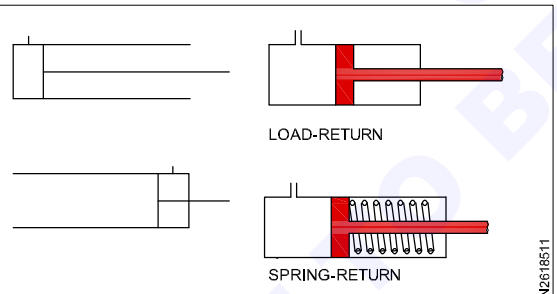
In a cylinder, the hydro-static pressure energy of the oil is converted into mechanical motion.

Working principle

Single acting cylinder

The Fig. 1 shows the cross-section of a single acting cylinder. Pressurised oil from the pump enter the pressure port. The pressure of oil exerts onto the piston and piston is moved (also against the force of spring tension), to other side.

Fig 1



SINGLE-ACTING CYLINDERS

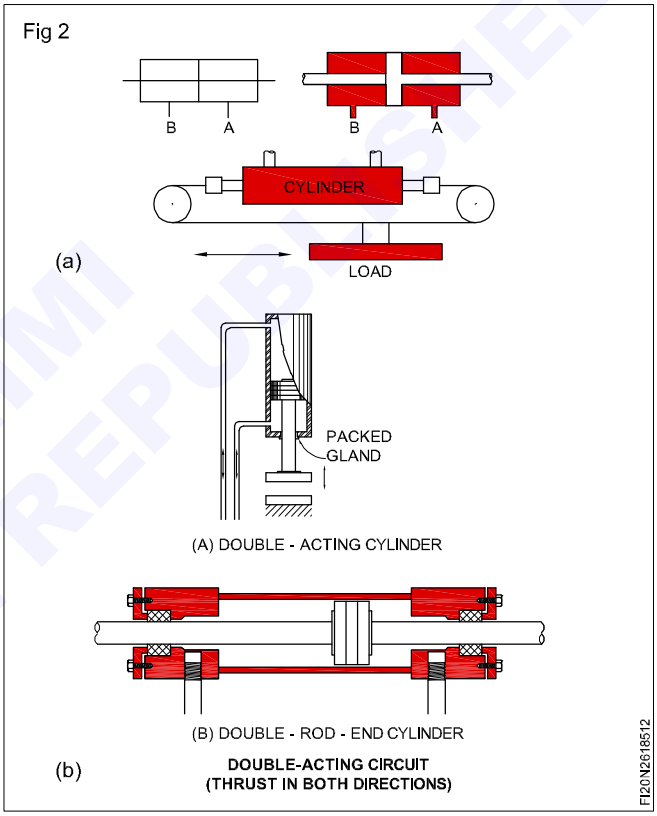
Useful work or movement can be attained from the free end of the piston-rod. After expansion of the oil, the spring tension overcomes the oil pressure. Now the spring pushes the piston to the left hand side. The oil is expelled through the same port.

Double acting cylinder

In a double acting cylinder Fig 2. Oil is supplied to both the sides of piston through ports A and B. When oil is supplied to port B, piston moves slowly. This is due to lesser area on the port side B, because force is proportional to the area. When the piston starts moving from left to right side, by the supply of oil pressure through port A, pressureless oil present on the right side is expelled through port `B' and vice versa.

To have an equal force on both the strokes, piston rod is provided on the left side of the piston also. (Fig 2a and 2b)

Fig 2



Construction of a double acting cylinder (Fig 3a)

The general construction of a double acting cylinder is shown in Fig 3a. Piston rod is made of a chrome plated and piston is made of cast steel. Cylinder head is honed inside and has rod bearing support and a port. Cylinder cap blocks the end of the cylinder and firmly attached to head by means of tie-rods and nuts.

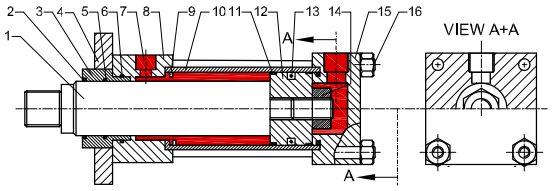
Static seals keeps the cylinder air-tight. Viper seals prevent the dust or other foreign particles from entering inside. The rod-bearing is usually replaceable by means of fasteners.

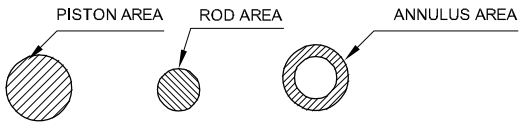
Piston seal prevents the oil from either-side of the piston, piston rings are made of high quality alloy steel/cast iron. (Fig 3b) For high pressures, cup packed seals are used.

These seals generally made of composition of rubber. For some right temperature applications, teflon seals are also used. Ports are threaded to connect the pipe ends/ connectors.

Leakage in between cylinder and head is prevented by O-rings made up of rubber as shown in the Fig. 3b. Better view of sealing arrangement can be seen in Figs. 3b.

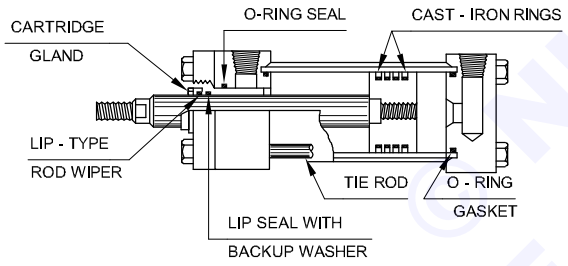
Fig 3





1 PISTON ROD
2 ROD WIPER
3 GUIDE BUSH
4 MOUNTING FLANGE
5 ROD SEAL
6 BUSH SEAL
7 OIL PORT
8 CYLINDER HEAD
9 TUBE SEAL
10 TUBE (BARREL)
11 GUIDE RING
12 PISTON
13 PISTON SEAL
14 LOCK NUT
15 CYLINDER CAP
16 TIE ROD

a. CONSTRUCTION - DOUBLE ACTING CYLINDER



b. NONCUSHIONED CYLINDER WITH CAST-IRON RINGS

End cushioning

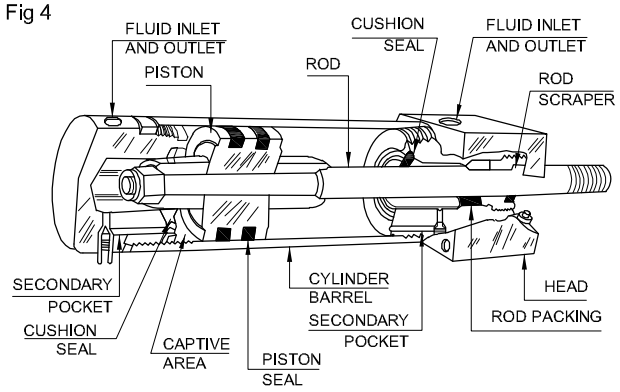
High pressure oil at the ends of the stroke will make the piston to impact on the ends of cylinder. To avoid this, end cushioning is generally provided. Springs find common application. But when the spring is compressed beyond its full home length, it is prone to damage. Hence cushioning is done by restricting the oil outlet as shown in the Fig. 4a. This arrangement is provided in the end portion of cylinder heads.

As shown in Fig. 4b the other side of the piston is provided with a plunger or cushioning piston. In the cylinder head, the check valve connects the passage from outlet to the cylinder. Another passage is connected by a restricted orifice 'O'.

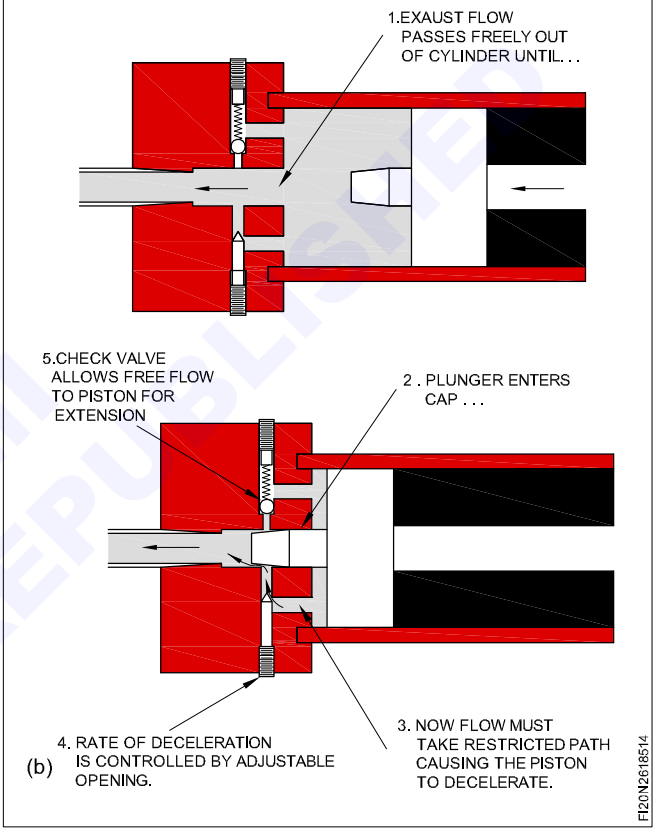
This orifice can be adjusted by a screw.

As the piston travel to the left-hand side, the plunger or cushioning piston enters outlet port 'E'. Now oil can escape through limited passages C and O only. But the check-valve blocks the oil passage by means of a ball. Now the oil can pass through the passage 'O' only. Thus travel of the piston is slowed down at the ends.

Fig 4



(a) CUSHIONED CYLINDER



(b)

Pressure and speed of piston

Pressure exerted by the piston = Pressure (Kg/cm^2) x Area of cross section of piston (cm^2)

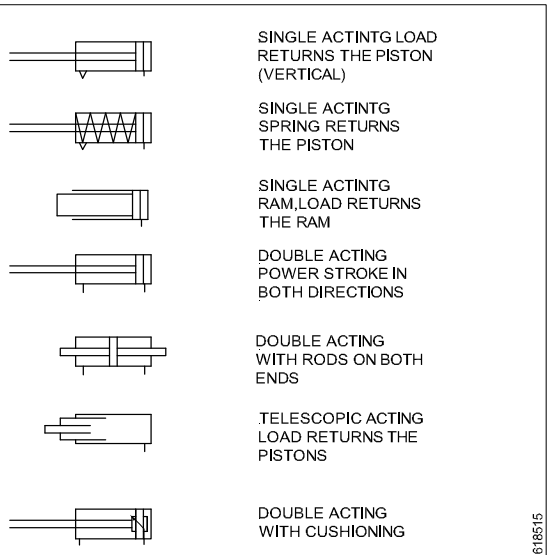
$$\text{Speed of the piston (cm/min)} = \frac{1000 \times \text{LPM}}{\text{Area of piston (cm}^2\text{)}}$$

Where LPM = Litres Per Minute.

Symbol

The symbols for hydraulic cylinders resembles the symbols of pneumatic cylinders. The symbols for commonly used cylinders are given in Fig 5.

Fig 5



GRAPHIC SYMBOLS FOR THE MORE COMMONLY USED LINER ACTUATIONS

Classification of cylinders

Two basic types of cylinders are

- Single acting cylinders
- Double acting cylinders

Single acting cylinders are further classified into

- Plunge type
- Piston type
- Ram type
- Telescopic type.

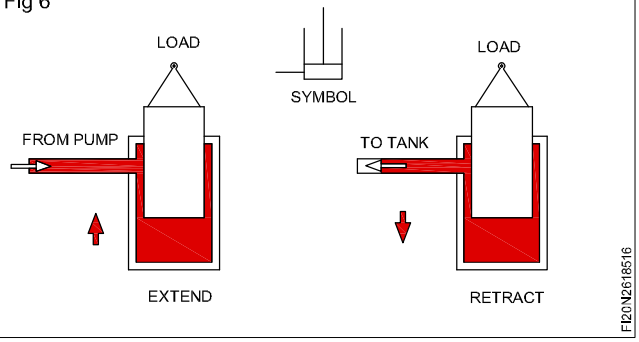
Double acting cylinders can be further classified into

- Single piston rod type
- Double sided piston rod
- D.A. cylinder with end cushioning
- Telescopic type
- Pressure intensifier
- Tandem cylinder.

Ram

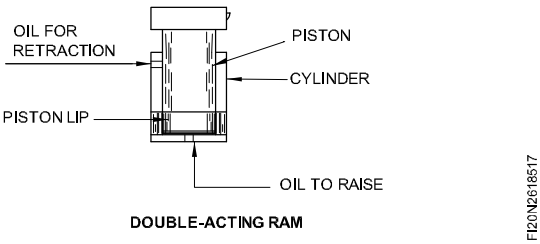
It is the simplest linear actuator as shown in Fig 6. It has only one chamber for oil. They are usually mounted vertical and ram descends down by its self weight. Rams are practically suitable for long strokes and used in elevators jacks and automobile.

Fig 6



Since the diameter of the Ram is throughout and there is no piston rod, if the Ram has to descends down at a faster rate than gravity, oil has to be supplied to the top as in the case of a double acting cylinder. (Fig 7)

Fig 7

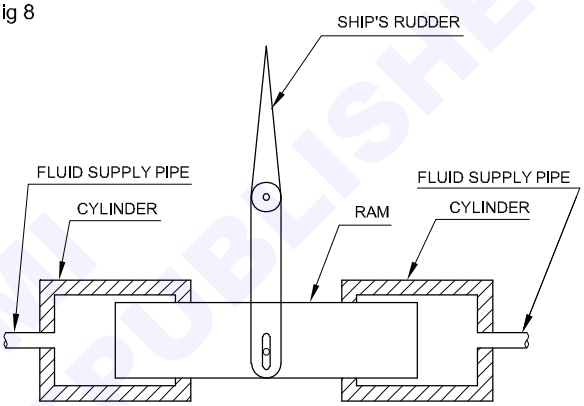


DOUBLE-ACTING RAM

However, the diameter of the Ram can be reduced only to a little extent to have piston rod.

The application of a double sided or dual Ram in turning the rudder of a ship is shown in Fig 8.

Fig 8

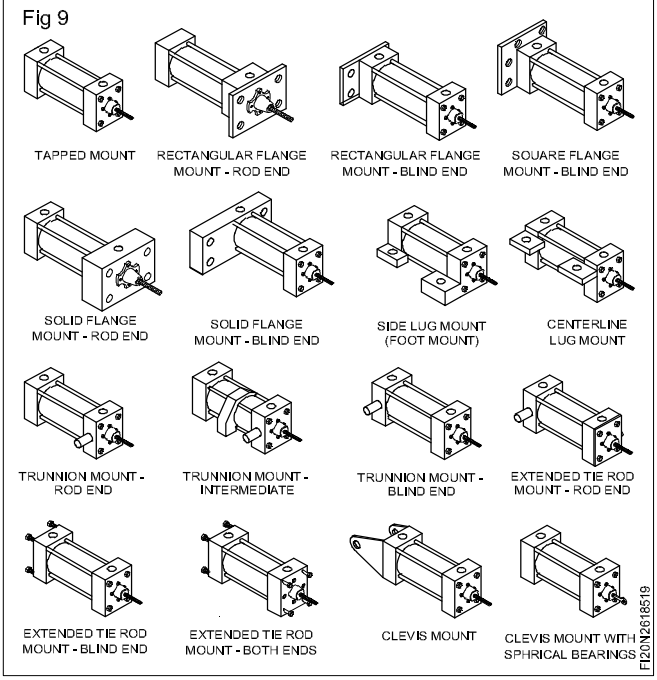


DUAL RAMS IN SHIP'S STEERING GEAR

Mountings of cylinders

Cylinders are mounted on different points to have a desirable movement space limitations, severity of load, direction of actuation etc. Fig 9 shows the possible methods of mounting a hydraulic cylinder.

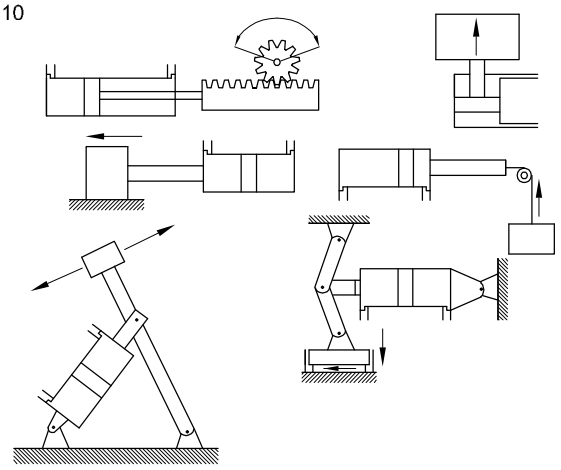
Fig 9



Actuation by linkages

Fig 10 shows the various methods of handling load, clamping, oscillation, lift, tilt and other kinds of applications of a cylinder along with mechanical linkages.

Fig 10



LINKAGES AND LOAD ATTACHED TO LINEAR ACTUATORS

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Hydro motors (Rotary actuators)

Objectives: At the end of this lesson you will be able to
- **state the principle of working of hydromotor**
- **state various types of hydromotor**
- **state the specification of hydromotor**
- **calculate the efficiency of hydromotor**
- **name the parts of the hydromotor.**

Hydromotor

This is a rotary actuator used in hydraulics, also called as hydraulic motors. This is very useful when a rotary motion is required. (The rotary action is achieved by this hydromotors) Similar to linear actuators, this also can be controlled in terms of displacement, direction of rotation, pressure or torque requirement. Nearly all elements used in linear circuits are used in rotary circuits also.

Cylinders provide linear motion where as hydromotors provide rotary motion.

Various types of hydromotors

Hydromotors are classified according to their internal design. Hydromotors are of three types namely:

- Gear type
- Vane type
- Piston type.

All these types have the common principle of working. These almost resemble a hydraulic pump in construction.

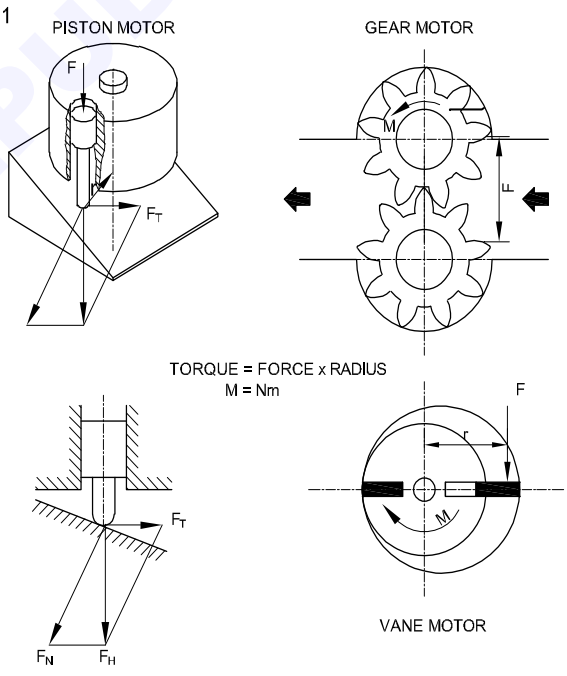
Operation of hydraulic motor is opposite to that of hydraulic pump.

The principle of working is shown with a simple line sketch in Fig 1

Gear type motors

Gear motors are designed either as

Fig 1



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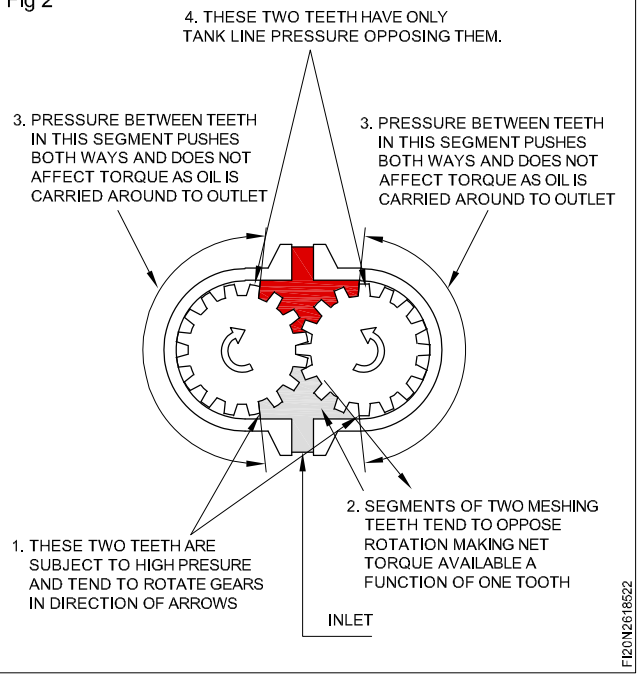
1 Gear on gear motor (external gear)

or

2 Gear in gear motor (internal gear).

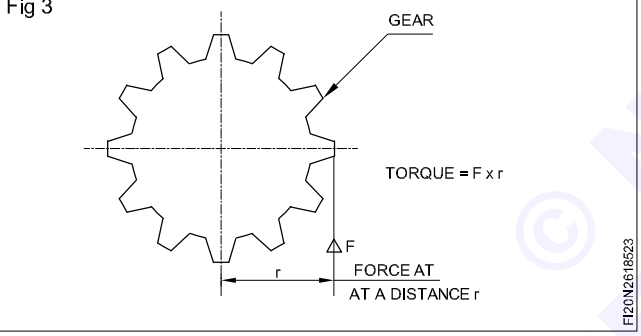
The figure 2 shows the gear on gear motor, oil enters the inlet port with pressure, this oil forces the gears to rotate and the oil flow out of the outlet. The speed of the motor depends on the amount of flow/minute and the motor torque depends on the pressure of oil. These motors have the lowest volumetric efficiency of about 70 to 80%.

Fig 2



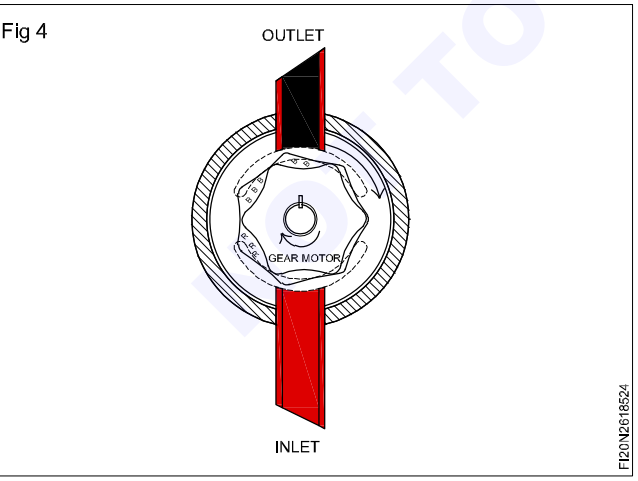
The pressure of oil creates the torque in the same way as that of on a lever. (Fig 3)

Fig 3



The internal gear motor usually of gear type shown in the Fig 4.

Fig 4



This is a motor which is very smooth in running and compact in design.

Vane type motors

This differs in the design when compared to gear motor. The simple line sketch in figure 5 shows the vane being moved along with the shaft by the oil flow. The prominent feature of the vane motor is the sliding vane. Each shaft will have more than one vane which ensures continuous rotation of the shaft. (Fig 6)

Fig 5

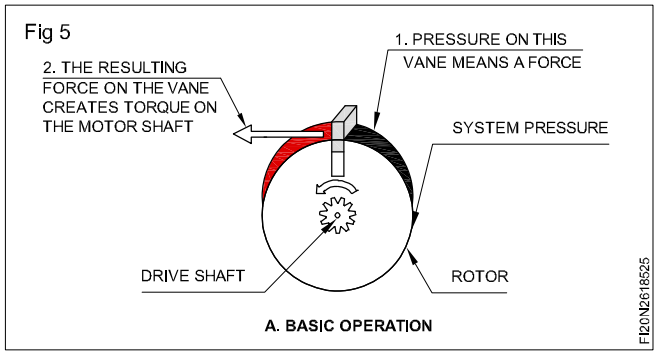
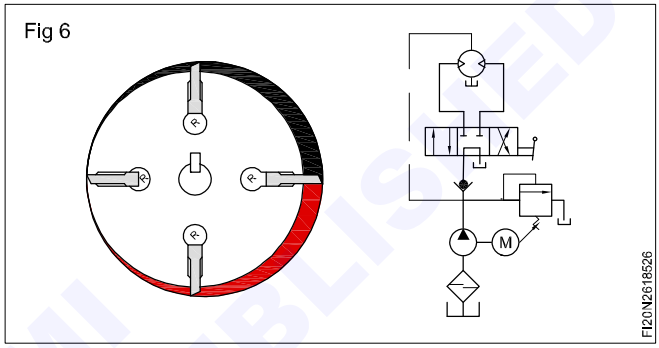


Fig 6



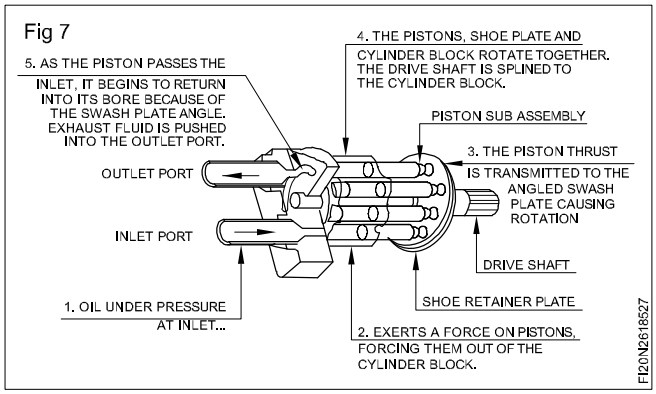
The vanes in the slots extent out by the action of centrifugal force and oil pressure. This has a high speed operating character.

Piston type motor

Piston motor is totally different from the other two types in its construction. Piston motors are of two types namely

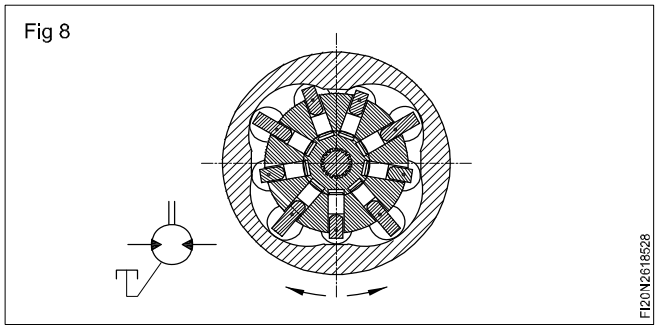
1 Axial piston motors (Fig 7)

Fig 7



2 Radial piston motors (Fig 8)

Fig 8



These motors are the most volumetrically efficient motors rating up to 95% efficiency.

The operating principle of these type of motors are shown in Fig 7&8. In a piston and barrel assembly when oil with pressure is allowed, it pushes the piston out.

This piston in turn in tune with the other pistons starts the rotary motion and continue the rotation.

Piston motors have the high volumetric efficiency and it is found its place in high efficiency, fast operating, high pressure circuitry.

Control of hydromotors

Hydromotors to perform effectively has to be controlled for it is speed and torque and direction.

Speed control of hydromotor

This is controlling the rpm of the hydromotor. This is usually done by controlling the quantity incoming fluid. This is also called as the displacement of the hydromotor. The control of flow of oil can be done by various methods which will be discussed in coming chapters.

Speed of a hydromotor depends on the quantity of oil passing through motor.

Torque control of hydromotor

Torque obtained in a hydromotor is the function of the fluid pressure. Thus by controlling the fluid pressure of the hydromotor the torque is also controlled.

Direction control of hydromotor

This is done by using a direction control valve in the circuit. This very much resembles the method of controlling the direction of movement of a double acting cylinder.

Direction of rotation of hydromotor depends on flow path of the oil.

Specification of a hydromotor

A hydromotor is usually designed and specified by the following parameters:

- max torque required
- max RPM required (outlet)
- max operating pressure
- efficiency.

Efficiency of hydromotor

Most of the times the hydromotor does not function as calculated. This is indicated by the various efficiencies of hydromotors. They are as follows

Volumetric efficiency

During operation same amount oil slip away without performing any work. This is a volumetric loss which is reflected in the volumetric efficiency

$$\eta(\text{Vol}) = \frac{\text{Theoretical flow rate}}{\text{Actual flow rate}}$$

Mechanical efficiency

During operation, particularly at low rpm and at high pressure conditions, there is a lot of mechanical losses. This is given by mechanical efficiency.

$$\eta(\text{Mech}) = \frac{\text{Actual torque}}{\text{Theoretical torque}} \times 100$$

Overall efficiency

This is used to calculate the power output of a hydraulic motor. It is expressed as the product of volumetric and mechanical efficiency.

$$\eta o = \frac{\eta \text{Vol} \times \eta \text{Mech}}{100}$$

Direction control valve

Objectives: At the end of this lesson you will be able to

- **explain function of various direction control valves and non return valve**
- **interprete direction control valve function in a hydraulic circuit**
- **define meaning of by - pass circuit**

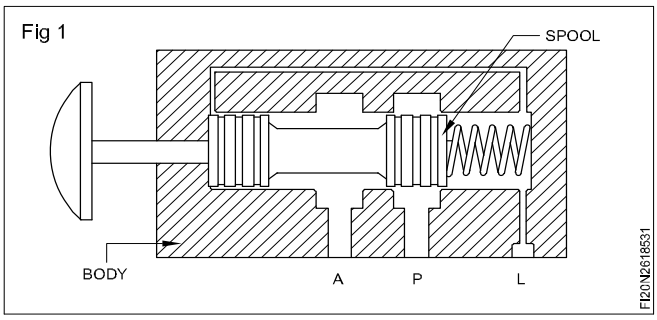
Direction control valve are components which change, open or close flow path in hydraulics system. They are used to control the direction of motion of hydraulic actuator as well as responsible to stop the motion of actuator.

Direction control valves are classified as following according to the number of ports and positions:-

- 2/2- Way valve
- 3/2- Way valve
- 4/2-Way valve
- 4/3-Way valve

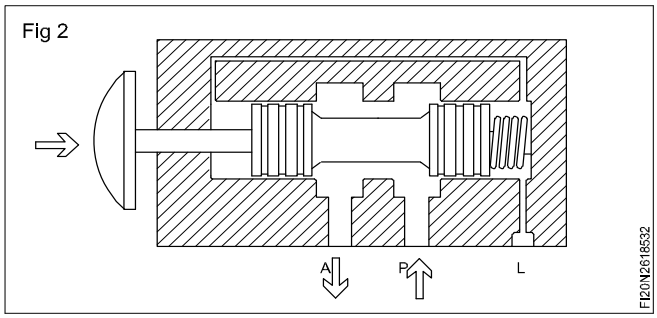
2/2 Way valve

The 2/2-way valve has a working port A, a supply port P and a leakage- oil port L. In the case of the valve shown here, of slide design, flow from P to A is closed in the normal position. (Fig 1)



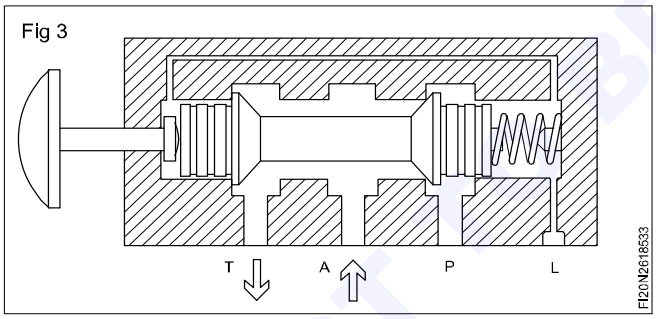
A relief line leading to the leakage - oil port is provided to prevent a build -up of pressure in the spring and piston chambers.

The 2/2-way valve is actuated and the passage from P to A is open. 2/2 -way valves are also available which are normally open from P to A. (Fig 2)

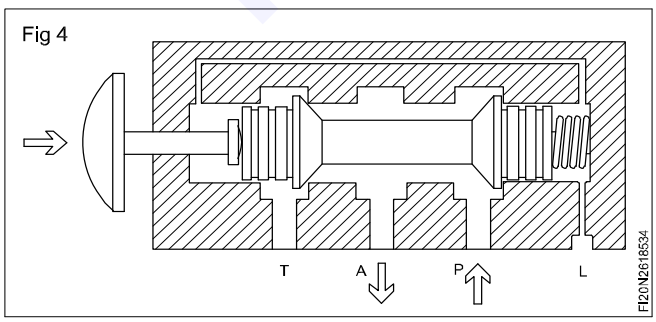


3/2-Way valve

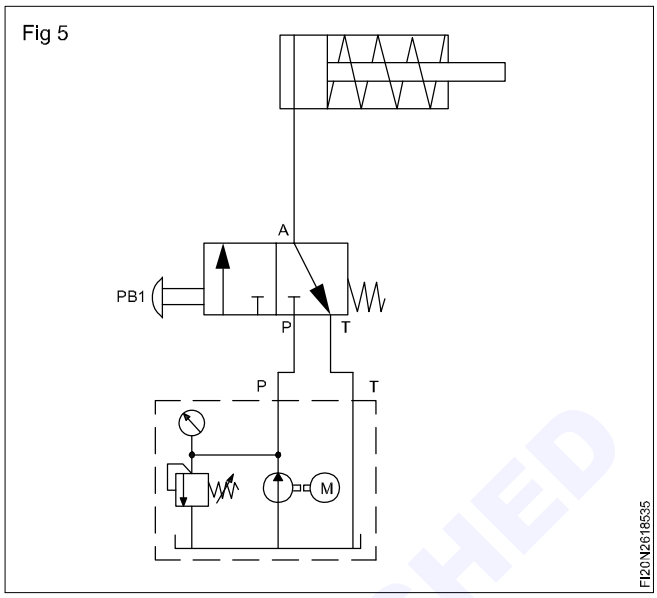
The 3/2-way valve has working port A, a supply port P and a tank port T. Volumetric flow can be routed from the supply port to the working port or from the working port to the tank port. The third port in each case is closed. In the normal position shown, P is closed and flow released from A to T. (Fig 3)



The 3/2-Way valve is actuated; flow is released from P to A, the outlet T is closed. 3/2-Way valves which are normally open from P to A and T closed are also available. (Fig 4)

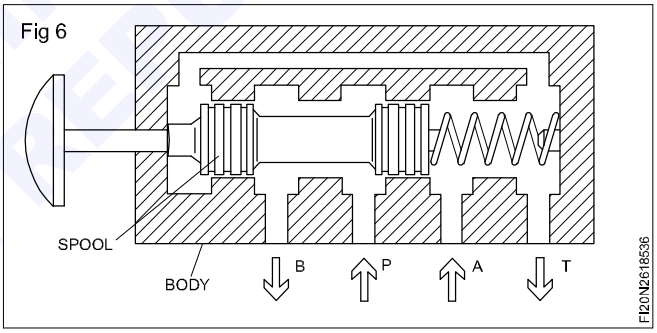


Example of 3/2 way circuit with single acting cylinder. (Fig 5)

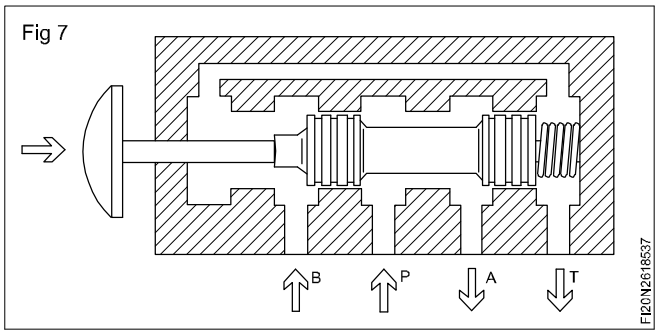


4/2 Way valve, two pistons

The 4/2-Way valve has two working ports A and B, a supply port P and a tank port T. The supply port is always connected to one of the working ports, while the second working port is routed to the tank. In the normal position, there is flow P to B and from A to T. (Fig 6)

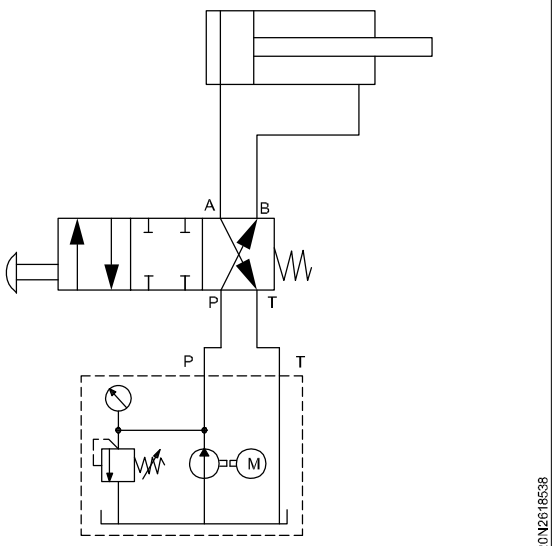


The 4/2-Way valve is actuated,and there is flow from P to A and from B to T. 4/2-way valves are also available which are normally open from P to A and from B to T. (Fig 7)



Example of 4/2 way circuit with double acting cylinder. (Fig 8)

Fig 8

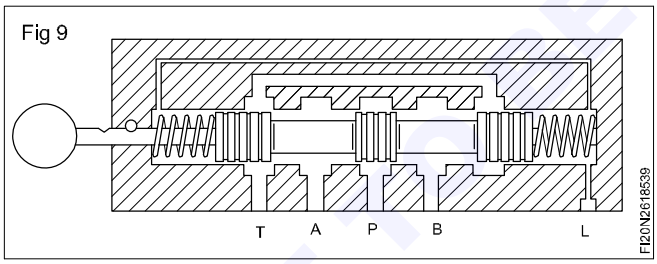


4/3- Way valve

From the logic point of view, 4/3-way valves are 4/2-way valves with an additional mid-position. There are various versions of this mid-position (in the mid-position in the example shown, the supply port P is directly connected to the tank T, see next illustration). In the switching position shown, there is flow from p to B and from A to T.

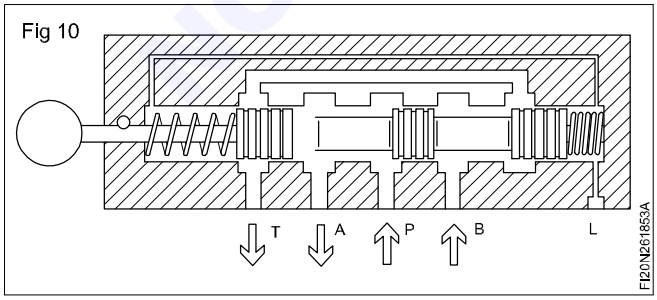
The 4/3-way valve is in its mid-position; there is flow from P to T, while A and B are closed. Since the output from the pump flows to the tank, this switching position is called pump bypass or also pump recirculation. In the case of pump bypass, the pump needs to operate only against the resistance of the valve, which has a favorable effect on the power balance. (Fig 9)

Fig 9



The valve is in its left-hand switching position; there is flow from P to A and from B to T. (Fig 10)

Fig 10



And the valve is in its right hand switching position there is flow from P to B and A to T. (Fig 11)

Example of 4/3 way circuit with double acting cylinder. (Fig 12)

Fig 11

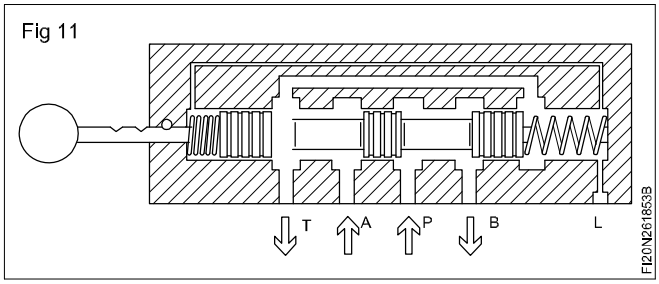
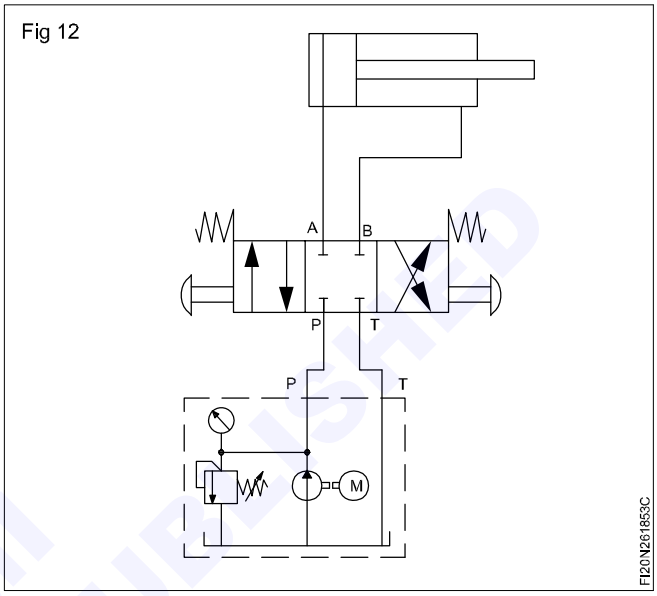


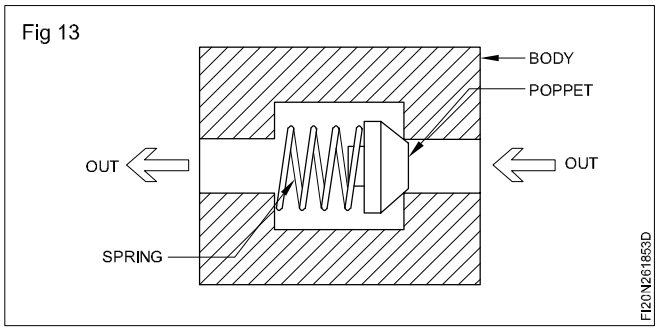
Fig 12



Non-return valve

Non-return valves block flow in one direction and allow free flow in the other. In the direction of flow shown, the sealing element is pressed against a seat by a spring and the hydraulic fluid. (Fig 13)

Fig 13



A spring loaded Non-return valve is shown in fig 13. If oil pressure is more on left side of NRV, poppet of valve will not open as well as it will not allow the flow of oil.

And when oil pressure is more on right side of valve then poppet of valve will move for opening and oil will flow through the valve. (Fig 14)

Fig 15 shows the application of non-return valve for pump protection. (Fig 15)

Fig 14

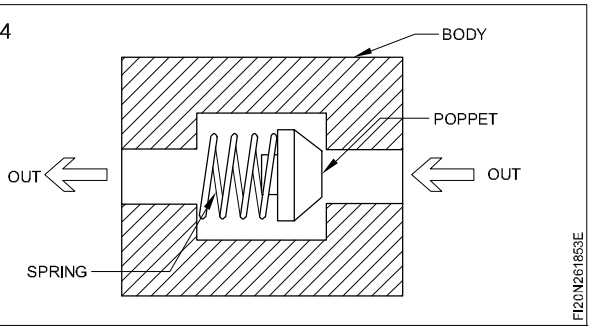
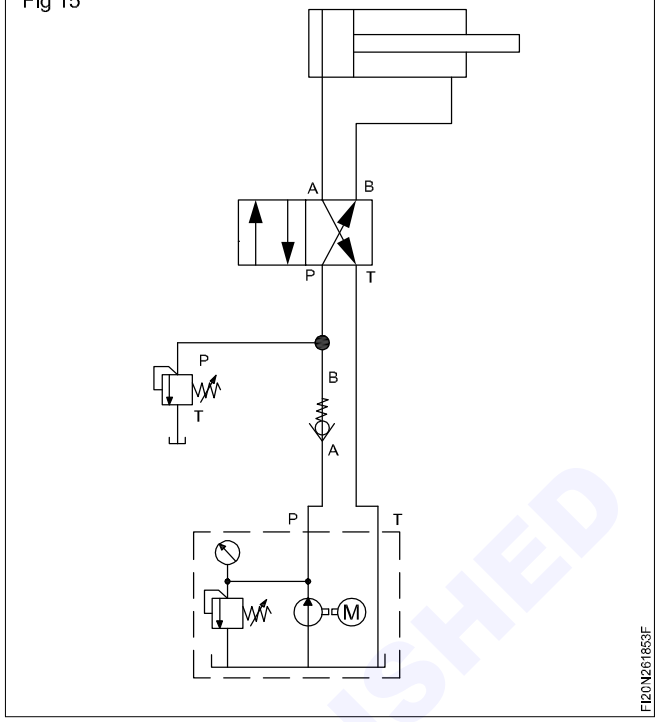


Fig 15



Flow control valve

Objectives: At the end of this lesson you shall be able to
- **state the need for flow control in a hydraulic circuit**
- **state the principle of operation of flow control valve**
- **draw different symbols of flow control valves and state the functions from the symbols.**

The whole purpose of a flow control valve is to vary the speed of an actuating cylinder or motor. This is possible by controlling the flow rate of the fluid.

A flow control valve accomplish any one or more of the following control functions:

- To limit the maximum speed of the linear or rotary actuators

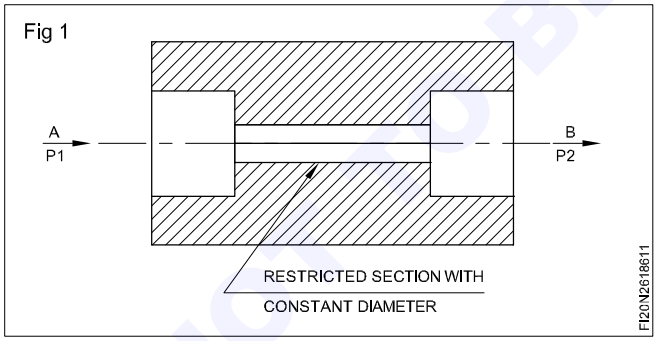
$$\left(\frac{\text{flow rate}}{\text{piston area}} = \text{piston speed} \right)$$

- To limit the maximum pressure available to branch circuits by limiting the flow. (power = flow rate x pressure)
- Proportionately divide or regulate the flow from pump to various branch circuits.

Principle of operation

As shown in Fig 1, the oil under pressure P1 enters the valve at A and flows through a restricted section, into the outlet B. While passing through the restricted passage, oil attains heat due to the friction. Thus the hydraulic energy in terms of pressure is converted into heat energy. The loss of energy is the result of drop in pressure.

Fig 1



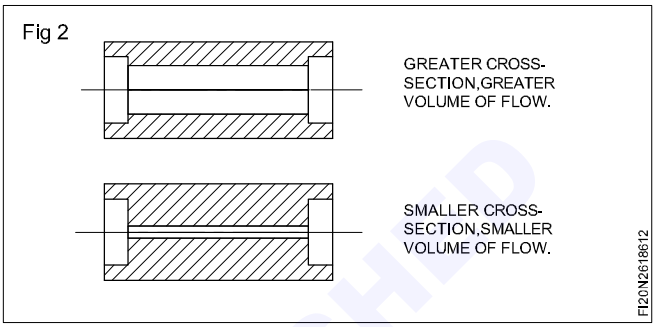
The difference between the two pressure is called pressure drop.

p = p1 - p2

The volume of flow (litres/min) is mainly dependent on the:

- Cross-section of restriction (Fig 2)
- Shape and length of orifice
- Pressure difference p
- Viscosity of the hydraulic oil.

Fig 2



The basic principle can be understood from Fig 3.

Symbol

As a general norm, the basic envelop is represented by a square to denote a valve. The flow line passes past through the square. The flow restrictions are denoted by curvatures above and below the flow line.

The arrow mark stroked across the curvatures means that, the flow restriction is adjustable. Sometimes full flow is to be ensured in the reverse direction. This can be made possible by connecting a check valve (non-return valve) in a right direction across the flow control valve. As indicated in Fig 3, in the forward direction, oil flows from pressure port (P) to working port (A). In the reverse direction oil flows from port A to port P, by pushing the spring loaded valve.

In case, if the return oil is to flow to the tank, the pressure port P will become tank port `T' by means of a direction control valve in the circuit.

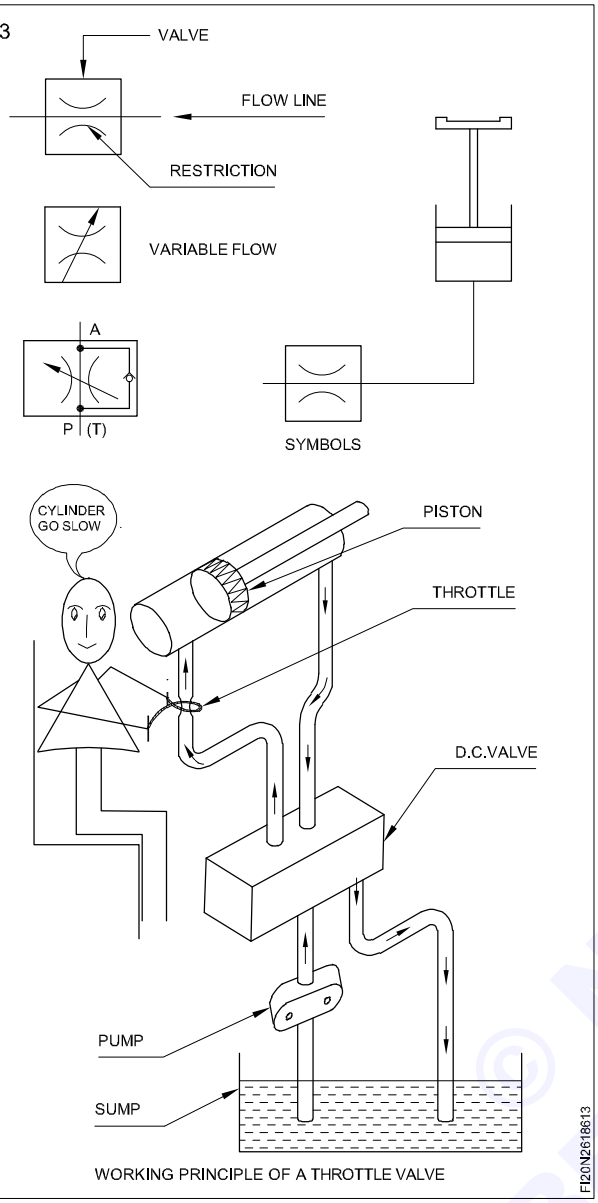
In Fig 4 symbols are given in combined operations. Fig 4A shows a control valve is adjustable and compensation is given for pressure as well as temperature. Fig 4B show a symbol for fixed type orifice and reducing valve-type compensation. Fig 4C indicates an adjustable orifice and relief valve type compensation.

The shape of on orifice and restrictor are shown in Fig 5. Restrictor is less sensitive to temperature variation.

The flow characters are changed in the following aspects

- The velocity past the valve.
- The pressure at the outlet of the valve is less than that of the inlet.

Fig 3



WORKING PRINCIPLE OF A THROTTLE VALVE

Fig 4

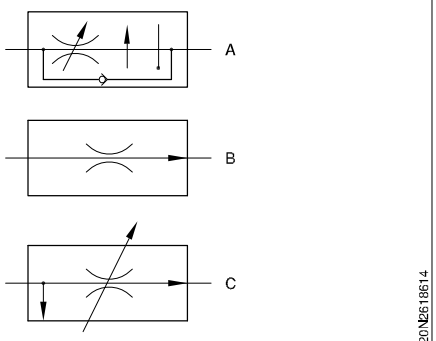
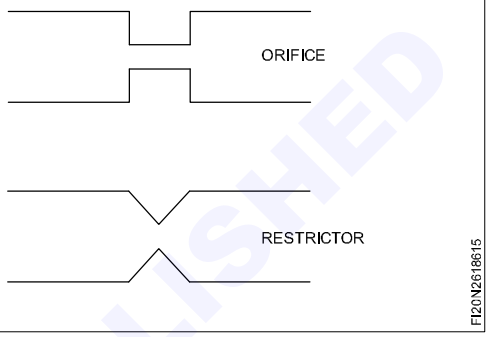


Fig 5



Variable flow control

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

- **state the need for a flow control valve**
- **state the principle of operation of a simple flow control valve**
- **name the different area of applications of a variable flow control valve**
- **distinguish the construction of a one way flow control valve**
- **name the areas of applications of one way flow control valves and different adjustable restrictors**
- **state the concept of maintaining constant flow rate.**

Need for flow control

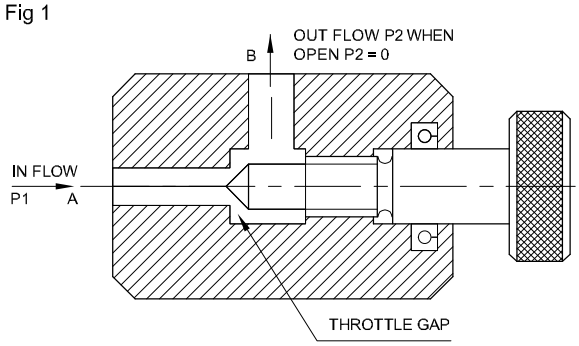
In a hydraulic circuit, to have a control over the speed of an actuator, the flow rate should be under control. This can be done by adjusting a variable delivery pump and a pressure relief valve. But the frequent adjustment of these elements will result in a power loss and reduction in their efficiency. Hence the need for separate flow control valve arises.

To enable the supply of variable flow to the circuits a flow control valve can be made adjustable. Tuning of a flow control valve to supply different flow rates is called 'Throttling' and the valve is also called throttle valve.

Principle of operation

As shown in Fig 1 oil enters the port A and its restricted flow enters port B. Flow is limited in the restricted passage called throttle. The amount of this gap can be varied by throttling screw. When the screw is fully closed, there is no flow at the outlet B.

Fig 1



It can be understood that the flow rate is dependent on the

- Pressure difference p = p1 - p2
- The size of throttle gap and
- Viscosity of oil.

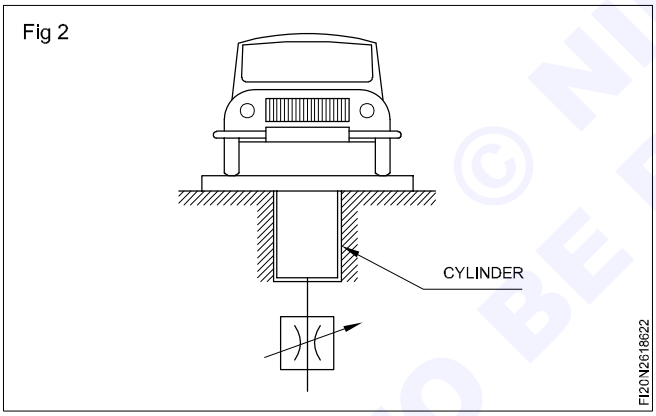
It is to be noted that valve can be operated in both the direction.

Application

By means of throttling, speed can be infinitely variable.

As shown in Fig 2, the platform for lifting a car can be raised faster or slower by means of cylinder movement. The cylinder movement, in turn can be varied by restricted oil supply through a flow control valve.

Fig 2



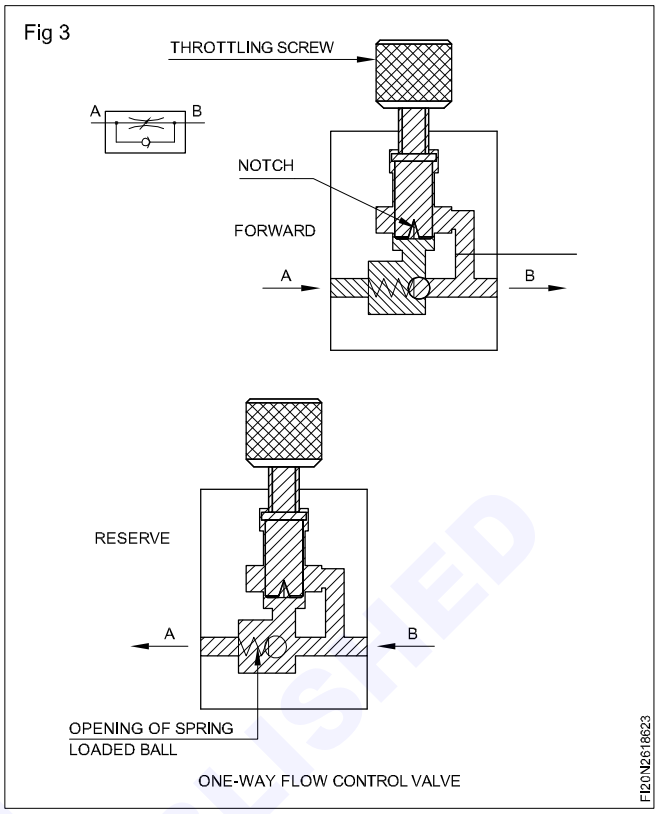
One-way flow control valve (Fig. 3)

A specific requirement of a flow control valve is that, an adjustable flow is required in one direction and a full flow is required in the reverse direction. It is possible, by the induction of a check valve.

As shown in Fig 3, the restricted passage is by means of a longitudinal notch in the valve body. Full flow oil coming from port A is restricted through this passage and only a limited oil flow through the outlet port B. It can be noticed that oil also acts on the ball in the spring direction, so that the ball firmly closes the port, that connects outlet port B.

Whereas in the reverse direction, i.e. from B to A, oil force acts on the ball against the spring force. Thus the ball is lifted off its seat and oil rushes to port A. At the same time, a limited passing of oil through the throttling passage also enters port A. Thus the full flow of oil is ensured at port A.

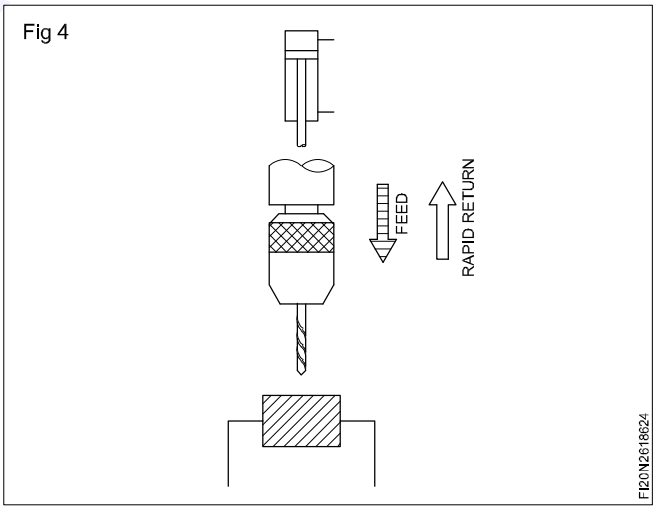
Fig 3



Application

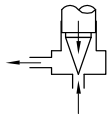
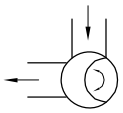
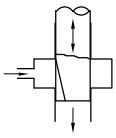
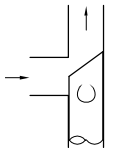
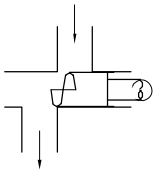
For a auto feed of the drilling operation as shown in Fig 4, the slow feed in vertical direction is imparted by a cylinder, receiving restricted flow of oil. After finishing the operation the drill head has to move fast in upward direction. This is possible by admitting full flow of oil against the check valve.

Fig 4



The following chart illustrates various designs of orifice restrictions, resistance offered, their dependence on viscosity, case of adjustment and effectiveness of the design.

Adjustable restrictors

Type	Resistance	Dependence on viscosity	Ease of adjustment	Design
Needle restrictor 	Increase in velocity, high friction owing to long throttling path	Considerable due to high friction	Excessive cross-sectional design	Economical simple
Circumferential restrictor  By radial slot	As above	As above, but lower than for the needle restrictor surface,total adjustment travel only 90°	Steady cross-sectional enlargement. Adjustment upto 90°	Economical, simple design more complicated than the needle restrictor
Longtiudinal retrictor  (By linear slot)	As above	As above	As above, however sensitive adjustment owing to long adjustment travel	As for circumferential restrictor
Gap restrictor or poppet 	Majority; increase in velocity, low friction short throttling path	Low	Unfavourable, even cross-sectional enlargement, adjustment travel of 180°	Economical
Gap restrictor with helix 	Increase in velocity, maximum friction	Independent	Sensitive, even cross-sectional enlargement adjustment travel to 360°	Expensive to produce helix

Requirements of adjustable restrictions

- Build-up of resistance
- Change in temperature and in turn the viscosity should not affect the resistance
- Adjustment of flow depends on the orifice cross-sec tional area and control surface area
- It should be economical in design
- Possibly it could allow the flow in either directions.

Maintaining constant flow-rate

The amount of flow out of a flow control valve, depends on the throttle passage, pressure difference and oil viscosity, set by the temperature.

The viscosity and passage remaining constant, the pressure difference on either side of the throttle alone affects the amount of flow. Hence if the flow is to be constant, the pressure, differential should also be constant. The flow control valve operating on this principle is called "Pressure compensated flow control valve". This type of valve can be also operated in either directions.

Common maintenance procedures for hydraulic and pneumatics control system

Objectives: At the end of this lesson you will be able to
- **plan hydraulics and pneumatic maintenance practices**
- **select proper practices of hydraulics and pneumatics maintenance.**

Key concepts

- Trouble shooting, done in a logical manner, can solve most hydraulic and pneumatic system problems.
- Safety should be the first consideration when trouble shooting.
- Inspect the equipment and question the operator to help solve problems in hydraulic and pneumatic systems.

Safety Precautions

Hydraulic systems operate under very high pressures. Shut the system down and relieve system pressure before opening any part of the system that is under pressure. Do not allow spray from any high pressure leak to contact any part of the body, as serious injection injuries may result. Pumps, valves and motor may beocme hot; be cautious of incidental contact between bare skin and hot surfaces. Keep hands and clothing away from moving parts of the system.

Basic hydraulics system maintenance

Weekly

- Check the systems performance and general condition.
- Check that the oil level in the reservoir is correct on the sight glass. (Hydraulic cylinder should be fully retracted when doing this) Check the oil color as compared to the sample of new oil.
- Check reservoir cover, solenoids and pipe connections for leaks and tighten as required.
- Check the indicator on filters and replace elements if required. When replacing elements, inspect for tell tale signs of impending unit failure, e.g., metal particles.
- Inspect relief valve locks, checking for unauthorized tampering.
- Check accumulator pre-charge (where fitted).

Annually and or every 3000 operation hours

- Check all mounting bolts for tightness. Remove coupling guards from pump / motor and check flexible couplings for wear. Replace the rubber sleeve if necessary.
- Check all the valve, pump and actuator for oil leak. Remove and replace the seals if necessary.
- Check filler breather, suction flter and systen filters element for cleanliness and replace if necessary.
- Check the cooler and clean the element. If necessary replace the seals.
- Have a sample of oil in the reserrvoir checked by a specialized laboratory for size end type of particle contamination. Drain the reservoir if recommended, clean the tank interior and refill with fresh oil of correct type if necessary.

Hydraulic system maintenance

Hydraulic system is recommended to be serviced at every 3000 operational hours or at least once a year.Continuous operation exceeding the mentioned period may cause increased contamination that may ruin components such hydraulic pump, valves, actuator, etc.,

More than 90% of all hydraulic systems failure are caused by contaminated hydraulic fluid. In order to reduce the contamination level, regular or schedule maintenance are essential.

Basic pneumatic system maintenance

Once in a Week

- Drain compressor, tank, filter, bowl, and any air lines that have drain cocks.
- Check compressor crankcase oil level
- Check compressor safety - relief valve

Once in a Month

- Inspect discharge air filter.
- Check pressure - reducing valve setting

Once in Every 3 Months

- Change crankcase oil
- Oil the compressor motors.
- Check compressor pressure switches.

Once in Every 6 Months

- Check for moisture, oil , and dirt in air lines.
- Clean the intake air filter, felt and screen types
- Check the compressor belt
- Check the pressure relief valves
- Check calibration, operation, nozzles, and and restrictors of transimt - temperature controllers, pressure controllers, thermostats and humidistats
- Check piping of pressure transmitters and controllers
- Clean elements and humidistats

Once in Year

- Replace cartridge - type intake air filters
- Check calibration of receiver controllers
- Check valves for tight close - off

Importance of technical English terms used in industries

Objectives : At the end of this lesson you shall be able to
- **state importance of english for employability skills**
- **state importance of english for soft skills.**

English as a language is important for professional courses It enhances:

- Employability skills: Trainees who possess the ability to understand,read,write and speak the language get better opportunity to get a job and retain in to scale heights in their career not only in the corporate,but also in the public sector.
- Soft skills: Apart from the hard skills that is the ability to acquire technical skills it has beocme very much necessary to master the art of soft skills equally in the under graduation level to develop the art of articulation in the world of competitive environment when the world has become very small with the access of internet and electronic media at our doorsteps.Being articulate it would be easier to build interpersonal relationship for smooth flow of communication to ensure productivity. The openness of the environement would ensure the confidence in decision making capability. Openness of the ambiance would lead to smart work which steer one to be multitasking.
- English as a language gained popularity not until 14 th century. Today it is a language of survival and sustenance
- Dominance of the British in every part of the world during the 19th and early 20th century by setting up colonies due to industiral revolution made the language richer and richest.

Different types of documentation as per industrial needs

Objectives : At the end of this lesson you shall be able to
- **state the purpose of documentation**
- **list the different types of documentation**
- **explain the documents format - batch processing, BOM, cycle time, productivity report, manufacturing inspection report.**

Documentation

Documentation and records are used throughout the manufacturing process as well as supporting processes (quality control) must meet the basic requirements. Documentation is a set of documents provided on paper, or online, or on digital or analog media, such as audio tape or CDs. Examples are user guides, white papers, online help, quick reference guides.

The stages of recording the documents is to

- prepare, review, update and approve documents.
- identify changes and current revision status of documents.
- use of applicable documents available at points of use with the control documents of external origin
- identify and distribute relevant versions to be identifiable and remain legible.
- prevent unintended use of obsolete documents and archiving.

The different types of documentation as per industrial needs includes

- Processing charts
- Bill of materials (BOM)
- Production cycle time format
- Productivity reports
- Manufacturing stage inspection report
- Job cards format
- Work activity log
- Batch production record format
- Estimation of work
- Maintenance log format

Process chart

A process chart is a graphical representation of the activities performed during manufacturing or servicing jobs. Graphical representation of the sequence of operations (workflow) constituting a process, from raw materials to finished product.

Process charts are used for examining the process in detail to identify areas of possible improvements.

The different types of process charts are

- Operation process chart
- Flow process chart (man/ material/ equipment type)

- Operator chart (also called two handed process chart)
- Multiple activity chart
- Simo chart

The following symbol set derived from Gilbreth's original work as the standard for process charts.

Symbol	Letter	Description	Examples
O	O	Operation	Saw cut, paint, solder, package
→	M	Transport	Conveyor / Fork lift / OTR truck
□	I	Inspection	Visual/dimension
D	D	Delay	WIP/Hold/ Queue
∇	S	Storage	Warehouse/tracked storage location

The application of symbols on a flow process chart is shown in the figure

Flow process chart(Machines)

Industry : _____

Product : _____

Summary

Function	Present		Proposed	
	*	Time	*	Time
Operation				
Inspection				
Transport				
Delays				
Storage				

Details	O→□ D∇	Qty	Time (in mins)	Analysis	Actions recommended
Raw material from stores	O→□ D∇				
To cutting machine	O→□ D∇				
Cutting of material to size	O→□ D∇				
Filling, Finishing	O→□ D∇				
To inspection for finished size	O→□ D∇				
To stores (Finished job)	O→□ D∇				

Batch record forms

The documents used and prepared by the manufacturing department provide step-by-step instructions for production-related tasks and activities, besides including areas on the batch record itself for documenting such tasks.

Batch production record is prepared for each batch should include information on the production and control of each batch. The batch production record should confirm that it is correct with standard operating procedure.

These records should be numbered with a unique batch or identification number and dated and signed when issued.

The batch number should be immediately recorded in data processing system. The record should include date of allocation, product identity and size of batch.

Documentation of completion of each significant step in the batch production records (batch produciton and control records) should include :

- Dates and, then appropriate time
- Major equipment used machinery and specific batch numbers of raw materials, reprocessed materials used during manufacturing.

- Critical process parameters records.
- Trial product or sample (if required).
- Signatures of staff for sequence of operation.
- Laboratory test results and line inspection notes.
- Achieved production against target.
- Packaging and label (if any) details.

Batch processing record : (Sample format - 1)

The format 1 used in documentation of batch processing record has the description of the job, necessarily mentioned with part number and name of the part.

A predetermined batch quantity with batch number alloted and identified with batch record number for documentation.

The product reference is made with purchase order number.

The production process is descriptively written about the sequence of operation to be carried out on the product.The batch processing record is signed with date mentioning name of person responsible and their designation.

The manufacturer organization name, period of manufacture preferably the year with starting date of manufacture and end date of manufacturer and number of pages of document according to batch quantity processed, and total number of pages of document, inclusive of inserted pages and manufacturing facilities is provided with.

The remarks if any on the process should be also mentioned then and there.

BATCH PROCESSING RECORD - FORMAT - 1

<table>
<tr><th colspan="4">Batch Processing Record</th></tr>
<tr><td colspan="2">Description of job</td><td colspan="2">Batch no. :</td></tr>
<tr><td colspan="2" rowspan="3">Part no. :
Name of part :</td><td colspan="2">Batch quantity :</td></tr>
<tr><td colspan="2">Batch record no. :</td></tr>
<tr><td colspan="2">Purchase order no. :</td></tr>
<tr><td colspan="4">Description of process :</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">Manufacturing Organisation :</td></tr>
<tr><td colspan="4">Period of manufacture (Year - Qtr): Start date of manufacture: End date of manufacture:</td></tr>
<tr><td colspan="4">Number of pages according to batch: Inserted pages: Manufacturing facilities:</td></tr>
<tr><td colspan="4">Total number of pages</td></tr>
<tr><td colspan="4">1. Operator / Technician
Date Name and signature</td></tr>
<tr><td colspan="4">2. Production in-charge:
Date Name and signature</td></tr>
<tr><td colspan="4">3. Section manager
Date Name and signature</td></tr>
<tr><td colspan="4">4. Plant in-charge:
Date Name and signature</td></tr>
<tr><td colspan="4">5. Production in-charge:
Date Name and signature</td></tr>
<tr><td colspan="4">Remarks (if any)</td></tr>
</table>

Bill of materials (BOM) format - 2

The list of parts involved in manufacturing of an assembly hierarchially is given in this format.

The format shown is as per bureau of Indian Standards IS:11666-1985 as example for Engineering Component drawings.

The BOM in the form of tabular columns has the component marked with item number, and its name is given under description and number of is mentioned under quantity, with reference drawing ie., sub assembly/part drawing number.

The material designation as per code of practice or standards is mentioned, and any other specific notes are given under remarks column.

The BOM is placed on the manufacturing drawing containing with assembly and parts in standard sheet sizes of engineering drawing.

BILL OF MATERIAL (BOM) - FORMAT - 2
as per IS: 11666-1985

S.No	Item No.	Description	Quantity	Reference dwg no.	Material as per standard	Remark

Cycle time

Cycle time is the total time from the beginning to the end of the process. Cycle time includes process time, during which a raw material worked with to bring it closer required form output, and delay time, during which the to workpiece waiting for next operation.

The time taken to perform one operation repeatedly measured from “Start to Start” the starting point of one product’s processing in a specified machine or operation until the start of another similar product’s processing in the same machine or process. Cycle time is commonly categorized into same machine/process.

Machine cycle time

The processing time of the machine working on a part.

Auto cycle time

The time a machine runs un-aided (automatically) without manual intervention.

Overall cycle time

The complete time it takes to produce a single unit. This term is generally used when speaking of a single machine or process.

Total cycle time

This includes all machines, processes, and classes of cycle time through which a product must pass to become a finished product. This is not lead time, but it does help in determining it.

Production cycle time (Format - 3)

This format 3 should contain mentioning the organization name department / section name. The process which is being observed for analysing the cycle time is mentioned with line in charge name and the date/time of the operations, with operator name is indicated.

The time observation on each operation, sequence noted in the column, and lowest repeatable is also mentioned for each operation. The times observation for machine cycle time is also noted, with any notes be recorded in respective operations in sequence.

PRODUCTION CYCLE TIME - FORMAT - 3

Organisation Name: **Department / Section :**	**Process:**	**Line Incharge:**	**Date/Time:**

Operator :									**Machine Cycle Time**	**Notes**
Operator Sequence	**Observed Times**							**Lowest Repeatable**		

Productivity report

Productivity report to measure and review the efficiency of a person, machine, factory, system, etc., in converting inputs into useful outputs. Productivity report is computed by dividing average output per period by the total costs incurred or resources (capital, energy, material, personnel) consumed in that period.

The base document daily production report which reveals the actual output against the target plan and on investment cost incurred as mentioned above decides the cost efficiency.

Daily production report (Format 4)

The output of production is shown in the format, referring the job order no quantity, material and size, every process involved, to produce a component, quality control, packing should contain the details of planned quantity and produced quantity is recorded in the document. This is the base details for arriving the productivity report.The incurred cost is worked out considering infrastructure, raw materials and facilities.

DAILY PRODUCTION REPORT - FORMAT - 4

	Daily Production Report	
Date:	**Department:** **Section:**	**Organisation Name:**

	Process - I		Process-II		Process-III		Process-IV		Quality Control		Packing	
	Planned	Completed	Planned	Completed	Planned	Completed	Planned	Completed	Planned	Completed	Planned	Completed
Job Order No. Quantity Material & Size												
Job Order No. Quantity Material & Size												
Job Order No. Quantity Material & Size												
Job Order No. Quantity Material & Size												
Job Order No. Quantity Material & Size												

Signature of section Incharge

Manufacturing stage inspection report (Format 5)

The format 5 is to monitor the production in various stages for which manufacturing stage inspection conducted for documentation to review the productivity. The format gives the details of product being inspected showing the details of customer reference by purchase order (PO) number and date, job order number and date, process involved in manufacture of product, the quality submitted for inspection. The accepted and rejected quality recorded with inspection record review date and the inspection person signature who conducted the stage inspection is recorded date wise for mentioned /specified period with start and end dates.

MANUFACTURING STAGE INSPECTION REPORT - FORMAT - 5

Status: From Date ..../..../..... To Date .../.../.....	Inspection Record No.								
	Inspection conducted by								
Organisation Name :	Date								
	Product ID/ Code								
	Customer								
	P.O No. & Date								
	Job Order No.								
	J.O Date								
	Process								
	Qty								
	Accepted								
	Rejected								

Documentations - 2

Objectives : At the end of this lesson you shall be able to
- **state the purpose of job card and its format details**
- **explain work activity log format details**
- **state the details of batch production format.**

Job card

A job card is a document showing the details of a job to be performed in a production shop. It is used to authorize and instruct the work team to take up the production work.

Job card format - 1

Job card has the details of commencing the job, customer name, work order no, document number, reference number and date.

The details which have to be recorded about the product line description showing the operations each into recording of start time and total time of operation. The location time recorded is to track if any delay/ reasons and necessary actions if taken with remarks.

If the product has to be completed with any of the further operations in sequence, this card will travel along with job for next workstations for further operations if any to complete the requirement of job, and recorded till finishing of the job.

JOB CARD - FORMAT-1

Job Card	Doc No.	
	Rev No.	
	Date	

Order Starting Date	
Customer	
Work Order No.	

Details

S.No.	Date	Production Line Description	Time (Minutes)			Location Time	Remarks
			Start Time	End Time	Total Time		

Lubrication methods

Objective: At the end of this lesson you shall be able to
- **state the systems of lubrication and their application.**

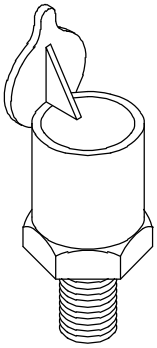
There are 3 systems of lubrication.

- Gravity feed system
- Force feed system
- Splash feed system

Gravity feed

The gravity feed principle is employed in oil holes, oil cups and wick feed lubricators provided on the machines. (Figs 1 & 2)

Fig 1



OIL CUP

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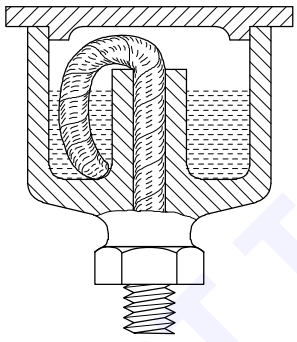
Fig 2



WICK FEED

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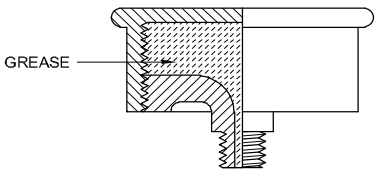
Force feed/Pressure feed

Oil, grease gun and grease cups

The oil hole or grease point leading to each bearing is fitted with a nipple, and by pressing the nose of the gun against this, the lubricant is forced to the bearing. Greases are also force fed using grease cup. (Fig 3)

Oil is also pressure fed by hand pump and a charge of oil is delivered to each bearing at intervals once or twice a day by operating a lever provided with some machines. (Fig 4) This is also known as shot lubricator.

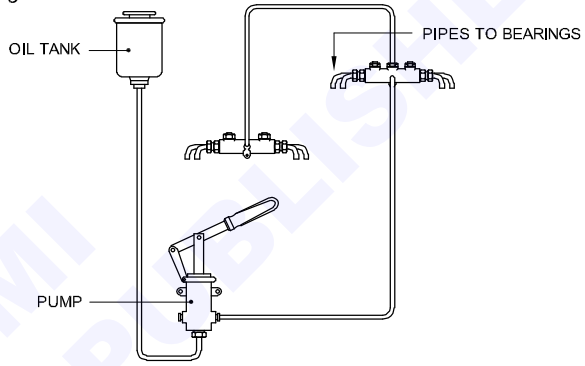
Fig 3



MANUAL SCREW DOWN GREASER

FI20N2718813

Fig 4



HAND PRESSURE FEED (SHOT LUBRICATED)

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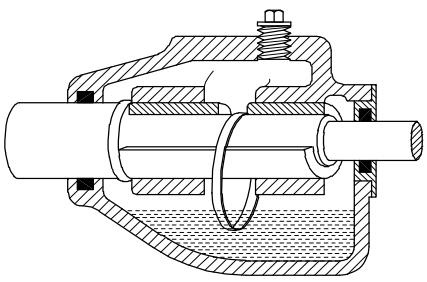
Oil pump method

In this method an oil pump driven by the machine delivers oil to the bearings continuously, and the oil afterwards drains from the bearings to a sump from which it is drawn by the pump again for lubrication.

Splash lubrication

In this method a ring oiler is attached to the shaft and it dips into the oil and a stream of lubricant continuously splashes around the parts, as the shaft rotates. The rotation of the shaft causes the ring to turn and the oil adhering to it is brought up and fed into the bearing, and the oil is then led back into the reservoir. (Fig 5) This is also known as ring oiling.

Fig 5



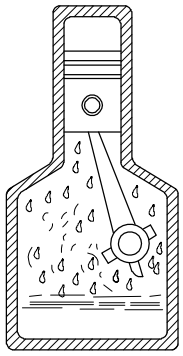
RING OILING

FI20N2718815

In other systems one of the rotating elements comes in contact with that of the oil level and splash the whole

system with lubricating oil while working. (Fig 6) Such systems can be found in the headstock of a lathe machine and oil engine cylinder.

Fig 6



SPLASH-LUBRICATING SYSTEM

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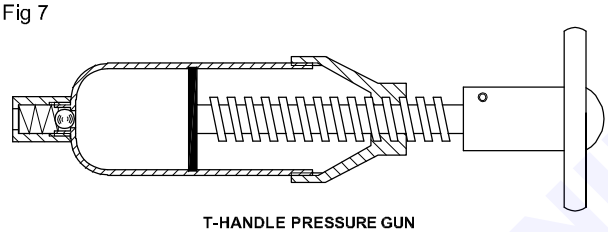
Types of grease guns

The following types of grease guns are used for lubricating machines.

- 'T' handle pressure gun (Fig 7)

Fig 7



T-HANDLE PRESSURE GUN

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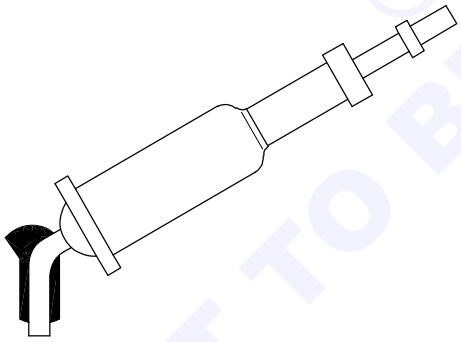
- Automatic and hydraulic type pressure gun (Fig 8)

Fig 8



AUTOMATIC HYDRAULIC-TYPE PRESSURE GUN

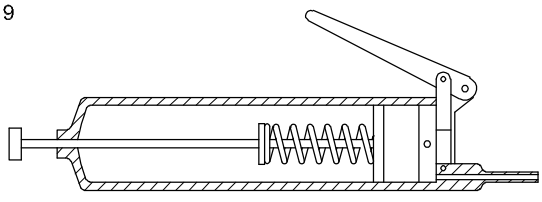
FI20N2718818

- Lever-type pressure gun (Fig 9)

Lubrication to exposed slideways

The moving parts experience some kind of resistance even when the surface of the parts seems to be very smooth.

Fig 9



PRESSURE GREASE GUN

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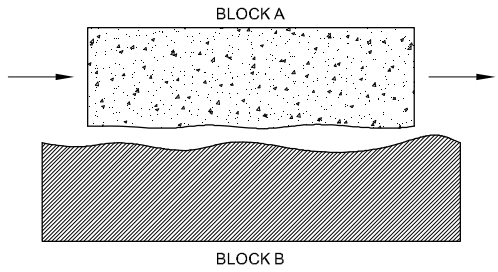
The resistance is caused by irregularities which cannot be detected by the naked eyes.

Without a lubricant the irregularities grip each other as shown in the diagram. (Fig 10)

Fig 10



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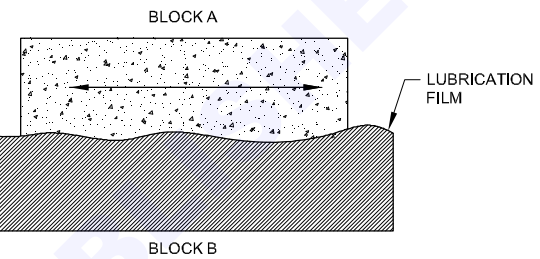
With a lubricant the gap between the irregularities fills up and a film of lubricant is formed in between the mating components which eases the movement. (Fig 11)

Fig 11



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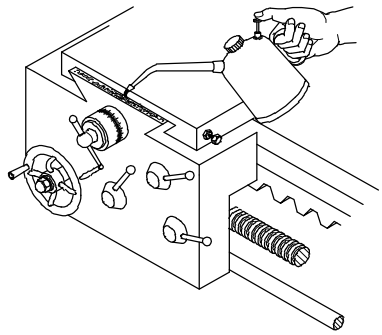
The slideways are lubricated frequently by an oilcan. (Fig 12)

Fig 12

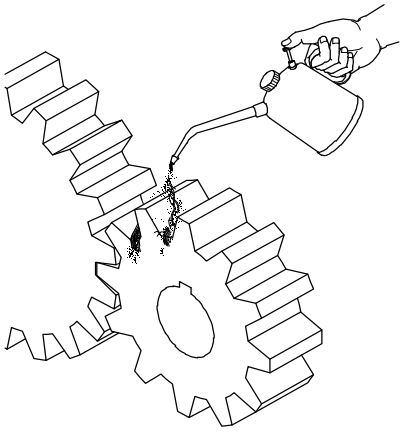


OIL THE SLIDES FREQUENTLY

FI20N271881C

After cleaning the open gears, oil them and repeat lubrication regularly. (Fig 13)

Fig 13



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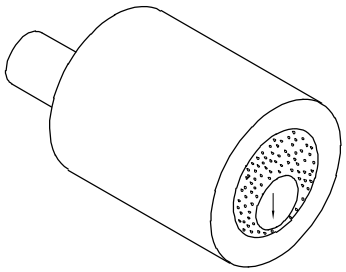
Lubricate bearings

A shaft moving in a bearing is also subjected to frictional resistance. The shaft rotates in a bush bearing or in ball/ roller bearing, experiencing friction.

When the shaft is at rest on the bottom of the bush bearing, there is hardly any lubricant between the shaft and the bush. (Fig 14)

Fig 14



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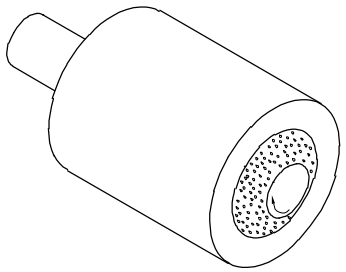
When the shaft starts rotating the lubricant maintains a film between the shaft and the bush and an uneven ring of lubricant builds up. (Fig 15)

Fig 15



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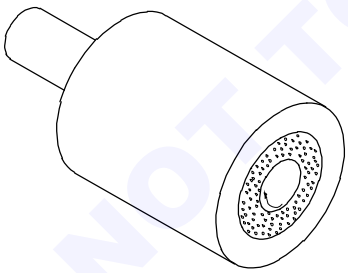
When the shaft is rotating at full speed a full ring of lubricating film surrounds the shaft (Fig 16) which is known as hydro dynamic lubrication.

This lubrication ring decreases the frictional resistance very much and at the same time protects the mating members against wear and changes.

Fig 16



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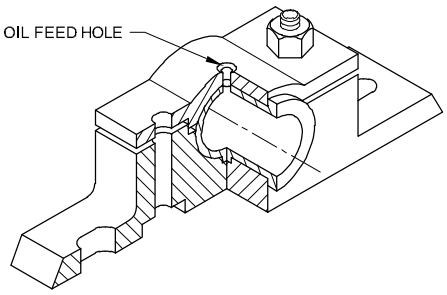
Some bush bearings have oil feeding holes over which the oil or grease cup is mounted and the lubricant is fed through the holes into the bearing by gravity feed system.(Fig 17)

Fig 17



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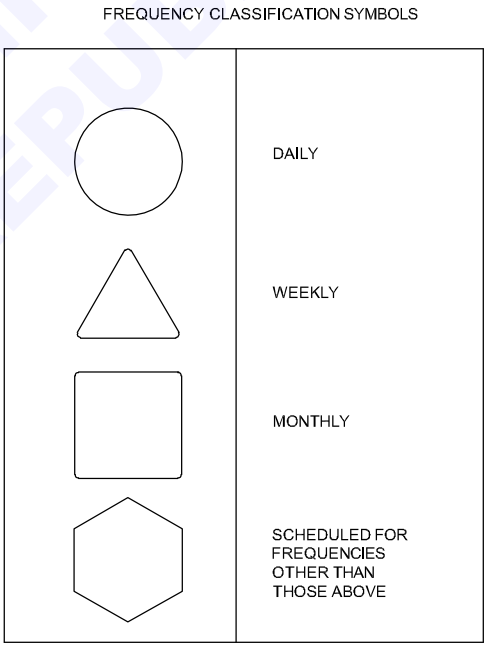
Hints for lurbicating machines:

- identify the oiling and greasing points
- select the right lubricants and lubricating devices
- apply the lubricants.

The manufacturer's manual contains all the necessary details for lubrication of parts in machine tools. Lubricants are to be applied daily, weekly, monthly or at regular intervals at different points or parts as stipulated in the manufacturer's manual.

These places are indicated in the maintenance manuals with symbols as shown in Fig 18.

Fig 18



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Cutting fluids

Objectives: At the end of this lesson you shall be able to
- **state what is cutting fluid**
- **state the function of cutting fluids & their advantages**
- **state the properties of a good cutting fluid**
- **identify different types of cutting fluids**
- **select appropriate cutting fluids for different materials.**

Cutting fluids and compounds are the substances used for efficient cutting while cutting operations take place.

Functions

The functions of cutting fluids are:

- to cool the tool as well as the workpiece
- to reduce the friction between the chip and the tool face by lubricating
- to prevent the chip from getting welded to the tool cutting edge
- to flush away the chips
- to prevent corrosion of the work and the machine.

Advantages

As the cutting fluid cools the tool, the tool will retain its hardness for a longer period; so the tool life is more.

Because of the lubricating function, the friction is reduced and the heat generated is less. A higher cutting speed can be selected.

As the coolant avoids the welding action of the chip to the tool-cutting edge, the built up edge is not formed. The tool is kept sharp and a good surface finish is obtained.

As the chips are flushed away, the cutting zone will be neat.

The machine or job will not get rusted because the coolant prevents corrosion.

Properties of a good cutting fluid

A good cutting fluid should be sufficiently viscous.

At cutting temperature, the coolant should not catch fire.

It should have a low evaporation rate.

It should not corrode the workpiece or machine.

It must be stable and should not foam or fume.

It should not create any skin problems to the operator.

Should not give off bad smell or cause itching etc. which are likely to irritate the operator, thus reducing his efficiency.

Should be transparent.

Types of cutting fluids

The following are the common cutting fluids.

- Straight mineral oil
- Chemical solution (synthetic fluids)
- Compounded or blended oil
- Fatty oils
- Soluble oil (Emulsified oil-suds)

Straight mineral oil

Straight mineral oils are the coolants which can be used undiluted. Use of straight mineral oil as a coolant has the following disadvantages.

It gives off a cloud of smoke.

It has little effect as a cutting fluid.

Hence straight mineral oils are poor coolants. But kerosene which is a straight mineral oil is widely used as a coolant for machining aluminium and its alloys.

Chemical solution (Synthetic oil)

These consist of carefully chosen chemicals in dilute solution with water. They possess a good flushing and a good cooling action, and are non-corrosive and non-clogging. Hence they are widely used for grinding and sawing. They do not cause infection and skin trouble. They are artificially coloured.

Compounded or blended oil

These oils are used in automatic lathes. These oils are much cheaper and have more fluidity than fatty oil.

Fatty oil

Lard oil and vegetable oil are fatty oils. They are used on heavy duty machines with less cutting speed. They are also used on bench-works for cutting threads by taps and dies.

Soluble oil (Emulsified oil)

Water is the cheapest coolant but it is not suitable because it causes rust to ferrous metals. An oil called soluble oil is added to water which gets a non-corrosive effect with water in the ratio of about 1: 20. It dissolves in water giving a white milky solution. Soluble oil is an oil blend mixed with an emulsifier.

Other ingredients are mixed with the oil to give better protection against corrosion, and help in the prevention of skin irritations.

Soluble oil is generally used as a cutting fluid for centre lathes, drilling, milling and sawing.

Soft soap and caustic soda serve as emulsifying agents.

A chart showing coolants for different metals is given below.

Recommended cutting fluids for various metals and different operations

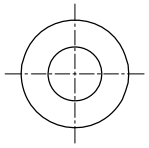
Material	Drilling	Reaming	Threading	Turning	Milling
Aluminium	Soluble oil Kerosene Kerosene and lard oil	Soluble oil Kerosene Mineral oil	Soluble oil Kerosene Lard oil	Soluble oil	Soluble oil Lard oil Mineral oil Dry
Brass	Dry soluble oil Mineral oil Lard oil	Dry soluble oil	Soluble oil Lard oil	Soluble oil	Dry soluble oil
Bronze	Dry soluble oil Mineral oil Lard oil	Dry soluble oil Mineral oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry soluble oil Mineral oil Lard oil
Cast iron	Dry Air jet Soluble oil	Dry soluble oil Mineral lard oil	Dry sulphurized oil Mineral lard oil	Dry soluble oil	Dry soluble oil
Copper	Dry soluble oil Mineral lard oil Kerosene	Soluble oil Lard oil	Soluble oil Lard oil	Soluble oil	Dry soluble oil
Steel alloys	Soluble oil Sulphurized oil Mineral lard oil	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Mineral
General purpose steel	Soluble oil Sulphurized oil Lard oil Mineral lard oil	Soluble oil Sulphurized oil Lard oil	Sulphurized oil Lard oil	Soluble oil	Soluble oil Lard oil

Washer types and calculation of sizes

Objectives : At the end of this lesson you shall be able to
- **state the various types of washers**
- **determine the sizes of washers**
- **state the uses of washerWashers**

Washers are used to distribute the clamping pressure over a larger area, and prevent the surface damaged (marking). they are also provide an increased bearing surface for bolt heads and nuts. Washers are manufactured in light, medium, heavy and extra heavy series. (Fig 1)

Fig 1



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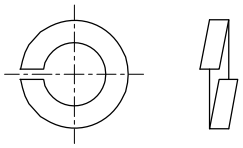
Lock washers

A lock washer is used to prevent a bolt or nut from loosening under vibration.

The split ring lock washer is being rapidly replaced by lock washers designed for specific applications. (Fig 2)

Fig 2



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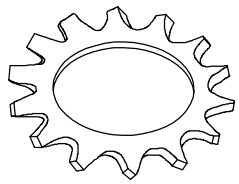
Tooth type lock washers

These washers have teeth that bite deep into both screw head and work surface. Their design is such that they actually lock lighter as vibrations increase.

External type

Should be used where possible as it provides the greatest resistance. (Fig 3)

Fig 3



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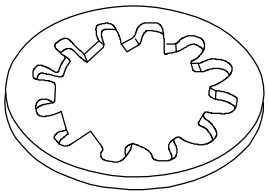
Internal type

Used with small head screws and where it is desirable to hide the teeth either for appearance or to prevent snagging. (Fig 4)

Fig 4



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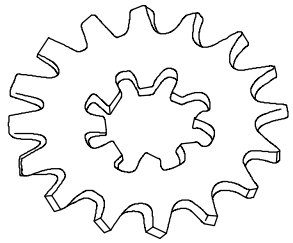
Internal and external type

Used when the mounting holes are over size. (Fig 5)

Fig 5



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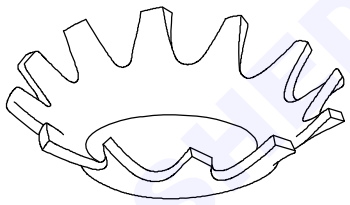
Countersunk type

For use with flat or oval type head screws. (Fig 6)

Fig 6



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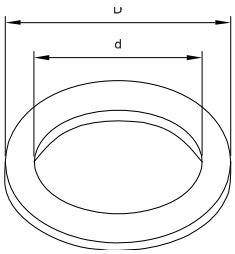
Calculation of washer



Specific bearing load (N/mm^2)

$$P = \frac{4W_t}{\Pi(D^2 - d^2)}$$

Sliding speed (m/s) rotation

$$V = \frac{\Pi \times D \times N}{60 \times 10^3}$$

Sliding speed (m/s)

$$V = \frac{\pi x D}{60 x 10^3} x \frac{2 a x Nos}{360}$$

p	Specific bearing load	N/mm^2
d	inside diameter	mm
D	outside diameter	mm
W_t	load on thrust washer	N
N	Speed of rotation	rpm
∂	angle of oscillations	degrees
Nos	frequency of oscillations	cycles /min
V	sliding speed	m/s

Type A is a series of steel whashers at broad tolerances.

Type B is a series of steel washer s chamfered at one end is shown in Fig 8.

Washer sizes are listed in Table 1.

Fig 8

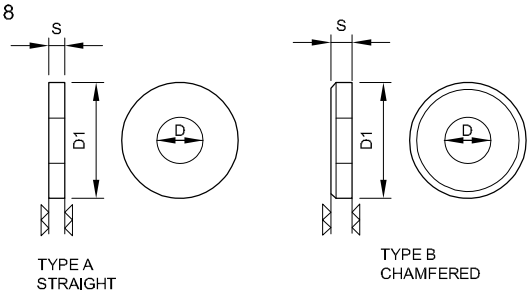


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TABLE 1

Washer sizes

Nominal diameter		D	D1	S	Weight kg/1000 pcs
M3		3.2	7	0.5	0.12
M4		4.3	9	0.8	0.3
M5		5.3	10	1	0.44
M6		6.4	12.5	1.6	1.14
M7		7.4	14	1.6	1.39
M8		8.4	17	1.6	2.14
M10		10.5	21	2	4.08
M12		13	24	2.5	6.27
M14		15	28	2.5	8.6
M16		17	30	3	11.3
M18		19	34	3	14.7
M20		21	37	3	17.2
M22		23	39	3	18.4
M24		25	44	4	32.3
M27		28	50	4	42.8
M30		31	56	4	53.6
M33		34	60	5	75.4
M36		37	66	5	92

Lubricants and lubrication

Objectives : At the end of this lesson you shall be able to
- **state the purpose of using lubricants**
- **state the properties of lubricants**
- **state the qualities of a good lubricant.**

With the movement of two mating parts of the machine, heat is generated. If it is not controlled the temperature may rise resulting in total damage of the mating parts. Therefore a film of cooling medium with high viscocity is applied between the mating parts which is known as a 'lubricant'.

A 'lubricant' is a substance having an oily property available in the form of fluid, semi-fluid, or solid state. It is the lifeblood of the machine, keeping the vital parts in perfect condition and prolonging the life of the machine. It saves the machine and its parts from corrosion, wear and tear, and it minimizes friction.

Purposes of using lubricants

- Reduces friction.
- Prevents wear.
- Prevents adhesion.
- Aids in distributing the load.
- Cools the moving elements.
- Prevents corrosion.
- Improves machine efficiency.

Properties of lubricants

Viscosity

It is the fluidity of an oil by which it can withstand high pressure or load without squeezing out from the bearing surface.

Oiliness

Oiliness refers to a combination of wettability, surface tension and slipperiness. (The capacity of the oil to leave an oily skin on the metal.)

Flash point

It is the temperature at which the vapour is given off from the oil (it decomposes under pressure soon).

Fire point

It is the temperature at which the oil catches fire and continues to be in flame.

Pour point

The temperature at which the lubricant is able to flow when poured.

Emulsification and de-emulsibility

Emulsification indicates the tendency of an oil to mix intimately with water to form a more or less stable emulsion. De-emulsibility indicates the readiness with which subsequent separation will occur.

Film of oil formed in journal bearing

In a sliding contact bearing, the journal is directly inserted into the bearing. This results in direct metal to metal contact between them. As a consequence the friction is higher between the inner surface of the bearing and the outer surface of journal, if there is no lubricating film present in between them. Bearings can be lubricated with three kinds of lubricants, viz. Liquids like mineral oil or vegetable oils, semi - solids like grease, and solids like graphite or molybdenum di-sulfide. These lubricants are used to reduce friction and wear, dissipate the frictional heat and to protect against corrosion. There are two basic modes of lubrication: (a) thick film and (b) thin film lubrication.

Thick film lubrication

In thick film lubrication, two surfaces of bearing in relative motion, (Viz., the journal and the bearing inner surface) are completely separated by a fluid film. The resistance to relative motion arises from the viscous resistance of the fluid. This does not depend on the structure of jurnal surface and bearing inner surface as they are not in contact with each other. Thick film lubrication is classified into: hydrodynamic and hydrostatic lubrication.

Hydrodynamic lubrication

Hydrodynamic lubrication is defined as a system of lubrication in which the load supporting fluid film is created by the shape and relative motion of the slideing elements. The principle of hydrodynamic lubrication in journal bearing is shown in Fig 1

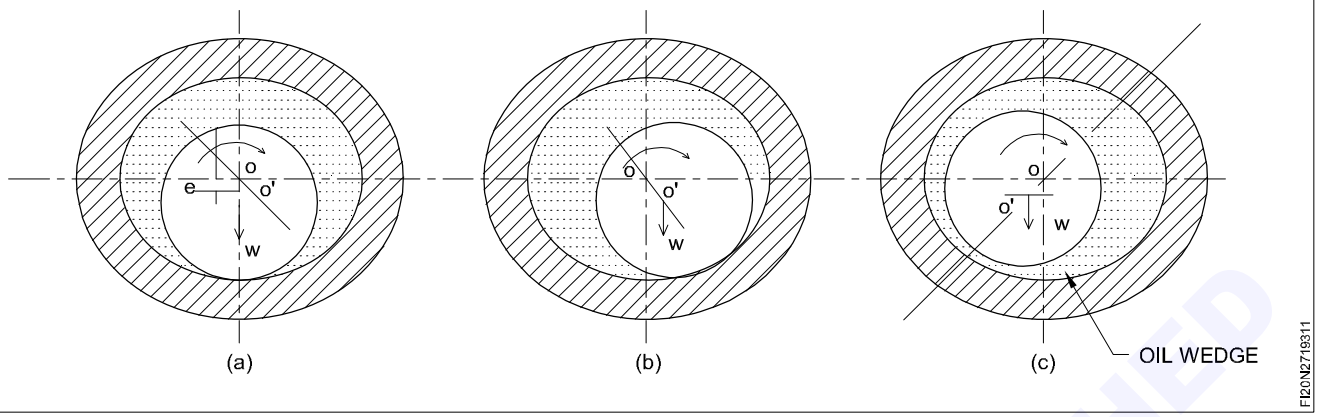
Hydrodynamic lubrication (a) Journal at rest (b) journal starts to rotate (c) journal at full speed

When the shaft (Centered at o') is at rest, it goes to the bottom of bearing (centered at O) under the action of load W. This load is due to the weights of shaft and various elements (gears, pulleys) supported by the shaft. The outer surface of journal and inner surface of bearing touch each other during rest, with no clearance at the bottom. The letter 'e' denotes the eccentricity, the offset between the axes of the journal and the bearing.

As the journal starts to rotate, it will climb bearing surface. When the speed is increased further, it forces the fluid into the wedge-shaped region between the journal and bearing. As more and more fluid is forced into the wedge shaped

region, pressure is generated within the fluid as shown in Fig.1 This fluid pressure generated in the clearance space supports the external load (W). It can be seen that the pressure distribution around journal varies greatly. Hydrodynamic lubrication does not need a supply of lubricants at high pressure from external soruce (pumps), as enough fluid pressure is, generated within the system. Bearings that use 'hydrodynamic lubrication' are called 'Hydrodynamic bearings'.

Fig 1



INDUSTRIAL LUBRICATING OILS **Annexure I**

Product	Kinematic viscosity Cst at 40°C.	VI	Flash point COC°C	Description/Application
General Purpose Machinery Oils				
Lubrex 57	54.60	..	160	Lubrex oils are low viscosity index straight mineral
Lubrex 68	64.72	..	160	lubricants having good inherent oxidation stability; they protect machine elements from excessive wear and provide economical lubrication. These oils are recommended for lubrication of bearings, open gears, lightly loaded slides and guideways of machine tools.
Flushing Oil				
Lubrex Flush 22	19.22	..	150	Lubrex Flush 22 is a light coloured, low viscosity, straight mineral oil specially developed for slushing of automotive and industrial equipment. The characteristics of Lubrex Flush 22 make it possible to easily clean all inacessible internal surfaces of various equipments.
Circulating and Hydraulics Oils (Anti-wear Type)				
Servosystem 32	29.33	95	196	Servosystem oils are blended from highly refined
Servosystem 57	55.60	95	210	base stocks and carefully selected anti-oxidant,
Servosystem 68	64.72	95	210	anti-wear,anti-rust and anti-foam additives.These
Servosystem 81	78-86	90	210	oils have long service life, and are recommended
Servosystem 100	95-105	90	210	for hydraulic systems and a wid of circulation
Servosystem 150	145-155	90	230	systems of industrial and automotive equipment. These oils are also used for compressor crank case lubrication, but are not recommended for lubrication of turbines and equipment having silver coated components.
Spindle Oils				
Servospin 2	2.0-2.4	..	70	Servospin oils are low viscosity lubricants contain-
Servospin 5	4.5-5.0	..	70	ing anti-wear, anti-oxidant, anti-rust and anti-foam
Servospin 12	11-14	90	144	additives. These oils are recommended for lubrication

				of textile and machine tool spindle bearings, timing gears, positive displacement blowers, and for tracer mechanism and hydraulic systems of certain high precision machine tools.
Machinery Oils				
Servoline 32	29.33	..	152	Servoline oils provide good oiliness for general lubrication even under boundary lubrication conditions, protect parts against rust and corrosion and maintain thin film strength and anti-rust additives. Servoline oils are general purpose lubricants for all loss lubrication systems of textile mills, paper mills, machine tools.
Servoline 46	42.50	..	164	
Servoline 68	64-72	..	176	
Gear Oils				
Servomesh 68	64-72	90	204	Servomesh oils are industrial gear oils blended with lead and sulphur compounds. These oils provide resistance to deposit formation, protect metal components against rust and corrosion, separate easily from water and are non-corrosive to ferrous and non-ferrous metals. Servomesh oils are recommended for lubrication of industrial gears, plain and anti-friction bearings subjected to shock and heavy loads and should be used in systems were operating tem
Servomesh 150	145-155	90	204	
Servomesh 257	250-280	90	232	

Foundation bolts and types

Objectives : At the end of this lesson you shall be able to
- **state the purpose of foundation bolts**
- **state the different types of foundation bolts and their uses**
- **designate the foundation bolts as per BIS**
- **mention the purpose of grouting**
- **name the different types of grouting.**

Purpose of foundation bolts

For some machine tools, it is very essential to hold down the machines firmly on the foundation to prevent them from moving. For this purpose various types of foundation bolts or anchor bolts are used.

Types of foundation bolts

Foundation bolts are divided into two groups. They are:

- fixed type
- removable type.

Fixed type of bolts

Fig 1 shows the ordinary foundation bolt with mild steel plate. The rag bolt shown in Fig 2 is usually forged and filled up with lead or cement. A simple form, shown in Fig 3, is known as eye foundation bolt. A bent type of bolt is shown in Fig 4.

Fig 1

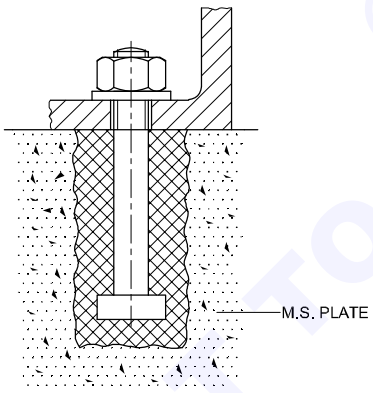


Fig 2

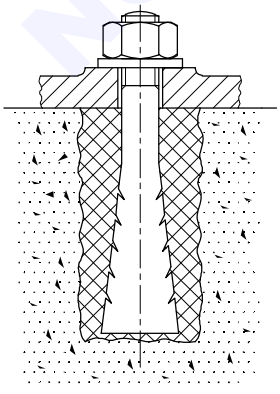


Fig 3

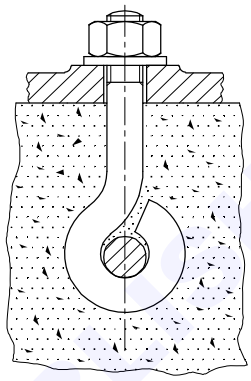


Fig 4

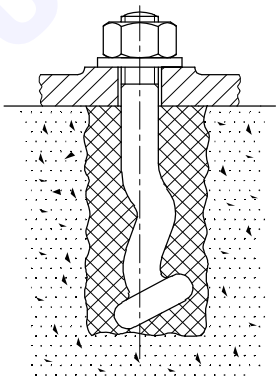
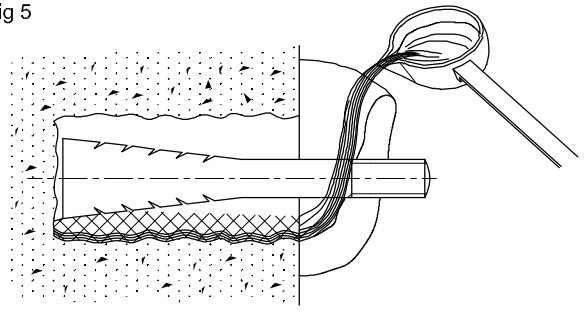


Fig 5 shows running up bolts in a horizontal position. A clay cap is formed around the bolt to support this and direct the lead into the hole. After running up, the lead should be caulked in position to consolidate this.

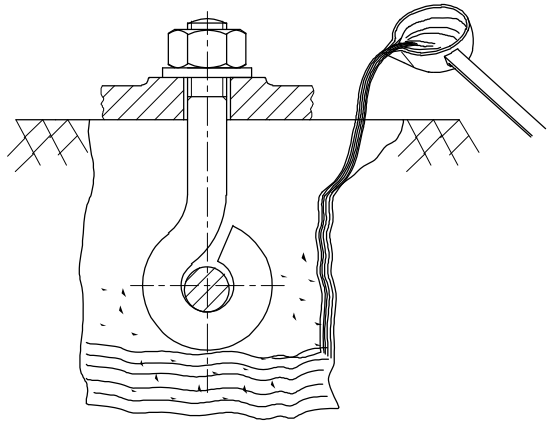
When running with lead, care should be taken to see that no water is collected in the hole; otherwise steam will be rapidly generated which will blow the lead out, which may cause serious burns.

Fig 5



As an alternative to lead, where quick setting is required, rock sulphur can be melted down in an old kettle or ladle and run into the bolt hole as quickly as possible. (Fig 6)

Fig 6



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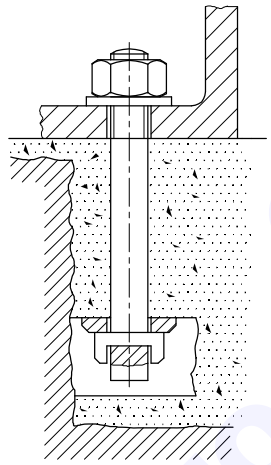
Removable type (Fig 7)

For large machines a long cotter bolt is commonly used. This bolt is provided with a square foundation plate and a removable cotter at the bottom. In forming the foundation, pockets are left in the sides of the bolt holes which are then capable of being replaced at any time, if necessary.

Fig 7



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The rawl bolt (Fig 8)

In this type four clamps are flexibly mounted on the bolt which expand by wedge action when tightened up. The advantage is that they can be removed and used again,if necessary.

Expanding conical washer foundation bolt (Fig 9)

This consists of a bolt on which are threaded conical washers and ferrule. On drawing up the bolt, the washers are flattened which grip the inside of the hole by expansion.

Grouting

After levelling the machines in the aligned condition with the foundation bolts and wedges, there will be a gap left over between the bottom of the machine and the top of the floor or foundation block. This space is filled up with grouting materials such as cement concrete or sulphur or lead and the process is known as 'grouting'.

Fig 8

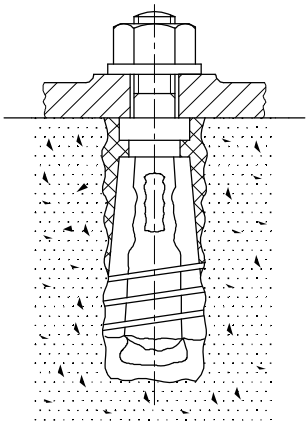

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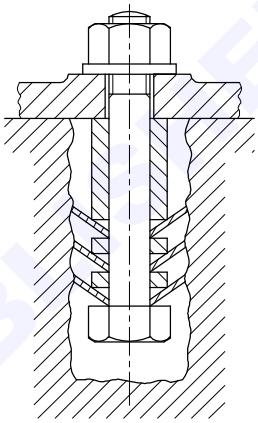
Fig 9



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When 'mould' boxes are used and the anchor or foundation bolts are suspended in their respective pockets, the pockets are filled up with the grouting material.

Purpose

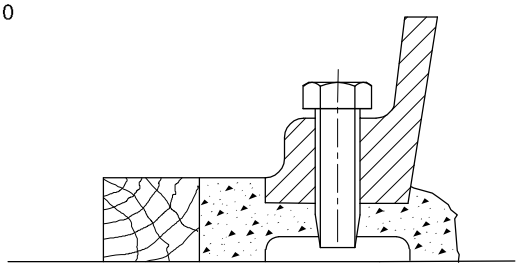
- To ensure that the machine rests firmly on the top of the foundation block or the floor.
- To prevent lateral shifting particularly for the machines like shaper, planer, surface grinder etc. which are having reciprocating motion.

Types of grouting

Cement concrete grout (Fig 10)

It is a most common grouting process wherein cement concrete mixture is used. This mixture can bear the compressive load of the machine. This is quite cheap and strong to withstand the displacement of the machine. This is not suitable for oil-soaked areas.

Fig 10



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Sulphur grouting

Since sulphur remains unaffected by oil or grease it is recommended as grouting material for oil-soaked areas.

Lead grout

Lead is mainly used as a grouting material for steam turbines. It is too expensive to be used for general machine foundation.

Moving equipment with crowbars

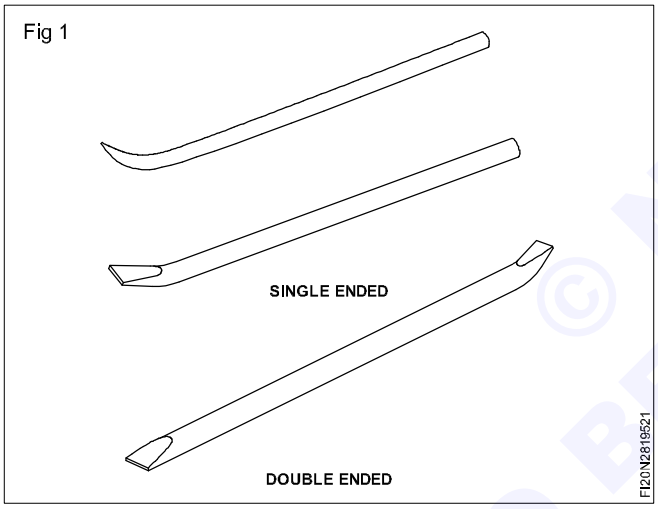
Objectives : At the end of this lesson you shall be able to
- **name the different types of crowbars**
- **state the uses of crowbars**
- **state the methods of lifting and moving machines with crowbars and rollers.**

Crowbars give leverage, so that heavy loads can be lifted or moved. They are made in differnt lengths with hexagonal or octogonal steel bars. Short crowbars are easier to handle and the point will fit into a narrow gap, but requires more force. Long crowbars provide a greater leverage.

Types of crowbars (Fig 1)

There are two types of crowbars, single or double ended. A single ended crowbar is safer to use as the handle has a rounded end. The double ended crowbar normally has a curved end used for lifting, and a straight end used for pushing.

Fig 1



Lifting equipment by crowbars

If the gap under the machine is not good enough to accept the tip of the crowbar, tap a small steel wedge If under the machine to increase the gap and place the toeof the crowbar under the machine and press the other end down to lift the machine. (Figs 2 & 3)

Fig 2

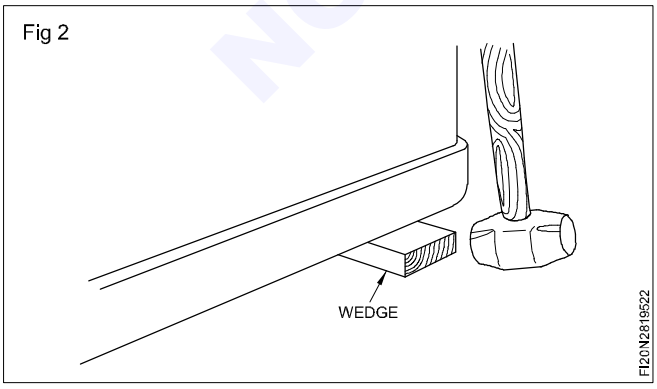
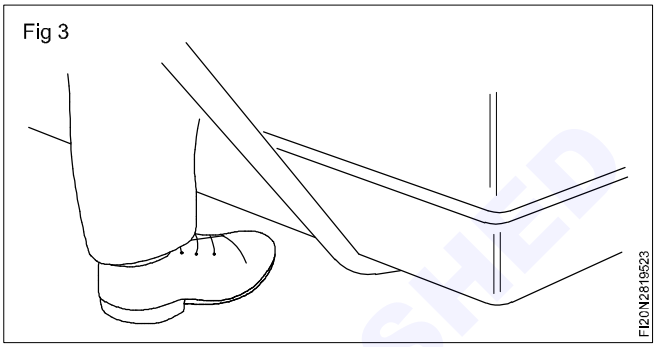


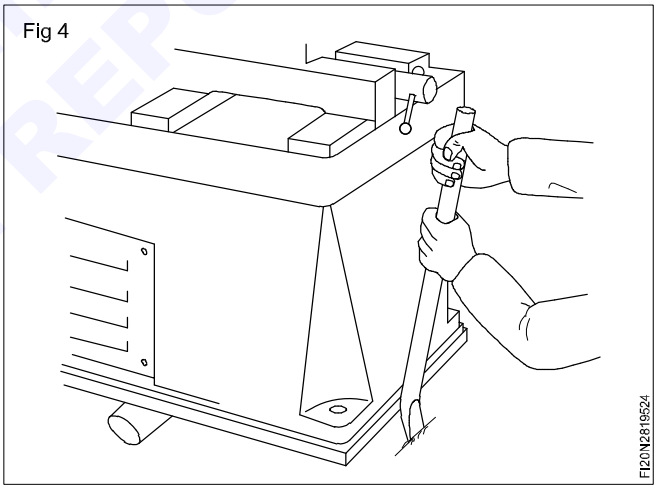
Fig 3



Position the handle so that no one will be endangered if the crowbar slips. When pushing or lifting, never push the crow bar close to the load or to the ground, as your fingers might be caught if the bar slips.

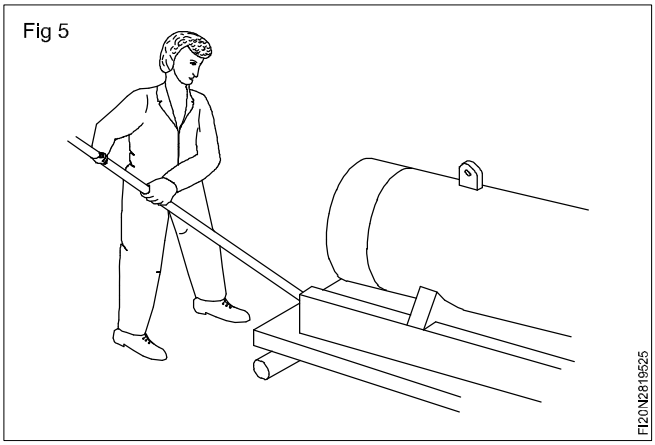
Always use both hands and hold close to the end of the crowbar to get maximum leverage. (Fig 4)

Fig 4



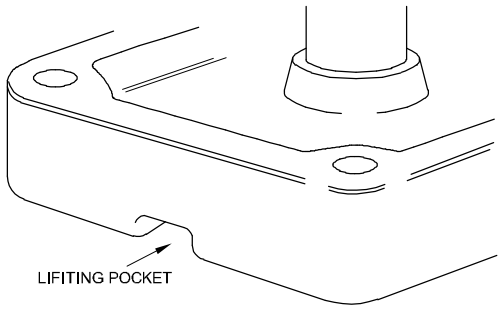
Stand with the legs apart so that the balance is not lost if the crowbar slips. (Fig 5)

Fig 5



Equipments are provided usually with a lifting pocket. Place the toe of the crowbar in it for lifting the machine and moving it. (Fig 6)

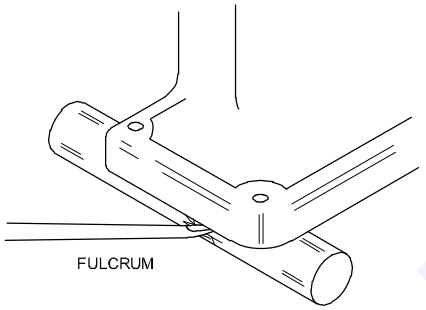
Fig 6



The fulcrum point must be firm enough to take the force. If the point of the crowbar is used as the fulcrum, it must be dug in firmly to prevent slipping. (Fig 7)

Check the condition of the crowbar, and if found bent or cracked, it must not be used. The burrs or sharp edges on the crowbar must be removed before using it.

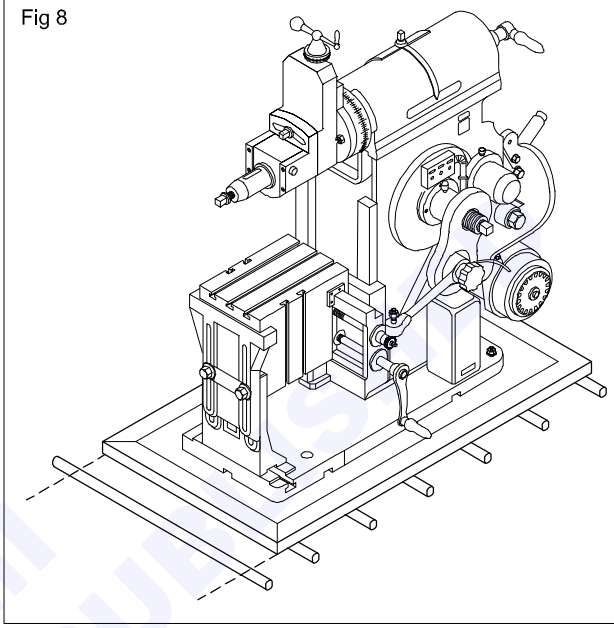
Fig 7



Rollers

Rollers are placed under the equipment so that they can be moved easily. Mild steel or G.I pipes of sufficient wallthickness can be used as rollers. The rollers should be long enough to project from both sides of the load so that they can be posi-tioned easily. The diameter must be large enough to roll over any unevenness along the route but small enough so that they can be lifted easily. (Fig 8)

Fig 8



Moving equipment using rollers

Before starting to move a load, check the route and remove any obstructions. The route should be flat and firm enough to take the weight of the moving equipment.

Precision spirit level

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

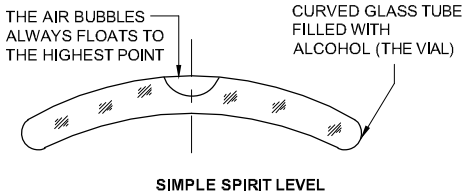
- **state the construction of a spirit level**
- **state the importance of a precision spirit level**
- **define the sensitivity of a precision spirit level**
- **state the relationship between vial radius and the sensitivity of a spirit level**
- **state the causes of errors in spirit level.**

Levelling of the machine is a very important operation before proceeding to conduct geometrical tests. A precision spirit level is used to level the machine tools accurately.

Spirit level

It consists of a curved glass tube called 'VIAL'containing industrial alcohol 'spirit' and a bubble of 'AIR' trapped in the tube. The spirit and the bubble are both acted upon equally by the force of gravity. (Fig 1)

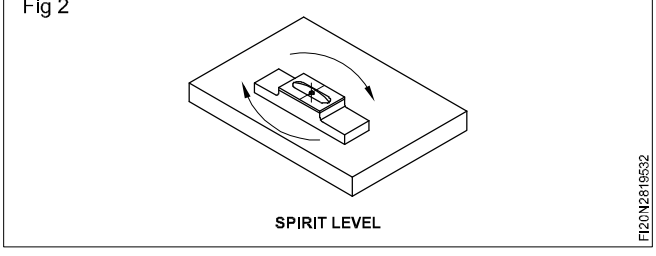
Fig 1



Since the spirit has a higher density, it is pulled down to the bottom of the tube and the bubble always floats to the top.

The vial is set in a cast iron base and adjusted such that the bubble rests at the centre of a scale (Fig 2) when the base is horizontal.

Fig 2

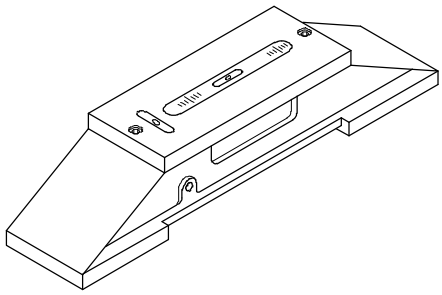


Precision spirit level (Fig 3)

Spirit levels used for high precision measurements should

have a sensitivity of about 0.02 to 0.05 millimetre per 1000 millimetres for each division.

Fig 3



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If the movement of the bubble by one division corresponding to a change in slope of 6 to 12 seconds

of a level of 0.04mm per 1000mm is chosen, then

1 division = 0.04 mm/1000 mm

3/4 division = 0.03 mm/1000 mm

1/2 division = 0.02 mm/1000 mm

1/4 division = 0.01 mm/1000 mm.

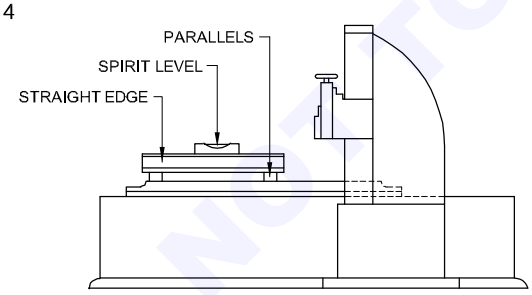
It is quite easy to estimate within a quarter of a division.

Hints on spirit level

Spirit levels which are too sensitive are difficult to bring to rest in a workshop in which machines are running. Levels with low sensitivity result in insufficient reading accuracy, as very small fractions of a division have to be estimated.

The bearing surfaces of spirit levels should be as long as possible. For testing medium size machines the level should not be less than 200mm long. It is often advisable to use a bridge piece (Fig 4) the feet of which are about 300 mm apart. The spirit level can then be placed on the scraped surface of the bridge. This method avoids errors which could be caused by irregular scraping of the surface to be measured.

Fig 4



TESTING INCLINATION OF BED WITH PARALLELES STRAIGHT EDGE AND SPIRIT-LEVEL BY BRIDGING

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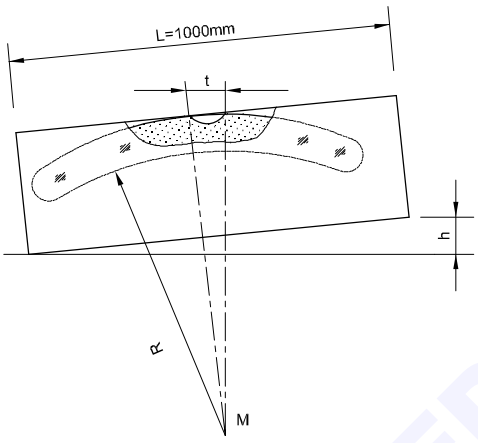
Sensitivity of spirit level

The sensitivity E of the spirit level is the movement of the bubble in millimetres which corresponds to a change in slope of 1 millimetre per 1000 millimetres.

$$E = \frac{\text{Movement of bubble in mm}}{\text{1milli metre per metre}}$$

The inside of the glass tube of a spirit level has a shape of a circular arc of radius R which moves during a change of slope around the centre M of its curvature. (Fig 5)

Fig 5



SENSITIVITY OF SPIRIT LEVEL

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If the slope is measured as a ratio of h/L, and the movement of the bubble is t then

t/h = h/L and

$$R = \frac{t}{h/L}$$

Since $E = \frac{t}{h/L}$

R = E.

Radius and sensitivity

The sensitivity of the spirit level is equal to the radius of curvature of the barrel shaped bubble tube. Therefore the sensitivity of the level depends only on the radius of the curvature of the bubble tube and not on the length of its bearing surface.

Causes for errors in spirit level reading

- Wrong position of the vial in the housing
- Faulty graduation
- The surface finish of the piece to be tested
- The influence of temperature
- Personal errors of the inspector

Reading spirit levels depends on:

- the quality and length of the bearing surface of the workpiece
- dimensional stability of the metal housing.

Ropes

Objectives : At the end of this lesson you shall be able to
- **name the different types of ropes and their uses**
- **state the precautions to be observed while using ropes**
- **state the general inspection points for using ropes.**

Ropes are made from individual fibres, spun together like string or yarn. Hemp, cotton, Manila, steel and synthetic wire are used in the manufacture of rope. Manila and hemp ropes are manufactured from the fibre of wild banana plants.

Ropes are manufactured in three or four strands. Manila and hemp ropes are used for light duty hoisting with a rope pulley block.

The following precautions should be observed while using the ropes.

- Avoid running the rope over sharp edges.
- Ropes should be kept dry because moisture hastens their decay.
- Hang wet rope loosely in an area where it can dry before it is used.
- Avoid dragging of rope over concrete, gravel and other rough surfaces.
- Frozen rope should not be used until it is thawed.

Wire ropes

Wire ropes or cables are built up of strands of wire laid together in the direction of opposite twists which form the rope. Standard wire rope is made from strands encompassing a single core.

Wire ropes are used for heavy duty hoisting

When the wires and strands are twisted in the same direction the rope is known as 'Lang lay rope' (Fig 1) and when twisted in the opposite direction it is known as regular lay rope. (Fig 2) The combined lay rope is shownin Fig 3.

Fig 1

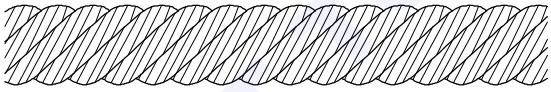

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Fig 2

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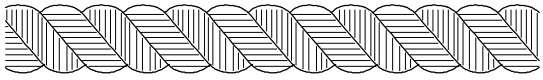
Fig 3



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Rope inspection

- Inspect ropes frequently for damage.
- Surface inspection will reveal broken or worn out strands.
- For interior inspection twist the rope in the opposite direction to the way it was spun.

This will open up and separate the strands so that the interior fibres can be examined.

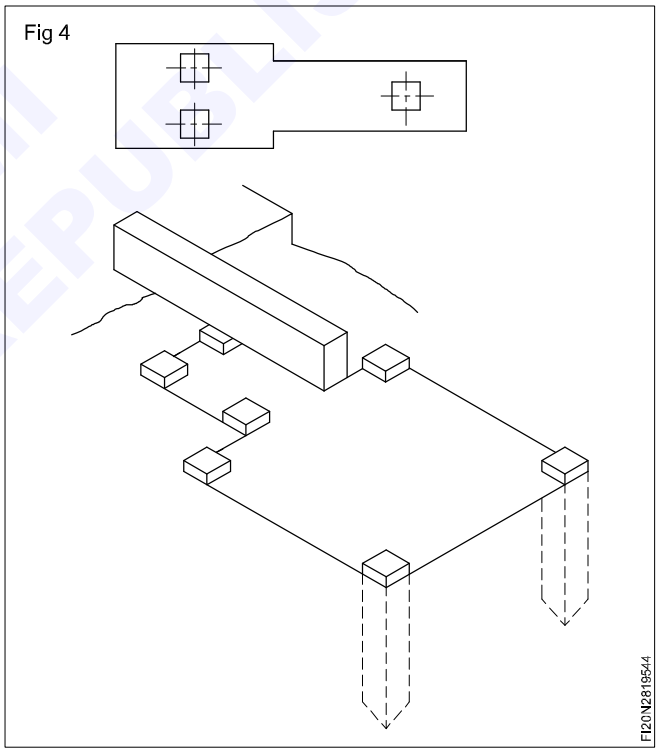
Wooden block

The position of the foundation is first determined, marked off and wooden pegs are driven if it is in the soil. (Fig 4)

The size of excavation is drawn with chalk if it is on a concrete floor.

Excavating the hole should be done as neatly as possible but should the soil persist in falling into the hole it may be advisable to shore this up by the use of shuttering. The excavation should be made a few millimetres deeper than the required foundation depth. The bottom surface is well rammed prior to and after placing a layer of clean bottoming stones or broken bricks.

Fig 4



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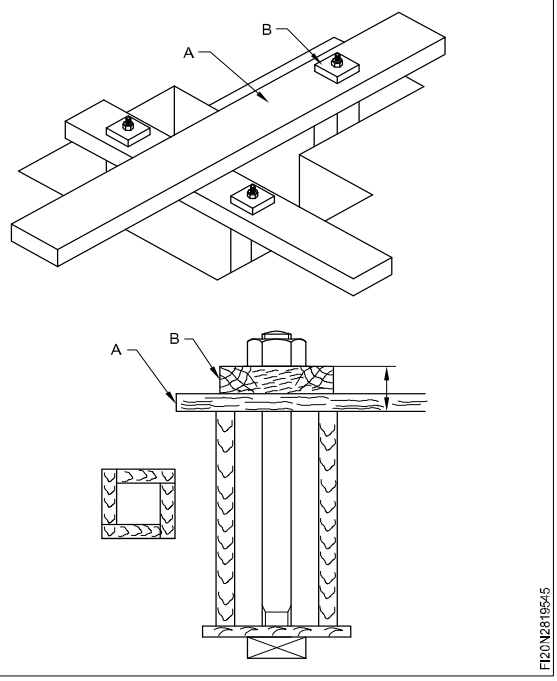
Wooden template

A wooden template is formed as shown in Fig 2 to represent the base of the machine and to support bolts over the excavation as shown. The combined thickness of the template frame A and blocks B should equal the thickness of the foot of the machine as shown. These boxes are formed of light timber and are suitably nailed for easy removal later.

Wooden forms

Wooden forms for concrete foundations are made and placed over the excavation.

Fig 5



Bracing the wooden form

After placing the wooden form in position in the excavation, it is firmly braced from the outside so as to withstand the pressure of the concrete and prevent any movement when the concrete is being poured.

Concrete

Should be prepared from clean cement on a wooden surface. Proportions for the mixture vary. A good average mixture is 1:2:4. ie 1 part cement, 2 parts sand and 4 parts stone. This is mixed thrice when dry and thrice after wetting and is immediatelty placed on the excavated area after a good spraying with water on the excavated area.

The foundation should be given a day atleast to set before the template is removed.

Pulley block

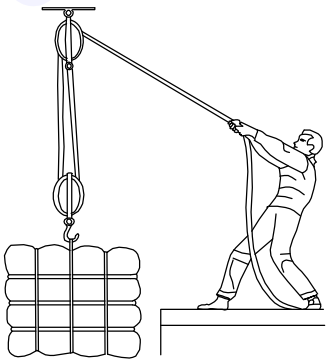
Objectives : At the end of this lesson you shall be able to
- **describe of pulley block**
- **use of pulley block.**

Pulley block (Fig 1)

Pulley block is a system of two or more pulleys with a rope or cable threaded between them, usually used to lift heavy loads. The pulleys are assembled together to form blocks and then blocks are paired so that one is fixed and one moves with the load. The rope is threaded through the pulleys to provide mechanical advantage that amplifies the force applied to the rope.

A block is a set of pulleys or "Sheaves" mounted on a single frame. An assembly of blocks with a rope threaded through the pulleys is called tackle. A block and tackle system amplifies the tension force in the rope to lift heavy loads. They are common on boats and sailing ships, where tasks are often performed manually.

Fig 1



Plumb bob

Objectives : At the end of this lesson you shall be able to
- **state the costruction of plumb bob**
- **state the use of plumb bob.**

The plumb bob (Fig 1)

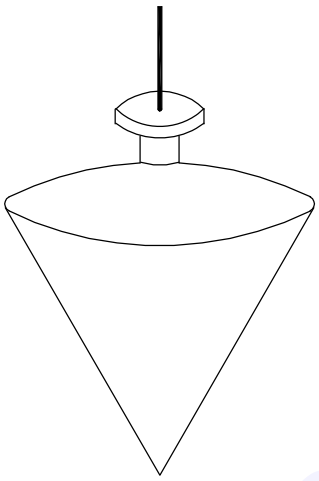
The plumb bob employs the law of gravity to establish. A string, suspended with a weight at the bottom will be both vertical and perpendicular to any level plane through which it passes. In a sense, the plumb bob is the vertical of the line level.

The plumb consists of a specially designed weight and coarse string made of twisted cotton or nylon threads. At end of the string weight is affixed.Precisely machined and balanced bobs have point tips and can be made of brass,steel or other materials

How to use a plumb bob

To use the plumb bob, the string is fixed at the point to be plumbed. The weight, or bob, is than allowed, to swing freely, when it stops, the point of the bob is precisely below the point at which the string is fixed above.

Fig 1



PLUMB BOB

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Sling load for shifting

Objectives: At the end of this lesson you shall be able to
- **state different type of slinging arrangement**
- **state the common types of chain sling**
- **mention different types of fastening bolts,hooks, lifting clamps etc.**
- **illustrate various method of slinging practice**
- **define rigging and various rigs and fittings.**

Slinging is an important skill in lifting and shifting load in industrial practices.

Slings are made with fibre rope, (manila, sisal,nylon, terylene and polypropylene) chain, wire rope etc. Other appliances like hooks, eye bolts, shackles, lifting clamps etc are used to make or sling considering the type of the load.

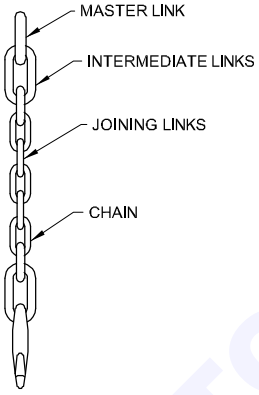
Chain sling

Chain links are fabricated by welding from carbon or alloyed steel. Links are formed to the shape and welded together to form a chain.

Chain slings are of different types, namely

- Single leg chain (Fig 1)

Fig 1



SINGLE LEG SLING

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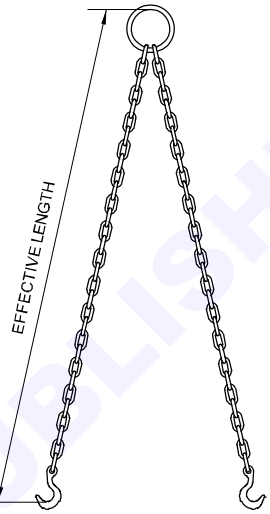
- Double leg chain (Fig 2)
- Four leg chain (Fig 3)
- Endless chain (Fig 4)

A chain will have the following components (Fig 1)

- Master link.
- Intermediate link.
- Joining link.
- Chain hook.

Fig 2



TWO-LEG CHAIN SLING, RING OR LINK AT ONE END, HOOKS AT OTHER ENDS

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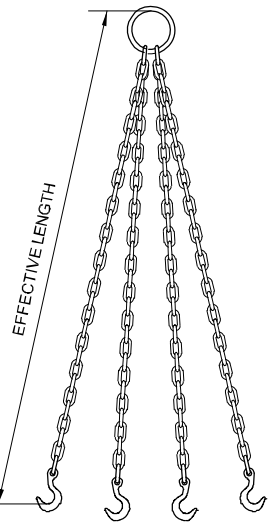
Fig 3



FOUR-LEG CHAIN SLING, RING OR LINK AT ONE END, HOOKS AT OTHER ENDS

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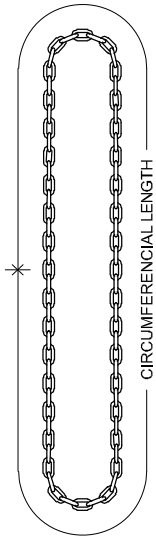
Wire rope sling

Wire rope slings are made of steel wire rope to form eye thimble mechanically spliced which accommodates a master ring on one side and or plain eye look is known as single legged sling (Fig 5a). Similarly, two legged, threel egged and four legged slings are shown in (Fig 5b,c and d) respectively.

Fig 4



ENDLESS CHAIN SLING

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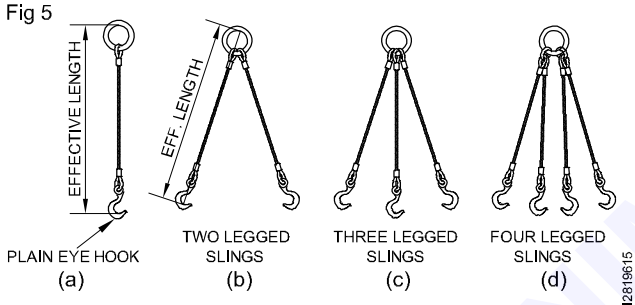
Fig 5



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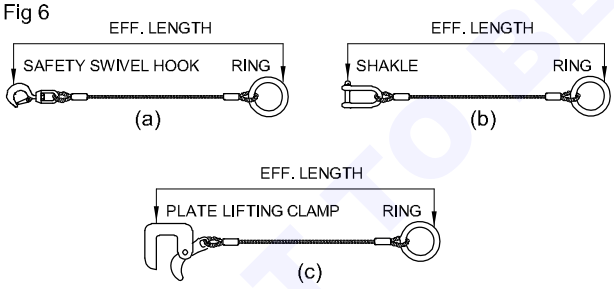
A few other slings like sling with safety swivel hook, Dee shackle and plate lifting clamp with effective length are shown in Fig (6a, b and c) respectively.

Fig 6



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Some other types of single part rope slings include plain loop on both ends (Fig 7a), basket hitch (Fig 7b) and choker hitch (Fig 7c) are shown.

The following points are to be noticed and followed strictly.

- Fibre rope sling should be used only for lifting and shifting lighter loads.
- In case of sharp edges use soft pads (packer,wooden blocks) Fig.8 to protect the sling and the edges of the load as well.
- Check the condition of the sling and consider the load carrying capacity of the sling.

Fig 7

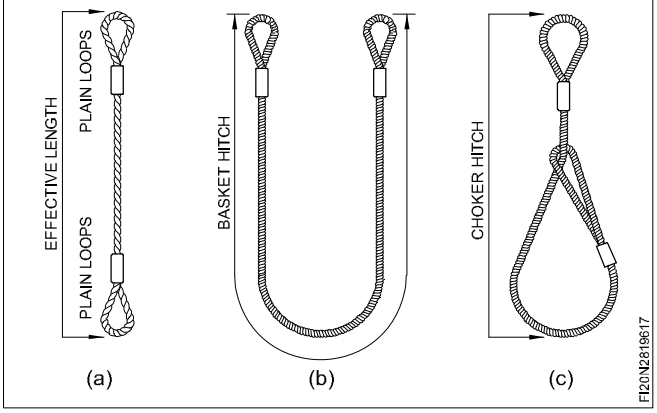

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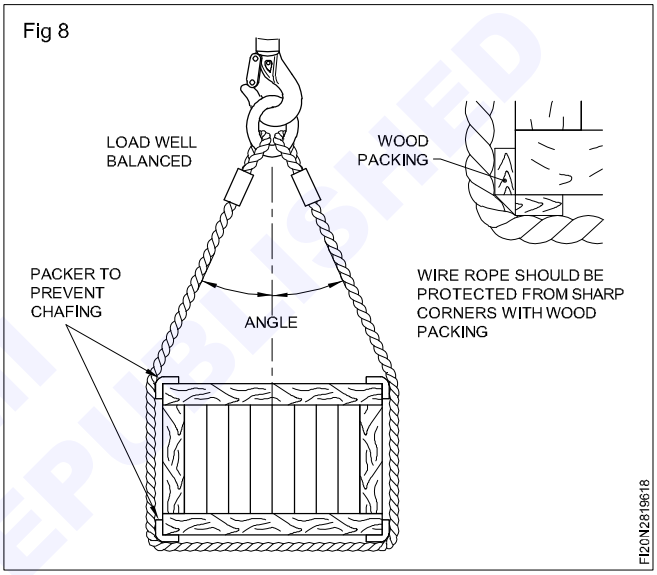
Fig 8



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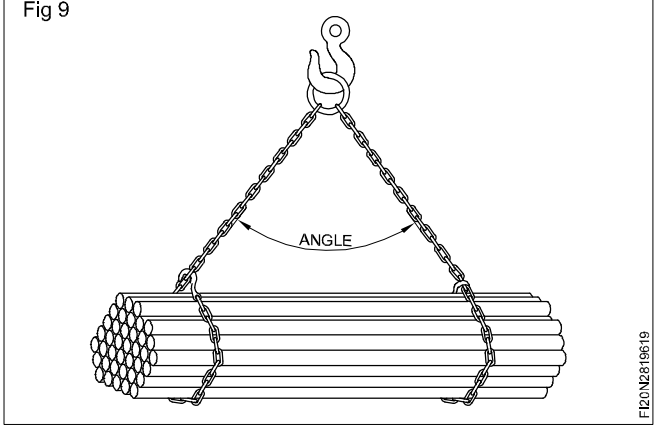
- Fibre rope get spoiled due to heat and in presence of toxic liquid and fumes. However, polypropylene ropes offer goods resistance to water chemicals and alkalis. They are stronger, reliable and durable comparing to other fibre ropes.
- Always prepare the sling to keep the load in well balanced condition.
- Prepare a sling for the load within permissible angle as in Fig.9 (30^0,90^0,120^0). Lesser the angle load carrying capacity of the slings is more. When the angle exceeds 120^0,the load carrying capacitiy of the sling is reduced to half.

Fig 9



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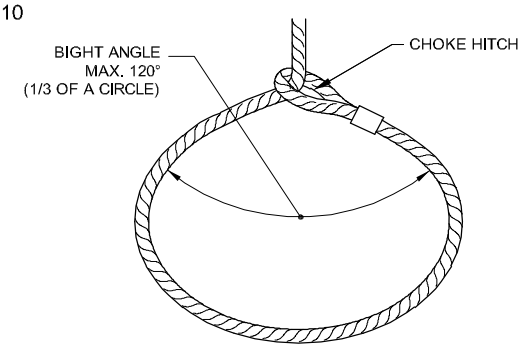
- Ensure about the safe working load (SWL) of the chain and wire rope slings.
- Chains should not be twisted for slinging.
- Avoid formation of loop in wire rope slings which will lead to damage.
- Avoid riding on the load.
- Use guide rope for lengthy article being handled by a single crane.
- Avoid putting a sling round a radius of less than three times the rope diameter.
- Sling cylindrical object with wire rope wherein bight angle should not exceed 120^0. (Fig 10)

Fig 10

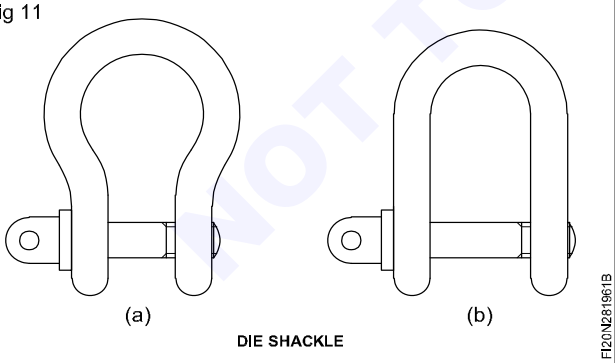


- Always keep yourself away from the suspended load.
- After completin of the work always return the hook fasten to the master ring.

Shackless

These are used for holding rings, eyes and hook which allow slings to adjust themselves easily to prevent bends, kinks etc in wire ropes. They are often used to join together the ends of slings. Bow shackle and Dee shackle are shown in (Fig 11a and b). Dynamo eye bolt (Fig 12a), Eye bolt with link (Fig 12b). These are used commonly to lift vertical load such as dynamo and other loads, provided with screwed holes to fit eye bolt.

Fig 11



Slinging hook

Hooks are used in chain and wire rope for anchoring load. A few common types are shown in (Fig 13a,b,c,d,e). These hooks are made of high Tensile steel and drop forged to the shape. Eye hook (Fig 13a) is commonly used for handling load by the crane. Bureau of indian Standard has recommend in eye hook with safety catch (Fig 13b) for general handling purposes. Swivel spring safety hook (Fig 13c) is capable of turning around and adjust itself to prevent twisting. Barrel hook (Fig 13d) is used for handling barrel. Chain clutch hook (Fig 13e) can be used for fastening to any portion of the chain after wrapping around the load. Cargo hook (Fig 14a) is used for handling general cargo in port. Ramshorm hook (Fig 14b) is used in heavy duty crane to fasten the sling from both sides of the hook. Joist or grider hook (Fig 14c) is used for handling joists or girders.

Fig 12

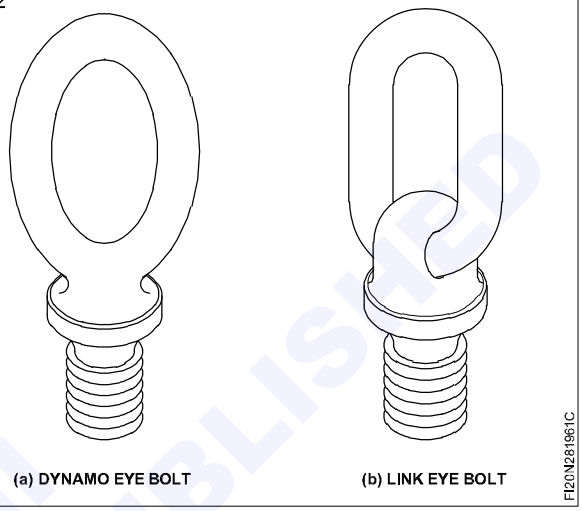


Fig 13

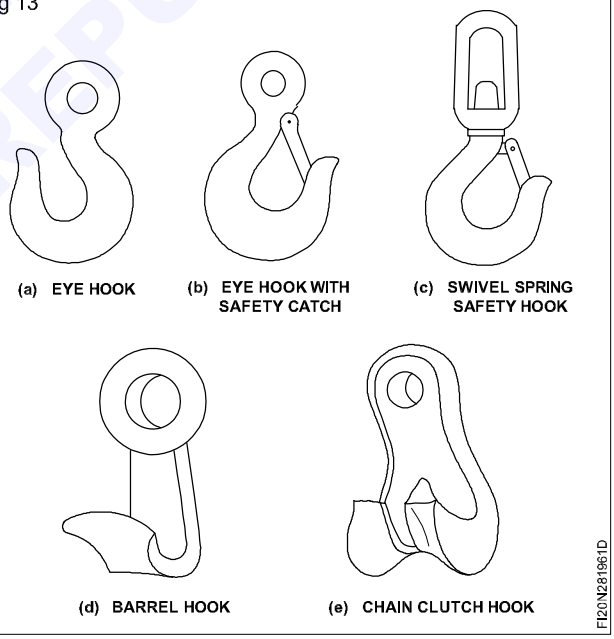
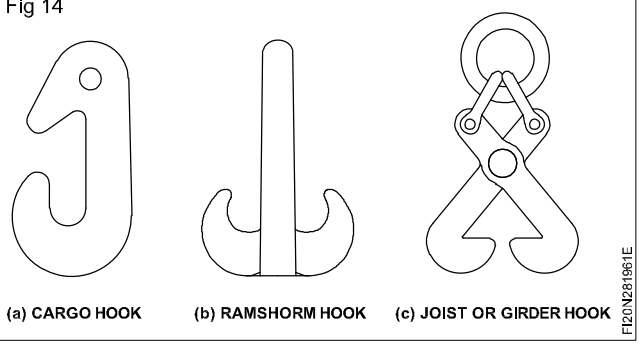


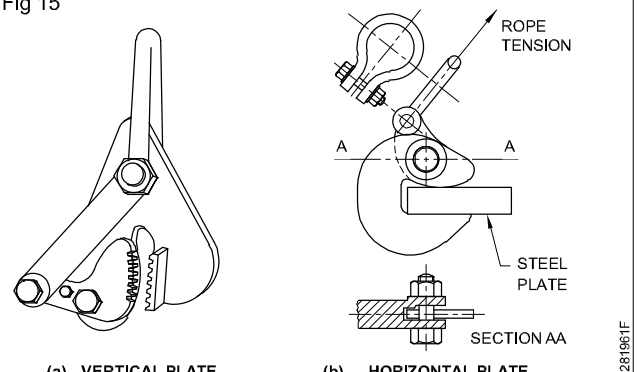
Fig 14



Lifting clamps

Lifting clamps are of various designs to suit the application. Vertical and horizontal plate lifting clamps as shown in (Fig 15a and b) respectively are used for lifting plates vertically and horizontally. As the tension is applied to the rope or chain, the jaws grip the plate tightly for effective lifting.

Fig 15



Tensioning screws

These screws or bolts are used in a situation where adjustment in tension is essential.

Common types

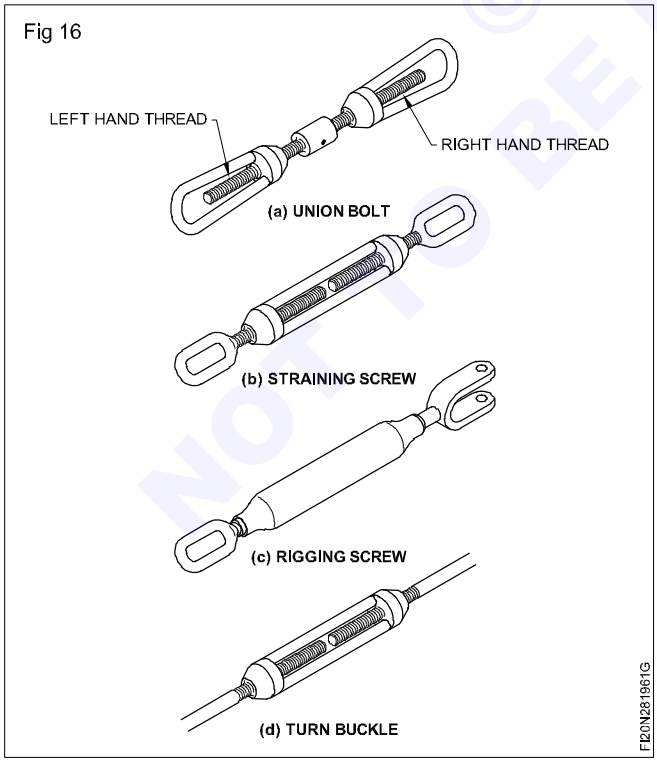
1 Union bolt (Fig 16a)

2 Straining screw (Fig 16b)

3 Rigging screw (Fig 16c)

4 Turn buckle (Fig 16d)

Fig 16



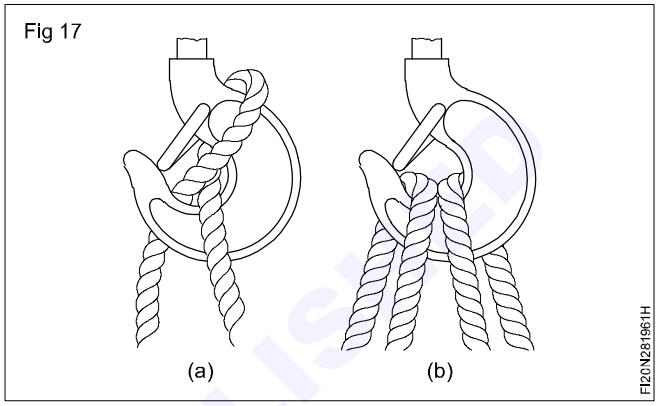
Union bolt is commonly on electrical post to keep it in erect condition. The centre part of the link is turned by tommy bar to keep the rope under tension.

Straining screw, rigging screw and turn buckle are also used in similar applications often in slinging ropes for adjusting the tension of the sling to keep the load in balanced condition.

Method of slinging

A few common methods of putting slings on the hooks have been shown in Figs 17a and 17b.

Fig 17



A cylindrical object slinging is shown by steel wire rope sling (basket hitch) Fig 18 which becomes automaticaly balanced when the slings are of equal size.

Fig 18

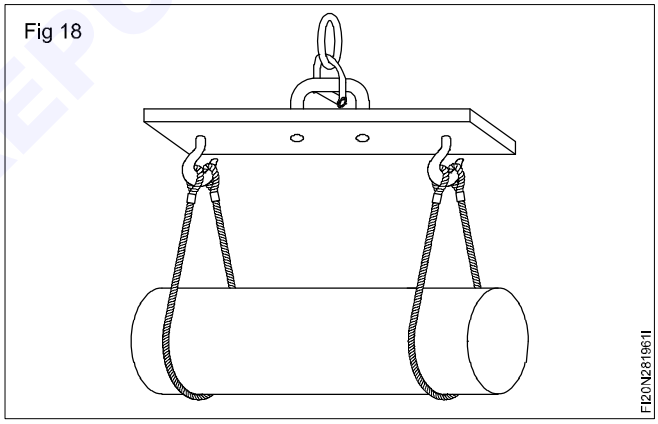
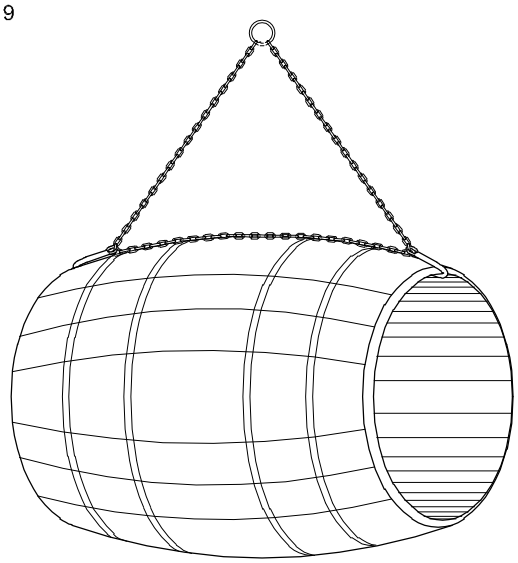


Fig 19 shows barrel slinging by chain using barrel hook. Fig 20 shows chain slinging with four legged chain sling using two endless chain wherein the object has the marking of slinging location.

Slinging methods

Wooden casing arrives at the purchaser's premises with sling marks as shown in Fig 21.The casing should be unpacked and suitable slings are made to shift to the place of installation.

Fig 19



BARREL OR CAN SLING

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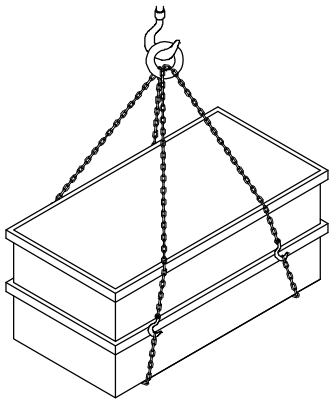
Fig 20



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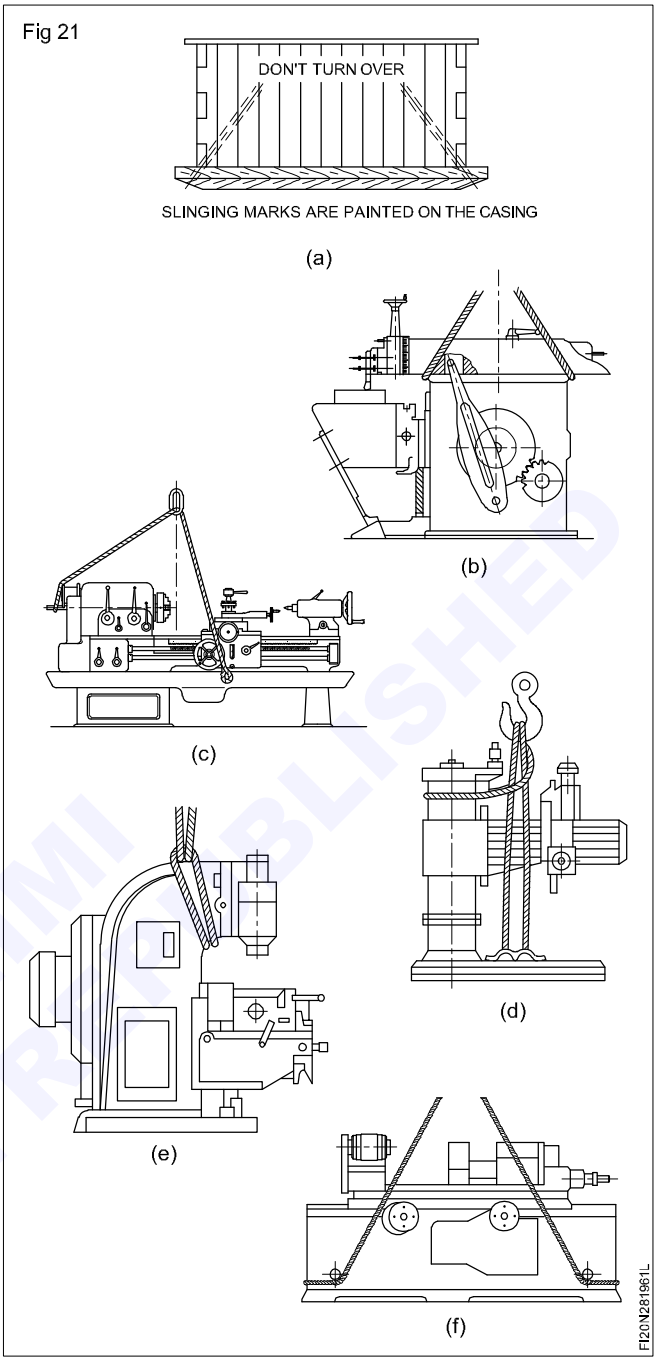
Such shifting is done commonly by fibre rope slings for lighter machines and comparatively heavier machines are shifted using suitable wire rope and chain slings. Suitable packings are to be used for protecting finished surfaces of the machineries.

A few mehtod of slinging shaper, lathe, radial drilling machine, vertical milling and universal cylindrical grinder are shown in Fig 21 respectively.

Rigging Theory

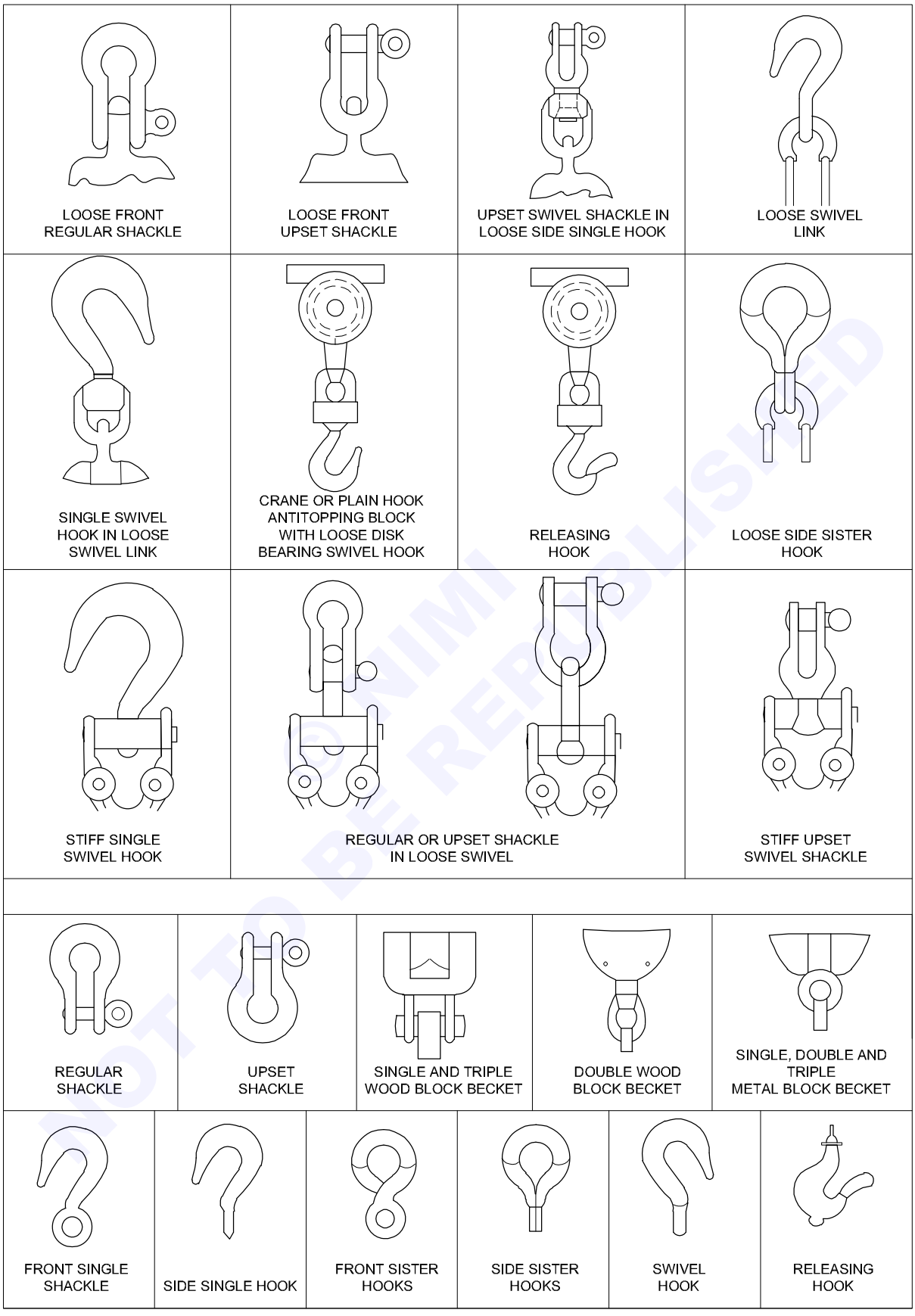
Rigging is the action of designing and installing the equipment, in the preparation to move objects. A team of riggers design and install the lifting or rolling equipment needed to raise, roll, slide or lift objects such as with a crane or block and tackle.

Fig 21



Rigging is the equipment such as wire rope. turnbuckles, clevis, jacks used with cranes and other lifting equipment (Fig 22) in material handling and structure relocation. Rigging systems commonly include shackles, master links and slings. Also, lifting bags in under water lifting.

Fig 22



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Fork lift and pallet truck

Objectives: At the end of this lesson you shall be able to
- **tell about fork lift (stacker)**
- **mention handling load by hand pallet truck**
- **state advantages of moving load by stracker and pallet truck.**

The fork lift is a small 4-wheel vehicle with diesel/petrol/electrically powered engine. Heavy counter weight are fitted to the rear of the units. There are two lifting fork or arms in front of the machine which are adjustable to carry the load. They are available in various designs and capacities for shifting and stacking load in different positions.

Types

1 Diesel automotive fork lifter.

2 Battery powered fork lift stacker.

3 Hydraulic stacker.

4 Mechanical stacker.

5 Hand pallet truck.

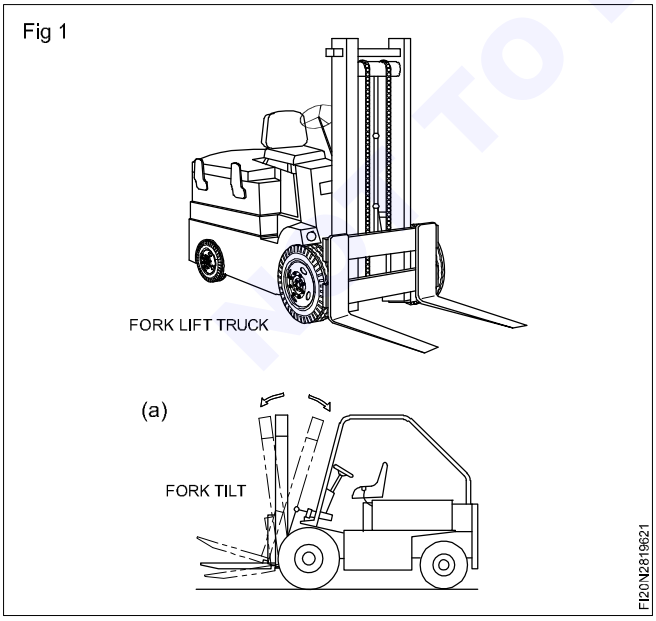
1 Diesel automotive fork lifter (Fig 1)

This diesel powered truck is driven by a driver to carry loads to considerable distances to and from the shop floor/yards to work place or for storage capacity 2 tonne to 10 tonne lift 2 meter height (common).

Fork unit can be hydraulically fitted, upto 15 degrees inward or outward and lifted to desired level. (Fig 1a)

This works very efficiently to move loads faster even on rough roads. Suitably used in harbour work,in industries, ware houses. transportation between lorry and railway terminals etc.

Fig 1



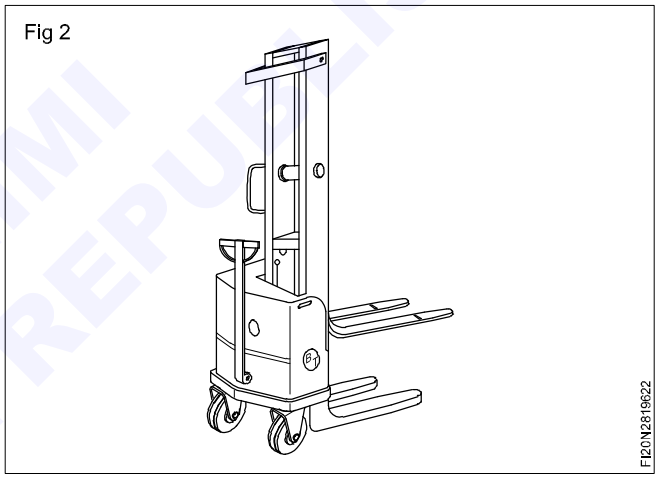
Maintenance

- Engine oil and hydraulic oils are to be changed periodically.
- Check for leakage in hydraulic cylinders.
- Cleaning and lubrication should be done to all motion parts including counter weight chain.

2 Battery powered fork lift stacker (Fig 2)

Powered fork lift stackers are compact in design and used to carry load mainly indoor within narrow space for shifting and stacking even to higher levels. The operator walks beside the truck to steer it. Lifting is done hydraulically.

Fig 2



They are commonly used in workshops, warehouse , rail containers, wagons etc. capacity 500 kg-2000 kg. Lift upto 5 meter commonly used.

Maintenance

- All motion parts are to be cleaned and lubricated periodically
- Hydraulic oil should be changed (Servo System 57/68 as recommended) once in two years.
- Oil seals are to be changed in case of leakage.
- Distilled water should be poured in the battery as and when the level goes down.
- Battery should be charged periodically.

3 Manually operated hydraulic stacker (Fig 3)

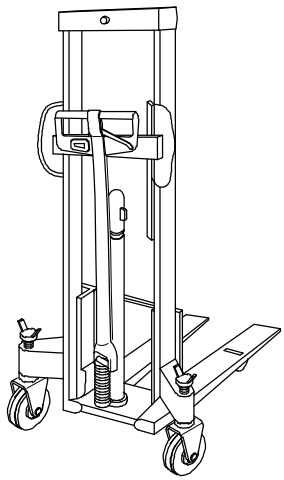
This type of stacker is used commonly as they are cheaper and can be easily handled manually for shifting and stacking load in a limited space.

Capacity- 500 Kg to 2000 Kg.

Lift upto 5 meter.

Beneficially used in light industries, ware house etc for loading, unloading and stacking.

Fig 3



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Maintenance

- Clean and lubricate all motion parts.
- Change hydraulic oil once in two years (servosystem 57or 68 as recommended to be used)
- Replace oil seal for oil leakage.

Mechanical stacker (Fig 4)

This type of stacker is mechanically handled for moving, lifting and stacking load. These can be operated in a limited space so they are used in small scale industries.

Capacity 500 Kg.

Lift upto 2 meter.

Maintenance

- Clean and lubricate all motion parts periodically.

Hand pallete truck (Fig 5)

Pallet trucks are basically used for carrying pallet bins (Fig 5a) and other loads on floors, warehouses wiht high rate of turn over even bulky goods.

Fig 4

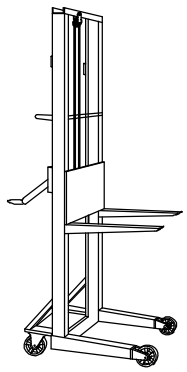

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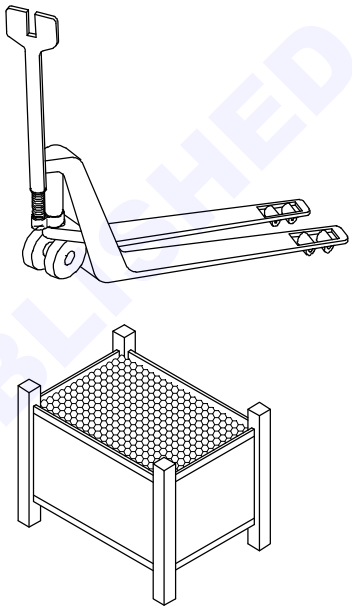
Fig 5



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Capacity 500 kg to 2000 kg.

Maintenance

- Change hydraulic oil once in two years (servosystem oil 57 or 68 as recommended). Topup oil periodically wherever required.
- Replace oil seals in case of oil leakage.
- Clean and lubricate other motion parts periodically.

Types of cranes

Objectives: At the end of this lesson you shall be able to
- **State basic function of crane**
- **mention the types of crane**
- **describe the application of various cranes**
- **state the highlights on troubleshooting**
- **narrate the safety on overhead crane repair.**

Basic function of crane

Crane is made up of sturdy structural member of steel, which are used in Industries, Port trust etc to shift the heavy materials from one place to another place for subsequent operation, assembly etc. The shape and its construction varies with application and types. There are many types of cranes are available.

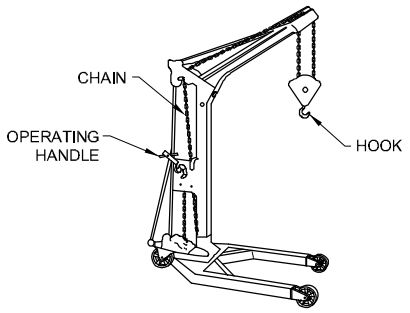
Types

- Floor cranes
- Jib cranes
- Derrick cranes
- Overhead cranes
- Gantry cranes
- Travelling cranes.

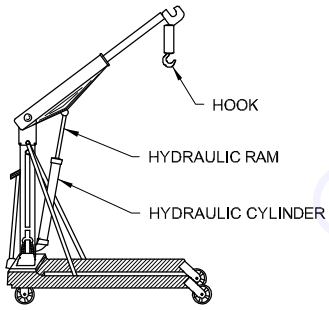
Floor cranes (Fig 1a & b)

Hand operated floor cranes are used for handling light loads (up to 2000 Kg.) on the shop floor.

Fig 1



(a) FLOOR CRANE



(b) HYDRAULIC OPERATED FLOOR CRANE

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Hydraulic floor cranes are also used for lifting and shifting loads. The boom of the crane is moved up and down approximately 30^0 hydraulically. The boom can be extended to work for a longer reach. As the boom extends the loads carrying capacity decreases. Capacity ranges from 1000 Kg to 5000 Kg.

These floor cranes are mounted on wheels and can be moved from one place to another by pushing.

Fig 2 shows simple jib crane mounted on the strong base and supported by bearing plate at the top. The jib also called boom is supported by vertical mast with guy support at the front and stiff legs at the rear.

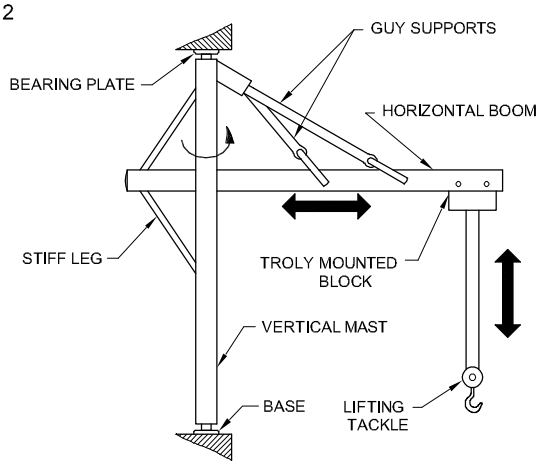
There are three possible movements of load ie.

a Raise or lower the load

b Horizontal movement of load between mast and end of boom

c 360^0 rotation of mast on its axis (slewing).

Fig 2



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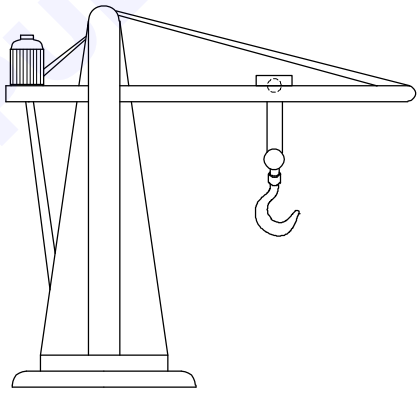
Pillar jib crane

Fig 3 show simple jib crane. The bottom is fastened to the mast about two-thirds of the way from the base. The rear end of the boom extends beyond the mast. Boom is supported by guys from the top of the mast to provide additonal support. The lifting tackle on the boom hangs from a trolley-mounted block, which slides along the length of the boom to shift the load at any position. The load can be rotated within a radius from mast.

Fig 3

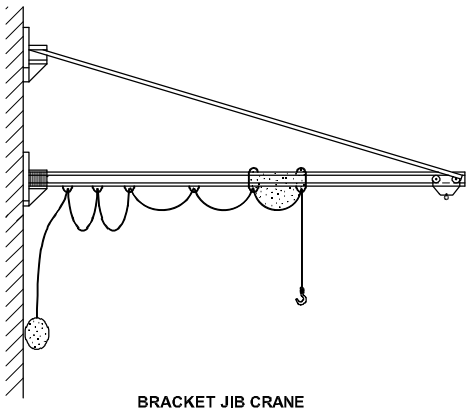


PILLAR JIB CRANE

FI20N2819633

Fig 4 shows the bracket jib crane used for light load.

Fig 4



BRACKET JIB CRANE

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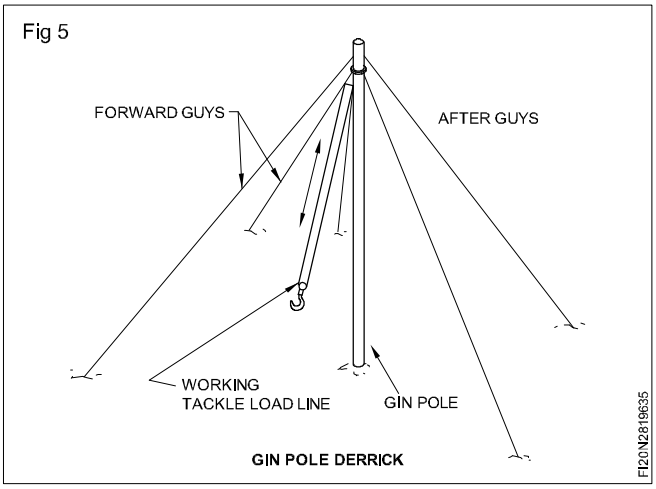
Derricks cranes

Gin pole derrick crane (Fig 5)

Gin pole derrick one single pole units with one end firmly secured at the base to prevent movement. It is used as a temporary hoist to raise and lower a number of light loads. In setting up a gin pole, use atleast two after guys to provide support for the working end of the pole.

Fig 5



Guyed derrick crane (Fig 6)

The derricks are made of steel or wood. Derrick made of steel are mostly used. The derrick or boom is supported with mast. Mast and boom are either hand operated or power operated. The boom is rotate through bull gear, fastened at the bottom of the most. The mast is pivoted both at bottom as well as at top. The derricks is rotated by rope passing through sheaves at the top of the bottom. Derricks of power operated by pinion meshing with gear fastened to power drive also used.

Fig 6

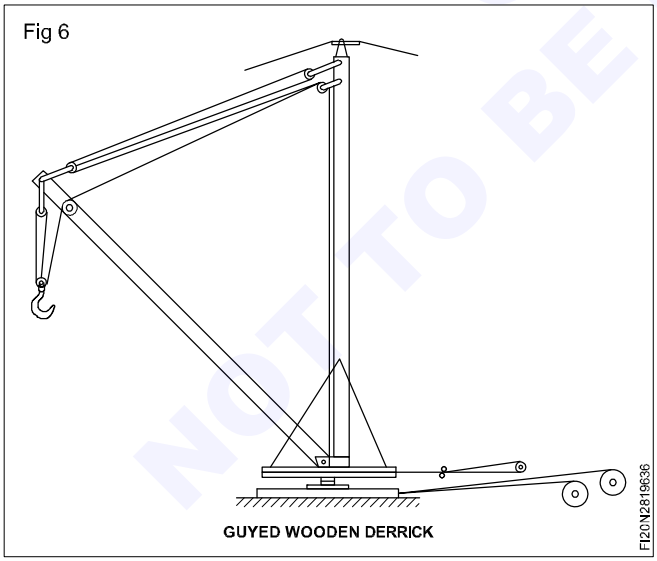


Fig 7 & 8 shows stiff leg derrick and breast derrick cranes used for matterial handling.

Fig 7

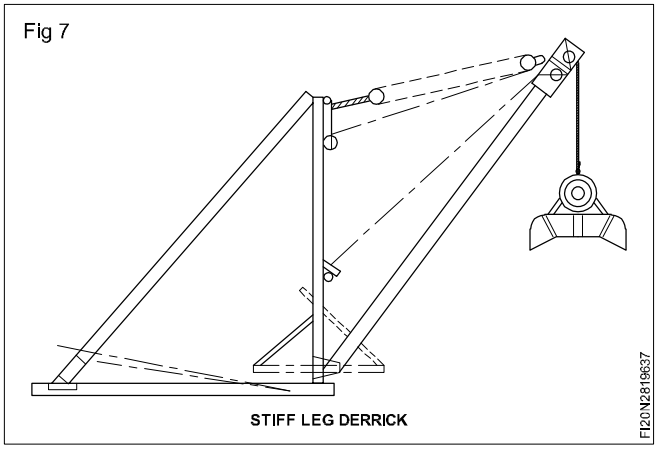
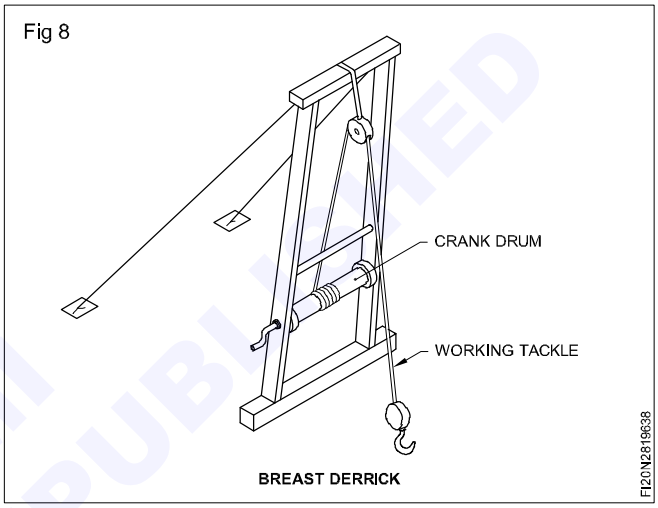


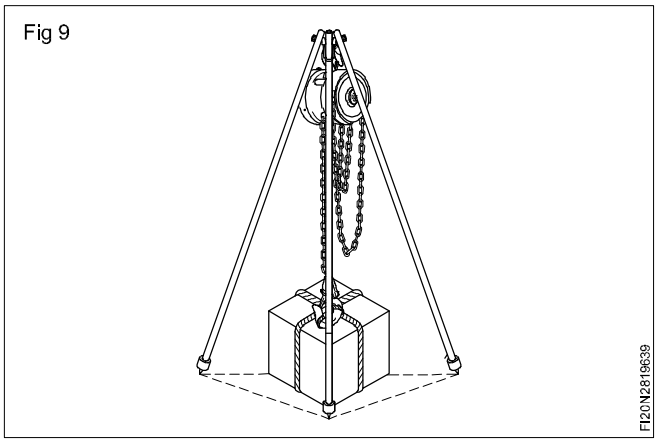
Fig 8



Tripod with chain pulley block

Each leg of the tripod is having a hole at its top end to fix up a stout bolt thorough ‘u’ shaped shackle. This bolt and shackle holds the tripod legs together at the top end and the chain pulley block can be hooked into the shackle. A nuts is screwed into the threaded end of the bolt which is riveted slightly to prevent unscrewing and coming out of nut. The bolt is kept a little loose adjust the position of three legs. (Fig 9)

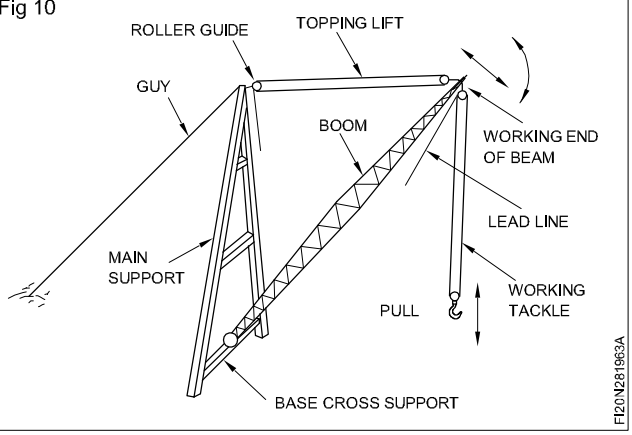
Fig 9



Frame derrick crane

A ‘frame derrick’ gets its name from the shape of its main support. The main support, as shwon in Fig 10 is triangular, with the base resting on the ground or floor.

Fig 10

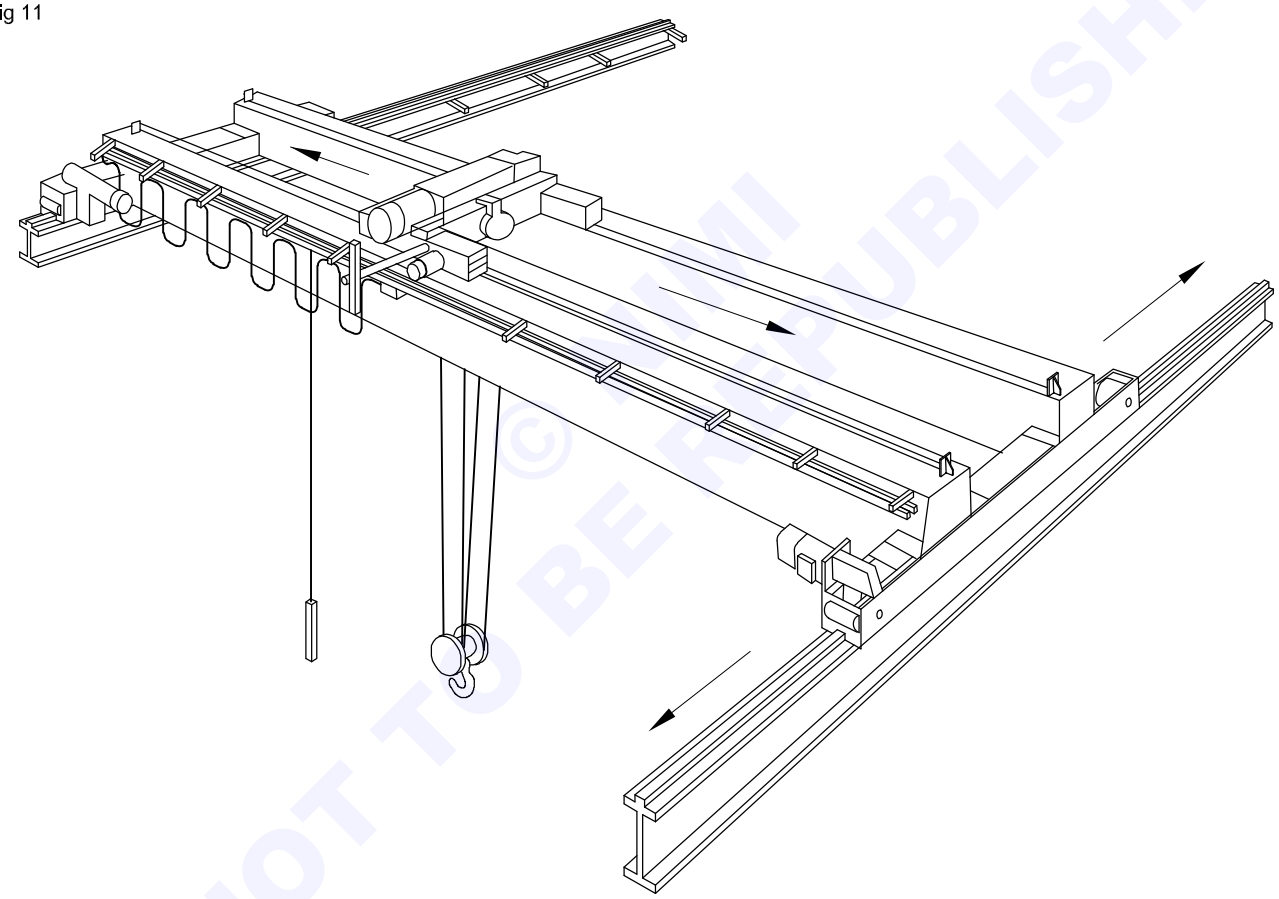


For light load frames are made of wood and for heavy duty frames are made from steel. Frames are mounted in position that prevents the base from moving or shifting under load. To operate a framed derrick, the boom or moving section, connects to a cross support at the base of the frame up-right support. The working end of the boom carries the upper block for raising the load.

Overhead crane (Fig 11)

An overhead travelling crane consists of a bridge constructed from one or several girders supporting a travelling hoist. Electrically operated overhead crane is called in short EOT crane. They are used in workshop engine rooms and in open yards to move materials to a considerable distance in fabrication and assembly works. The capactiy of the crane varies from 1 tonne (light duty) to 5 tonne (heavy duty) and above depends upon the application.

Fig 11



OVERHEAD CRANE

For assembling and dismantling of bulk component like diesel locomotive, carriege wagon etc. during periodical over hauling two cranes of equal capacity being used. Each crane is operated by individual certified operater. Both the operators should follow same signal at a time from the rigger. The operators sit in a cabin provided for them.

The crane normally having three individual drive are called.

- long travel
- cross travel
- hoisting

Each travel consists of individual motor drive coupled with reduction gear box. Heavy duty crane are provided with two hoisting one meant for higher load called main hoist and another one for light load called auxiliary hoist. The

capactiy of the crane is written on the structural member of the crane visibly is called safe working load (SWL).

While lifting the load by crane the load do not exceed safe working load of a crane at any circumstances.

They are standard signals that every crane operator should follow while handling the load to control the crane.

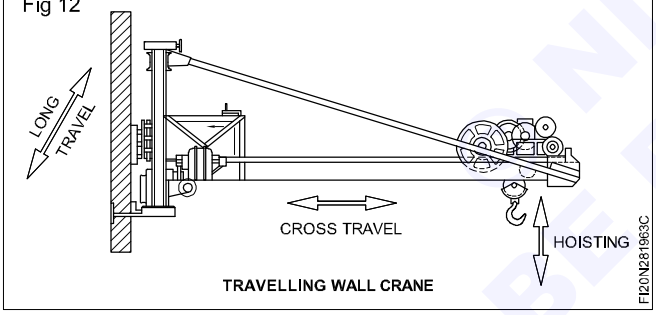
While lifting load by using chain having more than one legs, ensure all the legs should have equal length.

While lifting load the structural member of the crane subjected to deflection from its position. The permissible deflection is 1mm for each 900 mm span measured at midpoint of the span by keeping the load at the centre. A crane having 9 meters span i.e. distance between two rails of long travel, the permissible deflection is 10mm.

Travelling wall crane also used in assembly shop. The long travel wheels runs on rails mounted on wheels. Fig 12 shows travelling wall crane.

Gantry crane (Fig 13)

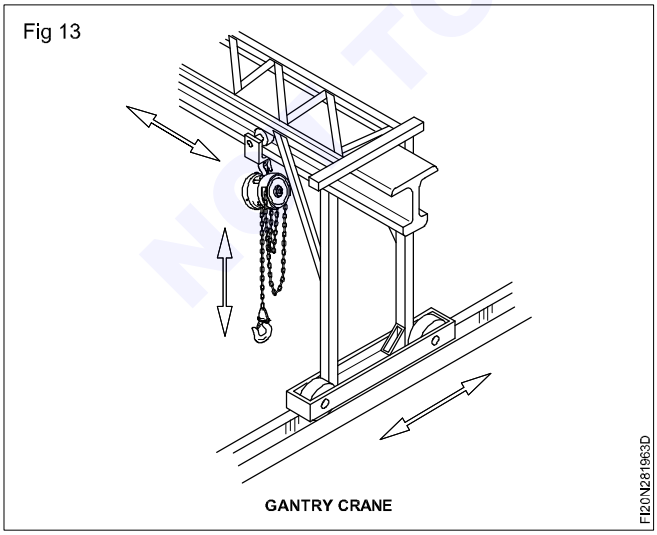
Fig 12



TRAVELLING WALL CRANE

Most gantry cranes are much larger than over head

Fig 13



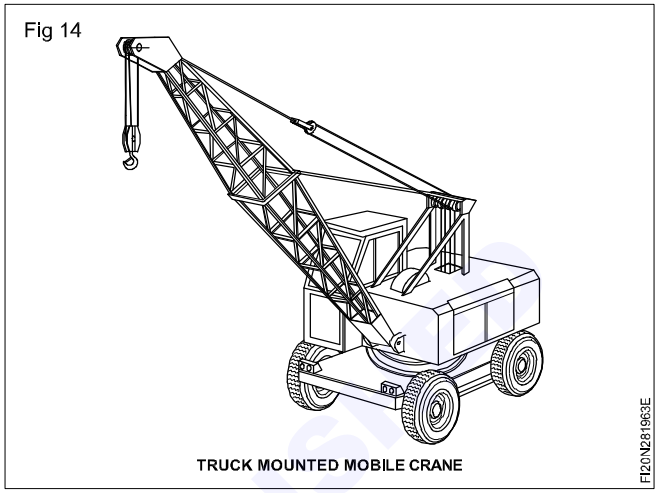
GANTRY CRANE

travelling cranes. It is used outside of the buildings. Gantry cranes also move on tracks,but their tracks are on the ground rather than suspended overhead. Trolleys are mounted on two upright structures separated by the connecting bridge.

Trolley wheels support the gantry. The gantry's load movement capabilities are the same as those of the travelling crane.

Trucks mounted mobile crane (Fig 14)

Fig 14



TRUCK MOUNTED MOBILE CRANE

There are locomotive cranes, truck-mounted cranes which are also used for lifting and moving the loads.

These crane can be used in remote places.

Problem - "The crane is not working when switched on".

When attending any repair on the overhead crane wear helmet and safety belt. The safety belt to be tied with structural member while attending repair to avoid accident by slipping.

Precautions in the removal and replacement of heavy parts

People who install or dismantle machinery and equipment could:

- Work in isolation
- Work on machinery and equipment at heights, or over machinery and equipment to connect services, such as electricity, air or water
- Work in low light, or with bright directional light
- access machinery and equipment from the top, sides or underneath
- Work with or near craness, forklifts or rigging to lift machinery and equipment
- work in confined spaces
- use power tools, welders, extension leads, which present electrical hazards if damaged or wet.

People operating machinery and equipment could:

- be required to place their hands close to the mechanism of the machinery and equipment that does the work, and may be injured if caught or trapped by moving parts

- be exposed to constant harmful noise, radiated, energy or fumes being emitted form the machinery and equipement being operated, or are close to
- inadvertently bump or knock poorly placed control levers or buttons
- be required to make adjustments to the mechanism of machinery and equipment while the machine is in motion
- be required to clear away scrap
- make minor adjusments, or reach into the moving mechanism of the machinery and equipment being operated.

People providing maintenance or repair services could:

- work alone
- work on machinery and equipment at height, or over machinery and equipment to connect services, such as electricity, air or water
- access machinery and equipment from the rear or sides
- be required to enter confined spaces of larger machiery and equipment
- be trapped by the mechanism of the machinery and equipment through poor isolation of energy sources or stored energy, such as spring-loaded or counter-balance mechanisms, compressed air or fluids, or parts held in position by hydraulics or pneumatic (air) rams
- Move heavy parts when changing the set up of machinery and equipment, or repairing failed parts, such as electric motors or gear box assemblies
- disable or remove normal safety systems to access the mechanisms of machinery and equipment.

People providing cleaning services could:

- work alone
- access machinery and equipment from the rear or sides, or in unexpected ways
- climb on machinery and equipment
- enter confined spaces, or larger machinery and equipment
- become trapped by the mechanism of the machinery and equipment through poor isolation of energy sources or stored energy, such as spring - loaded or counter - balance mechanisms, compressed air or fluids, or parts held in position by hydraulics or pneumatic (air) rams
- work with chemicals
- operate electrical equipment in wet areas.