AERONAUTICAL STRUCTURE & EQUIPMENT FITTER

NSQF LEVEL - 4

1st 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

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Trades : Aeronautical Structure & Equipment Fitter - 1st Year - Trade Theory - NSQF LEVEL - 4 (Revised 2022)

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of 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 **Aeronautical structure & Equipment Fitter, 1st Year Trade Theory NSQF Level - 4 (Revised 2022) in Capital Goods & Manufacturing Sector under Yearly Pattern.** The NSQF Level - 4 (Revised 2022) Trade Theory 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 Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

Addl. Secretary / Directorate General of Training
Ministry of Skill Development & Entrepreneruship
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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 syllabi 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.

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

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

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

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

Chennai - 600 032 **EXECUTIVE DIRECTOR**

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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 **Aeronautical structure & Equipment Fitter,** under the **Capital Goods & Manufacturing** Sector for ITIs.

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

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

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

INTRODUCTION

TRADE THEORY

The manual of trade theory consists of theoretical information for the 1st Year course of the **Aeronautical structure & Equipment Fitter** Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theortical 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 indicating about the corresponding practical exercise are given in every sheet of this manual.

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

Module 1	**Safety**
Module 2	**Basic fitting operations**
Module 3	**Sheet metal basic fitting operation**
Module 4	**Sheet metal components and assembly**
Module 5	**Structural panels**

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

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 1st Year course of the Aeronautical structure & Equipment fitter 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)

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

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

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

CONTENTS

LEARNING OUTCOME

On completion of this book you shall be able to

S.No.	Learning Outcome	Ref. Ex.No.
1	Recognize & comply with safe working practices, environment regulation and housekeeping.	1.1.01 to 1.1.11
2	Plan and organize the work to make job as per specification applying different types of basic fitting operation and Check for dimensional accuracy.	1.2.12 - 1.2.13
3	Making basic adjustment of sheet metal and Joining techniques for sheet metal and metal components.	1.2.14 to 1.2.15
4	Produce components by different operations and check accuracy using appropriate measuring instruments.	1.2.16 to 1.2.17
5	Make different fit of components for assembling as per required tolerance observing principle of interchangeability and check for functionality.	1.2.18 to 1.2.19
6	Check the mechanical properties of the different material and interpret the tensile test results	1.3.20
7	Make different types of simple sheet metal components for assembling using hand drill machine and check accuracy using appropriate measuring instruments according to required tolerances ±0.1 mm	1.3.21 - 22
8	Manufacturing simple sheet metal with bending and check accuracy using appropriate measuring instruments and according to required tolerances ±0.1 mm.	1.3.23 - 24
9	Make and assemble components by different handling fitting operations and checking accurancy using appropriate measuring instruments.	1.4.25 - 32
10	Produce straight and curved interchangeable metal components by sheet working operrations and check accurancy using appropriate measuring instruments and according to required tolerances ±0.1 mm.	1.4.33 - 34
11	Manufacturing sheet metal as per drawing and join them by basic riveting observing standard procedure.	1.4.35
12	Perform PR sealant application on structure panels without riveting and perform a tensile test for checking the correct bonding PR sealent application.	1.5.36 - 39
13	Manufacturing open and closed riveted box with two different thickness, bended sheets, anchor nuts and electrical bonding.	1.5.40 - 42

SYLLABUS
1st Year

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 84 Hrs; Professional Knowledge 16 Hrs	Plan and organize the work to make job as per specification applying different types of basic fitting operation and check for dimensional accuracy following safety precautions.	1. Importance of trade training, List of tools & Machinery used in the trade. 2. Safety attitude development of the trainee by educating them to use Personal Protective Equipment (PPE). 3. First Aid Method and basic training. 4. Safe disposal of waste materials like cotton waste, metal chips/burrs etc. 5. Hazard identification and avoidance. 6. Safety signs for Danger, Warning, caution & personal safety message. 7. Preventive measures for electrical accidents & steps to be taken in such accidents. 8. Use of Fire extinguishers. (42 hrs)	English technical vocabulary related to the task. All necessary guidance to be provided to the newcomers to become familiar with the working of Industrial Training Institute system including stores procedures. Soft Skills: its importance and Job area after completion of training. Importance of safety and general precautions observed in the in the industry/shop floor. Introduction of First aid. Operation of electrical mains. Introduction of PPEs. Response to emergencies e.g.; power failure, fire, and system failure. **Importance of housekeeping &good shop floor practices.** Introduction to 5S concept & its application. Occupational Safety & Health: Health, Safety and Environment guidelines, legislations & regulations as applicable. (08 hrs)
		9. Identification of tools & equipment as perdesired specifications for marking & sawing. 10. Selection of material as per application. 11. Visual inspection of raw material for rusting, scaling, corrosion etc. 12. Marking out lines, gripping suitably in vice jaws, hacksawing to given dimensions 13. Sawing different types of metals of different sections. (42 hrs)	English technical vocabulary related to the task. Aircraft Safety Practices: Foreign Object Damage, Inventory of tools before and after intervention, Traceability of specific tools used. Linear measurements- its units, dividers, callipers, hermaphrodite, center punch, dot punch, their description and uses of different types of hammers. Description, use and care of 'V' Blocks, marking off table. (08 hrs)
Professional Skill 105 Hrs; Professional Knowledge 20 Hrs	Perform making of basic adjustment of sheet metal and Joining techniques for sheet metal and metal components.	14. Make basic adjustment of sheet metal using Aluminum2024, size 150 mm x 150 mm, thickness1.5 mm, by performing operations of: - Tracing by using ruler, Vernier calipers, Vernier height gauge - Cutting process with Hack saw - Deburring (files handling) - Checking criteria and acceptance in accordance with geometric tolerances: perpendicularity, parallelism, flatness, angle	English technical vocabulary related to the task. Aircraft Safety Practices: Maintenance of tools, Clean the workstation. Metallic Material Science: properties - Physical & Mechanical Non-Ferrous metals: Aluminum Non-Ferrous Alloys: Aluminum series Introduction of Engineering Drawing reading plan. Introduction of Metrology

		- Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Micrometer](42 hrs)	Vernier and height gauge handling and maintenance. File handling, Machining file, Tracing, Sawing, Vice. (08hrs)
		15. Make basic adjustment of sheet metal with flanged holes using Aluminum 2024, **size 150 mm x 200 mm, thickness 2 mm, by performing operations of:** - Tracing - Debiting - Deburring - Adjustment of the parts with geometric tolerances: perpendicularity, parallelism, flatness, rounded - Making flanged holes - Appropriate Measuring Instrument. [Vernier calipers, Vernier Height Gauge, Cast Iron surface plates, Veeblocks, Square, Micrometer](63 hrs)	English technical vocabulary related to the task. Aircraft Safety Practices: Means of protection of the aircraft working area.Metallic Material Science: properties - Physical &Mechanical Non-Ferrous metals: Aluminum Non-Ferrous Alloys: Aluminum series File holding, Machining file, Tracing, Sawing, Vice. Bench vice construction, types, uses, care & maintenance, vice clamps, hacksaw frames and blades, specification, description, types and their uses, method of using hacksaws. Hydraulic press for Flanges holes.(12hrs)
Professional Skill 190 Hrs; Professional Knowledge 36 Hrs	Produce components by different operations and check accuracy using appropriate measuring instruments.	16. **Adjustment N°1** Perform deburring operations on a 10 mm Aluminum block (Al 2024), size 100mm x 50 mm, with geometric constraints (flatness, angle, rounded) by: - Tracing by using ruler, Vernier calipers, Vernier height gauge, marking blue, Dial comparator - Cutting process with Hack saw - Deburring - Perform adjustment operations with geometric and machining tolerances: - Drilling by using depth gauge and vertical drill machine - Fitting process by using files - Counter boring Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square ,Dial comparator, Micrometer](63 hrs)	English technical vocabulary related to the task. Human Factors: Human Performance and Limitations, Social Psychology, Factors Affecting Performance, Physical Environment, Physical work; Repetitive tasks; Visual inspection; Complex systems, Communication within and between teams; Human Error, Hazards in the Workplace. Vertical drill handling and maintenance (counterboring, countersinking) Marking- Prussian blue, their special application, description. Use, care and maintenance of scribing block. Surface plate and auxiliary marking equipment, angle plates, parallel block, description, types, uses, accuracy, care and maintenance.(12 hrs)
		17. **Adjustment N°2** Perform adjustment operations on a 20 mm Aluminum block (Al 2024), size 50 mm x 50 mm, with geometric constraints by: - Tracing by using ruler, Vernier, height gage, marking blue, dial comparator - Cutting process with Hack saw - Deburring	English technical vocabulary related to the task. Human Factors: Brief History of Aviation, General aircraft description, Aerodynamic notions, how does an aircraft fly? Counter sink, counter bore and spot facing-tools and nomenclature, Reamer-material, types (Hand and machine reamer).(12 hrs)

		- Drilling by using Vernier depth gauge and vertical drill machine - Fitting process (using files) - Countersinking - Checking criteria and acceptance - Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, dial comparator, Micrometer](63 hrs)	
		18. **Adjustment N°3** Perform adjustment operations on a 10 mm Aluminum block (Al 2024), size 50 mm x 50 mm, with geometric constraints by: - Tracing by using ruler, Vernier, Vernier height gage, marking blue, dial comparator - Cutting process with Hack saw - Deburring - Drilling by using depth gauge and vertical drill machine- - Fitting process (using files) - Reaming - Countersinking - Performing thread cutting - Checking criteria and acceptance - Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Dial comparator, " GO no GO" gauge, Micrometer] (64 hrs)	English technical vocabulary related to the task. Human Factors: Aircraft main parts (fuselage, wing and empennage, engine and pylons, Landing gear, equipment's) Taps and Thread Standards.(12hrs)
Professional Skill 65 Hrs; Professional Knowledge 12 Hrs	Make different fit of components for assembling as per required tolerance observing principle of interchangeability and check for functionality.	19. **Adjustment N°4** Make an assembly (size 100 mm x 50 mm) with Aluminum (Al 7075) and Stainless steel parts of different thicknesses, with geometric constraints by performing operations of: - Drilling - Fitting process (using files) - Countersinking - Reaming - Performing thread cutting - Filling with liquid shim (Aluminum filler) - Clearances measurement. / - Appropriate Measuring Instrument. [Vernier Caliper, Square, Dial comparator, "GOno GO" gauge, Micrometer, Clearance Gauge](63 hrs)	English technical vocabulary related to the task. Metallic Material Science: properties - Physical & Mechanical Non-Ferrous metals: Aluminum Non-Ferrous Alloys: Aluminum series Screw threads: terminology, parts, types and their uses. Screw pitch gauge. Clearance and tolerances, liquid shim handling and maintenance. (12 hrs)
Professional Skill 21 Hrs; Professional Knowledge 04 Hrs	Check the mechanical properties of the different materials and interpret the tensile test results.	20. **Tensile test N°1** Using Aluminum (2024, 5086,7075), AISI 316L Stainless steel, Titanium TA6V, Carbon Steel, tank 250 mm x 20 mm, make 3 tensile specimens by: - Tracing with geometric constraints	English technical vocabulary related to the task. Metallic Material Science: properties - Physical & Mechanical Types - Ferrous & Non-Ferrous, difference between Ferrous and Non- Ferrous metals, introduction

		- Cutting process with Hack saw - Fitting process (using files) - Interpretation of tensile test results(21 hrs)	of Iron, Steel, difference between Iron, steel and Cast iron, Alloy steel, carbon steel, stainless steel, Non-Ferrous metals: magnesium, titanium, copper, nickel. Screw threads: terminology, parts, types and their uses. Screw pitch gauge. Clearance and tolerances, liquid shim uses.(4 hrs)
Professional Skill 21 Hrs; Professional Knowledge 04 Hrs	Make different types of simple sheet metal components for assembling using hand drill machine and check accuracy using appropriate measuring instruments according to required tolerances ±0.1 mm.	21. **Perform manual drilling operations on Aluminum 2024, stainless steel 316L and titanium TA6V (size 400 mm x 200 mm for each) by: -** Tracing, Cutting process with Hack saw, fitting process (using files) on each sheet - Tracing for rivet pitch and edge distance calculation and drilling - Drilling - Counter drilling - Deburring - Temporary fitting (clamping pin)Appropriate Measuring Instrument.[Vernier Height Gauge, Cast Iron surface - plates, Vee blocks, Square, Micrometer] (21 hrs)	English technical vocabulary related to the task. Metallic Material Science: properties - Physical & Mechanical Types - Ferrous & Non-Ferrous, difference between Ferrous and Non-Ferrous metals, introduction of Iron, Steel, difference between Iron, steel and Cast iron, Alloy steel, carbon steel, stainless steel, Non-Ferrous metals: magnesium, titanium, copper, nickel. Drill-material, types, parts and sizes for metallic materials. Drill angle-cutting angle for different materials, cutting speed feed. R.P.M. for different materials. Drill holding devices- material, construction and their uses. Calculation of pitch and edge distance, importance of the pitch and the edge distance. (04 hrs)
Professional Skill 21 Hrs; Professional Knowledge 04 Hrs	Manufacture simple sheet metal with bending and check accuracy using appropriate measuring instruments and according to required tolerances ±0.1 mm. A A S / N 1 4 0 1	22 Performmanual bendingoperations on Aluminum 5086 (size 100 mm x 80 mm) by: - Tracing, Cutting process with Hacksaw, fitting process (using files) - Bending following drawings instructions - Appropriate Measuring Instrument - [Vernier Caliper, Vernier Height Gauge, Cast iron surface plates, Vee blocks, Square, Micrometer](21hrs)	English technical vocabulary related to the task. Metallic Material Science: properties - Physical & Mechanical Types - Ferrous & Non-Ferrous, difference between Ferrous and Non-Ferrous metals, introduction of Iron, Steel, difference between Iron, steel and Cast iron, Alloy steel, car bon steel, stainless steel, NonFerrous metals: magnesium, titanium, copper, nickel. Assembling techniques such as aligning, bending, fixing, mechanical jointing, threaded jointing, sealing, and torquing. Bending handling and maintenance. (04 hrs)
Professional Skill 21 Hrs; Professional Knowledge 04 Hrs	Manufacture sheet metal as per drawing and Join them by basic riveting observing standard procedure.	23. **Perform drilling operations on Aluminum sheet (2024, 7075), size 400 mmx 200 mm by:** - Tracing, Cutting process with belt saw - Fitting process (using files) - Using hand drill machine	English technical vocabulary related to the task. Metallic Material Science: properties - Physical & Mechanical Types - Ferrous & Non-Ferrous, difference between Ferrous and Non-Ferrous metals, introduction of Iron, Steel,

		- Deburring - Pitch and edge distance calculation - Temporary fitting (clamping pin) - Dial Comparator using - Self-check by using rivet gauge - Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Dial comparator, Rivet gauge, Micrometer]	difference between Iron, steel and Cast iron, Alloy steel, carbon steel, stainless steel, Non- Ferrous metals: magnesium, titanium, copper, nickel.
		24. Perform squeeze riveting or "C" squeeze on thickness 3 mm and angle profile (countersunk head and round head rivet with different dash diameters) by: - Manual countersinking - Dial Comparator using - Self-check by using rivet gauge - Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Dial comparator, Rivet gauge, Micrometer](21 hrs)	Sheet holders pins: material, construction, types, accuracy and uses.Basic riveting operations with squeeze et C riveting tools, care, maintenance, Solid Rivet definition, types, sizes, materials, length calculation. (04 hrs)
Professional Skill 125 Hrs; Professional Knowledge 25 Hrs	Make and assemble components by different handling fitting operations and checking accuracy using appropriate measuring instruments.	25. **Part manufacturing** (example: little bended aircraft):Perform adjustment operations on Aluminum sheet (Al 5086), size 200 mm x 100 mm, thickness of 1.5 mm by: - Tracing with template, Cutting process with belt saw, Fitting process (using files) - Using hand drill machine / - Deburring - Temporary fitting (clamp) - Rivet pitch and edge distance calculation 26. Perform deburring on the manufactured part. 27. Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Micrometer] (25hrs) 28. **Part manufacturing** (example: little bended aircraft):Perform duplicate operations of the previous work (Aluminum sheet (Al 5086), size 200 mm x 100 mm, thickness of 1.5 mm) - Adjustment - Tracing - Cutting process with belt saw - Fitting process (using files) - Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Micrometer](21 hrs)	**Metallic Material Science:** properties - Physical & Mechanical Types - Ferrous & Non-Ferrous, difference between Ferrous and Non-Ferrous metals, introduction of Iron, Steel, difference between Iron, steel and Cast iron, Alloy steel, carbon steel, stainless steel, Non-Ferrous metals: magnesium, titanium, copper, nickel. Assembling techniques such a aligning, bending, fixing, mechanical jointing, threaded jointing, sealing and torquing. Fixing, mechanical jointing, threaded jointing, sealing and torquing. Sheet holders pins: material, construction, types, accuracy and uses. Perform basic riveting operations viz., squeeze etc., riveting tools, care, maintenance, specification, description, types and their uses, method of using.(04 hrs)

		29. **Part manufacturing** (Example: little bended aircraft):Using Aluminum 5086, size 200 mm x 100 mm, perform operations of: - Drilling, Counter drilling - Temporary fitting (clamping pin) - Rivet pitch and edge distance calculation - Bending - Appropriate Measuring Instrument. [Vernier, Height Gauge, Micrometer] (21 hrs)	English technical vocabulary related to the task. Metallic Material Science: properties - Physical & Mechanical Types - Ferrous & Non-Ferrous, difference between Ferrous and Non-Ferrous metals, introduction of Iron, Steel, difference between Iron, steel and Cast iron, Alloy steel, carbon steel, stainless steel, Non- Ferrous metals: mag nesium, titanium, copper, nickel. Assembling techniques such as aligning, bending, fixing, mechanical jointing, threaded jointing, sealing, and torquing.(04 hrs)
		30. **Part manufacturing** (example: little bended aircraft):Using Aluminum 5086, size 200 mm x 100 mm, perform operations of: - Bending - Deburring, Temporary fitting - Riveting (squeeze riveting, "C" squeeze) - Self-check by using rivet gauge - Appropriate Measuring Instrument. [Rivet gauge, etc.] (21 hrs)	English technical vocabulary related to the task. Metallic Material Science: properties - Physical & Mechanical Types - Ferrous & Non-Ferrous, difference between Ferrous and Non-Ferrous metals, introduction of Iron, Steel, difference between Iron, steel and Cast iron, Alloy steel, carbon steel, stainless steel, Non- Ferrous metals: magnesium, titanium, copper, nickel. Sheet holders pins: material, construction, types, accuracy and uses. Perform basic riveting operations viz., squeeze etc., riveting tools, care, maintenance, specification, description, types and their uses, method of using.(05 hrs)
		31. **Using Aluminum 2024, size 250 mm x 20 mm, perform operations of:** - Tracing - Cutting process with belt saw - Fitting process (using belt sanding machine) - Using hand drill machine - Deburring - Temporary fitting (clamping pin) - Manual and micrometric countersinking - Self-check by using rivet gauge - Riveting using rivet gun (different diameters, different thicknesses, angle profile, countersunk head and round head rivets) Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Dial indicator, Rivet gauge, Micrometer] (21 hrs)	English technical vocabulary related to the task.Metallic Material Science:properties - Physical & Mechanical Types - Ferrous & Non-Ferrous, difference between Ferrous and Non-Ferrous metals, introduction of Iron, Steel, difference between Iron, steel and Cast iron, Alloy steel, carbon steel, stainless steel, Non-Ferrous metals: Magnesium, titanium, copper, nickel. Sheet holders pins: material, construction, types, accuracy and uses. Riveting operations with Rivet gun tools, care, maintenance, specification, description, types and their uses, handling andmaintenance.(04 hrs)

		32. **Tensile test N°2:** Using Aluminum 2024, tank 250mmx20mm, make 3 riveted tensile specimens by: - Tracing with geometric constraints - Cutting process with belt saw - Fitting process (using files) - Riveting - Perform tensile tests(20 hrs)	**English technical vocabulary** related to the task. Basic study of stress-strain curve for MS.(RDM) Stress, strain, ultimate strength, factor of safety. Physical properties of engineering metal: colour, weight, structure, and conductivity, magnetic, fusibility, specific gravity. method of using. (04 hrs)
Professional Skill 50 Hrs; Professional Knowledge 07 Hrs	Produce straight and curved interchangeable metal components by sheet metal working operations and check accuracy using appropriate measuring instruments and according to required tolerance	33. **Structure parts manufacturing N°1:** Using Aluminum 2024, sheet size 400 mm x 150mm, thickness of 1.5 mm, bending radius 4,5, manufacture primary parts by performing operations of - Tracing - Cutting process with belt saw - Bending - Drilling with hand drill machine - Flanged holes Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Micrometer](21 hrs)	English technical vocabulary related to the task. Temperature measuring instruments. Specific heats of solids & liquids. Assembling techniques such as aligning, bending, fixing, mechanical jointing, threaded jointing, sealing, and torquing. (03 hrs)
		34 **Structure parts manufacturing N°2:** (Example: frames, stringers, splices) Using Aluminum 2024, sheet size 2000 mm x1000 mm thickness of 1.5 mm or 2 mm, bending radius 4,5 , manufacture primary parts with geometric constraints (angle, rounded, flatness) - Tracing - Cutting process with belt saw - Bending - Drilling with hand drill machine - Flanged holes Appropriate Measuring Instrument. [Vernier Caliper,Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Micrometer] (21 hrs)	English technical vocabulary related to the task. Thermal Conductivity, Heat loss and heat gain. Average Velocity, Acceleration & Retardation. Related problems. Sheet metal working techniques such as growing, shrinking. (04 hrs)
Professional Skill 21 Hrs; Professional Knowledge 04 Hrs	Manufacture sheet metal as per drawing and Join them by basic riveting observing standard procedure.	35. **Assembly of structure parts (by team of 2 trainees):** Using the previous manufactured parts, with Aluminum 2024, sheet size 2000 mm x 1000 mm, perform operations of: - Drilling with hand drill machine - Riveting using rivet gun, drilling grid, countersunk head and round head rivets, different diameters of rivets - Self-check by using rivet gauge - Joogling sheet metal Appropriate Measuring Instrument. [Vernier Caliper, Rivet Gauge](21 hrs)	English technical vocabulary related to the task. Circular Motion: Relation between circular motion and Linear motion, Centrifugal force, centripetal force. Drill- material, types, parts and sizes for metallic materials. Drill angle-cutting angle for different materials, cutting speed feed. R.P.M. for different materials. Drill angle holding devicesmaterial, construction and their uses. (04 hrs)

Professional Skill 84 Hrs; Professional Knowledge 16 Hrs	Perform PR sealant application on structure panels without riveting and perform a tensile test for checking the correct bonding PR sealant application.	36. **PR sealant application:** Using Aluminum 2024, sheet size 400 mm x 200 mm, perform operations of: - Tracing, Cutting process with belt saw with geometric constraints - Drilling with hand drill machine - Counter drilling - Pickling - Temporary fitting - PR sealant application Appropriate Measuring Instrument. [Vernier Caliper](21 hrs)	English technical vocabulary related to the task. Aircraft Safety Practices: Identification of ingredients with limited shelf life, how to store them and discard them. PR sealant types, uses, curing, pot life, storage, care and maintenance (04 hrs)
		37. **Tensile Test N°3:** Using Aluminum 2024, sheet size 250 mm x 20 mm, perform operations of: - Bonding PR sealant application with surface preparation on tensile specimens - Tensile tests on the realized specimens Appropriate Measuring Instrument. [Tensile test machine](21 hrs)	English technical vocabulary related to the task. PR physical properties, surfaces treatment associated. (04 hrs)
		38. **Rivets removal Using:** Aluminum 2024, sheet size 2000 mm x 1000 mm, perform rivets removals by manual drilling and using center punch and pin drift. (21 hrs)	English technical vocabulary related to the task. Solid Rivet definition, types, sizes, removal operations. (04 hrs)
		39. **Structure parts manufacturing N°3:**Using Aluminum 2024, sheet size300 mm x 100 mm, thickness of 1.5 mm, adjust curved parts by performing: - Tracing, Cutting process with Hack saw with geometric constraints - Debiting - Deburing - Bending - Adjustment and shrinking sheet metal - Clearances measurement Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Clearance gauge, Micrometer](21 hrs)	English technical vocabulary related to the task. Sheet metal working techniques such as growing, shrinking. Shrinking machine handling and maintenance. (04 hrs)

Professional Skill 42 Hrs; Professional Knowledge 08 hrs	Manufacture open and closed riveted box with two different thicknesses, bended sheets, anchor nuts nd electrical bonding	40. **Open riveted box manufacturing:** Using Aluminum 2024, different thicknesses sheet, size 400 mm x 400 mm, perform operations of : - Bending - Drilling, counter drilling - Countersinking - Riveting - Flanged hole (2 spars with thickness 1.5mm, 2 spars with thickness 2.5mm) Appropriate Measuring Instrument. [Vernier Caliper, Rivet gauge](8 hrs)	English technical vocabulary related to the task. Sheet holders pins: material, construction, types, accuracy and uses. Perform riveting operations viz., Rivet gun tools, care, maintenance, specification, description, types and their uses, method of using.(02 hrs)
		41. **Open riveted box manufacturing** on dedicated support, perform operations of: - Assemblies of anchor nuts - Assemblies of equipment and electrical harness supports - Electrical Bonding using electrical bonding brush Appropriate Measuring Instrument. [Ohmmeter] (12 hrs)	English technical vocabulary related to the task. Bonding definition, uses, protection. Bonding brush handling and maintenance(03 hrs)
		42. **Riveted closed profile manufacturing :** Using Aluminum 2024, Titanimn TA6V, sheet size 400 mm x 300 mm, Perform operations of: - Rolling, - Shaping, - Bending, - Joggling - Drilling (with angle drill machine), counter drilling - Countersinking - Riveting on sheets of different thicknesses, - Pickling - PR sealant application, / - Making flanged holes / - Making movable access door Appropriate Measuring Instrument. [Vernier Caliper, Vernier Height Gauge, Cast Iron surface plates, Vee blocks, Square, Rivet gauge, Micrometer] (22 hrs)	English technical vocabulary related to the task. Drillmaterial, types, parts and sizes for metallic materials. Drill anglecutting angle for different materials, cutting speed feed. R.P.M. for different materials. Drill angle holding devicesmaterial, construction and their uses.(03hrs)

Familiar with industrial training institute

Objectives: At the end of this lesson you shall be able to
- **explain about DGT affiliated institutions under MSDE**
- **familiarise with working of ITI using organisational chart of ITI**
- **state the function of store procedures in training institutes.**

Introduction

Directorate General of Training (DGT)

Directorate General of Training (DGT) in Ministry of Skill Development & Entrepreneurship is an apex organization for development and coordination of the vocational training including Women's Vocational Training of the employable youth in the country and to provide skilled man power to the economy.

Two verticals of Directorate General of Employment &Training (DGE&T) working under Deputy Director General (Training) & Deputy Director General (Apprenticeship Training) along with their support systems were transferred to Ministry of Skill Development & Entrepreneurship (MSDE).

DGT affiliated institutions offers a wide range of training courses catering to the needs of different segments in the Labour market. Courses are available for school leavers, ITI pass outs, ITI instructors, industrial workers, technicians, junior and middle level executives, supervisors/foremen, women, physically disabled persons and SC/STs.

It also conducts training oriented research and develops instructional media packages for the use of trainees and DGT acts a secretariat and implementing arm of National Council for Vocational Training (NCVT).

Training Institutes under DGT

- 13350 Industrial Training institutes (ITIs).
- 31 Central Institutes.
- 10 Advanced Training Institutes (ATIs).
- 2 ATI-EPIs (Advanced Training Institutes – Electronic Process Instrumentation).
- 2 Foremen Training Institutes (FTIs).
- 1 Central Training Institutes (CTI).
- 1 National Vocational Training Institute (NVTI) for Women.
- 15 Regional Vocational Training Institutes (RVTIs) for Women.
- 12 Private Institute for Training of Trainers (IToTs).
- 2 State Government IToTs.
- Central Staff Training and Research Institute (CSTARI).
- National Instructional Media Institute (NIMI).

Familiar with the working of Industrial Training Institute system including stores procedures

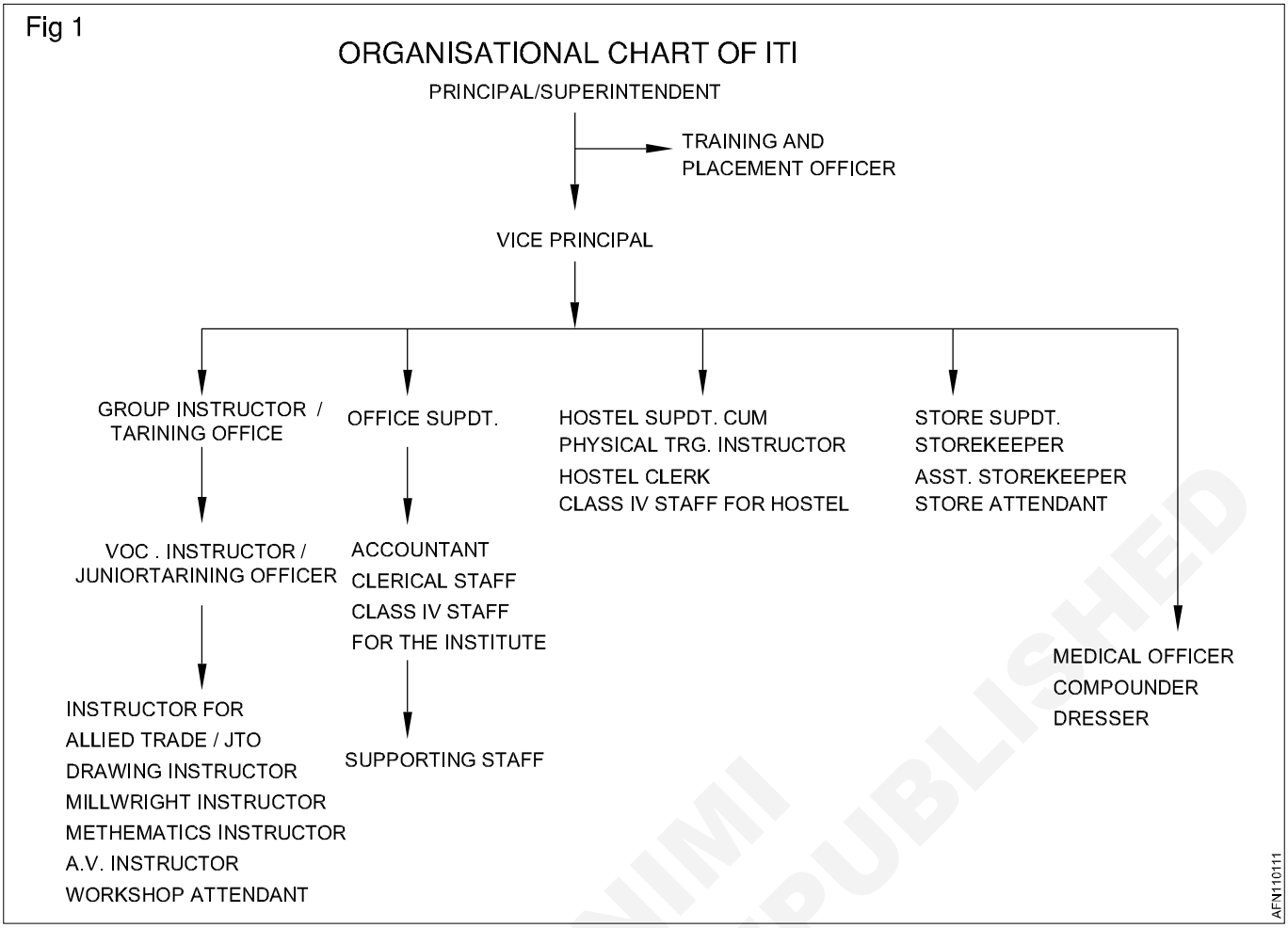
Objectives: At the end of this lesson you shall be able to
- **to familiarise with working of ITI**
- **identify the staff structure of the institute**
- **identify the available trades in the institute and their function**
- **brief about the stores procedure.**

The industrial training institute throughout India follow the same syllabus pattern given by the National council for Vocational Training (NCVT). In India, there are about 13,350 Government ITIs and Private ITI 's Based on the Govt. of India, Ministry of Skill Development and Entrepreneurship (MSDE) Annual report of 2016-2017. The Government Industrial Training Institute in each state work under the Directorate of Employment and Training which is a department under the Labour Ministry in most of the states.

The head of the industrial training institute is the Principal, under whom there is one vice-principal, Group Instructor(s) Training officers and a number of Vocational Instructor(s) Assistant Training Officer(s) and Junior Training Officer and so on as shown in the Organisation Chart of ITI (Fig 1).

In every industrial training institute, there is a store and the in charge of the store is storekeeper for inward and outward movement of tools, equipment and consumable. The instructor will indent the training requirement on receiving from stores, the instructor will issue the training requirement to the trainees according to the graded exercises as per syllabus.

Fig 1

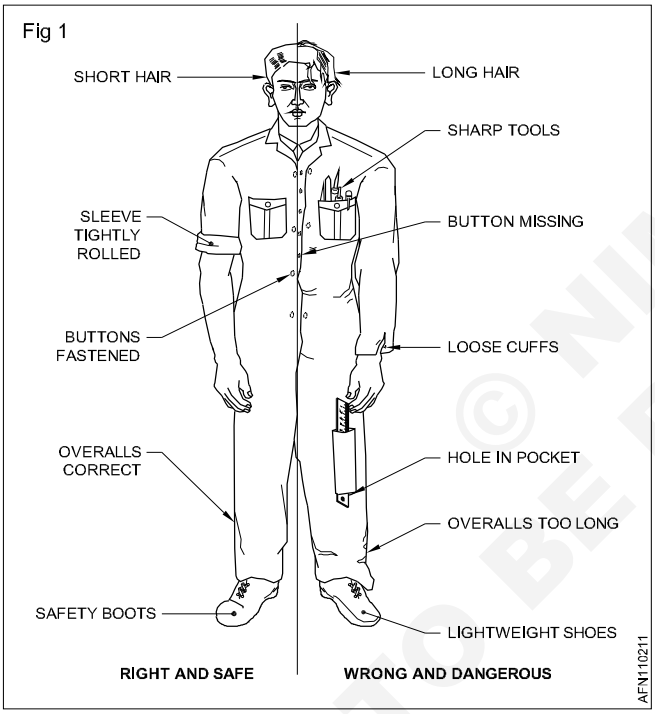


Importance of safety and general precautions observed in the industry/shop floor

Objectives: At the end of this lesson you shall be able to
- **state the importance of safety**
- **list out the safety precautions to be observed in a industry/shop floor**
- **list out the personal safety precautions to be observed in machine shop**
- **list out the safety precautions to be observed while working on the machines.**

Generally, accidents do not happen; they are caused. Most accidents are avoidable. A good craftsman, having a knowledge of various safety precautions, can avoid accidents to himself and to his fellow workers and protect the equipment from any damage. To achieve this, it is essential that every person should follow safety procedure. (Fig 1)

Fig 1



Safety in a workshop can be broadly classified into 3 categories.

- General safety.
- Personal safety.
- Machine safety.

General safety

Keep the floor and gang ways clean and clear.

Move with care in the workshop, do not run.

Don't leave the machine which is in motion.

Don't touch or handle any equipment/ machine unless authorised to do so.

Don't walk under suspended loads.

Don't cut practical jokes while on work.

Use the correct tools for the job.

Keep the tools at their proper place.

Wipe out split oil immediately.

Replace worn out or damaged tools immediately.

Never direct compressed air at yourself or at your co-worker.

Ensure adequate light in the workshop.

Clean the machine only when it is not in motion.

Sweep away the metal cuttings.

Know everything about the machine before you start it.

Personal safety

Wear Keep Don't use ties and scarves.

Roll up the sleeves tightly above the elbow.

Wear safety shoes or boots

Cut the hair short.

Don't wear a ring, watch or chain.

Never lean on the machine.

Don't clean hands in the coolant fluid.

Don't remove guards when the machine is in motion.

Don't use cracked or chipped tools.

Don't start the machine until:

- The workpiece is securely mounted.
- The feed machinery is in the neutral.
- The work area is clear.

Don't adjust clamps or holding devices while the machine is in motion.

Never touch the electrical equipment with wet hands.

Don't use any faulty electrical equipment.

Ensure that electrical connections are made by an authorised electrician only.

Concentrate on your work. Have a calm attitude.

Do things in a methodical way.

Don't engage yourself in conversation with others while concentrating on your job.

Don't distract the attention of others.

Don't try to stop a running machine with hands.

Machine safety

Switch off the machine immediately if something goes wrong.

Keep the machine clean.

Replace any worn out or damaged accessories, holding devices, nuts, bolts etc as soon as possible.

Do not attempt operating the machine until you know how to operate it properly.

Do not adjust tool or the workpiece unless the power is off.

Stop the machine before changing the speed.

Disengage the automatic feeds before switching off.

Check the oil level before starting the machine.

Never start a machine unless all the safety guards are in position.

Take measurements only after stopping the machine.

Use wooden planks over the bed while loading and unloading heavy jobs.

Safety is a concept, understand it.

Safety is a habit, cultivate it.

Approach on soft skills

Objectives: At the end of this lesson you shall be able to
- **state the concept of soft skill**
- **list the important common soft skills**
- **brief the employability aspect of training**
- **brief the further learning scope.**

Concept

Soft skills - refer to the cluster of personality traits, social graces, facility with language, personal habits, friendliness, and optimism that mark people to varying degrees. The same can also be defined as-ability to interact communicate positively & productively with others. Sometimes called "Character skills".

More and more business are considering soft skills as important job criteria. Soft skills are used in personal and professional life. Hard skills/technical skills do not matter without soft skills.

- Common Soft Skills
- Strong work ethic.
- Positive attitude.
- Good communication skills.
- Interpersonal skills.
- Time management abilities.
- Problem-solving skills.
- Team work.
- Initiative, Motivation.
- Self-confidence.
- Loyalty.
- Ability to accept and learn from criticism.
- Flexibility, Adaptability.
- Working well under pressure.

Job area completion of training: This highlights the employability aspect on completion of training. The trainee should be aware of various prospects available in present market scenario along with scope for self-employment.

For example, a trainee with NTC engineering trade may opt for:

Various job available in different industries in India and Abroad

After successful completion of ITI training in any one of the engineering trade one can see appointment in engineering workshop/Factories (Public Sector, Private Sector and Government Industries) in India and Abroad as technician/ Skilled worker.

Self-employment

One can start his own factory/ancillary unit or design products manufacture and became an entrepreneur.

Further learning scope

- Apprentice training in designated trade.
- Craft Instructor certificate course.
- Diploma in relevant Engineering.

Personal protective Equipment

Objectives: At the end of this lesson you shall be able to
- **state what is personal protective equipment and its purpose**
- **name the two categories of personal protective equipment**
- **list the most common type of personal protective equipment**
- **list the conditions for selection of personal protective equipment.**

Personal Protective Equipment (PPE)

Devices, equipments, or clothing used or worn by the employees, as a last resort, to protect against hazards in the workplace. The primary approach in any safety effort is that the hazard to the workmen should be eliminated or the workmen through the use of personal protective controlled by engineering methods rather than protecting the workmen through the use of personal protective equipment (PPE). Engineering methods could include design change, substitution ventilation, mechanical handling, automation, etc. in situations where it is not possible to introduce any effective engineering methods for controlling hazards, the workman shall use appropriate types of PPE.

As changing times have modernized the workplace, government and advocacy groups have brought more safety standards to all sorts of work environments. The Factories Act, 1948 and several other labour legislations 1996 have provisions for effective use of appropriate types of PPE.

Use of PPE is very important.

Ways to ensure workplace safety and use personal protective equipment (PPE) effectively

- Workers to get up-to date safety information from the regulatory agencies that oversees workplace safety in their specific area.
- To use all available text resources that may be in work area and for applicable safety information on how to use PPE best.
- When it comes to the most common types of personal protective equipment, like goggles, gloves or body suits, these items are much less effective if they are not worn at all times, or whenever a specific danger exists in a work process. Using PPE consistently will help to avoid some common kinds of industrial accidents.
- Personal protective gear is not always enough to protect workers against work place dangers, knowing more about the overall context of your activity can help to fully protect from anything that might threaten health and safety on the job.
- Inspection of gear thoroughly to make sure that it has the standard of quality and adequately protect the user should be continuously carried out.

Categories of PPE-Small's'

Depending upon the nature of hazard, the PPE is broadly divided into the following two categories.

Non-respiratory: Those used for protection against injury from outside the body, i.e. for protecting the head, eye, face, hand, arm, foot, leg and other body parts

Respiratory: Those used for protection from harm due to inhalation of contaminated air.

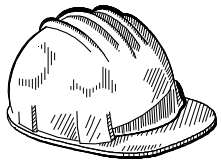
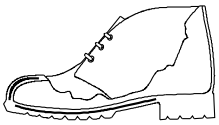
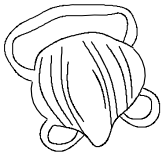
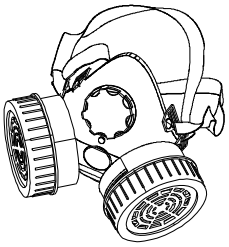
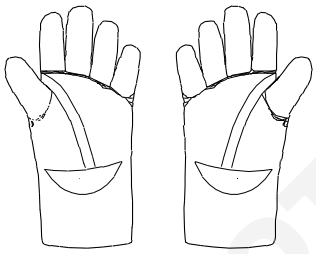
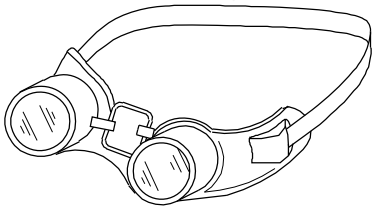
They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

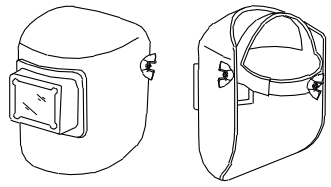
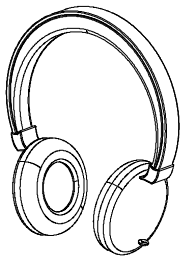
The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programmer with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

Table 1

No	Title
PPE1	Helmet
PPE2	Safety footwear
PPE3	Respiratory protective equipment
PPE4	Arms and hands protection
PPE5	Eyes and face protection
PPE6	Protective clothing and coverall
PPE7	Ears protection
PPE8	Safety belt harness

Personal protective equipments and their uses and hazards are listed in Table 2

Types of protection	Hazards	PPE to be use
Head protection (Fig 1) 	- Falling objects - Striking against objects - Spatter	Helmets Protective cap
Foot protection (Fig 2) 	- Falling objects	Safety shoes
Nose (Fig 3) 	- Dust particles - Fumes	Nose mask
Nose (Fig 4) 	Fumes/gases/vapors	Cartridge nose mask
Hand protection (Fig 4) 	- Heat burn - Cutting - Abrasion	Hand gloves
Eyes protection (Fig 5) 	- Flying dust particles - Liquid projection	Goggles

Face protection (Fig 6) 	- Flying dust particles - Liquid projection	Liquid projection Face shield
Ear protection (Fig 7 & 8) Ear muff (Fig 8) 	Hight noise level	Ear plug (Fig 7)
Body protection (Fig 9) 	- Dust projection - Cutting - Abrasion	Protective clothing

Quality of PPE's

PPE must meet the following criteria with regard to its quality-provide absolute full protection against possible hazard and PPE's be so designed and manufactured out of materials that it can withstand the hazards against which it is intended to be used.

Selection of PPE's requires certain conditions

- Nature and severity of the hazard.
- Type of contaminant, its concentration and location of contaminated area with respect to the source of respirable air.
- Expected activity of workman and duration of work, comfort of workman when using PPE.
- Operating characteristics and limitation of PPE.
- Easy of maintenance and cleaning.
- Conformity to Indian/International standards and availability of test certificate.

Proper use of PPEs

Having selected the proper type of PPE, it is essential that the workman wears it. Often the workman avoids using PPE. The following factors influence the solution to this problem.

- The extent to which the workman understands the necessity of using PPE.
- The ease and comfort with which PPE can be worn with least interference in normal work procedures.
- The available economic, social and disciplinary sanctions which can be used to influence the attitude of the workman.
- The best solution to this problem is to make wearing of PPE' mandatory for every employee.
- In other places, education and supervision need to be intensified. When a group of workmen are issued PPE for the first time.

First - aid

Objectives: At the end of this lesson you shall be able to
- **state what is first aid**
- **list the key aims of first aid**
- **explain the ABC of the first aid**
- **brief how to give first - aid for a victim who need first aid.**

First aid is defined as the immediate care and support given to an acutely injured or ill person, primarily to save life, prevent further deterioration or injury, plan to shift the victims to safer places, provide best possible comfort and finally help them to reach the medical centre/ hospital through all available means. It is an immediate life-saving procedure using all resources available within reach.

Imparting knowledge and skill through institutional teaching at younger age group in schools, colleges, entry point at industry level is now given much importance. Inculcating such habits at early age, helps to build good health care habits among people.

First aid procedure often consists of simple and basic life saving techniques that an individual performs with proper training and knowledge.

The key aims of first aid can be summarized in three key points:

- **Preserve life:** If the patient was breathing, a first aider would normally place them in the recovery position, with the patient leant over on their side, which also has the effect of clearing the tongue from the pharynx. It also avoids a common cause of death in unconscious patients, which is choking on regurgitated stomach contents. The airway can also become blocked through a foreign object becoming lodged in the pharynx or larynx, commonly called choking. The first aider will be taught to deal with this through a combination of 'back slaps' and 'abdominal thrusts'. Once the airway has been opened, the first aider would assess to see if the patient is breathing.
- **Prevent further harm:** Also sometimes called prevent the condition from worsening, or danger of further injury, this covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed becoming dangerous.
- **Promote recovery:** First aid also involves trying to start the recovery process from the illness or injury,and in some cases, might involve completing a treatment, such as in the case of applying a plaster to a small wound.

Training: Basic principles, such as knowing to use an adhesive bandage or applying direct pressure on a bleed, are often acquired passively through life experiences. However, to provide effective, life-saving first aid interventions requires instruction and practical training. This is especially true where it relates to potentially fatal illnesses and injuries, such as those that require cardiopulmonary resuscitation (CPR); these procedures may be invasive and carry a risk of further injury to the patient and the provider. As with any training, it is more useful if it occurs before an actual emergency, and in many countries, emergency ambulance dispatchers may give basic first aid instructions over the phone while the ambulance is on the way.

Training is generally provided by attending a course, typically leading to certification. Due to regular changes in procedures and protocols, based on updated clinical knowledge, and to maintain skill, attendance at regular refresher courses or re-certification is often necessary.

First aid training is often available through community organization such as the Red cross and St.John ambulance.

ABC of first aid : ABC stands for airway, breathing and circulation.

- **Airway:** Attention must first be brought to the airway to ensure it is clear. Obstruction (choking) is a life-threatening emergency.
- **Breathing:** Breathing if stops, the victim may die soon. Hence means of providing support for breathing is an important next step. There are several methods practiced in first aid.
- **Circulation:** Blood circulation is vital to keep person alive. The first aiders now trained to go straight to chest compressions through CPR methods.

When providing first aid one needs to follow some rule. There are certain basic norms in teaching and training students in the approach and administration of first aid to sick and injured.

Not to get panic: Panic is one emotion that can make the situation more worse. People often make mistake because they get panic. Panic clouds thinking and causes mistakes. First aider need calm and collective approach. If the first aider himself is in a state of fear and panic gross mistakes may result. It's far easier to help the suffering, when they know what they are doing, even if unprepared to encounter a situation.

Emotional approach and response always lead to wrong doing and may cloud one to do wrong procedures. Hence be calm and focus on the given institution. Quick and confident approach can lessen the effect of injury.

Call medical emergencies: If the situation demands, quickly call for medical assistance. Prompt approach may save the life.

Surroundings play vital role: Different surroundings require different approach. Hence first aider should study the surrounding carefully. In other words, one need to make sure that they are safe and are not in any danger as it would be of no help that the first aider himself get injured.

Do no harm: Most often over enthusiastically practiced first aid viz. Administering water when the victim is unconscious, wiping clotted blood (which acts as plug to reduce bleeding), correcting fractures, mishandling injured parts etc., would leads to more complication.

Patients often die due to wrong "FIRST AID" methods, who may otherwise easily survive.

Do not move the injured person unless the situation demands. It is best to make him lie wherever he is because if the patient has back, head or neck injury, moving him would causes more harm.

This does not mean do nothing. It means to make sure that to do something the care givers feel confident through training would make matters safe. If the first aider is not confident of correct handling it is better not to intervene of do it. Hence moving a trauma victim, especially an unconscious one, need very careful assessment.

Removals of an embedded objects (Like a knife, nail) from the wound may precipitate more harm (e.g. increased bleeding). Always it is better to call for help.

Reassurance: Reassure the victim by speaking encouragingly with him.

Stop the bleeding: If the victim is bleeding, try to stop the bleeding by applying pressure over the injured part.

Golden hours: India have best of technology made available in hospitals to treat devastating medical problem viz. head injury, multiple trauma, heart attack, strokes, etc., but patients often do poorly because they don't gain access to that technology in time. The risk of dying from these conditions, is greatest in the first 30 minutes, often instantly.

This period is referred to as Golden period. By the time the patient reach hospitals, they would have passed that critical period. First aid care come handy to save lives. It helps to get to the nearest emergency room as quickly aspossible through safe handling and transportation. The shorter that time, the more likely the best treatment applied.

Maintain the hygiene: Most importantly, first aider needs to wash hands and dry before giving and first aid treatment to the patient or wear gloves in order to prevent infection.

Cleaning and dressing: Always clean the wound thoroughly before applying the bandage lightly wash the wound with clean water. Not to use local medications on cuts or open wounds. They are more irritating to tissue than it is helpful. Simple dry cleaning or with water and some kind of bandage are best.

CPR (Cardio-Pulmonary Resuscitation) can be life-sustaining: CPR can be life sustaining. If one is trained in CPR and the person is suffering from choking or finds difficulty in breathing, immediately begin CPR. However, if one is not trained in CPR, do not attempt as you can cause further injury. But some people do it wrong. This is a difficult procedure to do in a crowded area.

Also, there are many studies to suggest that no survival advantage when by standers deliver breaths to victims compared to when they only do chest compressions. Second, it is very difficult to carry right manoeuvre in wrong places. But CPR, if carefully done by highly skilled first aiders is a bridge that keeps vital organs oxygenated until medical team arrives.

Declaring death: It is not correct to declare the victim's death at the accident site. It has to be done by qualified medical doctors.

How to report an emergency?

Reporting an emergency is one of those things that seems simple enough, until actually when put to use in emergency situations. A sense of shock prevails at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passer-by would like to get involved to assist the victims. Hence first aid management is often very difficult to attend to the injured persons.

The first aiders need to adapt multi-task strategy to control the crowd around, communicate to the rescue team, call ambulance etc., all to be done simultaneously. The mobile phones help to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A crime, especially one that is currently in progress. If you're reporting a crime, give a physical description of the person committing the crime.
- A fire - If you're reporting a fire, describe how the fire stated and where exactly it is located. If someone has already been injured or is missing, report that as well.
- A life-threatening medical emergency explain how the incident occurred and what symptoms the person currently displays.
- A car crash - Location, serious nature of injures, vehicle's details and registration, number of people involved etc.

Call emergency service: The emergency number varies - 100 for Police & Fire 108 for Ambulance.

Report your location: The first thing the emergency dispatcher will ask is where you are located, so the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.

Give the dispatcher your phone number: This information is also imperative for the dispatcher to have, so that he or she can call back if necessary.

Describe the nature of the emergency: Speak in a calm, clear voice and tell the dispatcher why you are calling. Give the most important details first, then answer the dispatcher's follow-up question as best as you can.

Do not hang up the phone until you are instructed to do so. Then follow the instructions you were given.

Basic first aid: Basic first aid refers to the initial process of assessing and addressing the needs of someone who has been injured or is in physiological distress due to choking, a heart attack, allergic reactions, drugs or other medical emergencies. Basic first aid allows one to quickly determine a person's physical condition and the correct course of treatment.

Important guideline for first aiders

Evaluate the situation: Are there things that might put the first aider at risk. When faced with accidents like fire, toxic smoke, gasses, an unstable building, live electrical wires or other dangerous scenario, the first aider should be very careful not to rushin to a situation, which may prove to be fatal.

Remember ABC's: The ABCs of first aid refer to the three critical things the first aiders need to look for.

- Airway - Does the person have an unobstructed airway?
- Breathing - Is the person breathing?
- Circulation - Does the person show a pulse at major pulse points (wrist, carotid artery, groin)

Avoid moving the victim: Avoid moving the victim unless they are in immediate danger. Moving a victim will often make injuries worse, especially in the case of spinal cord injuries.

Call emergency services: Call for help or tell someone else to call for help as soon as possible. If alone in at the accident scene, try to establish breathing before calling for help, and do not leave the victim alone unattended.

Determine responsiveness: If a person is unconscious, try to rouse them by gently shaking and speaking to them.

If the person remains unresponsive, carefully roll them on the side (recovery position) and open his airway.

- Keep head and neck aligned.
- Carefully roll them onto their back while holding his head.
- Open the airway by lifting the chin. (Fig 1)

Fig 1

AFN110311

Look, listen and feel for signs of breathing

Look for the victim's chest to raise and fall, listen for sounds of breathing. If the victim is not breathing, see the section below;

- If the victim is breathing, but unconscious, roll the monto their side, keeping the head and neck aligned with the body. This will help drain the mouth and prevent the tongue or vomit from blocking the airway.

Check the victim's circulation: Look at the victim's colour and check their pulse (the carotid artery is a good option; it is located on either side of the neck, below the jaw bone or take the pulse at the wrist with three fingers). If the victim does not have a pulse, start CPR.

Treat bleeding, shock and other problems as needed

After establishing that the victim is breathing and has a pulse, next priority should be to control any bleeding.

Particularly in the case of trauma, preventing shock is the priority.

- **Stop bleeding:** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock:** Shock, a loss of blood flow from the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental status, and have pale colour to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.
- **Choking victim:** Choking can cause death or permanent brain damage within minutes.
- **Treat a burn:** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth.

  Remove clothing and jewellery from the burn, but do not try to remove charred clothing that is stuck to burns.

- **Treat a concussion:** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are: loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea, and lethargy.
- **Treat a spinal injury victim:** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Stay with the victim until help arrives : Try to be a calming presence for the victim until assistance can arrive.

Unconsciousness (COMA): Unconscious also referred as Coma, is a serious life-threatening condition, when a person lie totally senseless and do not respond to calls, external stimulus. But the basic heart, breathing, blood circulation may be still intact, or they may also be failing. If unattended it may lead to death.

The condition arises due to interruption of normal brain activity. The causes are too many.

- Shock (Cardiogenic, Neurogenic)
- Head injury (Concussion, Compression)
- Asphyxia (obstruction to air passage)
- Extreme of body temperature (Heat, Cold)
- Cardiac arrest (Heart attack)
- Stroke (Cerebro-vascular accident)
- Blood loss (Haemorrhage)
- Dehydration (Diarrhoea & vomiting)
- Diabetes (Low or high sugar)
- Blood pressure (Very low or very high)
- Over dose of alcohol, drugs
- Poisoning (Gas, Pesticides, Bites)
- Epileptic fits (Fits)
- Hysteria (Emotional, Psychological)

The following symptoms may occur after a person has been unconscious:

- Confusion
- Drowsiness
- Headache
- Inability to speak or move parts of his or her body (see stroke symptoms)
- Light headedness
- Loss of bowel or bladder control (incontinence)
- Rapid heart beat (palpitation)
- Stupor

First aid

- Call "EMERGENCY" number.
- Check the person's airway, breathing, and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.
- If there is a spinal injury, the victims position may haveto be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.
- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they become conscious.

DO NOT

- Do not give an unconscious person any food or drink.
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face to try to revive him.

Loss of consciousness may threaten life if the person is on his back and the tongue has dropped to the back of the throat, blocking the airway.

Make certain that the person is breathing before looking for the cause of unconsciousness. If the injuries permit, place the casualty in the recovery position with the neck extended. Never give anything by mouth to an unconscious casualty.

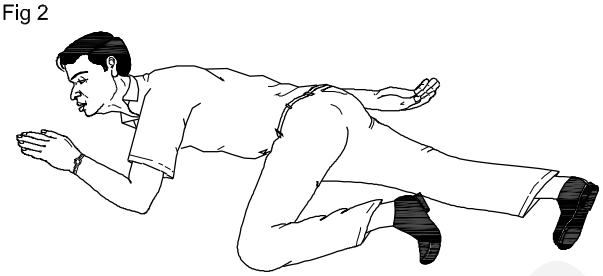
How to diagnose an unconscious injured person

- **Consider alcohol:** look for signs of drinking, like empty bottles or the smell of alcohol.
- **Consider epilepsy:** are there signs of a violent seizure, such as saliva around the mouth or a generally dishevelled scene?
- **Think insulin:** might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock")?
- **Think about drugs:** was there an overdose? Or might the person have under dosed - that is not taken enough of a prescribed medication?

- **Consider trauma:** is the person physically injured?
- **Look for signs of infection:** redness and/ or red streaks around a wound.
- **Look around for signs of Poison:** an empty bottle of pills or a snake bite wound.
- **Consider the possibility of psychological trauma:** Might the person have a psychological disorder of some sort?
- Consider stroke, particularly for elderly people.
- Treat according to what you diagnose.

Shock: A severe loss of body fluid will lead to a drop-in blood pressure. Eventually the blood's circulation will deteriorate, and the remaining blood flow will be directed to the vitalorgans such as the brain. Blood will therefore be directed away from the outer area of the body, so the victim will appear pale and the skin will feel ice cold.

Fig 2



Guidelines for good shop floor maintenance

Objectives: At the end of this lesson you shall be able to
- **list the benefits of a shop floor maintenance**
- **state what is 5S**
- **list the benefits of 5S.**

Benefits of a shop floor maintenance : Some of the benefits which may be derived from the utilisation of a good Shop Floor Maintenance are as follows:

- Improved productivity.
- Improved operator efficiencies.
- Improved support operations such as replenishment moves and transportation of work in process and finished goods.
- Reduction of scrap.
- Better control of your manufacturing process.
- More timely information to assist shop floor supervisors in managing their assigned production responsibilities.
- Reduction of down time due to better machine and tool monitoring.
- Better control of work in progress inventory, what is and where it is improved on time schedule performance.

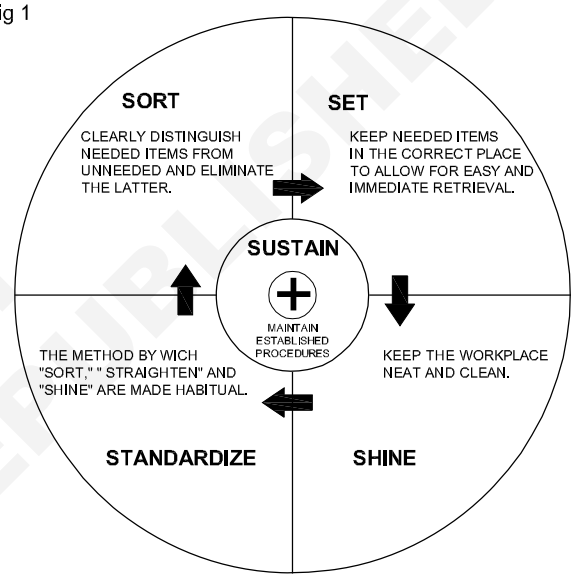
5S concept: 5S is a Japanese methodology for works place organisation. In Japanese, it stands for seiri (SORT),seiton (SET), seiso (SHINE), seiketsu (STANDARDIZE) and shitsuke (SUSTAIN).

The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. The list describes how to organize a work space for efficiency and effectiveness by identifying and storing the items used. maintaining the area and items, and sustaining the new order.

5S Wheel (Fig 1): The Benefits of the 5s system

- Increases in productivity.
- Increases in quality.
- Reduction in cost.

Fig 1



Importance of housekeeping

Objectives: At the end of this lesson you shall be able to
- **list the steps involves in housekeeping**
- **state good shop floor practices followed in industry.**

Housekeeping: The following activities to be performed for better up keep of working environment:

1 **Cleaning of shop floor:** Keep clean and free from accumulation of dirt and scrap daily.

2 **Cleaning of Machines:** Reduce accidents to keep machines cleaned well.

3 **Prevention of Leakage and spillage:** Use splash guards in machines and collecting tray.

4 Disposal of Scrap- Empty scrap, wastage, swarf from respective containers regularly.

5 Tools Storage - Use special racks, holders for respective tools.

6 **Storage Spaces:** Identify storage areas for respective items. Do not leave any material in gangway.

7 Piling Methods- Do not overload platform, floor and keep material at safe height.

8 **Material handling:** Use forklifts, conveyors and hoist according to the volume and weight of the package.

Good shop floor practices followed in industry

Good Shop floor practices are motivating action plans for improvement of the manufacturing process.

- All workers are communicated with daily target on manufacturing, activities.
- Informative charts are used to post production, quality and safety results compared to achievements.
- Workers are trained on written product quality standards.
- Manufactured parts are inspected to ensure adherence to quality standards.
- Production processes are planned by engineering to minimize product variation.
- 5S methods are used to organize the shop floor and production lines.
- Workers are trained on plant safety practices in accordance with Occupational Safety Health (OSH) standards.
- Workers are trained on "root cause" analysis for determining the causes of not following.
- A written preventive maintenance plan for up keep of plant, machinery & equipment.
- Management meets with plant employees regularly to get input on process improvements.
- Process Improvement Teams are employed to implement "best practices".

Disposal of waste material

Objectives: At the end of this lesson you shall be able to
- **state what is waste material.**
- **list the waste materials in a workshop**
- **explain the methods of disposal of waste material**
- **state advantage of disposal of waste material**
- **state colour code for bins for waste segregation.**

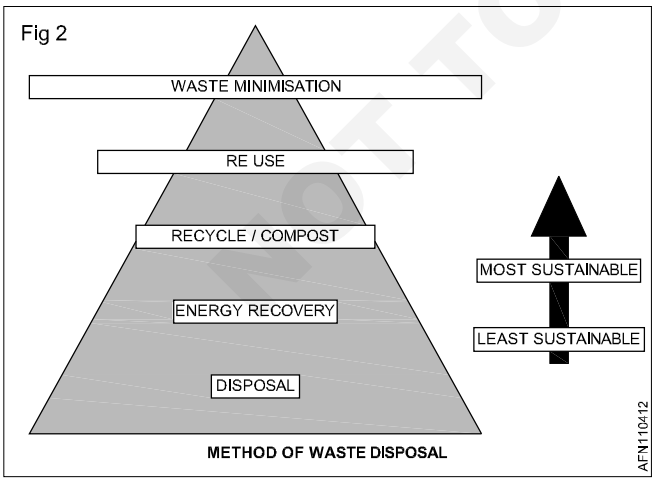
Waste material: Industrial waste is the waste produced by industrial activity such as that of factories, mills and mines.

List of waste material

- Cotton waste.
- Metal chips of different material.
- Oily waste such as lubricating oil, coolant etc.
- Other waste such electrical, glass etc.

Methods of waste disposal

Fig 2



METHOD OF WASTE DISPOSAL

Recycling: Recycling is one of the most well-known method of managing waste. It is not expensive and can be easily done by you.

If you carry out recycling. you will save a lot of energy, resources and there by reduce pollution.

Composting: This is a natural process that is completely free of any hazardous by-products. This process involves breaking down the materials into organic compounds that can be used as manure.

Landfills: Waste management through the use of landfills, involves the use of a large area. This place is dug open and filled with the waste.

Burning the waste material: If you cannot recycle or if there are no proper places for setting up landfills, you can burn the waste matter generated in your household. Controlled burning of waste at high temperatures to produce steam and ash is a preferred waste disposal technique.

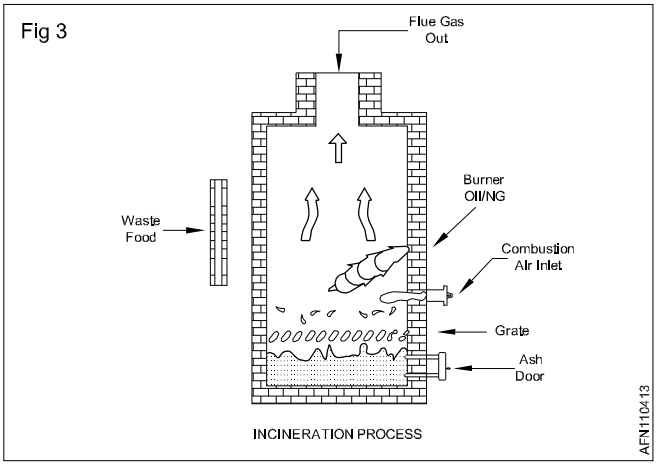
Advantage of waste disposal:

- Ensures workshop neat & tidy.
- Reduces adverse impact on health.
- Improves economic efficiency.
- Reduce adverse impact on environment.

Incineration (Fig 3)

It is the process of controlled combustion of garbage to reduce it to incombustible matter, ash, waste gas and heat. It is treated and released into the environment .This reduced 90% volume of waste, sometime the heat generated used to produce electric power.

Fig 3



INCINERATION PROCESS

Waste compaction: The waste materials such as cans and plastic bottles compact into blocks and send for recycling. This process space need, thus making transportation and positioning easy.

Color code for bins for waste segregation given in table-1.

Table 1

S.No	Waste Material	Color code
1	Paper	Blue
2	Plastic	Yellow
3	Metal	Red
4	Glass	Green
5	Food	Black
6	Others	Sky blue

Occupational health and safety

Objectives: At the end of this lesson you shall be able to
- **define safety**
- **state the goal of occupational health and safety**
- **explain need of occupational health and safety**
- **state the occupational hygiene**
- **explain occupational hazards**
- **brief the occupational disease.**

Safety: Safety means freedom or protection from harm, danger, hazard, risk, accident, injury or damage.

Occupational health and safety

- Occupational health and safety is concerned with protecting the safety, health and welfare of people engaged in work or employment.
- The goal is to provide a safe work environment and to prevent hazards.
- It may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are affected by the workplace environment.
- It involves interactions among many related areas, including occupational medicine, occupational (or industrial) hsygiene, public health, and safety engineering, chemistry, and health physics.

Need of occupational health and safety

- Health and safety of the employees is an important aspect of a company's smooth and successful functioning.
- It is a decisive factor in organizational effectiveness. It ensures an accident-free industrial environment.
- Proper attention to the safety and welfare of the employees can yield valuable returns.
- Improving employee morale.
- Reducing absenteeism.
- Enhancing productivity.
- Minimizing potential of work-related injuries and illnesses.
- Increasing the quality of manufactured products and / rendered services.

Occupational (Industrial) hygiene

- Occupational hygiene is anticipation, recognition, evaluation and control of work place hazards (or) environmental factors (or) stresses
- This is arising in (or) from the workplace.
- Which may cause sickness, impaired health and well-being (or) significant discomfort and inefficiency among workers.

Anticipation (Identification): Methods of identification of possible hazards and their effects on health.

Recognition (Acceptance): Acceptance of ill-effects ofthe identified hazards

Evaluation (Measurement & Assessment): Measuring or calculating the hazard by Instruments, Air sampling and Analysis, comparison with standards and taking judgement whether measured or calculated hazard is more or less than the permissible standard.

Control of workplace hazards: Measures like Engineering and Administrative controls, medical examination use of Personal Protective Equipment (PPE) education, training and supervision.

Occupational hazards

"Source or situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment, or a combination of these"

Types of occupational health hazards

- Physical Hazards
- Chemical Hazards
- Biological Hazards
- Physiological Hazards
- Psychological Hazards
- Mechanical Hazards
- Electrical Hazards
- Ergonomic Hazards

1 Physical hazards

- Noise
- Heat and cold stress
- Vibration
- Radiation (ionising & Non-ionising)
- Illumination etc.

2 Chemical hazards

- Inflammable
- Explosive

- Toxic
- Corrosive
- Radioactive

3 Biological hazards

- Bacteria
- Virus
- Fungi
- Plant pest
- Infection

4 Physiological

- Old age
- Sex
- Ill health
- Sickness
- Fatigue.

5 Psychological

- Wrong attitude
- Smoking
- Alcoholism
- Unskilled
- Poor discipline
- Absenteeism
- Disobedience
- Aggressive behavior
- Accident proneness etc.
- Emotional disturbances
- violence
- bullying
- sexual harassment

6 Mechanical

- Unguarded machinery
- No fencing
- No safety device
- No control device etc.

7 Electrical

- No earthling
- Short circuit
- Current leakage
- Open wire
- No fuse or cut off device etc.

8 Ergonomic

- Poor manual handling technique
- Wrong layout of machinery
- Wrong design
- Poor housekeeping
- Awkward position
- Wrong tools etc.

Safety Slogan

A safety rule breaker, is an accident maker

Safety practice

Objectives: At the end of this lesson you shall be able to
- **state the responsibilities of employer and employees**
- **state the safety attitude and list the fpur basic categories of safety signs.**

Safety: The state of being safe, freedom from the occurrence or risk of injury, danger or loss.

Responsibilities: Safety doesn't just happen - it has to be organised and achieved like the work-process of which it forms a part. The law states that both an employer and his employees have a responsibility in this behalf.

Employer's responsibilities: The effort a firm puts into planning and organising work, training people, engaging skilled and competent workers, maintaining plant and equipment, and checking, inspecting and keeping records - all of this contributes to the safety in the workplace.

The employer will be responsible for the equipment provided, the working conditions, what the employees are asked to do, and the training given.

Employee's responsibilities: You will be responsible for the way you use the equipment, how you do your job, the use you make of your training, and your general attitude to safety.

A great deal is done by employers and other people to make your working life safer; but always remember you are responsible for your own actions and the effect they have on others. You must not take that responsibility lightly.

Rules and procedure at work: What you must do, by law is often included in the various rules and procedures laid down by your employer. They may be written down, but more often than not, are just the way a firm does things - you will learn these from other workers as you do your job. They may govern the issue and use of tools, protective clothing and equipment, reporting procedures, emergency drills, access to restricted areas, and many other matters. Such rules are essential and they contribute to the efficiency and safety of the job.

Safety signs: As you go about your work on a construction site you will see a variety of signs and notices. Some of these will be familiar to you - a 'no smoking' sign for example; others you may not have seen before. It is up to you to learn what they mean - and to take notice of them. They warn of the possible danger, and must not be ignored.

Safety signs fall into four separate categories. These can be recognised by their shape and color. Sometimes they may be just a symbol; other signs may include letters or figures and provide extra information such as the clearance height of an obstacle or the safe working load of a crane.

The four basic categories of signs are as follows:

- Prohibition signs (Fig 1 & Fig 5)
- Mandatory signs (Fig 2 & Fig 6)
- Warning signs (Fig 3 & Fig 7)
- Information signs (Fig 4& Fig 8)

Fig 1

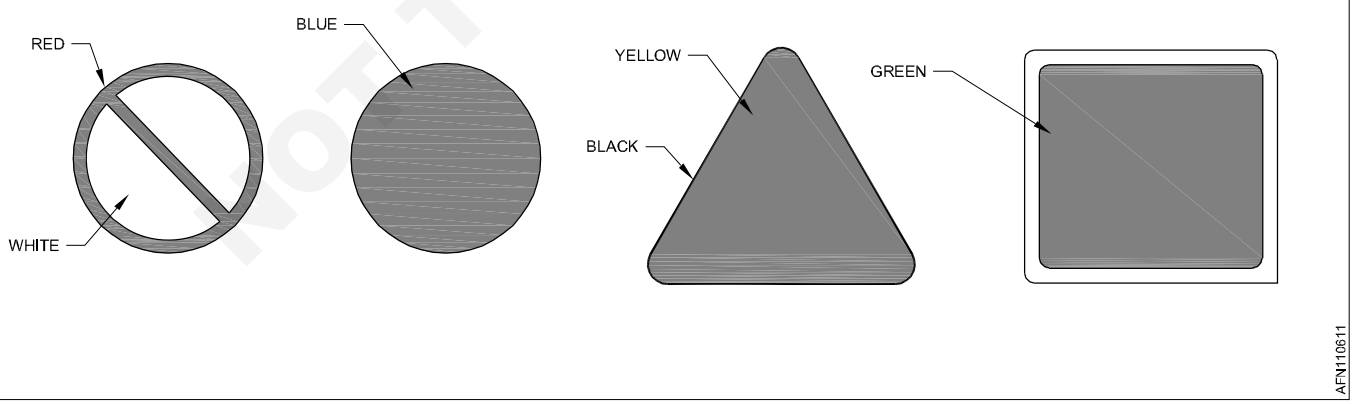


Fig 2

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Fig 3

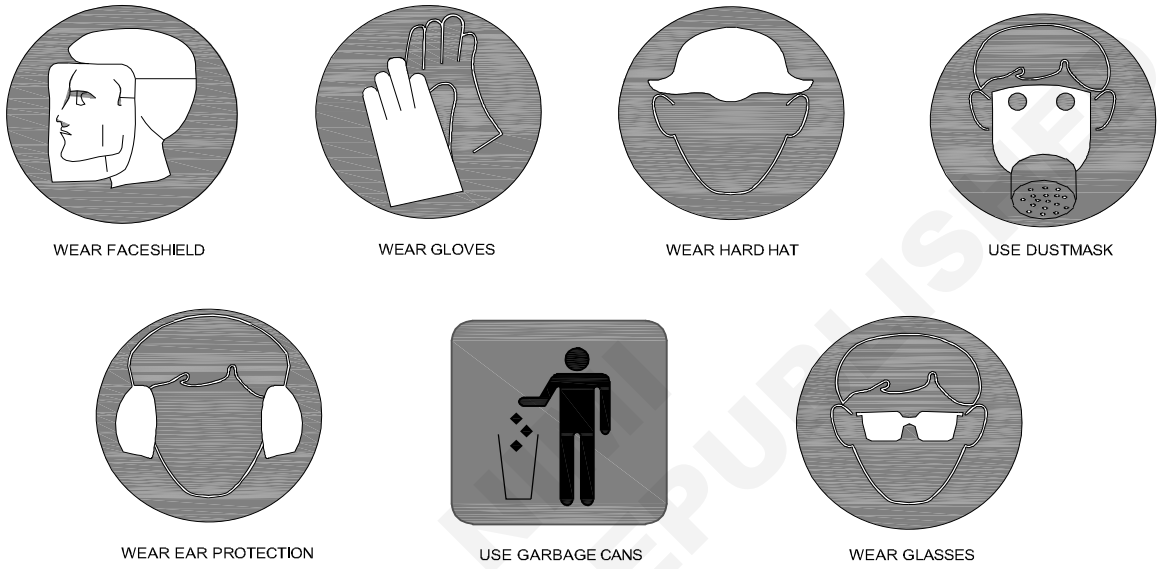

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Fig 4

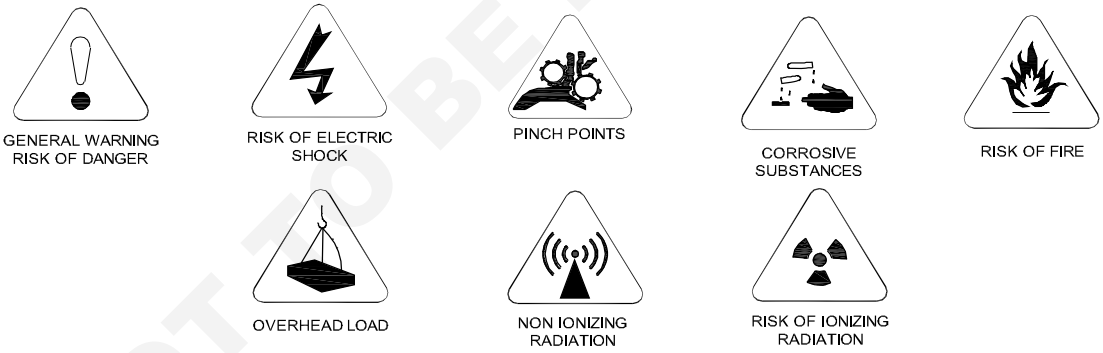

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Fig 5

AFN110615

Response to emergencies - Power failure, System failure & Fire

Objectives: At the end of this lesson you shall be able to
- **state the reason of emergency power failure**
- **state the cause of system failure**
- **state the fire safety and immediate actions.**

1 If there is a power failure, start the emergency generator.

This provides power to close the shutter, which is the first priority. The generator will also keep the UPS sand the cryogenic compressors running,

- Get a flash light.
- Look out for power transfer switch and switch over to normal power to emergency power by pressing the latch.
- Check the fuel valves open or not - Open the valves.
- Check to see that the main breaker switch ON the generator is in OFF position.
- Move the starter switch of the generator to run position. The engine will start at once.
- Allow few minutes to warm up the engine.
- Check all the gauges, pressure, temperature, voltage and frequency.
- Check the "AC line" and "Ready" green light on the front panel.

2 System failure

- If the bug or virus, invades the system. The system failure happens.
- Several varieties of bugs are there
  1 Assassin bug
  2 Lightening bug
  3 Brain bug
- For more details refer instruction manual for "System failure".

3 Fire failure

When fire alarm sounds in your buildings

- Evacuate to outside immediately.
- Never go back
- Make way for fire fighters and their trucks to come
- Never use an elevator
- Do not panic

Reporting emergency

Objectives: At the end of this lesson you shall be able to
- **explain the report an emergency**
- **report through emergency services.**

Report an emergency: Reporting an emergency is one of those things that seems simple enough, until actually when put to use in emergency situations. A sense of shock prevails at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passer-by would like to get involved to assist the victims.

Hence first aid managements are often very difficult to attend to the injured persons. The first aiders need to adapt multi-task strategy to control the crowd around, communicate to the rescueteam, call ambulance etc,. all to be done simultaneously. The mobile phones help to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure that the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A fire - If you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured, missing, report that as well.
- A life - threatening medical emergency, explain how the incident occurred and what symptoms the person currently displays.

Call emergency service: The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location: The first thing the emergency dispatcher will ask where you are located, so the emergency services can get thereas quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.

Operation of electrical mains/ circuit breakers and electrical safety

Objectives: At the end of this lesson you shall be able to
- **understand the operation of electrical mains/circuit breaker**
- **state the importance of electrical safety.**

Electrical safety

Electric shock : If a person happens to come in contact with an electrical live wire and if he has not insulated himself, then electric current flows through his body. Since the human body cannot with stand current flow more than a few tens of milliamps, the human body suffers a phenomenon generally known as electric shock. Electric shock may turn out to be hazardous to some of the parts of the human body and some times even to the life of the person. The severity of an electric shock depends on:

- the level of current passing through the body
- how long does the current keep passing through the body.

Therefore, the higher the current or longer the time, the shock may result in a causality.

In addition to the above factors, other factors which influences the severity of shock are:

- age of the person receiving a shock
- surrounding weather condition
- condition of the floor (wet or dry)
- voltage level of electricity
- insulating property of the footwear or wet footwear, and so on.

Effects of electric shock : The effect of electric shock at very low voltage levels (less than 40V) may only be an unpleasant tingling sensation. But this shock itself may be sufficient to cause someone to lose his balance and fall, resulting in casualty.

At higher voltage levels the muscles may contract and the person will be unable to break off from the contact by himself. He may lose consciousness. The muscles of the heart may contract spasmodically (fibrillation). This may even turn out to be fatal.

At an excessive level of voltage, the person receiving a shock may be thrown off his feet and will experience severe pain and possibly burns at the point of contact. This in most cases is fatal.

Electric shock can also cause burning of the skin at the point of contact.

Action to be taken in case of an electric shock

If the victim of an electric shock is in contact with the supply, break the contact the victim is making with the electricity by any one or more of the following.

Switch off the electric power, insulate yourself and pull away the person from the electrical contact

or

Remove the mains electric plug. Avoid direct contact with the victim. Wrap your hands using dry cloth or paper, if rubber gloves are not available.

or

Remove the electric contact made by wrenching the cable/equipment/point free from contact using whatever is at hand to insulate yourself such as a wooden bar, rope, a scarf, the victim's coat-tails, any dry article of clothing, a belt, rolled up newspaper, non-metallic hose, PVC tubing, baked paper, tube etc,. and break the contactby pushing or pulling the person or the cable/equipment/point free

or

Stand on some insulating material such as dry wood, rubber or plastic, or whatever is at hand to insulate yourself and break the contact by pushing or pulling the person or the cable/equipment/point free.

If you are uninsulated, do not touch the victim with your bare hands. Otherwise you also will get a shock and become a victim.

If the victim is aloft(working on a pole or at raised place), take suitable measures to prevent him from falling orat least ensure that his fall is safe.

Treatment to be given for the victim of electric shock

Electric burns on the victim may not look big/large. But it may be deep rooted. Cover the burnt area with a clean, sterile dressing. Get a doctor's help to treat him as quickly as possible.

If the victim is unconscious after an electric shock, but is breathing, carry out the following first aid:

- loosen the clothing at the neck, chest and waist
- place the victim in the recovery position.
- Keep a constant check on the breathing and pulse rate. If you find them feeble, immediately give artificial respiration and press the lower rib to improve the heart beat.
- Keep the casualty warm and comfortable.
- Send for a doctor immediately.

Do not give an unconscious person anything through the mouth.

Do not leave a unconscious person unattended.

A person having received electric shock may also have burn injuries. DO NOT waste time by applying first aid to the burns until breathing has been restored and the patient can breathe normally unaided.

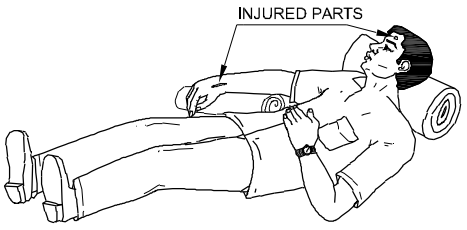
Treatment to be given in case of burns, severe bleeding

Burns caused due to electrical shock are very painful. If a large area of the body is burnt, clean the wound using clear water, or with clean paper, or a clean shirt. This treatment relieves the victim of pain. Do not give any other treatment on your own. Send for a doctor for further treatment.

A wound which is bleeding profusely, especially in the wrist, hand or fingers must be considered serious and must receive a doctor's attention. As an immediate first aid measure, carry out the following:

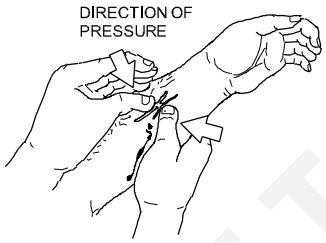
- make the patient lie down and rest
- if possible, raise the injured part above the level of the body as shown in Fig 1.

Fig 1



Squeeze together the sides of the wound as shown in Fig 2. Apply pressure as long as it is necessary to stop the bleeding.

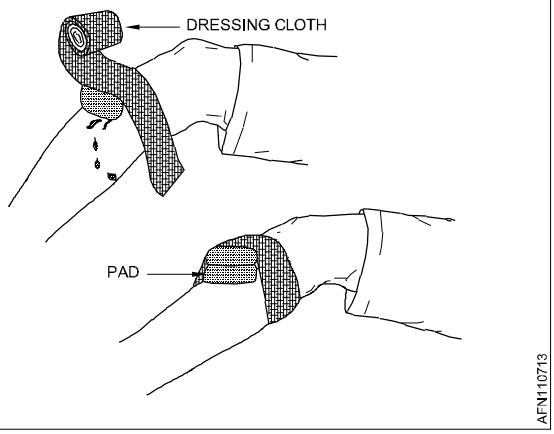
Fig 2



When the bleeding stops temporarily, put a dressing over the wound using sterilized cotton, and cover it with a pad of soft material as shown in Fig 3.

If the wound is in the abdominal area (stab wound), caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.

Fig 3



General procedural steps to be adopted for treating a person suffering from an electrical shock.

1 Observe the situation. Choose the appropriate method (listed in earlier paragraphs) to release the person from electrical contact.

Do not run to switch off the supply that is far away or start searching for the mains switch.

2 Move the victim gently to the nearest ventilated place.

3 Check the victim's breathing and consciousness. Check if there are injuries in the chest or abdomen. Give artificial respiration/applying pressure on the heart if found necessary (refer in this lesson/exercise).

Use the most suitable method of giving artificial respiration depending upon the injuries if any on the chest/abdomen.

4 Send for a doctor.

Till the doctor arrives, you stay with the victim and render help as best as you can.

5 Place the victim in the recovery position.

6 Cover the victim with a coat, socks or any such thing to keep the victim warm.

Actions listed above must be taken systematically and briskly. Delay in treating the patient may endanger his life.

Area of control of switches - operation on emergency

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

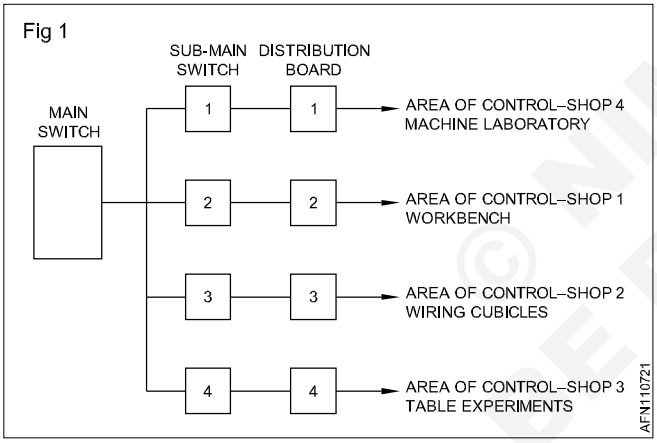
- **explain the report an emergency**
- **explain the term 'emergency'**
- **explain the need to switch off the circuit during emergency**
- **explain the method of locating the area sub-main and switches in the shop floor**
- **explain the position of handle with respect to ON & OFF in case of iron clad switches, MCB and ordinary household switches**

An emergency is an unexpected occurrence and requires immediate action. In a place like a workshop such a situation can arise when a person gets a shock due to electrical current or a person gets injured by the rotating part of a machine.

In such situations, switching off the supply will be the first and best solution to avoid further damage to the victim. For this, every person involved in the workshop should know which switch controls the area where the victim of shock remains.

Normally the total wiring in a workshop is controlled by a main switch and the different areas within the workshop may have two or more sub-main switches as shown in Fig 1.

Fig 1



To ascertain the area of the sub-main control, switch off one of the sub-main switches and try to switch 'on' the lights, fans and power points in that suspected area. If they do not work, then the area covered by the fan, light and power points are controlled by the sub-main switch. One after another, switch off the sub-main switches and locate their area of control. Mark the area of control of the switch in the plan of the wireman's section.

In a well organised workshop, the main switch, the sub main switches and distribution ways will have clear marking to show their area of control. (Fig 1) If this is not found, do this now. However, If you are not sure about the area of control the sub-main of the switches it is always better to switch 'off' the main switch itself.

The handle of iron clad switches and the knob of MCB should be pushed down to switch 'off ' the circuits as shown in Fig 2. where as in the ordinary switches, the switch off the circuit should be done by pushing the switch to upward position. (Fig 3)

Fig 2

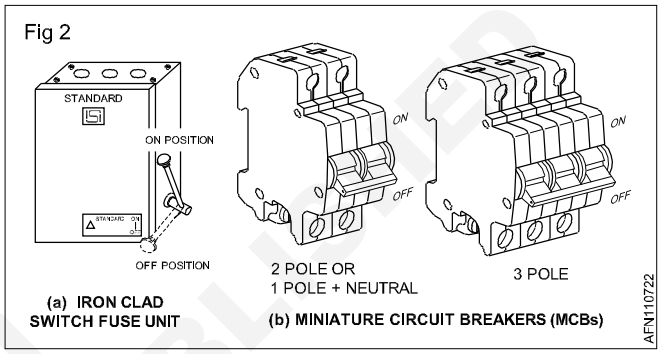
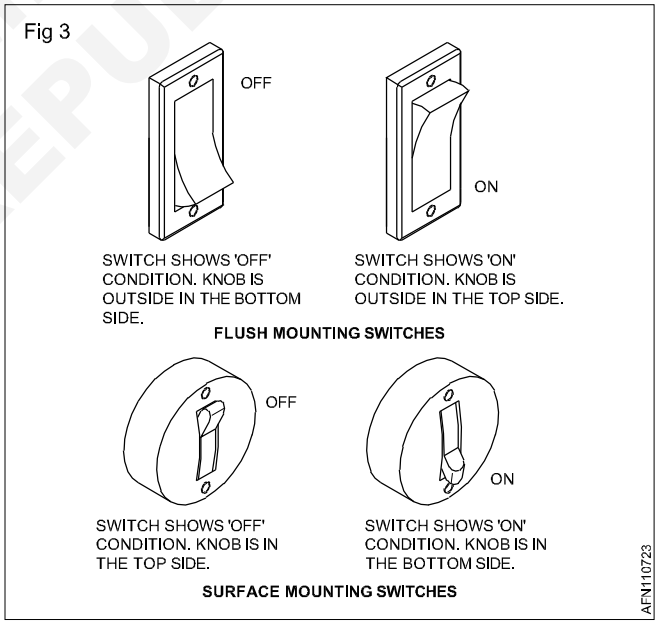


Fig 3



The emergency situations could happen even at home. Hence, identify the area of control of the switch and mark them in the main/sub-main/ distribution bound of your house switch board as a safety measure. Educate the intimates of the house how to switch off the circuit in case of any emergency.

Safety rules on electrical equipments

Objectives: At the end of this lesson you shall be able to
- **explain the necessary of adopting the safety rules**
- **list the safety rules and follow them.**

Safety rules

Necessity of safety rules: Safety consciousness is one of the essential attitudes required for any job. A skilled electrician always should strive to form safe working habits. Safe working habits always save men, money and material.

Unsafe working habits always end up in loss of production and profits, personal injury and even death. The safety hints given below should be followed by Electrician to avoid accidents and electrical shocks as his job involves a lot of occupational hazards.

The listed safety rules should be learnt, remembered and practiced by every electrician. Here a electrician should remember the famous proverb, “Electricity is a good servant but a bad master”.

Safety rules

- Only qualified persons should do electrical work
- Keep the workshop floor clean, and tools in good condition.
- Do not work on live circuits, if unavoidable, use rubber gloves rubber mats, etc.
- Use wooden or PVC insulated handle screw drivers when working on electrical circuits.
- Do not touch bare conductors.
- When soldering, place the hot soldering irons in their stand. Never lay switched ‘ON’ or heated soldering iron on a bench or table as it may cause a fire to break out.
- Use only correct capacity fuses in the circuit. If the capacity is less it will blow out when the load is connected. If the capacity is large, it gives no protection and allows excess current to flow and endangers men and machines, resulting in loss of money.
- Replace or remove fuses only after switching off the circuit switches.
- Use extension cords with lamp guards to protect lamps against breakage and to avoid combustible material coming in contact with hot bulbs.
- Use accessories like sockets, plugs and switches and appliances only when they are in good condition and be sure they have the mark of BIS (ISI). (Necessity using BIS (ISI) marked accessories is explained under standardisation.
- Never extend electrical circuits by using temporary wiring.
- Stand on a wooden stool, or an insulated ladder while repairing live electrical circuits/appliances or replacing fused bulbs. In all the cases, it is always good to open the main switch and make the circuit dead.
- Stand on rubber mats while working/ operating switch panels, control gears etc.
- Position the ladder, on firm ground.
- While using a ladder, ask the helper to hold the ladder against any possible slipping.
- Always use safety belts while working on poles or high-rise points.
- Never place your hands on any moving part of rotating machine and never work around moving shafts or pulleys of motor or generator with loose shirt sleeves or dangling neck ties.
- Only after identifying the procedure of operation, operate any machine or apparatus.
- Run cables or cords through wooden partitions or floor after inserting insulating porcelain tubes.
- Connections in the electrical apparatus should be tight. Loosely connected cables will heat up and end in fire hazards.
- Use always earth connection for all electrical appliances along with 3-pin sockets and plugs.
- While working on dead circuits remove the fuse grips; keep them under safe custody and also display ‘Men on line’ board on the switchboard.
- Do not meddle with inter locks of machines/switch gears
- Do not connect earthling to the water pipe lines.
- Do not use water on electrical equipment.
- Discharge static voltage in HV lines/equipment and capacitors before working on them.

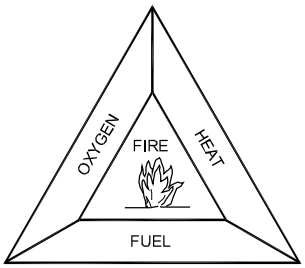
Safety practice - Fire extinguishers

Objectives: At the end of this lesson you shall be able to
- **state the effects of a fire breakout**
- **state the causes for fire in the workshop**
- **state the conditions required for combustion relevant to fire prevention**
- **state the general precautionary measures to be taken for fire prevention.**

Fire is the burning of combustible material. A fire in an unwanted place and on an unwanted occasion and in uncontrollable quantity can cause damage or destroy property and materials. Fires injure people, and sometimes, cause loss of life. Hence, every effort must be made top revent fire. When a fire out break is discovered, it must be controlled and extinguished by immediate correct action.

Is it possible to prevent fire? Yes, by eliminating anyone of the three factors that cause fire. (Fig 1)

Fig 1



The factors that must be present in combination for a fire to continue to burn are as follows.

Fuel Any substance, liquid, solid, or gas will burn if given oxygen and high enough temperature.

Heat say Every fuel will begin to burn at a certain temperature. Solids and liquids give off vapour when heated and it is this vapour which ignites. Some liquids give off vapour even at normal room temperature15°C, e.g. petrol.

Oxygen Usually it exists in sufficient quantity in air to keep a fire burning.

Extinguishing of fires

Isolating or removing any of these factors from the combination will extinguish the fire. There are three basic ways of achieving this.

- Starving the fire of fuel by removing the fuel in the vicinity of fire.
- Smothering - i.e. by isolating the fire from the supply of oxygen by blanketing it with foam, sand etc.
- Cooling - i.e. by using water to lower the temperature.

Preventing fires

The majority of fires begin with small outbreaks which burn unnoticed until they become big fires of uncontrollable magnitude. Most of the fires could be prevented with more care and by following some rules of simple common sense.

Accumulation of combustible refuse (cotton waste soaked with oil, scrap wood, paper, etc.) in odd corners are of fire risk. Refuse should be removed to collection points.

The cause of fire in electrical equipment is misuse or neglect. Loose connections, wrongly rated fuses or cables overloaded circuits cause over heating which may in turn lead to fire. Damage to insulation between conductors in cables also causes fire.

Clothing and anything else which might catch fire should be kept well away from heaters. Make sure the heater is shut off at the end of a working day.

Highly flammable liquids and petroleum mixtures (Thinner, Adhesive solutions, Solvents, Kerosene, Spirit, LPG Gas etc.) should be stored in a separated place called the flammable material storage area.

Blow lamps and torches must not be left burning when they are not in use.

Classification of fires and recommended extinguishing agents

Fire are classified into four types in terms of the nature of fuel.

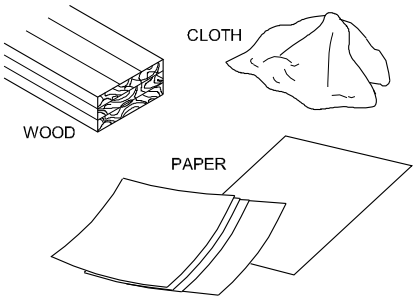
Different types of fire have to be dealt with different ways and with different extinguishing agents.

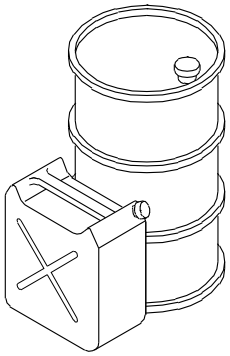
An agent is the material or substance used to put out the fire, and is usually (but not always) contained in a fire extinguisher with a mechanism for spraying into the fire.

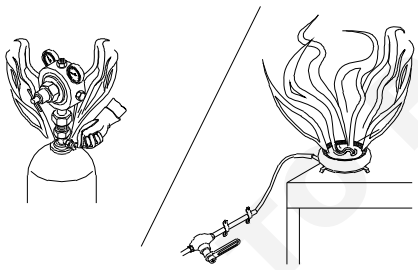
It is important to know the right type of agent for a particular type of fire using the wrong one can make things worse.

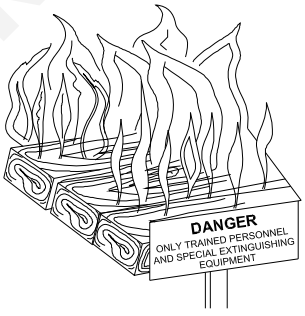
There is no classification for 'electrical fires' as such since these are only fires in materials where electricity is present.

Fuel		Extinguishing
CLASS 'A' Fire	Wood, paper, cloth, etc. Solid materials	Most effective i.e. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.
CLASS 'B' Fire	Flammable liquid. Liquefiable solids	Should be smothered. The aim is to cover the entire surface of the burning liquid. This has the effect of cutting off the supply of oxygen to the fire. Water should never be use on burning liquids. Foam, dry powder or CO_2 may be used on this type of fire.
CLASS 'C' Fire	Gas and liquefied gas	Extreme caution is necessary in dealing with liquefied gases. There is a risk of explosion and sudden spreading of fire in the entire vicinity. If an appliance fed from a cylinder catches fire – shutoff the supply of gas. The safest course is to raise an alarm and leave the fire to be dealt with by trained personnel. Dry powder extinguishers are used on this type of fire. Special powders have now been developed which are capable of controlling and/or extinguishing this type of fire.
CLASS 'D' Fire	Involving metals	The standard range of fire extinguishing agents is inadequate or dangerous when dealing with metal fires. Fire on electrical equipment. Carbon dioxide, dry powder and vaporising liquid (CTC) extinguishers can be used to deal with fires in electrical equipment. Foam or liquid (e.g. Water) extinguisher must not be used on electrical equipment under any circumstances.









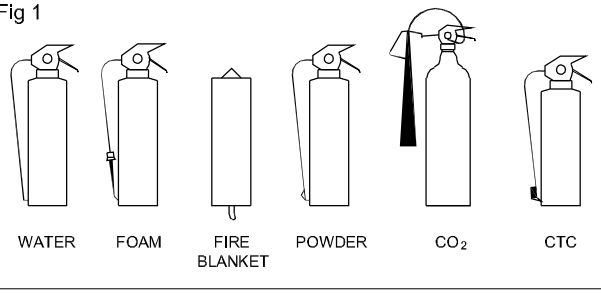
Types of fire extinguishers

Objectives: At the end of this lesson you shall be able to
- **distinguish different types of fire extinguishers**
- **determine the correct type of fire extinguisher to be used based on the class of fire**
- **describe the general procedure to be adopted in the event of a fire.**

A fire extinguisher, flame extinguisher or simply extinguisher is an active fire protection device used toextinguish or control small fires, often in emergency situation. It is not intended for use on and out of control fire.

Many types of fire extinguishers are available with different extinguishing 'agents' to deal with different classes of fires. (Fig 1)

Fig 1



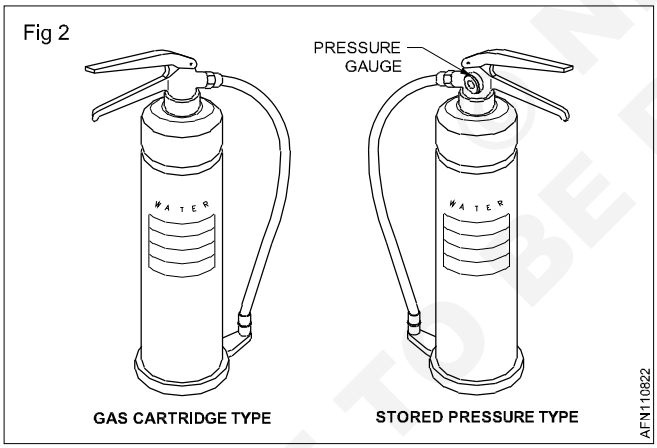
Water-filled extinguishers

There are two methods of operation. (Fig 2)

1 Gas cartridge type

2 Stored pressure type

Fig 2



With both methods of operation, the discharge can be interrupted as required, conserving the contact and preventing unnecessary water damage.

Foam extinguishers (Fig 3) : These may be of stored pressure or gas cartridge types.

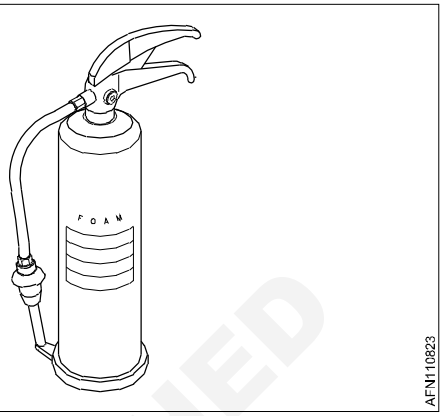
Always check the operating instructions on the extinguisher before use.

Foam extinguishers are most suitable for:

- Flammable liquid fires
- Running liquid fires

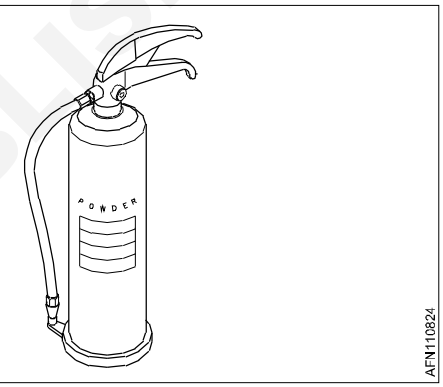
Must not be used where electrical equipment is involved.

Fig 3



Dry powder extinguishers (Fig 4)

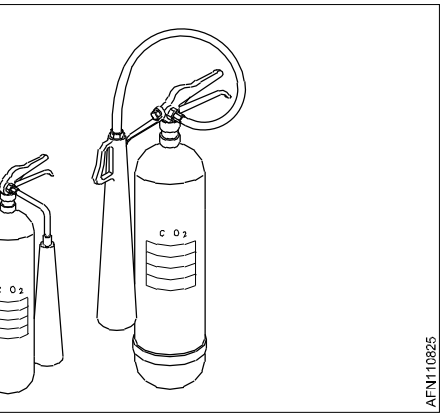
Fig 4



Extinguishers fitted with dry powder may be of the gas cartridge or stored pressure type. Appearance and method of operation is the same as that of the water-filled one. The main distinguishing feature is the fork- shaped nozzle. Powders have been developed to deal with class D fires.

Carbon dioxide (CO_2): This type is easily distinguished by the distinctively shaped discharge horn. (Fig 5)

Fig 5

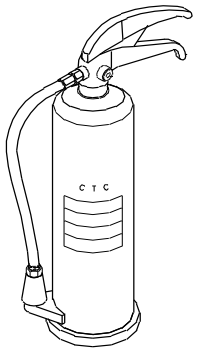


Suitable for class B fires. Best suited where contamination by deposits must be avoided. Not generally effective in open air.

Always check the operating instructions on the container before use, available with different gadgets of operation such as -plunger, lever trigger etc.

Halon extinguishers (Fig 6)

Fig 6



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Theses extinguishers may be filled with carbon tetrachloride and bromo chlorodi fluoromethene (BCF).

They may be of either gas cartridge or stored pressure type.

They are more effective in extinguishing small fires involving pouring liquids. These extinguishers are particularly suitable and safe to use on electrical equipment as the chemicals are electrically non-conductive.

The fumes given off by these extinguishers are dangerous, especially in confined space.

General procedure to be adopted in the event of a fire to be adopted.

- Raise an alarm.
- Turn off all machinery and power (gas and electricity).
- Close the doors and windows, but do not lock or bolt them. This will limit the oxygen fed to the fire and prevent its spreading.
- Try to deal with the fire if you can do so safely. Do not take risk, getting in trapped.
- Anybody not involved in fighting the fire should leave calmly using the emergency exits and go to the designated assembly point. Failure to do this may mean that some person is unaccounted for and others may have to put themselves to the trouble of searching for him or her at risk to themselves.

Working on fire extinguishers

Objectives: At the end of this lesson you shall be able to
- **state about the selection of the fire extinguishers according to the type of fire**
- **state the method of operation of the fire extinguishers**
- **explain how to extinguish the fire.**

Alert people surrounding by shouting fire, fire, fire when observe the fire (Fig 1a& b).

Inform fire service or arrange to inform immediately. (Fig 1c)

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

Put “off” electrical power supply.

Don’t allow people to go nearer to the fire

Analyze and identify the type of fire. Refer Table 1.

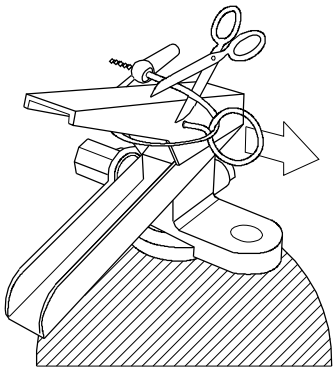
Table 1

Class ‘A’	Wood, paper, cloth, solid material
Class ‘B’	Oil based fire (grease, gasoline, oil), liquefiable gases
Class ‘C’	Gas and liquefiable gases
Class ‘D’	Metal and electrical equipment

Assume the fire is ‘B’ Type (flammable liquefiable solids)

- Select CO_2 (Carbon di oxide) fire extinguisher.
- Locate and pick up CO_2 fire extinguisher. Click for its expiry date.
- Break the seal (Fig 2)

Fig 2



BREAK THE SEAL

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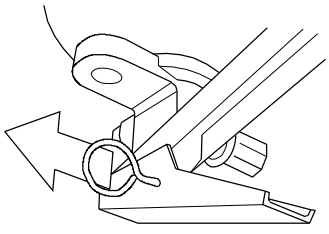
- Pull the safety pin from the handle (Pin located at the top of the fire extinguisher) (Fig 3)

Fig 3



PULL THE SAFTY PIN

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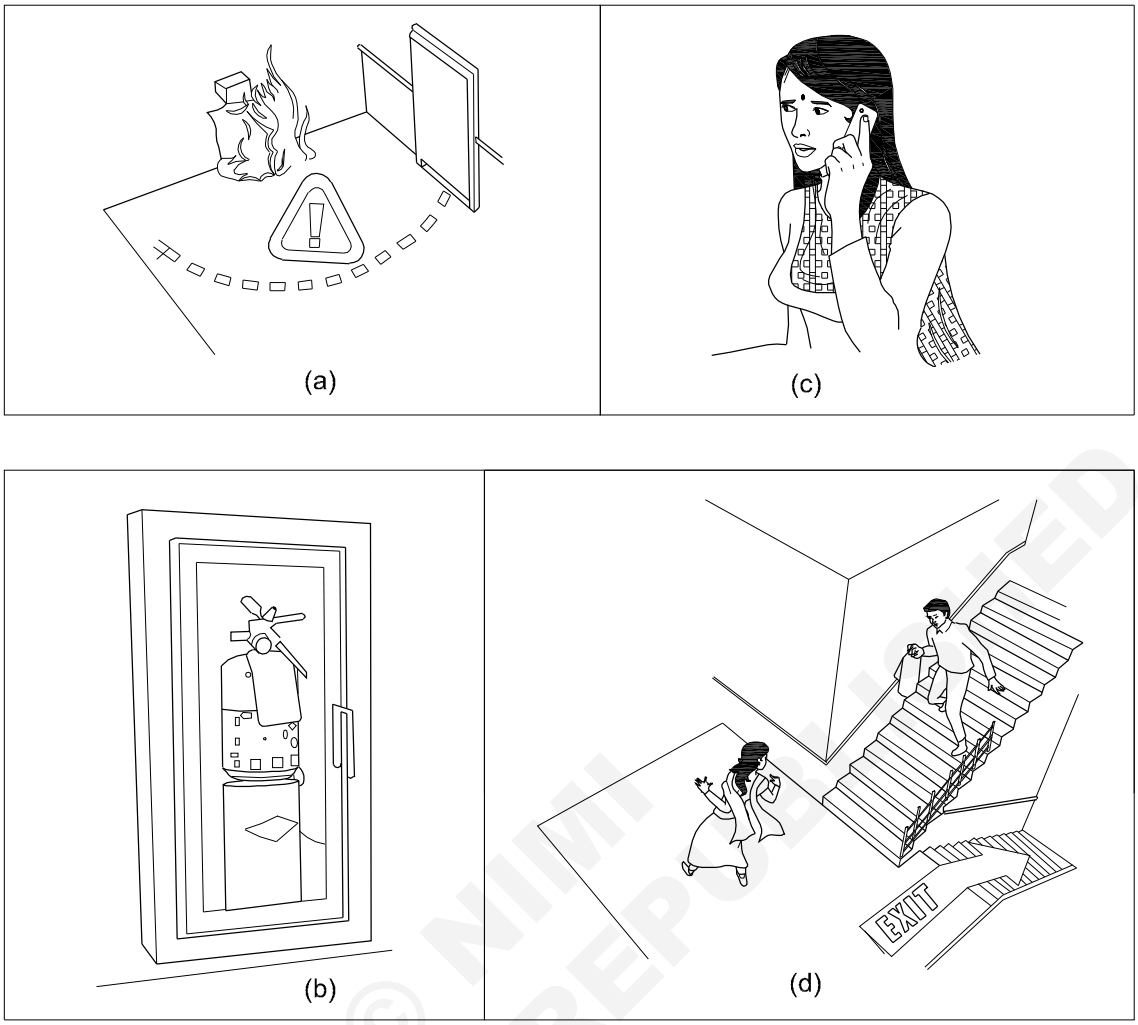
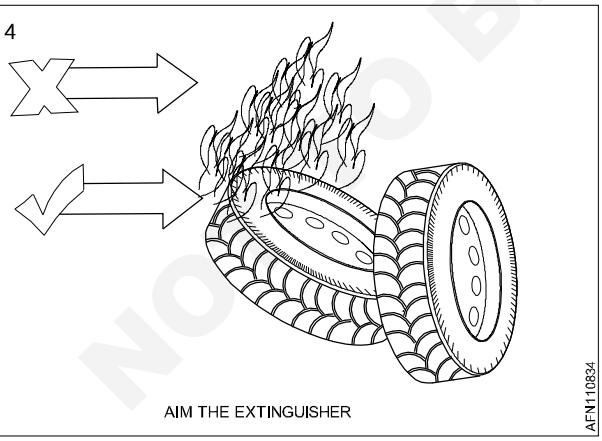
Fig 1



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

Fig 4

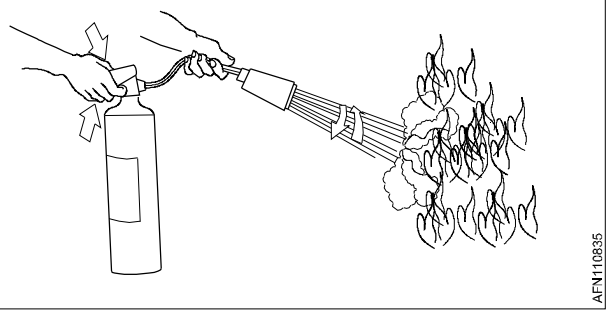


Keep yourself low

- Squeeze the handle lever slowly to discharge the agent (Fig 5)
- Sweep side to side approximately 15cm over the fuel fire until the fire is put off (Fig 5)

Fire extinguishers are manufactured for use from the distance.

Fig 5



Caution

- **While putting off fire, the fire may flare up**
- **Do not be panicked before it is put off promptly.**
- **If the fire doesn't respond well after you have used up the fire extinguisher move away yourself away from the fire point.**
- **Do not attempt to put out a fire where it is emitting toxic smoke leave it for the professionals.**

- **Remember that your life is more important than property. So, don't place yourself or others at risk.**

In order to remember the simple operation of the extinguisher, remember P.A.S.S.

This will help you to use the fire extinguisher.

P for Pull

A for Aim

S for Squeeze

S for Sweep

Safety, health and environment guidelines

Objectives: At the end of this lesson you shall be able to
- **state safety, health and environment guidelines**
- **state various section provide in factories act, 1948 on occupational safety and health.**

Safety, Health and Environment guidelines as per

Rules & regulations followed in India are listed as follows:

1 1 The Environment (Protection) Act, 1986

2 The Environment (Protection) Rules, 1986

3 Environmental Impact Assessment of Development Projects 1994

4 The Prevention and control of pollution (uniform consent procedure) Rules,1999

5 Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989

6 Manufacture, Storage and Import of Hazardous chemical (Amendment) Rules, 2000

7 Hazardous Wastes (Management and Handling) Rules, 1989

8 Bio-Medical Waste (Management and Handling) Rules, 1998

9 Batteries (Management & Handling) Rules, 2000

10 Ozone Depleting Substances (Regulation) Rules, 2000

11 The Air (Prevention and Control of Pollution) Act, 1981 as amended by Amendment Act, 1987

12 The Air (Prevention and Control of Pollution) Act, 1982

13 The Air (Prevention and Control of Pollution) Rules, 1982

14 The Tamil Nadu Air (Prevention and Control of Pollution) Rules, 1983

15 Noise Pollution (Regulation and Control) Rules, 2000

16 The Water (Prevention and Control of Pollution) Act, 1974 as amended in 1978 & 1988

17 The Tamil Nadu Water (Prevention and Control of Pollution) Rules,1983

18 The Water (Prevention and Control of Pollution) Cess Act, 1977 as amended by Amendment Act, 1991.

19 The Water (Prevention and Control of Pollution) Cess Rules, 1978

20 Factories Act, 1948

21 Tamilnadu Factories Rules, 1950

22 The Gas Cylinders Rules, 1981

23 The Indian Electricity Act, 1910

24 The Indian Electricity Rules, 1956

25 The Petroleum Act, 1934

26 The Petroleum Rules,1976

27 The Public Liability Insurance Act, 1991

28 The Public Liability Insurance Rules, 1991

29 Hazardous Wastes (Management and Handling) Rules,2000

Poor working conditions affect a worker's health and safety. Unsafe or unhealthy working conditions are not eliminated to industries and can be anywhere. Whether inside or outside, the workshop workers may face many health and safety hazards. It also affects the environment of the workers. Occupational hazards have harmful effects on workers, their families, and other people in the community, as well as on the physical environment around the workplace.

The provisions made in as applicable to the Factories Act, 1948 (Act No.63 of 1948), as amended by the Factories (Amendment) Act, 1987 (Act 20 of 1987) are as follows:

Occupational safety and health : Various sections provided in factories act, 1948 are under the following headings:

- Fencing of machinery
- Work on or near machinery in motion
- Employment of young persons on dangerous machines
- Striking gear and devices for cutting off power
- Self-acting machines
- Casing of new machinery
- Prohibition of employment of women and children near cotton-openers
- Hoist and lifts
- Lifting machines, chains, ropes and lifting tackles
- Revolving machinery

- Pressure plant
- Floors, stairs and means of access
- Excessive weights
- Protection of eyes
- Precautions against dangerous fumes, gases, etc.
- Precautions regarding the use of portable electric light
- Explosive or inflammable dust, gas, etc.
- Precautions in case of fire
- Power to require specifications of defective parts or test of stability
- Safety of buildings and machinery
- Maintenance of buildings
- Power to make rules to supplement this Chapter
- Cleanliness
- Disposal of wastes and effluents
- Ventilation and temperature
- Dust and fume
- Artificial humidification
- Over crowding
- Lighting
- Drinking water
- Latrines and urinals
- Spittoon

Basic understanding on hot work, confined space work and material handling equipment

Objectives: At the end of this lesson you shall be able to
- **state what is hot working**
- **brief confined space work**
- **use of material handling equipments.**

Hot work : Hot work is defined as forging, gas cutting, welding,soldering and brazing operations for construction, maintenance/repair activities.

Hot work fire and explosive hazards. Workers performing hot work such as welding, gas cutting, brazing, soldering are exposed to the risk of fires from ignition or flammable or combustible materials in the space, and from leaks of flammable gas into the space, from hot work equipment.

A confined space also has limited or restricted means for entry or exist and is not designed for continuous occupancy. It includes but are not limited to tanks, vessels, silos,storage bins, hoppers, vaults, pits, manholes, tunnels,equipment housings, duct work, pipelines, etc.

Materials handling equipment : Materials handling equipment is a mechanical equipment used for the movement, storage, control and protection /protecting of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal.

Different types of material handling equipment
- Tools
- Vehicles
- Storage units
- Appliance and accessories

Racks

Pallet racks, drive-through or drive-in racks, push back racks, and sliding racks.

Truck/Trolley

Conveyor system
- Fork lift.
- Cranes.
- Pallet truck.

Lifting and handling loads

Objectives: At the end of this lesson you shall be able to
- **state the types of injury caused by the improper method of lifting and carrying loads and how to prevent them**
- **state the 6 points in the process of manual lifting methods.**

Many of the accidents reported involve injuries caused by lifting and carrying loads. An Electrician may need to install motors, lay heavy cables, do wiring, which may involve a lot of lifting and carrying of loads. Wrong lifting techniques can result in injury.

A load need not necessarily be very heavy to cause injury. The wrong way of lifting may cause injury to the muscles and joints even though the load is not heavy.

Further injuries during lifting and carrying may be caused by tripping over and object and falling or striking an object with a load.

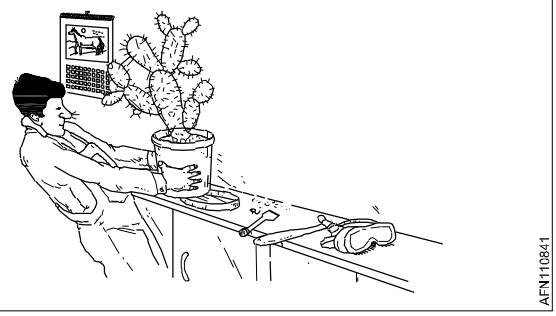
Type of injury and how to prevent them?

Cuts and abrasions

Cuts and abrasions are caused by rough surfaces and jagged edges:

By splinters and sharp or pointed projections. (Fig 1)

Fig 1

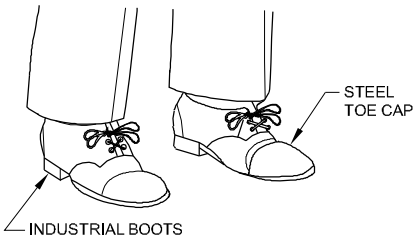


Leather hand gloves will usually be sufficient for protection, but the load should be checked to make sure of this, since large or heavy loads may involve body contact as well.

Crushing of feet or hands: Feet or hands should be so positioned that they will not be trapped by the load. Timber wedges can be used when raising and lowering heavy loads to ensure fingers and hands are not caught and crushed.

Safety shoes with steel toe caps will protect feet (Fig 2)

Fig 2



Strain to muscles and joints : Strain to muscles and joints may be result of:

- Lifting a load which is too heavy, or of lifting incorrectly.

Sudden and awkward movements such as twisting or jerking during a lift can put severe strain on muscles.

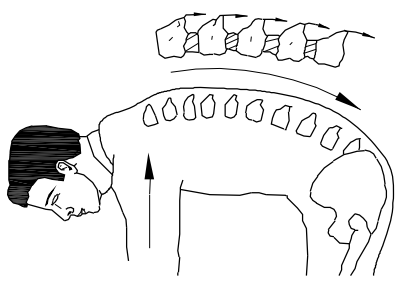
Stop lifting'-lifting from a standing position with the back rounded increases the chance of back injury.

The human spine is not an efficient weight lifting machine and can be easily damaged if incorrect techniques are used.

The stress on a rounded back can be about six times greater than if the spine is kept straight.

Fig 3 shows and example of stoop lifting.

Fig 3



Preparing to lift: Before lifting or handling any load ask yourself the following questions.

- What has to be moved?
- Where from and where to?
- Will assistance be required?
- Is the route through which the load has to be moved is clear of obstacles?
- Is the place where the load has to be kept after moving is clear of obstacles?

Load which seems light enough to carry at first will become progressively heavier, the farther you have to carry it.

The person who carries the load should always be able to see over or around it.

The weight that a person can lift will vary according to:

- Age
- Physique, and
- Condition

It will also depend on whether one is used to lifting and handling heavy loads.

What makes an object difficult to lift and carry?

1 Weight is not the only factor which makes it difficult to lift and carry.

2 The size and shape can make an object awkward to handle.

3 Loads high require the arms to be extended in front of the body, place more strain on the back and stomach.

4 The absence of hand holds, or natural handling points can make it difficult to raise and carry the object.

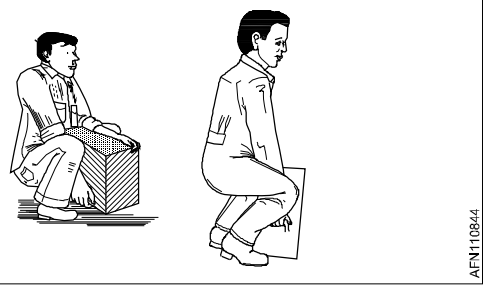
Correct manual lifting techniques

1 Approach the load squarely, facing the direction of travel

2 The lift should start with the lifter in a balanced squatting position, with the legs slightly apart and the load to be lifted held close to the body.

3 Ensure that a safe firm hand grip is obtained. Before the weight is taken, the back should be straightened and held as near the vertical position as possible. (Fig 4)

Fig 4



1 To raise the load, first straighten the legs. This ensures that the lifting strain is being correctly transmitted and is being taken by the powerful thigh muscles and bones.

2 Look directly ahead, not down at the load while straightening up, and keep the back straight, this will ensure a smooth, natural movement without jerking or straining. (Fig 5)

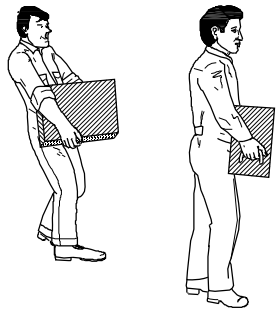
Fig 5

AFN110845

1 To complete the lift, raise the upper part of the body to the vertical position. When a load is near to an individual's maximum lifting capacity it will be necessary to lean back on the hips slightly (to counter balance the load) before straightening up. (Fig 6)

Keeping the load well near to the body, carry it to the place where it is to be set down. When turning, avoid twisting from the waist- turn the whole body in one movement.

Fig 6



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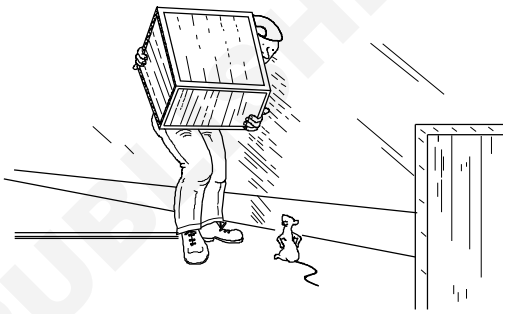
Lowering the load : Make sure the area is clear of any obstructions. (Fig 7)

Bend the knees to a semi- squatting position, keep the back and head erect by looking straight ahead, not down at the load. It may be helpful to rest the elbows on the thighs during the final stage of lowering.

Fig 7



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Moving heavy equipment

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

- **name the methods followed in industry to move heavy equipment**
- **describe the procedure to be followed for moving heavy equipment on layers and rollers**
- **list the safety consideration while raising a load and moving a load.**

Heavy equipments are moved in industry using any of the following methods.

Crane and slings

Winches

Machine moving platforms

Layers and rollers

Using crane and slings

This method is used whenever loads are to be lifted and moved. (Fig 1)

Examine the steel rope sling for any cut, abrasion, wear fraying or corrosion.

Damaged slings must not be used.

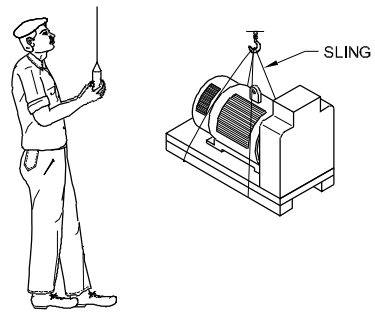
Distribute the weight as evenly as possible between the slings when using more than one sling. (Fig 1)

Keep the slings as near to vertical as possible.

Winches

Winches are used to pull heavy loads along the ground.

Fig 1



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They may be power-driven (Fig 2) or hand operated. (Fig 3)

Ensure that the safe working load (SWL) of the winch is adequate for the task.

Secure the winch to a structure which is strong enough to withstand the pull.

On open ground, drive long stakes into the ground and secure the winch to them.

Fig 2

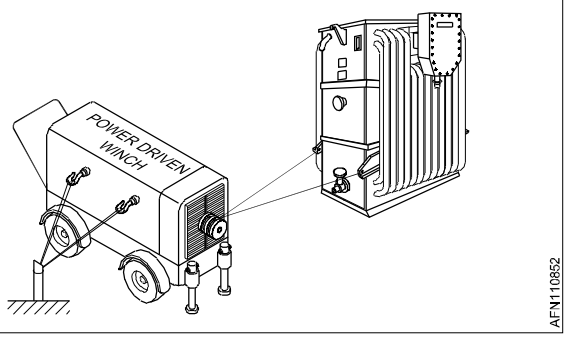
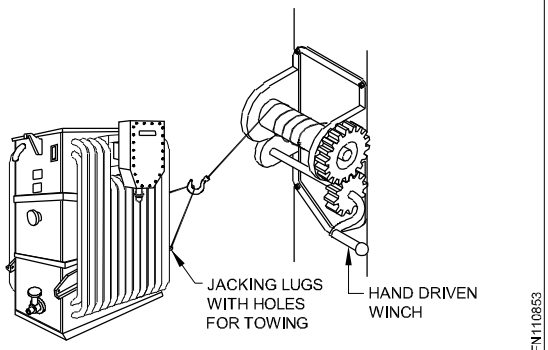


Fig 3



Choose a suitable sling and pass it around the base of the load. Secure it to the hook of the winch.

Some heavy items have special lugs welded to them for jacking and towing purposes.

Safety consideration

Before using any winch, check that the brake and ratchet mechanism are in working order.

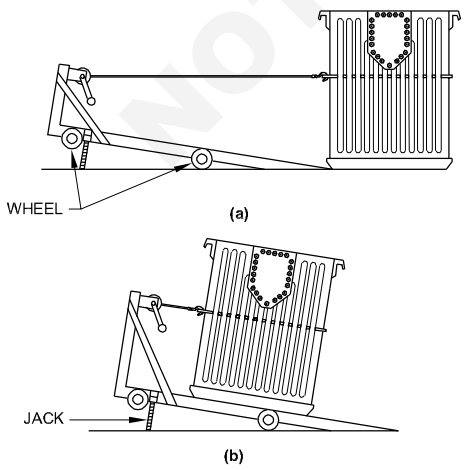
Practice how to use the brakes.

Keep hands and fingers well away from the gear wheels.

Keep the bearings and gears oiled or greased.

Machine moving platforms : This is a special device made to move heavy equipment in industry. Fig 4 shows the method of loading a heavy transformer.

Fig 4



Pass a suitable sling round the load at a convenient height.

Attach the sling to the hook of the winch and draw the load on the platform until its centre of gravity lies between the front and rear wheels.

Lower the jacks so that the platform rests on its wheels.

For unloading follow the procedure in the reverse order.

Using layers and rollers

Sometimes a load cannot be moved along the ground because of the irregular shape of its base or because it is not rigid enough.

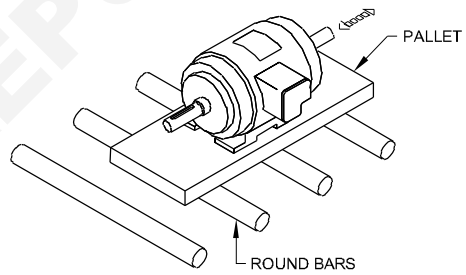
Place such a load on a flat-bottomed pallet or 'layer' resting on the round bars. (Fig 5)

Ensure the bars (rollers) are long enough to project at each side of the load, for ease of handling.

They should be large enough to roll easily over any uneven surface along the route but should be small enough to be handled easily.

Two or three bars of equal diameter are sufficient for most loads but if four or more are used, the load may be moved faster as there is no delay when moving the rear bar to the front. (Fig 5)

Fig 5



Move the load by using a crowbar as shown in Fig 6.

Keep the crowbar at the end of the pallet with an angle and a firm grip on the ground. Apply the force at the top of the bar as shown.

Caution

When a load is on rollers, only shallow slopes can be negotiated.

Hold the load in check all the time if it is on the slope.

Use a winch with an effective brake for this operation.

To negotiate a corner on rollers

For a moderate load, insert one roller a little larger in diameter than the others as the corner is approached.

When this roller is under the centre of gravity of the load, the load can be rocked to and fro on the roller and swiveled around sideways. (Fig 7)

Fig 6

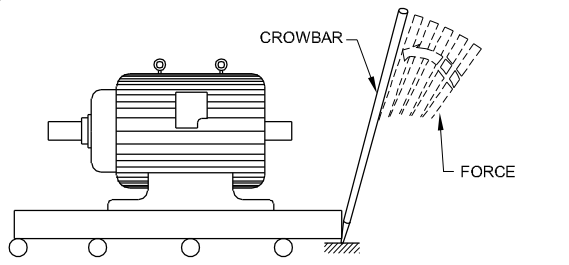
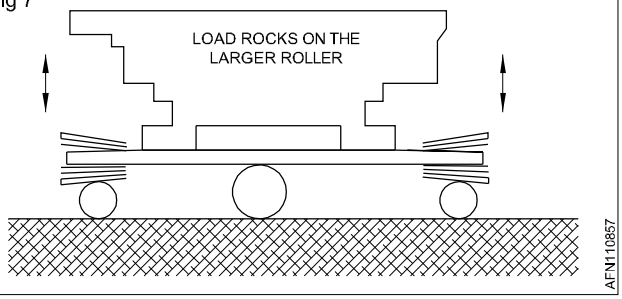


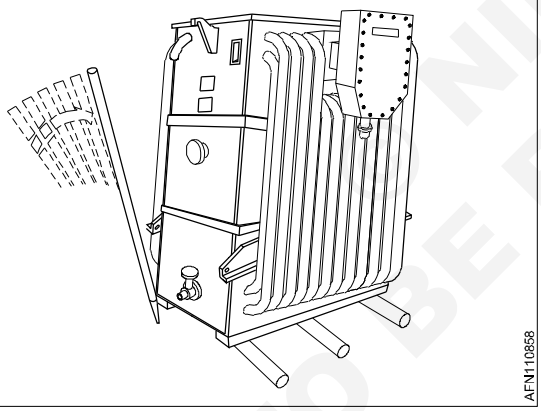
Fig 7



For heavier loads: Stop the load on the roller at the beginning of the corner.

Twist the load round on the rollers by pushing the side swith crowbars until the load is just over the ends of the rollers. (Fig 8)

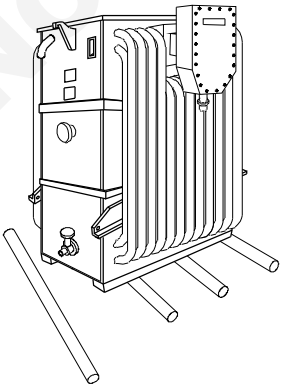
Fig 8



Place some rollers at an angle to the front of the load. (Fig 9)

Push the load forward on to these rollers.

Fig 9



Twist the load further round and place the freed rollers infront of and at an angle to the load.

Continue until the load is pointing in the desired direction.

Safety consideration

Moving heavy loads with crowbars or jacks

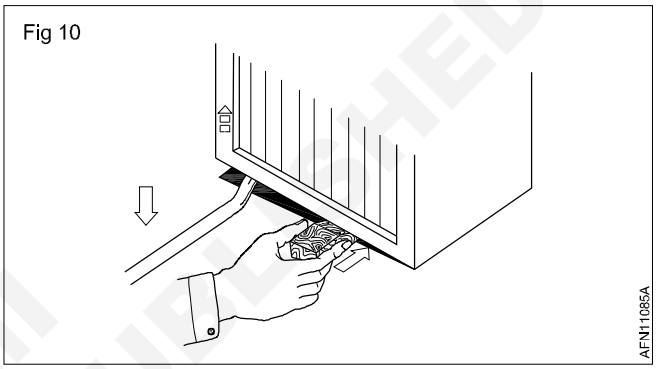
Make sure your hands are clear of the load before lower ingit on to the packing or rollers.

Do not use your hands underneath the packing when positioning it. Use a push block.

Place the packing on the floor and push it under the load. (Fig 10)

Hold it by its side faces keeping the fingers well away from the lower edge of the load and from the floor. (Fig 10)

Fig 10



Raising a load: Check that the slings are correctly secured to the load and to the hook. Ensure they are not twisted or caught on a projecting part of the load.

Before starting to lift a load, if you cannot see an assistant on the far side of the load, verify that he is ready to lift the load and ensure that his hands are clear of the slings.

Warn nearby workers that the lifting is about to begin.

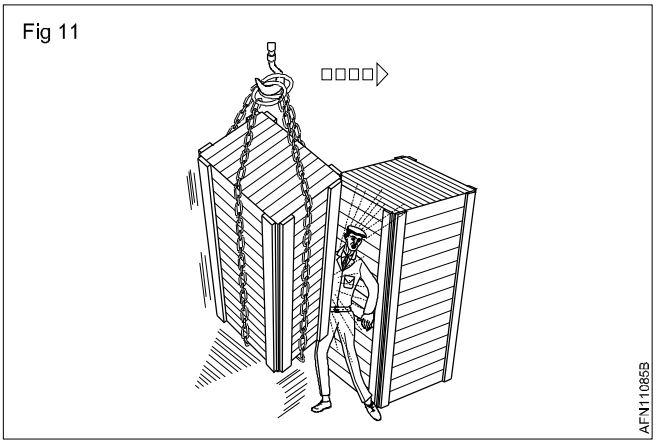
Lift slowly.

Take care to avoid being crushed against other objects as the load rises. (Fig 11) It may swing or rotate as it leaves the ground.

Minimise such movement by locating the hooks as accurately as possible above the centre of gravity of the load.

Keep the floor clear of unnecessary objects.

Fig 11



Moving a load

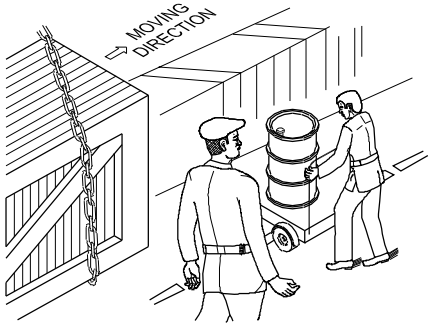
Check that there are no obstacles in the way of the crane and load. (Fig 12)

Stand clear off the load and move it steadily.

Be prepared to stop the load quickly if somebody moves into its path.

Allow for the natural swing of the load when changing speed or direction.

Fig 12



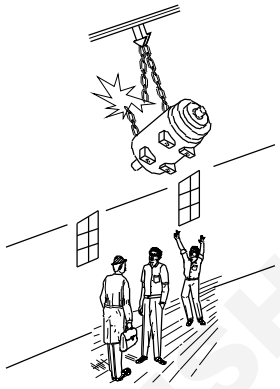
Ensure that the load will not pass over the head of other people. (Fig 13)

The tackle or sling may fall or slip.

Warn other workers to stand clearly away from the route of the load.

Remember that accidents do not happen, they are caused.

Fig 13



Tools & equipments for marking & sawing

Objectives: At the end of this lesson you shall be able to
- **know the tools related to the task.**

Fig 1

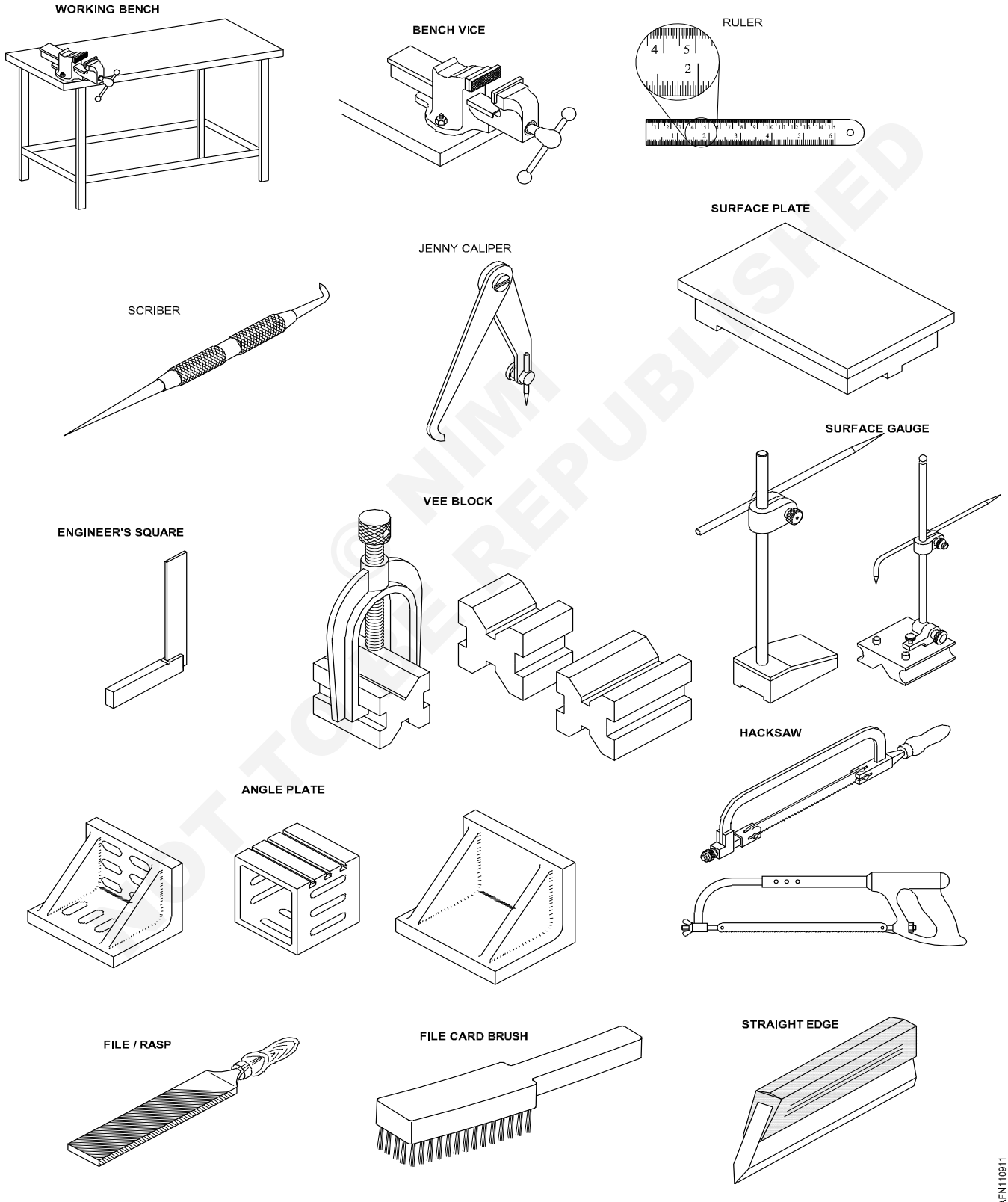
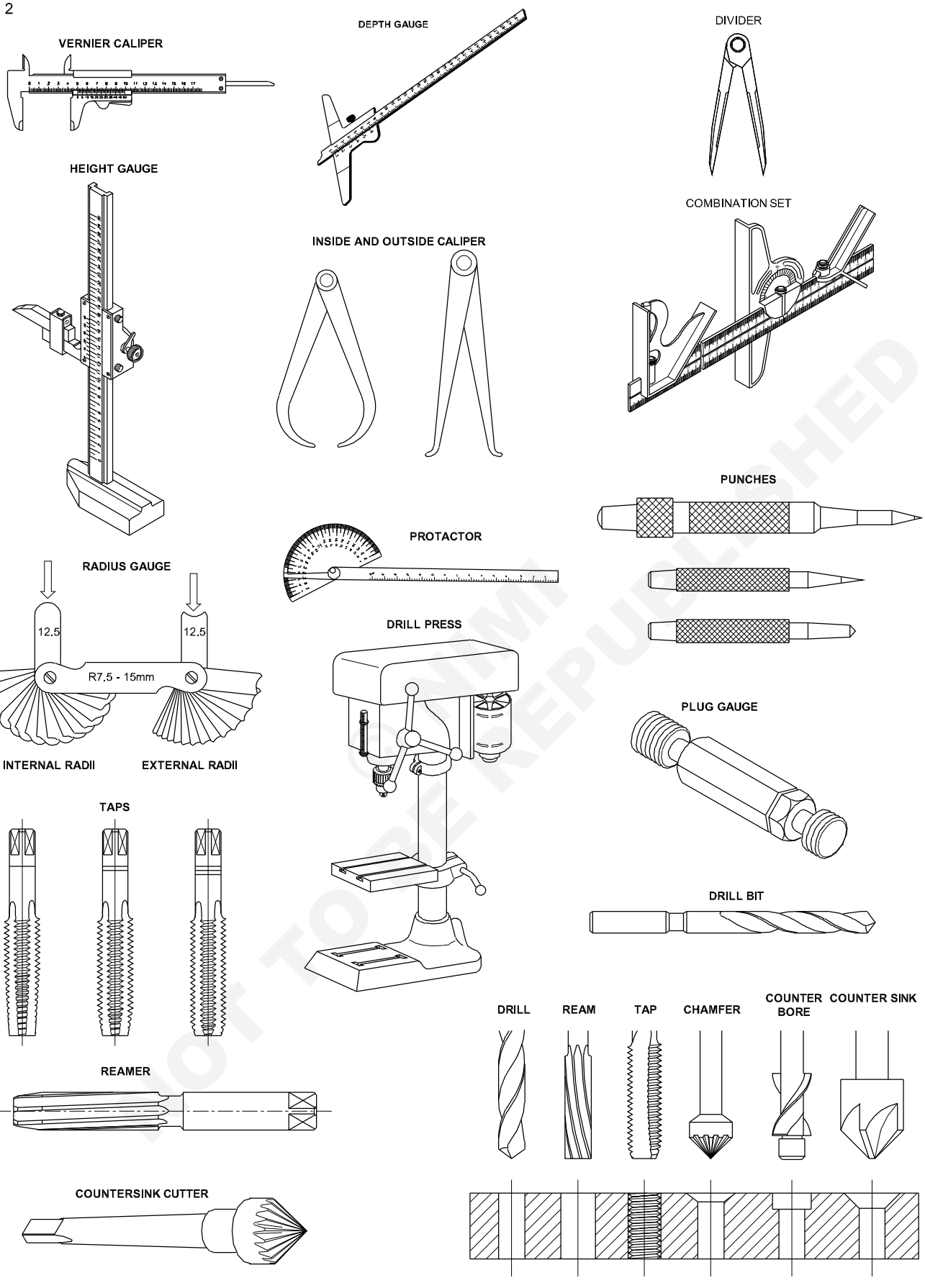


Fig 2



Aircraft safety practices: Foreign object deb rise/damage (FOD)

Objectives: At the end of this lesson you shall be able to
- **understant FOD area signs and markings**
- **know the procedures to avoid FODs**
- **understand the procedures to be followed in case of equipment loss.**

What is a FOD?

FOD is the acronym for "Foreign Object Debris / Damage".

FOD refers to any object in the operating environment of an aircraft or within one of its assemblies that may pose a risk of material or physical damage.

The FOD is a significant threat to the aviation industry.

You can have debris without damage, but never damage without debris.

Damage caused by FOD is called "FOD damage".

The indication of FOD zones

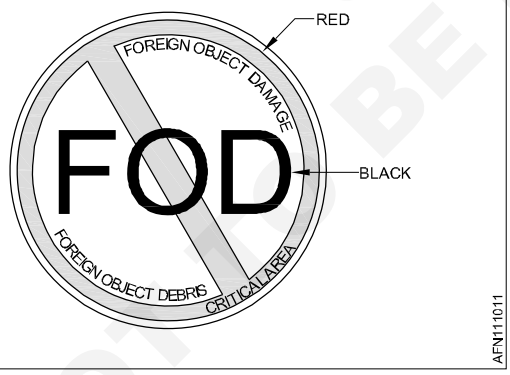
FOD-non sensitive areas: Areas where the risk of migration and retention in the final product is low.

NO SIGN

FOD-sensitive areas (Fig 1)

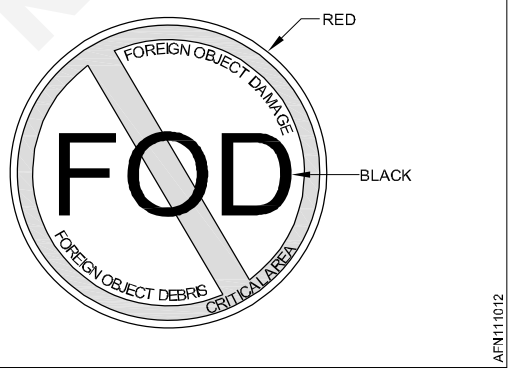
Areas where the risk for the sub assembly or assembly to contain FOD is moderate.

Fig 1



FOD-critical areas (Fig 2)

Fig 2



Areas where the risk for the subassembly or assembly to contain a FOD and where the FOD may affect the safety of the product is high.

How to avoid FOD

A series of precautions should be strictly followed to avoid FOD in production.

- Personal tools or tools that are not referenced are not allowed in the workplace.
- All tools must be marked with a permanent, legible and traceable identification number.
- A tool inventory must be made and documented at least before the product leaves the work area to enter the next industrial phase.
- In critical FOD areas, an inventory of tools and equipment must be carried out and documented before entering and leaving the critical area (check-In/check-Out) and at the end of the operation.
- The number of tools transported on critical FOD areas must be reduced to the minimum necessary for the task to be performed.
- Tools must be kept in boxes or on panels to facilitate inventory and maintenance practices.
- Operators must remove all equipment from the intervention area once their task is completed.
- The workstation must be kept clean and tidy throughout the working phase.

Loss of equipment in the FOD area

Losing an element is a mistake.

Failure to report this mistake is a fault.

(Violation of the rules)

Lost items must be reported to the operational manager and the quality manager.

Each time an item is reported lost or missing:

- Stop the activity in the concerned area and search the item.
- Continue this search until the element is found or until it has been properly verified that the element is not in the assembly.
- If the lost item cannot be located after the search, the lost item must be documented, and the records saved.

Knowledge of the materials used and empirical recognition

Objective: At the end of this lesson you shall be able to
- **empirically classify materials by visual comparison.**

The main materials used are:

- Aluminium and its alloys
- Steel and steel alloys
- Stainless steel
- Titanium and its alloys
- Carbon fibre
- Fiberglass

They are easily recognisable visually or by touch.

Different materials can be identified by their relative weight and colour. Table displays the densities and colours of frequently used materials.

Material	Approximate density*	Colour
Aluminium & its alloys	2.7	Light grey
Steel and steel alloys	7.8	Dark grey
Stainless steel	8	Bright grey
Titanium and its alloys	5	Medium grey
Carbon fibre + resin	1.8	Black
Fiberglass + resin	2.5	Yellowish

* Depends on the composition of the alloy or resin charge

Commercial and finished shapes

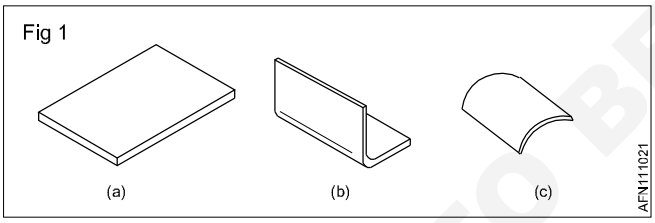
Objectives: At the end of this lesson you shall be able to
- **know the different commercial shapes**
- **name the various commercial shapes of materials.**

The materials can be delivered in different shapes. The most common ones are presented below.

Sheet metal, plate (Fig 1)

- Flat sheet (A)
- Bended sheet (B)
- Rolled sheet (C)

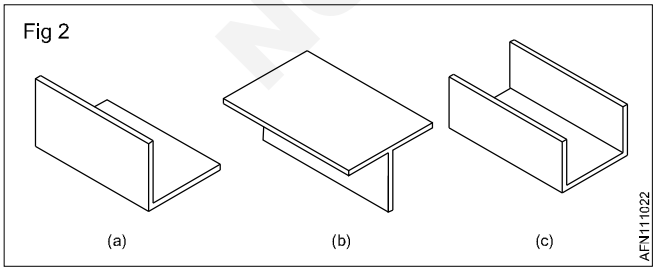
Fig 1



Extrusions (Fig 2)

- Angle (A)
- Tee-section (B)
- Channel (C)

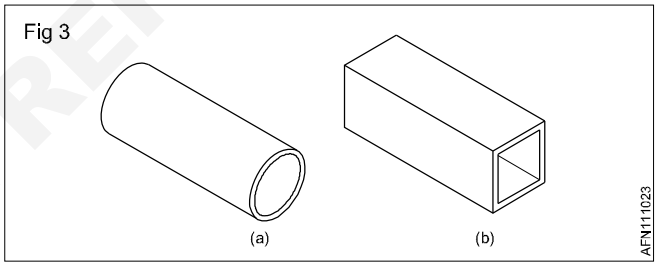
Fig 2



Tubes and pipes (Fig 3)

- Round tube (A)
- Square tube (B)

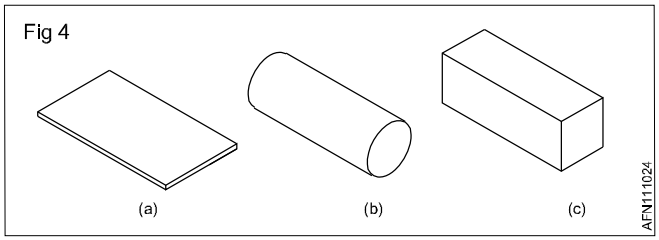
Fig 3



Bars (Fig 4)

- Flat bar (A)
- Round bar (B)
- Square bar (C)

Fig 4



The main defects and their visual recognition

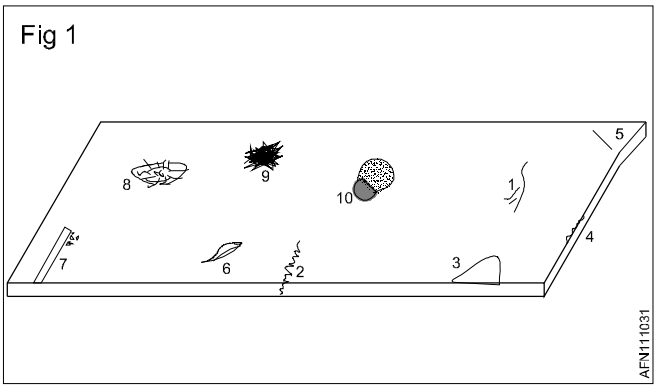
Objectives: At the end of this lesson you shall be able to
- **identify the most frequent defects and name them**
- **know the origin of defect to avoid its recurrence.**

During manufacture or handling, a part may be damaged. Defects can be caused by friction, shock, poor storage, etc.

Before and during work, it is recommended to check the general condition of the part.

The different visible defects can be (Fig 1).

Fig 1



Scratch (1): A cut on a surface caused by a sharp object.

Crack (2): A fine or thin cut in the surface of a metal, with an irregular profile, resulting from abnormal stress.

Nick (3): A local indentation or notch on an edge. It is usually caused by a displacement of metal rather than a loss.

Burr (4): An unintentional excess of thin material to be pushed back during adjustment, sawing, drilling, etc., often sharp.

Deformation, distortion (5): Dimensional and shape variations that permanently affect an element.

Gouge (6): Deep groove in, or breakdown of, a metal surface caused by the contact with a foreign object under heavy pressure.

Mark (7): A trace or imprint left by one body on another, or caused by a blow, a shock, etc.

Dent (8): An indentation, depression in a metal surface caused by an object striking with force. The surface surrounding the indentation will be slightly upset without perforation.

Abrasion (9): Wear mark caused by the friction between elements.

Corrosion (10): The degradation of a material in powder form and rough surface due to aggression by chemical or electrochemical action.

Stain: A mark left by a dirty substance.

Blotch: An alteration of the colour of a treatment or paint in the form of irregular vein-shaped spots.

Linear measurment - International system of unit of measurement (SI)

Objectives: At the end of this lesson you shall be able to
- **name the base unit of linear measurement as per SI**
- **state multiples of a metre and their values.**

When we want to measure an object, we use graduated tools. These tools are controlled in relation to an international reference: the International System of Unit of Measurement (SI).

The international unit of length measurement is the metre.

Its symbol is “m”.

There are also multiples and submultiples of the reference unit given in Table 1.

Measurement in engineering practice: Usually, in engineering practice, the preferred unit of length measurement is the millimetre.

Both large and small dimensions are presented in millimetres.

Table 1

Name	Symbol	Factor
Kilometre	km	10^3
Hectometre	hm	10^2
Decametre	Dam	10^1
Metre	**m**	**1**
Decimetre	dm	10^{-1}
Centimetre	cm	10^{-2}
Millimetre	mm	10^{-3}
Micrometre	ìm	10^{-6}

Surface plate and marking table

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a surface plate**
- **care and properly maintain a surface plate.**

This plate with a flat surface of great accuracy is used to test the flatness of other surfaces. Together with other instruments it can also be used to measure, test and mark out.

Surface plates are generally made of good quality cast iron, which are stress-relieved to prevent distortion.

When accurate dimensional features are to be marked, it is essential to have a datum plane with a perfectly flat surface.

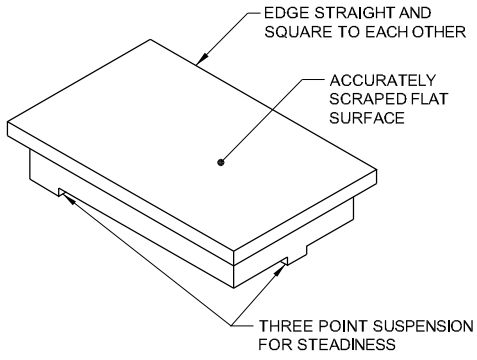
A marking table (marking-off table) is used as a reference surface to mark on workpieces.

These tables are also used to set measuring instruments, and to check sizes, parallelism and angles.

Care and maintenance

- Clean before and after use to avoid dust and other particles.
- Do not keep workpieces on the surface plate.
- Do not keep any cutting tool on the table.
- Apply a thin film of oil regularly to avoid corrosion.

Fig 1



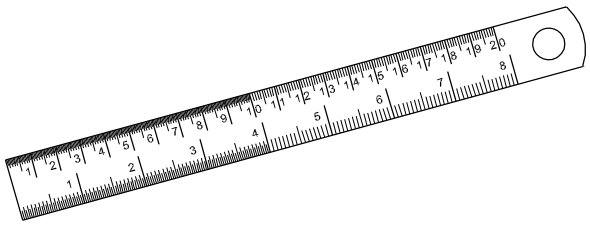
Rule

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a steel rule**
- **state the precautions to be followed while using a steel rule**
- **use the rule correctly.**

Rules are usually made of flexible or rigid steel and measure between 100 and 1000 mm long.

A typical rule is shown in Fig 1.

Fig 1



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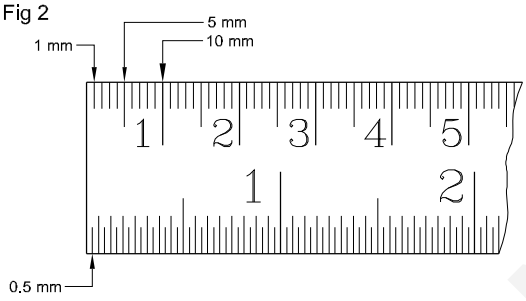
When dimensions are given in a drawing without any indication about the tolerance, it has to be assumed that measurements are to be made with a steel rule.

They are used to measure the linear dimension of workpieces.

They are graduated in 0.5 and 1 mm divisions (Fig 2).

Fig 2



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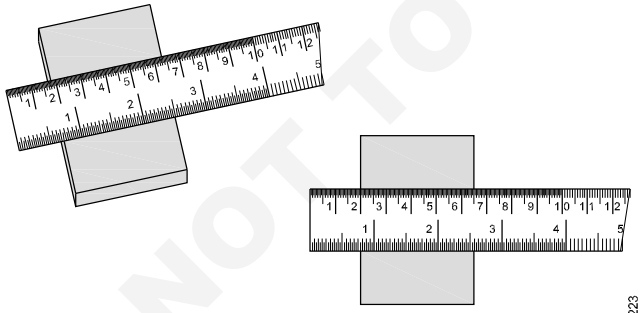
Use of rules: If used properly, rules enable precise measurements.

The most common cause of user error when reading a rule is called a parallax. If a rule is read from an angle, the reading can be wrong (Fig 3).

Fig 3



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You need to make sure the rule is straight across the dimension you are measuring and lying flat. If the rule is placed at an angle, the measurements will not be correct (Fig 4).

Whenever possible, take measurements between gradation lines, rather than from the end of the rule (Fig 5).

Measurements taken from the end of a rule can be less accurate.

Fig 4

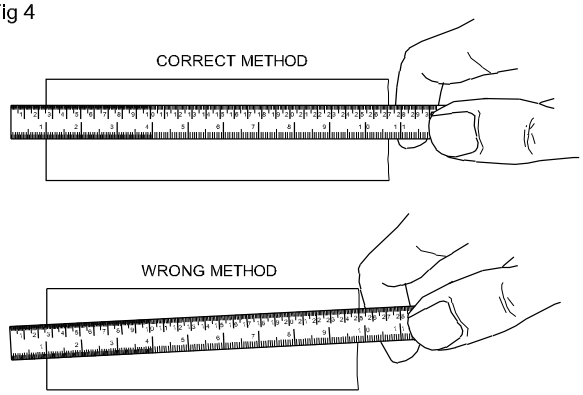

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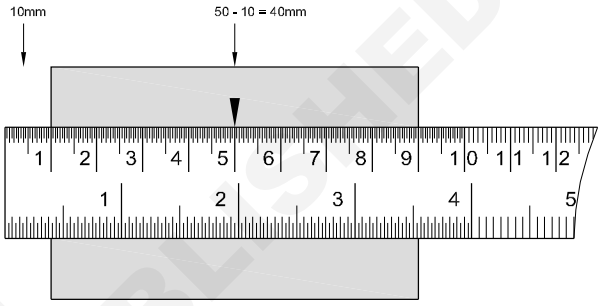
Fig 5



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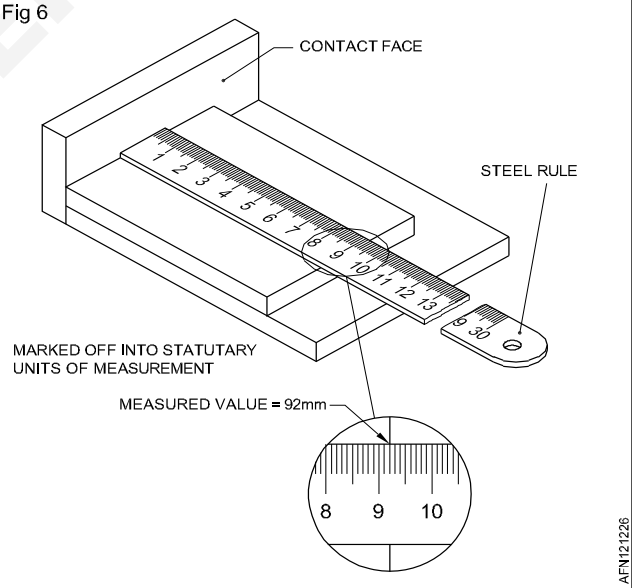
The rule can be placed against this stop to obtain a more accurate measurement (Fig 6).

Fig 6



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This stop can be a square, a surface plate, or any other straight tool.

Care of rules: Keep rules clean and dry to ensure reasonably accurate measurements. Store rules in a place in which they will not become bent or damaged by other tools.

Apply a thin film of oil regularly to avoid corrosion.

Do not use a rule to deburr edges of the workpiece.

Scriber

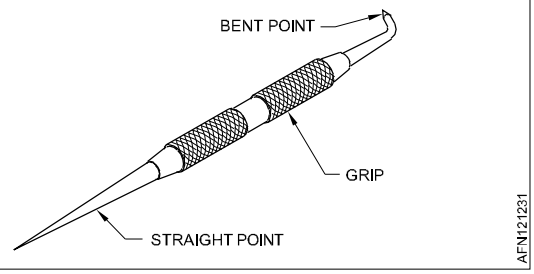
Objectives: At the end of this lesson you shall be able to
- **state the features of scribers**
- **state the uses of scribers.**

In layout work, it is necessary to scribe lines to indicate the dimensions of workpieces to be filed or machined.

The scriber is a tool used for this purpose. It is made of high carbon steel, which is hardened.

Scribers are available in different shapes and sizes. The most common ones are the plain scriber and the double-ended scriber (Fig 1).

Fig 1



The double-ended scriber features a straight point at one end of the scriber and can have a variety of angled points at the other.

Advantages

The advantages of scribers over other marking tools are that the lines traced with them are very thin and therefore more accurate.

Disadvantages

The disadvantages of scribers over other marking tools are that the lines traced with them cannot easily be removed, without grinding or sanding. This means scribers are not always the most appropriate tool for marking out an aircraft part.

Use a scriber only to trace lines that will disappear after adjustment, drilling, cutting, etc.

Tracing with a hard tip scriber can cause a crack.

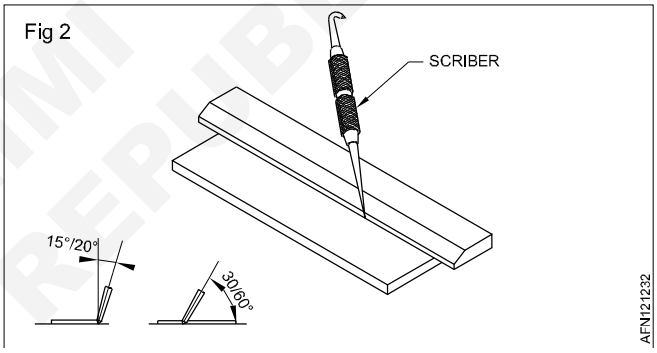
While tracing lines, the scriber is used like a pencil so that the lines drawn are close to the straight edge.

Hold the scriber at an angle of 30 to 60° to the workpiece and 15 to 20° to the rule so that the tip is in contact with the rule (Fig 2).

Scriber pointy tips are very sharp; do not put the scriber in your pocket.

Place a cork on the pointy tips when not in use to prevent accidents.

Fig 2



Jenny calliper (hermaphrodite calliper)

Objectives: At the end of this lesson you shall be able to
- **state the purpose of a jenny calliper**
- **state the constructional features of a jenny calliper**
- **name the types of jenny callipers.**

A jenny calliper is a tracing tool used for:

- marking lines parallel to the inside and outside edges (Fig 2)
- marking lines parallel to the curved edges
- finding the centre of round bars.

The standard jenny calliper has one leg with an adjustable divider point, while the other is a bent leg (Fig 1).

Another type of jenny calliper has a heel to facilitate its positioning on the workpiece (Fig 2A).

To trace a line on a thick part (without the possibility of leaning the calliper towards the surface) use a jenny calliper with a heel (Fig 2A).

To trace a line from the outside on a part with a flange, place the jenny calliper against the flange of the part as shown in Figure 2B.

To trace a line from outside on a thin workpiece, place the jenny calliper against the edge of the workpiece and on the work surface (Fig 2C).

The jenny calliper should be slightly inclined while scribing lines.

The length of both legs should be equal when setting dimensions and scribing lines.

Use a jenny calliper only when the tracing line will disappear after adjustment, drilling, cutting, etc.

Tracing with a hard tip jenny calliper can cause a crack.

Fig 1

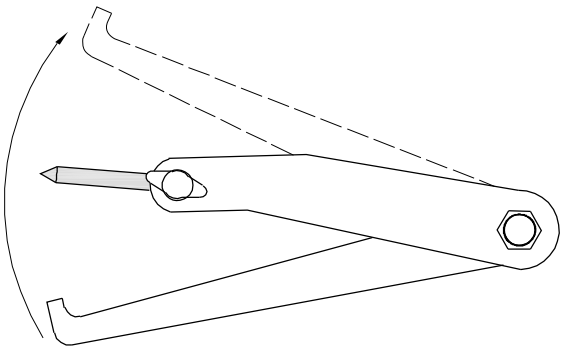


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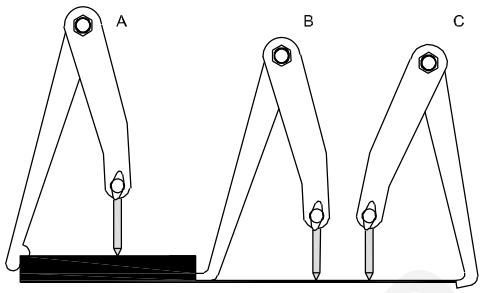
Fig 2



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Surface gauge

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

- **state the purpose of a surface gauge**
- **state the precautions to be followed while using a surface gague**
- **use the surface gauge correctly to trace.**

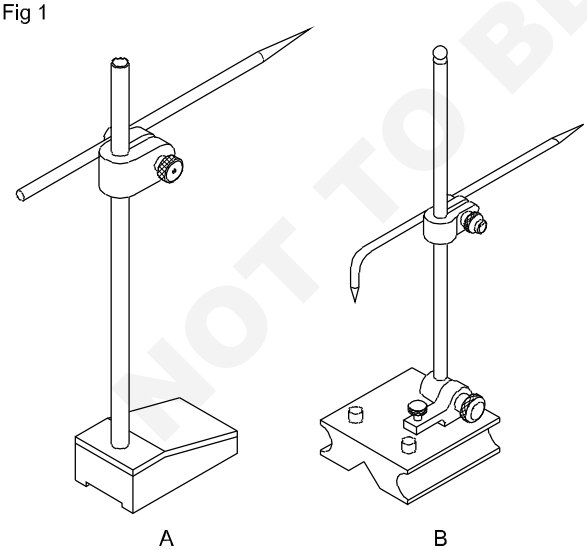
A surface gauge is a tracing tool used to transfer measurements to the workpiece by scribing a line.

The surface gauge consists of a base with an adjustable spindle to which a scriber can be clamped.

There are two types of surface gauges:

- fixed type surface (Fig 1A)
- universal surface gauge (Fig 1B)

Fig 1



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Fixed type: it consists of a heavy flat base and a spindle, fixed upright, to which a scriber is attached with a snug and a clamp nut.

Universal surface gauge: it has some additional features: the spindle can be set to any position; fine adjustments can be made quickly; and it can be used on cylindrical surfaces. Setting the height on a surface gauge.

To set the height of a surface gauge

- Put a combination square and the surface gauge on a layout table or surface plate. If a combination square is not available, use a rule with a rule holder.
- Set the scriber to the approximate height required, using the adjusting clamp that holds the scriber onto the spindle.
- Make the final adjustment for the exact height required with the adjusting screw on the base of the gauge (Fig 2).

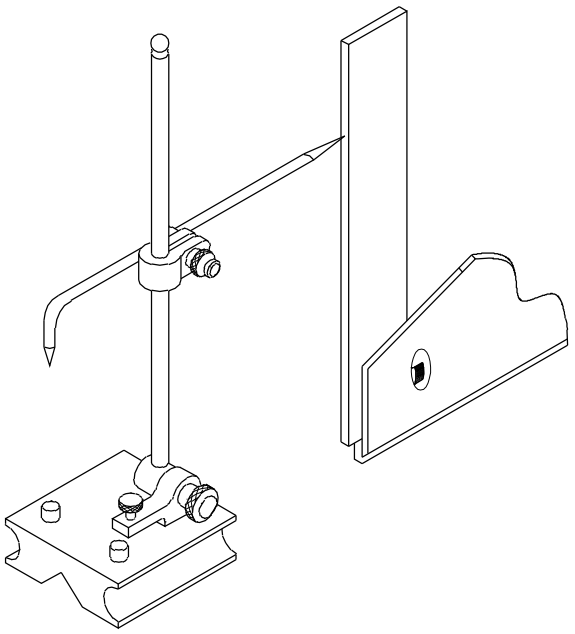
Care and maintenance

- Clean before and after use.
- Apply a thin layer of oil to the bottom of the surface base before using it for marking.
- Sharpen the scriber if necessary.
- Do not exert too much pressure while marking.

Use a surface gauge only when the tracing line will disappear after adjustment, drilling, cutting, etc.

Tracing with a hard tip surface gauge can cause a crack.

Fig 2



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Angle plate

Objectives: At the end of this lesson you shall be able to
- **name the types of angle plates**
- **state the uses of different types of angle plates**
- **specify angle plates.**

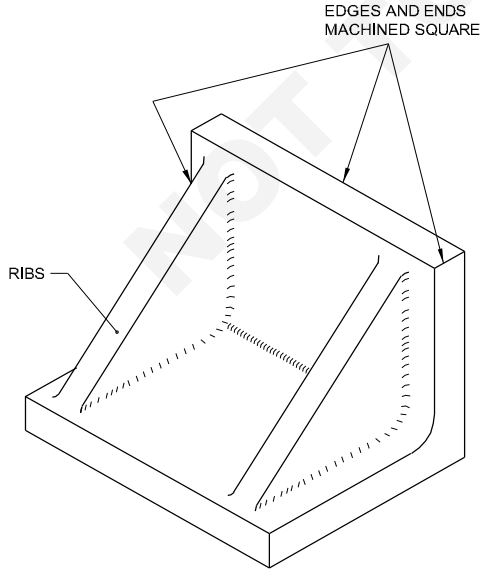
Angle plates have two or more plane surfaces, machined perfectly flat and at right angles.

Generally, these are made of closely grained cast iron or steel. The edges and ends are also machined square. They have ribs on the rear part for good rigidity and to prevent distortion.

There are four types of angle plates.

Plain angle plate (Fig 1)

Fig 1



ANGLE PLATE

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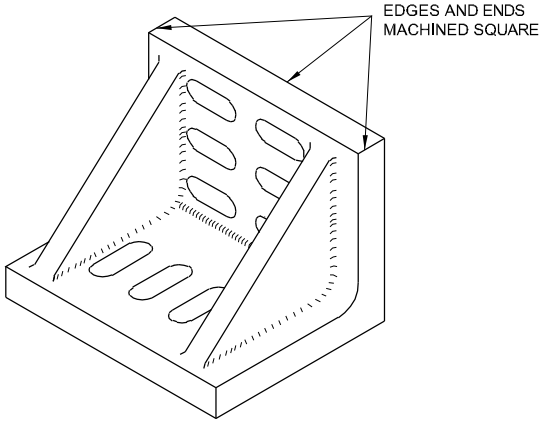
The plain solid angle plate is the most common. It has two plane surfaces perfectly machined at 90° to each other. Plain angle plates are suitable to support workpieces during layout work. They are smaller in size.

Slotted angle plate (Fig 2): The two plane surfaces of this type of angle plate have slots milled. It is bigger in size than the plain solid angle plate.

Fig 2



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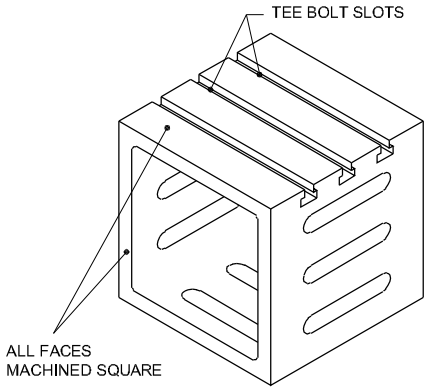
The slots are machined on the top plane surfaces to accommodate clamping bolts. This type of angle plate can be tilted 90° along with the workpiece for marking or machining.

Box angle plate (Fig 3): They have similar applications to other angle plates. All the faces of the plate are machined square to each other.

Fig 3



BOX ANGLE PLATE

After setting, the work can be turned over with the box, enabling further marking out or machining. This offers a significant advantage over the other plates.

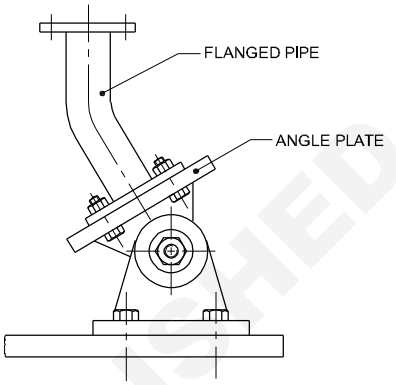
Swivel angle plate (Fig 4): This is adjustable so that the two surfaces can be kept at an angle. The two machined surfaces are on two separate pieces, which are assembled. Graduations are marked on one piece to indicate the angle of tilt with respect to the other.

When both zeros coincide, the two plane surfaces are at 90° to each other. A bolt and nut are provided for locking in the position.

Care and maintenance

- Clean before and after use to avoid dust and other particles.
- Do not keep any cutting tool in contact with the angle plate.
- Apply a thin film of oil regularly to avoid corrosion.

Fig 4



Vee block (“V” block)

Objectives: At the end of this lesson you shall be able to
- **name the types of Vee blocks**
- **state the constructional features of Vee blocks.**

Vee Blocks are devices used for marking and setting up round bars on machines.

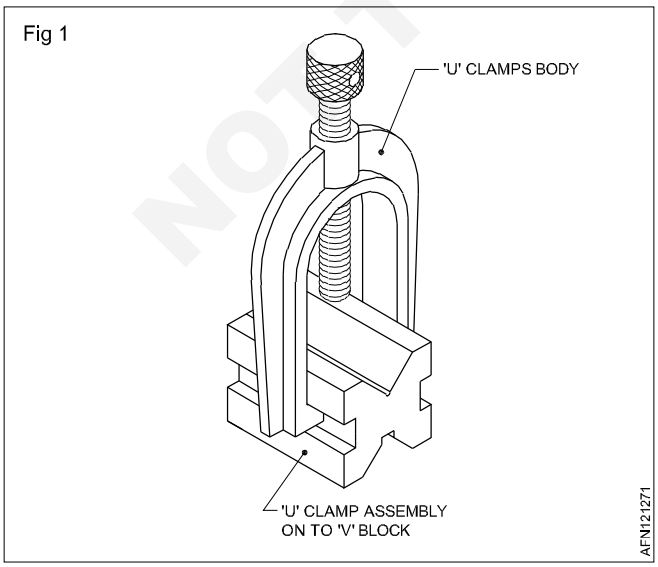
In addition to being used with round bars, they can also be used instead of blocks.

The angle of the “V” is 90° in all cases.

They are finished to a high accuracy regarding dimension, flatness and squareness.

With clamp for marking round bar (Fig 1)

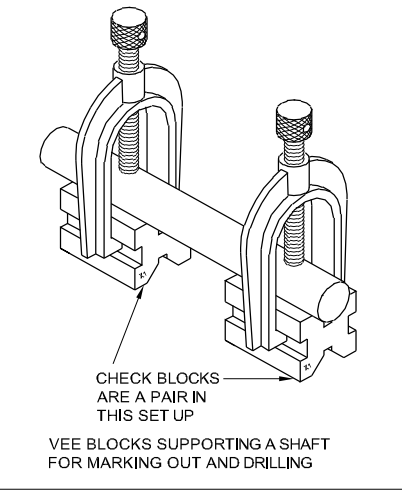
Fig 1



This Vee block has a slot machined on each side so that a clamp, which is supplied with the block, can be used to lock small workpieces for light drilling operations, etc.

A pair of Vee blocks can be used when the length of bar is too big for drilling operations (Fig 2).

Fig 2



VEE BLOCKS SUPPORTING A SHAFT
FOR MARKING OUT AND DRILLING

Matched pair Vee Block: These blocks are available in pairs that have the same size and the same grade of accuracy. They are identified by the number or letter given by the manufacturer. These sets of blocks are used to support long shafts parallel on machine tables or marking off tables.

Several types of V-blocks exist:

- with a notch on the top and a flat bottom (Fig 3)
- with four notches of different sizes (Fig 4)

Magnetic Vee blocks (Fig 5): Magnetic vee blocks have internal electromagnets that emit a magnetic charge and hold parts made out of ferrous metals.

Care and maintenance

- Clean before and after use.
- Choose the correct size of 'V' block for the required job.
- Apply a thin film of oil regularly to avoid corrosion

Fig 3

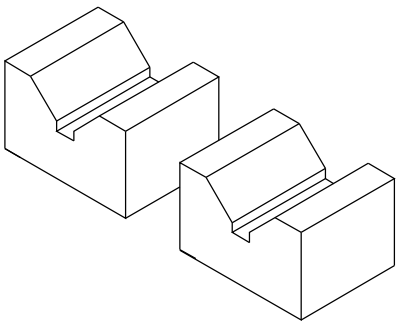


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Fig 4

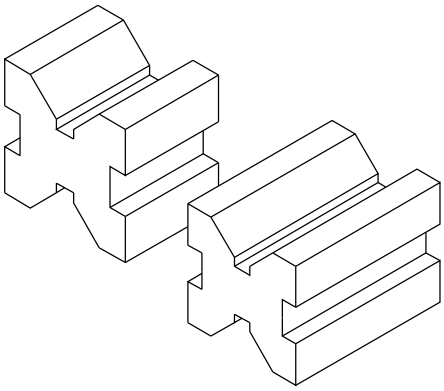

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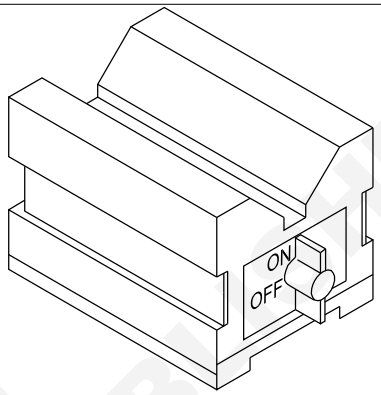
Fig 5



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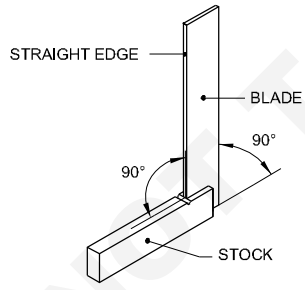
Engineer's square with stock

Objectives: At the end of this lesson you shall be able to
- **name the parts of an engineer's square**
- **state the uses of an engineer's square.**

An engineer's square (or machinist square) is the metalworkers' equivalent to a try square.

The square (Fig 1) is an instrument to check the squareness (angles of 90°) of a surface.

Fig 1



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The accuracy of a try square is about 0.002 mm per 10 mm-length, which is accurate enough for most workshop purposes. The try square has a blade with parallel surfaces.

The blade is fixed to the stock at 90°.

A small notch is present at the inside corner of the square. This prevents small particles from accumulating at the juncture and affecting the square's reading.

Uses: The try-square is used to:

- check the squareness (Fig 2)
- check the flatness (Fig 3)
- mark lines at 90° to the edges of workpiece (Fig 4)

Care and maintenance

- Clean before and after use.
- Store rules in a place in which they cannot be damaged by other tools.
- Apply a thin film of oil regularly to avoid corrosion.

Fig 2

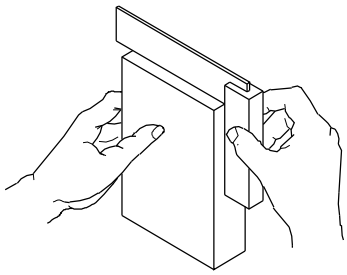

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Fig 3

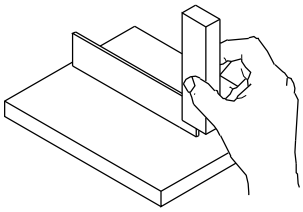

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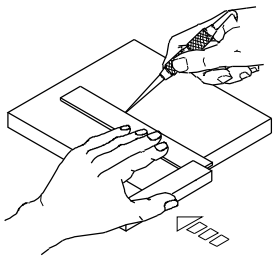
Fig 4



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Hacksaw and blades

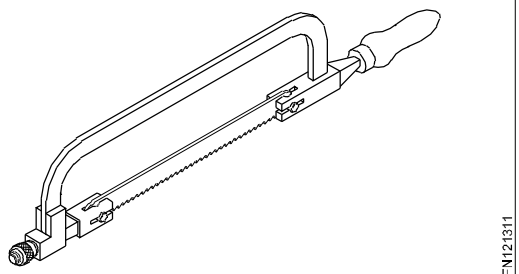
Objectives: At the end of this lesson you shall be able to
- **name the different types of hacksaw frames**
- **specify hacksaw blades**
- **name the different types of hacksaw blades**
- **describe the method of sawing.**

Hacksaw frame: A hacksaw frame is used along with a blade to cut metals of different sections.

Types of hacksaw frames used

Solid frame (Fig 1): Only a balde of particular standard length can be fitted to this frame. i.e 250mm or 300mm.

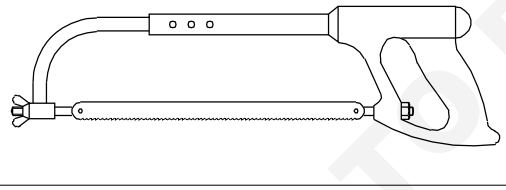
Fig 1



Adjustable flat frame type: Different standard lengths of blades can be fitted to this frame i.e. 250 mm and 300 mm.

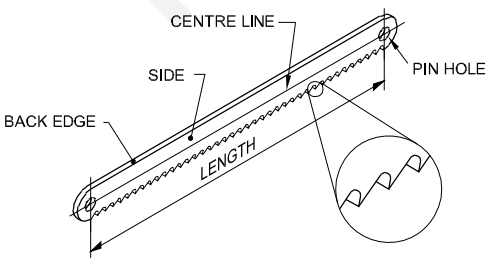
Adjustable tubular frame type (Fig 2): This is the most frequently used type. It gives a better grip and control while sawing.

Fig 2



Hacksaw blades (Fig 3): The hacksaw blade is a thin, narrow, steel band with teeth and two pin holes at the ends. It is used along with a hacksaw frame. These blades are made of either low alloy steel or high-speed steel and are available in standard lengths of 250 mm and 300 mm.

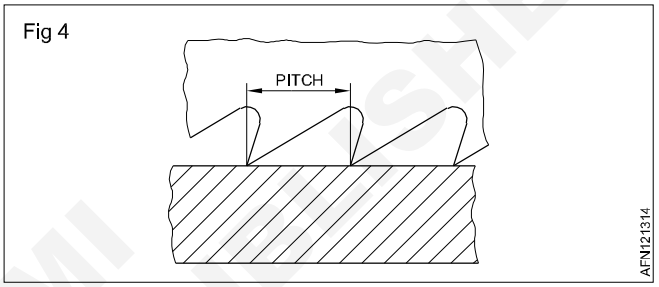
Fig 3



- All-hard blades: the width between the pin holes is hardened all along the length of the blade.
- Flexible blades: for these types of blades only the teeth are hardened. Because of their flexibility, these blades are useful for cutting along curved lines.

Pitch of the blade: This is the distance between two adjacent teeth. Hacksaw blades are designated according to length, pitch and the type of blade (Fig 4).

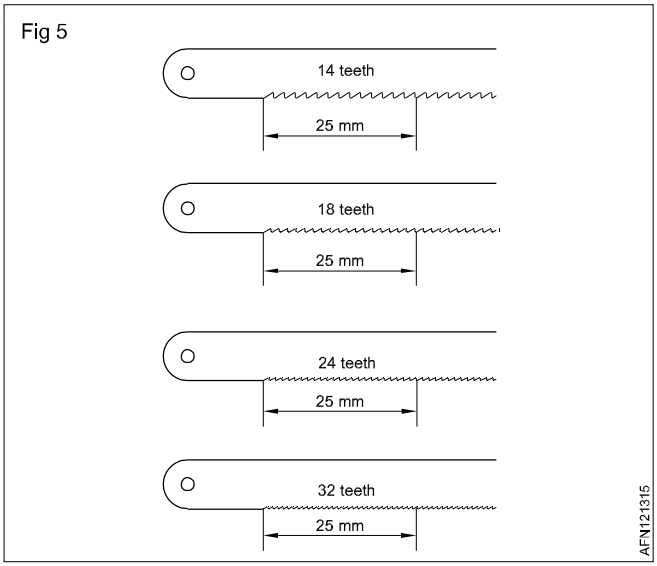
Fig 4



Saw blades for hacksaws are available with small and large cutting of teeth, depending on the type and size of the material they are to cut. The size of the teeth is directly related to their pitch, which is specified by the number of teeth per inch (TPI) of the cutting edge.

Hacksaw blades are available in different pitches as shown in Fig 5.

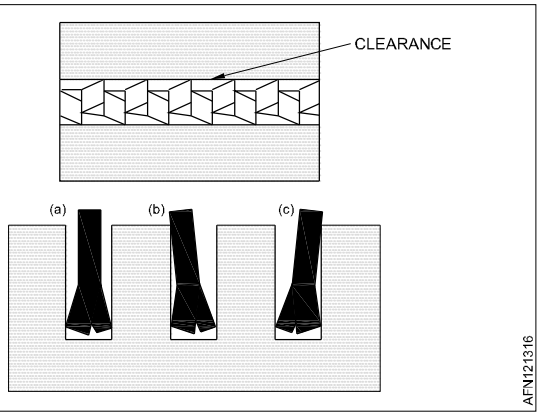
Fig 5



To prevent the hacksaw blade from jammed when penetrating the material, and to allow free movement of the blade, the cut has to be broader than the thickness of the hacksaw blade. This is achieved by the setting of the hacksaw teeth.

Wave set (Fig 6): the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

Fig 6



The clearance created allows the blade to be inclined and thus change the cutting direction.

A straight cut B to the right

C to the left

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

The general rule is that at least 3 teeth should extend across the surface of the material to be cut.

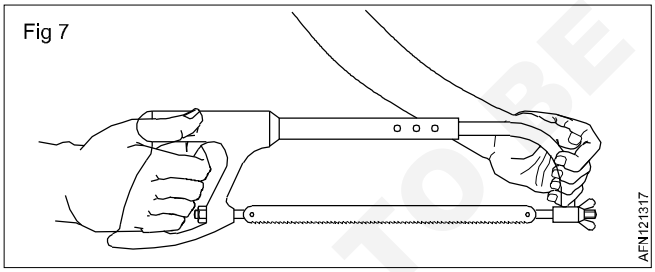
Method of sawing: Select the correct blade for the material to be cut.

Select the correct number of teeth / inch.

One hand holds the hacksaw handle, as the index finger points in the direction of cutting.

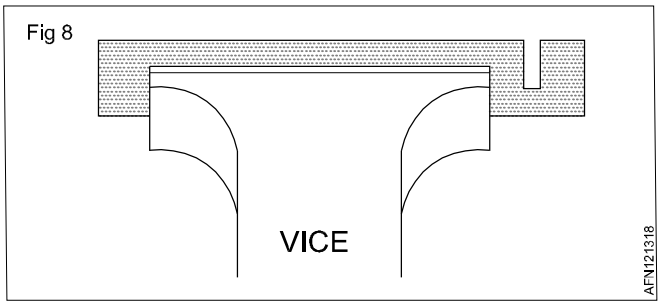
The other hand holds the frame as shown in Fig 7.

Fig 7



Cutting should be carried out close to the jaws of the vice to ensure that the metal does not flex or bend under the force of the hacksaw and the sawing motion (Fig 8).

Fig 8



Cutting speed with hacksaw: In general, the cutting speed depends on the material that is to be cut:

- from 50 to 60 strokes per minute on mild steel,
- from 60 to 80 blows per minute on aluminium,
- 20 or 25 strokes per minute on a harder steel, such as stainless steel.

Care to be taken for better cutting

Mount the blade on the frame in the direction indicated on it (tooth forward, cut by pushing).

Apply the correct tension to the blade.

Press lightly during the cutting stroke to prevent deviation of the cut.

Do not press during the return stroke to prevent damage to the teeth.

Do not start cutting on sharp edges.

Start the cut at a slight angle and apply light pressure, gradually increasing the pressure as more teeth come in contact with the job.

For extremely thin sections, clamp the section between two pieces of wood and cut as a whole.

Callipers

Objectives: At the end of this lesson you shall be able to
- **name the commonly used callipers**
- **state the advantages of spring joint callipers.**

Callipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

Callipers are classified according to their joints and their legs.

Joints

- Spring joint callipers (Fig 1A)
- Firm joint callipers (Fig 1B)

Legs

- Inside calliper for internal measurement. (Fig 2A)
- Outside calliper for external measurement (Fig 2B)

Callipers are used along with steel rules, and the accuracy is limited to 0.5 mm; parallelism of jobs etc. can be checked with higher accuracy by using callipers with sensitive feel.

Spring joint callipers have the advantage of quick setting with the help of an adjusting nut (Fig 3).

For setting a firm joint calliper, tap the leg lightly on a wooden surface.

Fig 1

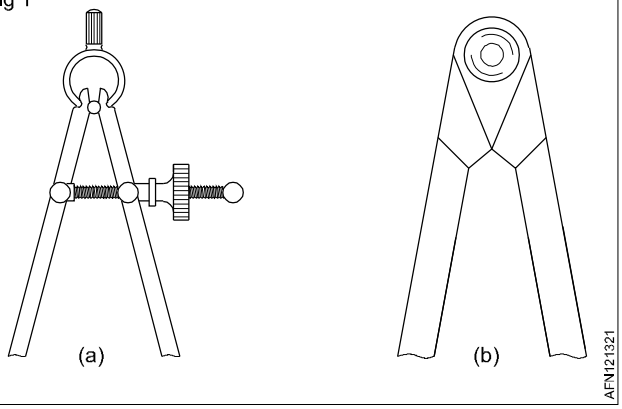


Fig 2

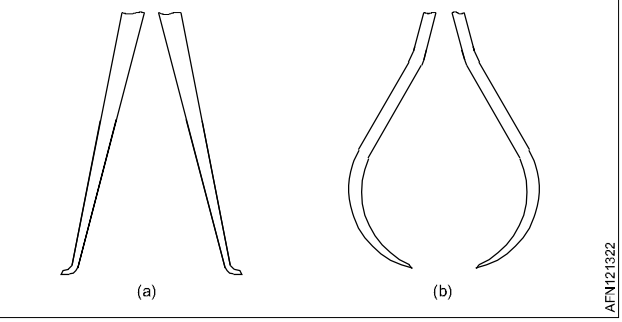
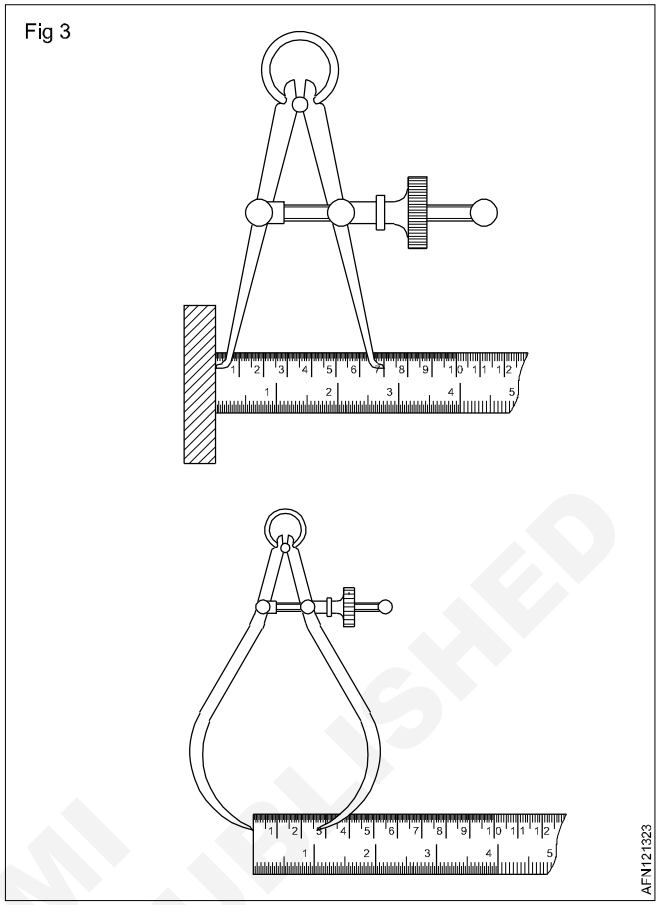


Fig 3



Dividers

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

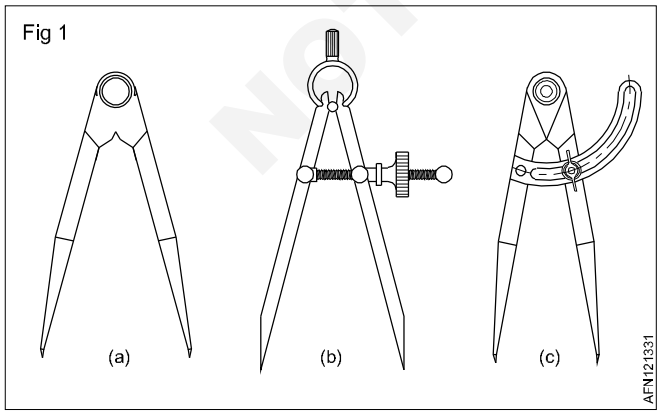
- **state the uses of dividers**
- **state the specification of dividers**
- **state the important aspects to be considered in respect of divider points.**

Divider: Dividers are used for scribing arcs, circles, transferring measurement and stepping of distances. Dividers are available with:

- firm joint (Fig 1A)
- spring joint (Fig 1B)
- locking wing (Fig 1C)

The measurements are set on the dividers with a steel rule.

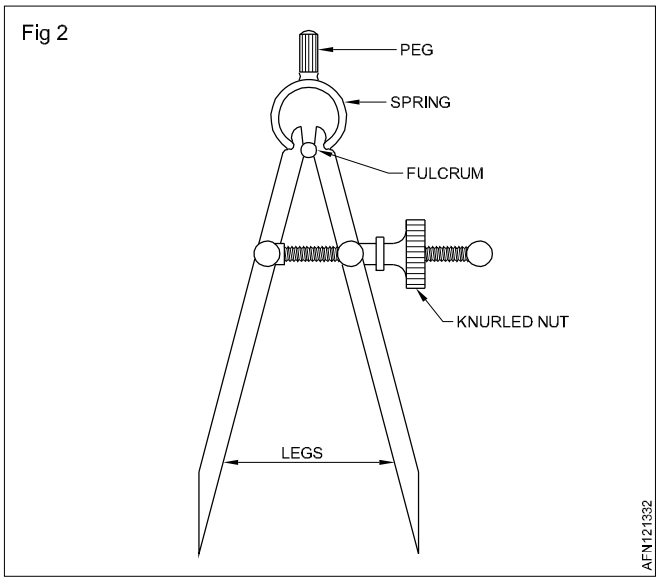
Fig 1



Constructional features of spring joint divider

Dividers are made of tool steel, sharp pointed legs. The points are hardened and tempered. The legs are joined by a fulcrum roller and bow spring. The distance should be adjusted between the points with a ball headed screw and knurled nut. A peg is provided on the top of the bow spring for easy handling.

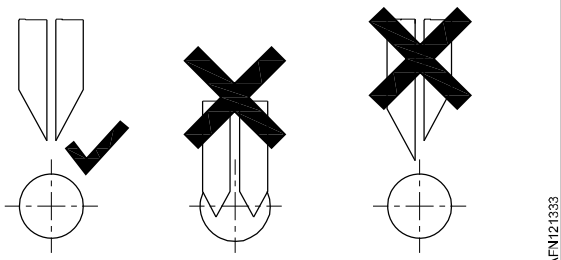
Fig 2



The size of dividers ranges from 50 mm to 200 mm. The distance from the point to the centre of the fulcrum roller (pivot) is the size of the divider.

Divider points: The two legs of the divider should always be of equal length (Fig 3).

Fig 3



The divider point should be kept sharp in order to produce fine lines. Frequent sharpening with an oilstone is better than sharpening by grinding.

Sharpening by grinding will make the points soft.

Note: The terms compass and divider are often interchanged. Each instrument can be used to draw arcs, circles, mark divisions, divide a given distance or mark a distance.

Technically, a compass is a drafting instrument that has one pen or pencil point and one sharp point that is positioned at the centre of the circle to be described, while a divider, on the other hand, has two sharp points, one for the centre and the other for scribing or marking.

Marking punches

Objectives: At the end of this lesson you shall be able to
- **name the different punches in marking**
- **state the features of each punch and its uses.**

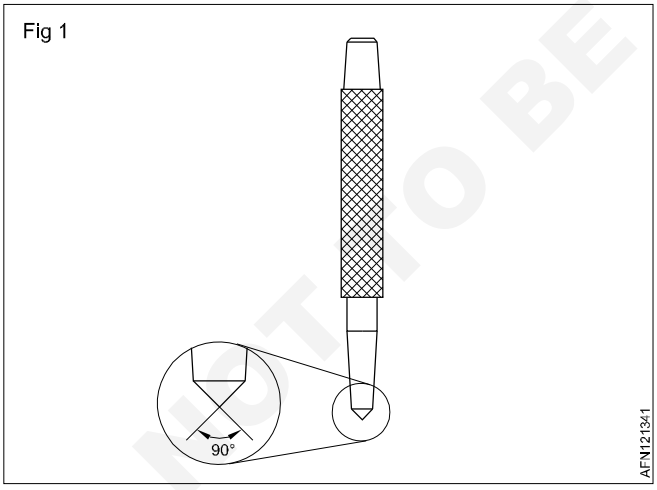
Punches are used in order to make certain dimensional features of the permanent layout.

There are two types of punches. They are centre punch and dot (or prick) punch made of high carbon steel, hardened and ground.

Centre punch: The angle of the point is 90° in a centre punch. The punch mark made by this is wide and not very deep. This punch is used for locating centre of the holes.

The wide punch mark gives a good seating for starting the drill. (Fig 1)

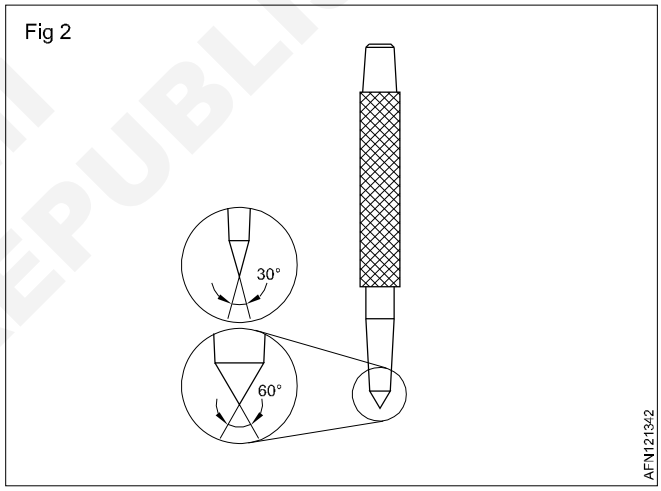
Fig 1



Dot punch: The angle of the dot punch is 30° or 60° (Fig 2).

The 30° dot punch is used for making light punch marks needed to position dividers. The divider point will get a proper seating in the punch mark.

Fig 2

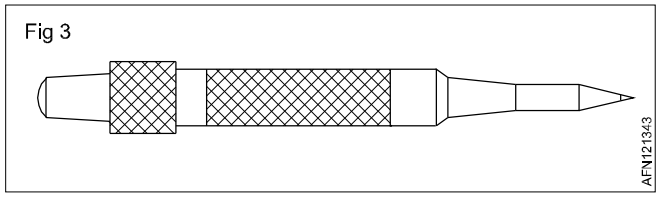


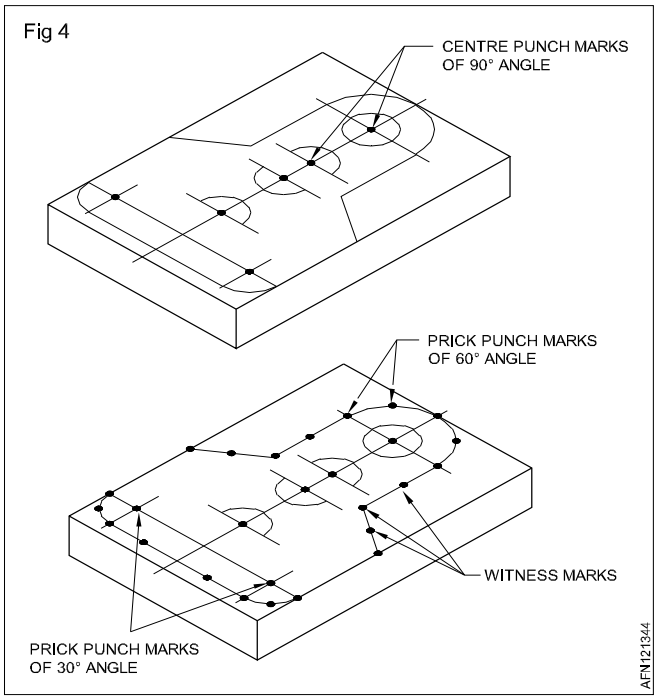
The 60° dot punch is used for marking witness marks and called as dot punch. (Fig 4)

Automatic punch: It performs the same function as an ordinary centre punch but without the need for a hammer. When pressed against the workpiece, it produces the dimple. (Fig 3)

The point can be easily removed for regrinding or replacement.

Fig 3





Hammers

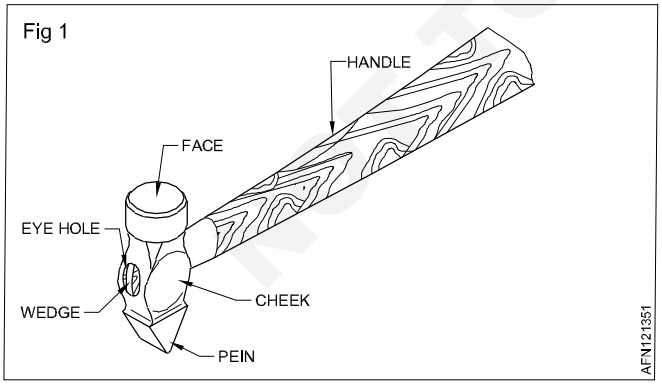
Objectives: At the end of this lesson you shall be able to
- **state the uses of an engineer's hammer**
- **identify the parts of an engineer's hammer**
- **name the types of engineer's hammer**
- **specify the engineer's hammer.**

An engineer's hammer is a hand tool used for striking purposes while punching, bending, straightening, chipping, forging or riveting.

Major parts of a hammer: The major parts of a hammer are the head and the handle.

Hammer is made of drop-forged carbon steel, while the wooden handle must be capable of absorbing shock.

The parts of a hammer-head are the face, peen, cheek and the eyehole. (Fig 1)

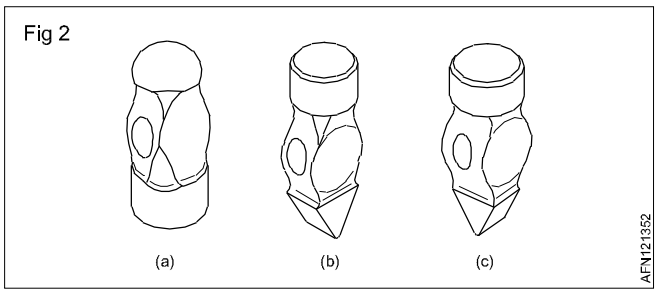


Face: The face is the striking portion.

A slight convexity is given to it to avoid digging of the edge. It is used for striking while chipping, bending, punching, etc.

Peen (Pein in American English): The peen is the other end of the head. It is used for shaping and forming work like riveting and bending. The peen is of different shapes such as:

- Ball peen. (Fig 2A)
- Cross-peen. (Fig 2B)
- Straight peen. (Fig 2C)



The face and the peen are case hardened.

Cheek: The cheek is the middle portion of the hammer head.

The weight of the hammer is stamped here.

This portion of the hammer-head is left soft.

Eyehole: The eyehole is meant for fixing the handle. It is shaped to fit the handle rigidly.

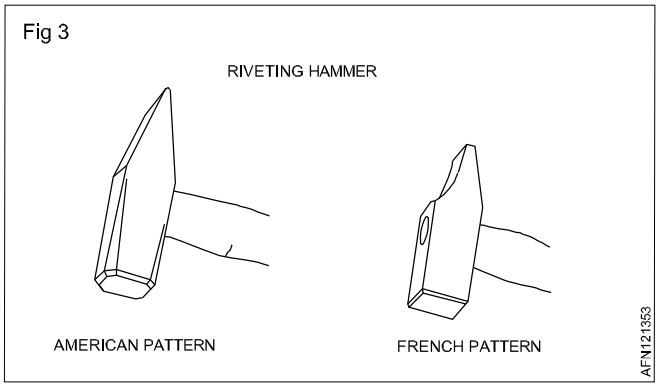
Wedge: The wedges fix the handle in the eyehole.

Application of hammers: The cross-peen hammer is used for spreading the metal in one direction.

The straight peen hammer is used at the corners.

The ball peen hammer and riveting hammer (Fig 3) are used for driving a chisel in parting metal, riveting, marking, etc.

Fig 3



Specification

An engineer's hammers are specified by their weight and the shape of the peen. Their weight varies from 125 g to 750 g.

The weight of an engineer's hammer, used for marking purposes, is 250 g.

Before using a hammer

- Make sure the handle is properly fitted.
- Select a hammer with the correct weight suitable for the job.
- Check the hammer head and handle whether any crack is there.
- Ensure that the face of the hammer is free from oil or grease.

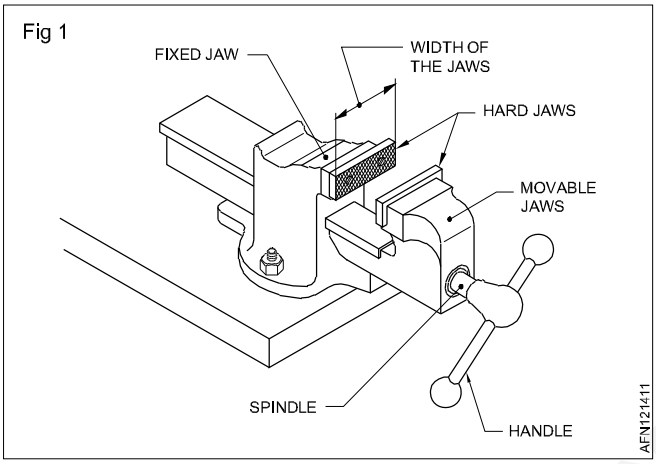
Bench vice

Objectives: At the end of this lesson you shall be able to
- **state the uses of bench vice**
- **name the parts of bench vice**
- **mention the care and maintenance of vices.**

A bench vice is made of cast iron or cast steel and it is used for holding the workpiece for filing, sawing, threading among other hand operations.

Parts of a bench vice (Fig 1)

Fig 1



Jaws: A vice has two jaws: a stationary jaw and a sliding jaw. The size of the jaws varies depending on the size, type and model of the vice.

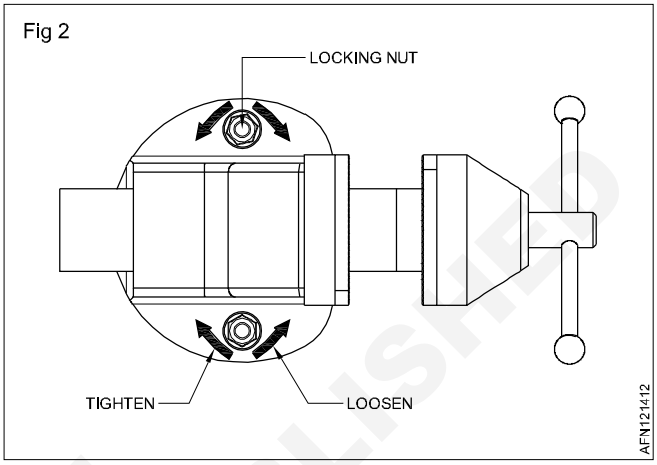
The jaws can be covered with pads made of softer materials to prevent workpiece damaging.

Handle: Turn clockwise or anti-clockwise to open or close the jaws.

Base: The base is the part of a vice that mounts to the workbench. There are two types of bases:

- A vice with a fixed base is attached straight to the workbench and is stationary.
- A vice with a swivel base can be rotated, allowing the vice to be placed in various positions while working.
- To adjust the base, the nut is loosened by a small handle allowing the vice to be moved into the desired position. The nut is then tightened to keep the vice static. (Fig 2)

Fig 2



Anvil: Some metalworking vices have an anvil fitted onto their fixed bodies.

This anvil allows for light hammering or shaping. The anvil may come in use when completing small tasks for hammering.

Care and maintenance

To keep your vice in optimal condition, always keep all threaded and moving parts clean by wiping the vice with a cloth after each use. This will clear any grit, dirt and debris.

Make sure to oil and lubricate the joints, threaded parts, and sliding section often. This is essential to maintain the smooth opening and closing of the jaws. Use machine oil on your vice to prevent rusting.

To oil the sliding section, open the jaws completely and apply a layer of grease to the slide. Move the sliding jaw in and out a few times to distribute the grease.

At the end of the work, unscrew the jaws of the vice. Leaving a vice tight damages the thread screw.

Eelement of file and rasp

Objectives: At the end of this lesson you shall be able to
- **name the parts of a file and a rasp**
- **state the material of a file and a rasp.**

File

A file is a tool used to remove fine amounts of material from a workpiece.

Files are used in several steps of the process, from roughing to finishing. Different forms are available that we will see in another course.

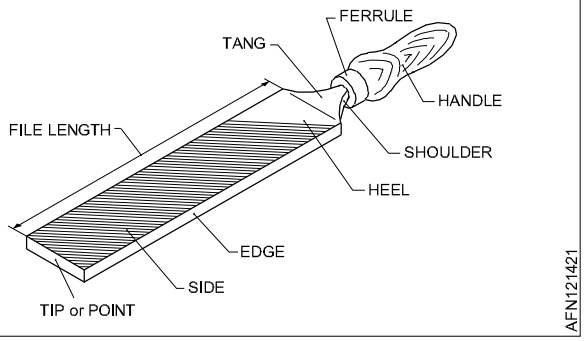
Rasp: A rasp is a kind of file with individually cut teeth used for removing large amounts of material.

The rasp is generally allowed for roughing work in thick parts.

In the adjustment of thin aluminium sheet metal, the rasp allows flat surfaces to be produced quickly and scratch-free.

Materials: Generally, files are made of high carbon or high-grade cast steel. The body portion is hardened and tempered. The tang is, however, not hardened.

Fig 1



Tip or Point: the end opposite to tang.

Side or face: the broad part of the file with teeth cut on its surface.

Edge: the thin part of the file with a single row of parallel teeth.

Heel: the portion of the broad part without teeth.

Tang: the narrow and thin part of a file which fits into the handle

Handle: the part fitted to the tang for holding the file.

Ferrule: a protective metal ring to prevent cracking of the handle.

Length: the files are available in lengths of 100, 150, 200, 250, 300 and 400mm.

Care and maintenance of files and rasps

Never hit a file or rasp on the workbench or vice. These tools are hardened and may break in shock.

Clean the file and rasp regularly with a file card brush to remove chips. See below.

Do not use files having the blunt cutting edge

- Remember that files cut on the push stroke. Never apply the pressure on the pull stroke, or you could crush the file teeth, blunt them or cause them to break off.
- Prevent from pinning.
- Normally do not apply any oil while filing.
- Files should be stored separately so that their faces cannot rub against each other or against other tools.

Safety and security

Check that the handle is correctly fitted onto the tang and that it is in good condition.

Never use a file without a handle. Tang may cause serious injuries.

Files and rasp are classified according to their cross-sectional shapes, the form of the cutting edges, and the coarseness of the cut.

Cuts of files and rasps

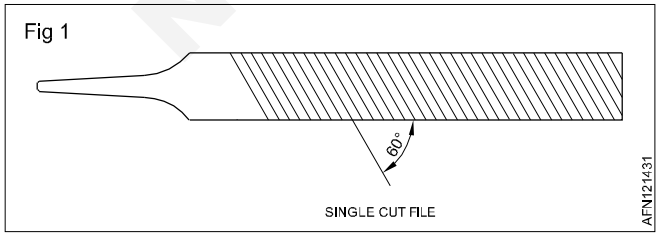
Objectives: At the end of this lesson you shall be able to
- **name the different cuts**
- **state the uses of each type of cut.**

Types of cuts: There are four types of cut.

Single cut, Double cut, Rasp cut and Milled cut.

Single cut file (Fig 1): A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60°.

Fig 1

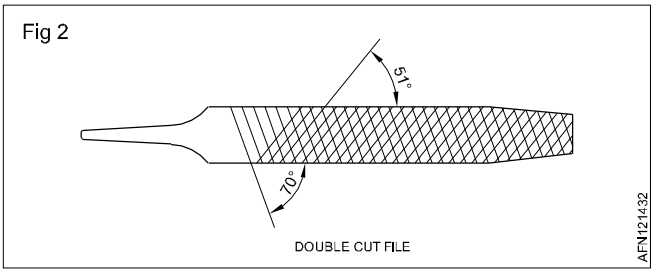


It can cut chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper.

Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.

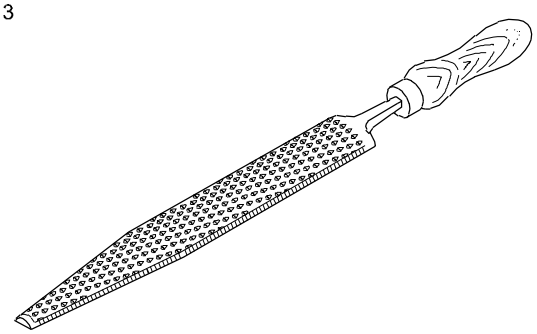
Double cut file (Fig 2): A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is known as OVER-CUT and they are cut at an angle of 70°. The other cut, made diagonal to this, is known as UP-CUT, and is at an angle of 51°. This removes stock faster than the single cut file.

Fig 2



Rasp cut file (Fig 3): The rasp cut has individual, sharp, pointed teeth in a line, and is useful for filing wood, leather and other soft materials. These files are not used for metal working.

Fig 3



RASP CUT FILE

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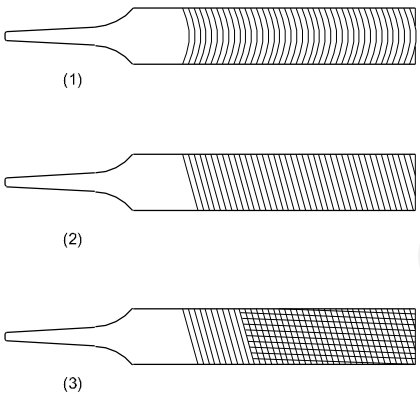
Milled cut file (Fig 4): Also called aluminium rasp or car body file, these files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper, and plastic.

The teeth of aluminium rasps are formed by cuts made on its side.

Fig 4



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Rasps have cuts of different types.

An aluminium rasp-cut has a series of individual teeth that are formed by a single-pointed tool.

There are three types of cuts (Fig 4)

- curved-cut (1)
- straight-cut (2)
- straight-cut with chip breaker (3)

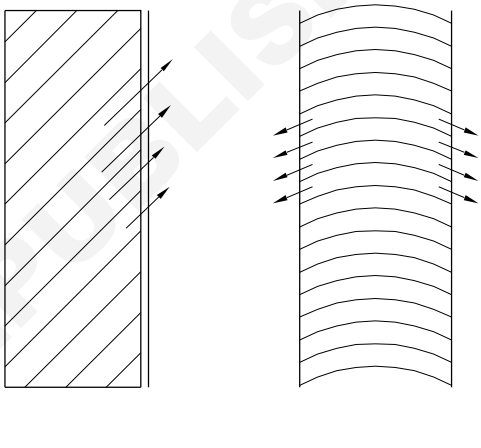
When working on thick parts, the rasp is used like a file (which we will learn in a course of the next exercise).

When working on thin parts, the rasp movement is sliding all along the part.

The operating angle is between 15 and 20° to ensure sufficient contact between the part and the tool

To avoid pinning, the chips are pushed out the teeth (Fig 5).

Fig 5



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Cross-sectional shapes of files

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

- **identify the different shape of files (types)**
- **state the uses of flat files, hard files square, round, half round, triangular and knifr- edge files**
- **state the correct shape of files for filing different profiles.**

The area to be filed will determine specific cross-section to be used.

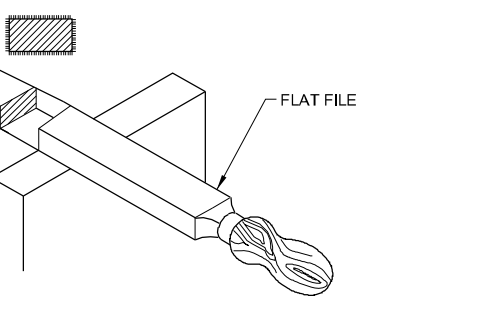
For filing and finishing different profiles, files of different shapes are used

The shape of files is stated by its cross section.

Common files of different shapes: Flat file, Hand file, Square file, Round file, Half round file, Triangular file, Knife-edge file, etc.

Flat file (Fig 1): These files are of a rectangular cross section. The edges along the width of these files are parallel up to two-thirds of the length, and then they taper towards the point. The faces are double cut, and the edges single cut. These files are used for general purpose work. They are useful for filing and finishing external and internal surfaces.

Fig 1



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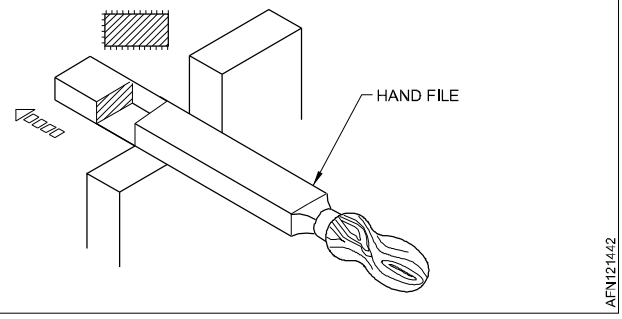
Hand file (Fig 2): These files are similar to the flat files in their cross section.

The edges along the width are parallel throughout the length.

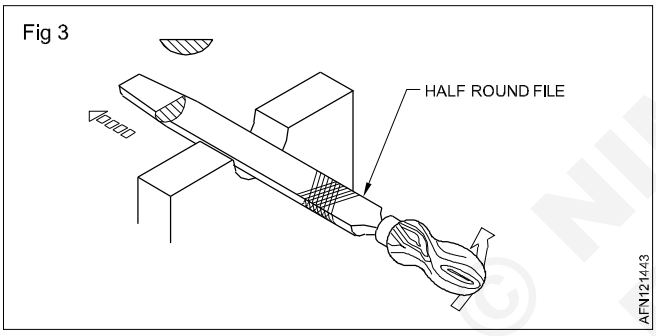
The faces are double cut. One edge is single cut whereas the other is safe edge. Because of the safe edge, they are useful for filing surfaces which are at right angles to surfaces already finished.

Fig 2



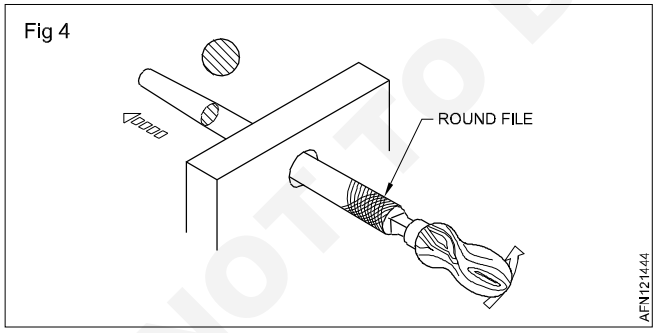
Half-round file (Fig 3): A half round file is in the shape of a segment of a circle. It is used for filing internal curved surfaces.

Fig 3



Round file (Fig 4): A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets.

Fig 4



Square file (Fig 3): The square file is square in its cross section.

It is used for filing square holes, internal square corners, rectangular openings, keyways and splines.

Three-square / Triangular file (Fig 6): A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60°.

Fig 5

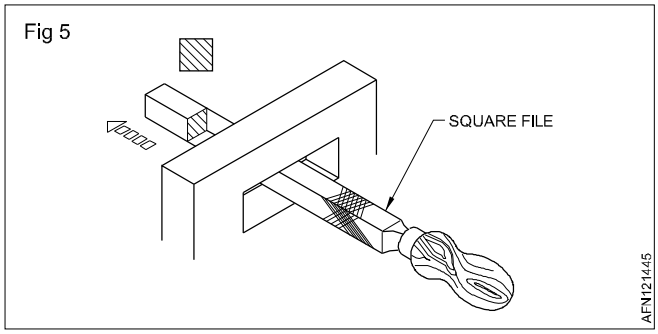
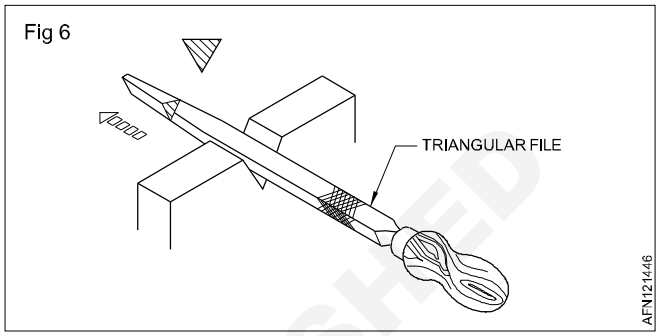


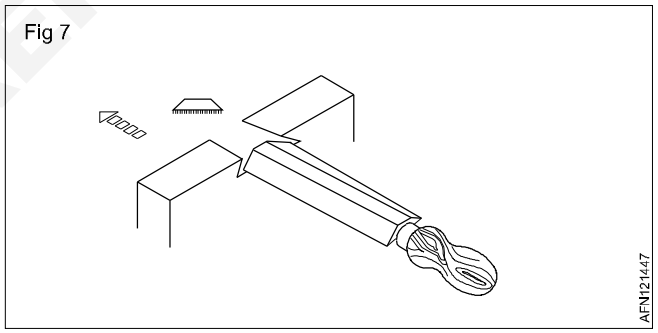
Fig 6



Barrette file (Fig 7): Barrette files are machinist's files that are easily identified by the fact they are only cut on one face. Barrette files usually have trapezoid cross sections.

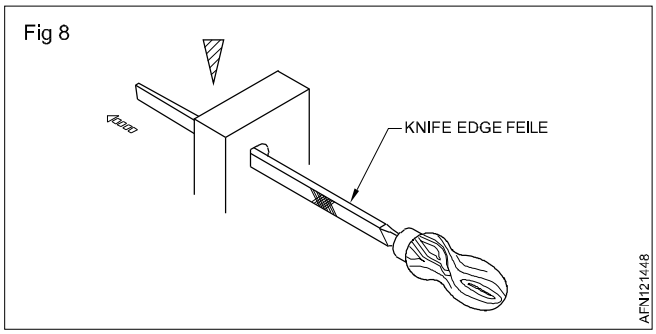
This means that they can be used for filing keyways, internal angles in slots and for general finishing and deburring, without fear of accidental wear to another surface during the filing process.

Fig 7



Knife edge file (Fig 8): A knife edge file has the cross section of a sharp triangles. It is used for filing narrow grooves and angles above 10°.

Fig 8



Coarseness or grade of files

Objectives: At the end of this lesson you shall be able to
- **name the different grades of file**
- **state the uses of each grades of file.**

Files are manufactured in different types and grades to meet the various needs.

The term 'coarseness' refers to how rough or smooth a file is.

Coarseness can be measured in teeth per inch but, conventionally, they are measured using one of two different systems:

- Swiss pattern
- American pattern.

Swiss pattern files use a numbering system that moves from the coarsest 00, through 0, 1, 2, 3 and 4, to 6, which is the finest.

American pattern files use a different system, using specific terminology. From smoothest to coarsest, these are; dead smooth, smooth, second cut, bastard and coarse.

American 'bastard cut' is equivalent to Swiss 'grade 00'.

American 'second cut' is equivalent to Swiss 'grade 0'.

American 'smooth cut' is equivalent to Swiss 'grade 2'.

Work to be accomplished, roughing or finishing, will determine type of teeth and coarseness for each application.

The degree of coarseness is greater in longer files, but differences between bastard, second and smooth are proportionate

Fig 1A: A rough (coarse) file is used for removing rapidly a larger quantity of metal.

It is mostly used for trimming the rough edges of soft metal castings.

Fig 1B: A **bastard file** is used in cases where there is a heavy reduction of material.

Fig 1C:A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals.

It is useful for bringing the jobs close to the finishing size.

Fig 1D: A **smooth file** is used to remove small quantity of material and to give a good finish.

Fig 1E: A **dead smooth file** is used to bring the material to accurate size with a high degree of finish.

The most used grades of files are bastard, second cut, smooth and dead smooth. These are the grades recommended by the Bureau of Indian Standards (BIS)

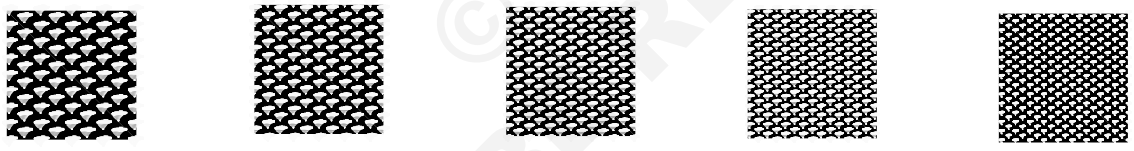


Fig 1A Fig 1B Fig 1C Fig 1D Fig 1E

Cleaning files

Objectives: At the end of this lesson you shall be able to
- **state the uses of file card brush**
- **describe the cleaning of files.**

After constant use, the teeth of a file will become clogged with small bits of metal, particularly when working with soft metals. If the teeth become clogged, then the file will not work as effectively. This is known as 'pinning' of files. (Fig 1)

When filing a workpiece to a smooth finish more 'pinning' will take place because the pitch and depth of the teeth are less.

If you do not clean the file, it will scratch the metal surface you are working on.

File card brush (Fig 2): Pinning of the files is removed by using a file brush also called a file card brush, with either forward or backward stroke.

Fig 1

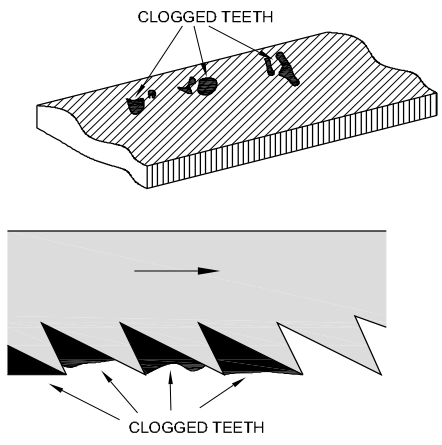
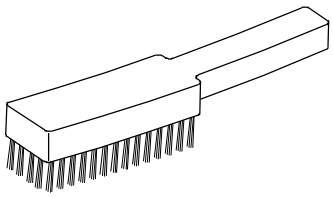


Fig 2



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A file card brush is a hand tool used to clean files.

A file card brush contains a number of metal bristles set in a rectangle.

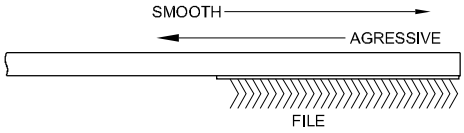
File card brushes come with wires that are already bent over. The wires are bent over to show the direction in which you are supposed to run the brush over the file.

The bristles are bent towards the handle of the tool, so the brush should be pulled towards you. This creates a more aggressive brushing action.

The brush can also be pushed away from you, causing the bristles to glide over the teeth of the file and produce a smooth brushing action. (Fig 3)

When using a file card, run the teeth in the direction of the cuts in a single cut file.

Fig 3



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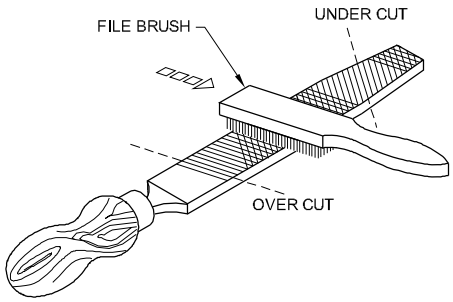
With a double cut file, you still have to brush at the angle of the upper-cut in the crossing rows (Fig 4).

Fig 4



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A double cut file contains two sets of teeth that cross each other, forming diamond-shaped teeth.

Repeat the brushing technique you are using and run the brush over the clogged-up teeth until the filings and any other material are removed.

How to prevent a file clogging

When filing soft metals, to prevent a file from clogging up, rub the file with a piece of chalk to fill the teeth.

This reduces the clogging of filings and other materials, making it easier to remove the most persistent debris. Chalk does not prevent the file from doing its job because the chalk is soft and acts as a lubricant.

Sheet metal deburring

Objectives: At the end of this lesson you shall be able to
- **name the different type of deburring tools and their uses**
- **know why the deburring is important.**

Burr is usually an unwanted piece of material and is removed with a deburring tool in a process called 'deburring'. Burrs are most commonly created by machining operations.

Deburring is just removing the burr without cutting too much material.

Deburring with file: Particularly on steel, deburring with a file is possible.

Be careful not to file too much at the risk of making a chamfer.

Deburring hand tools: Sheet metal deburring hand tools eliminate sheet metal burrs or sharp square edges that are potential liabilities.

Several manual deburring tools are available. Here are the main ones:

- To deburr the edges (Fig 1)
- To deburr straight edges, large diameter holes or curves (Fig 2)
- To deburr the drilling holes (Fig 3)

Deburring with a ruler is not recommended as it may damage it.

If no deburring tools are available and the use of the ruler is necessary, use the end furthest from zero to avoid damaging the measurement area or erasing the graduations (Fig 4).

Fig 1

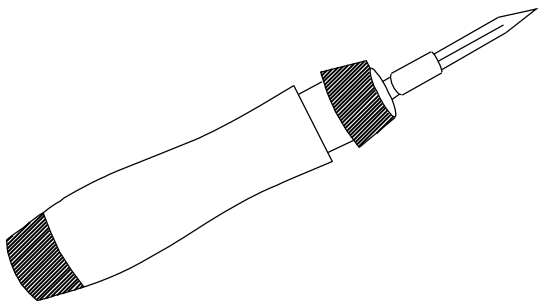

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Fig 2

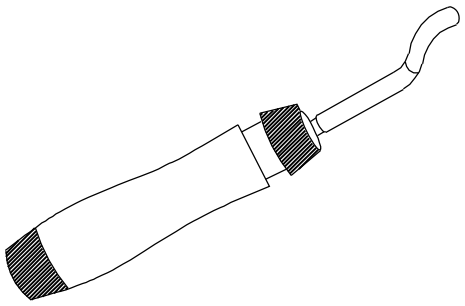

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Fig 3

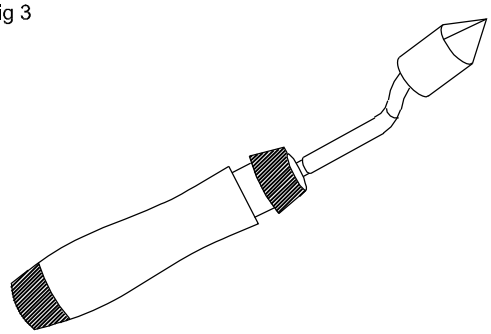

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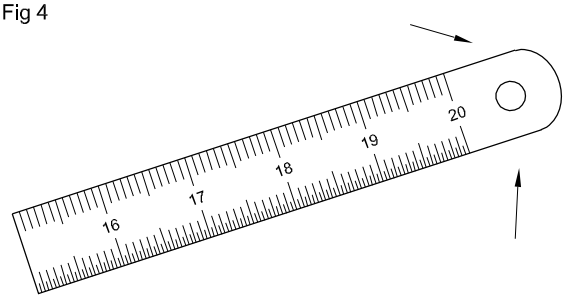
Fig 4



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Graduations and reading of metric vernier

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

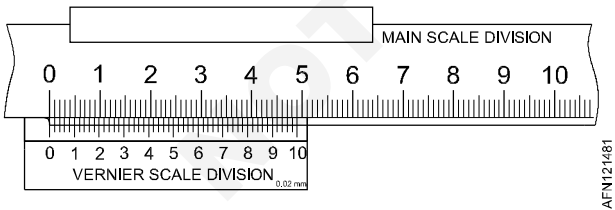
- **determine the least count of metric vernier**
- **state how graduations are made on a metric vernier with 0.02 mm least count**
- **read metric vernier measurements.**

This accuracy/least count is determined by the graduations of the main scale and the vernier scale divisions.

Vernier Principle: The vernier principle states that two different scales are constructed on a single known length of line and the difference between them is taken for fine measurements.

Determining the least count of vernier: Fig 1 shows the graduations of a common type of vernier calliper with a least count of 0.02 mm.

Fig 1



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In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Example

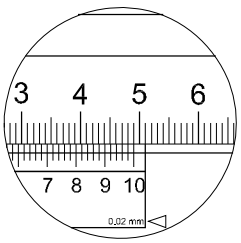
Calculate the least count of the vernier given in Fig 2.

Least count = 1 mm - 49/50 mm

= 1/50 mm

= 0.02 mm

Fig 2



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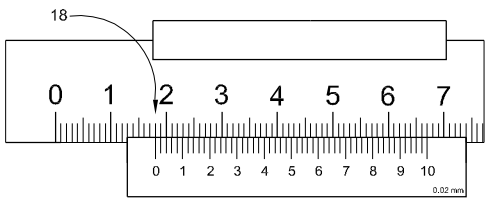
The least count is marking in the Vernier (Fig 2).

Reading metric Vernier with 0.02 mm least count

Read the value of the last scale of the main rule just before the 0 of the vernier. (Fig 3)

Fig 3



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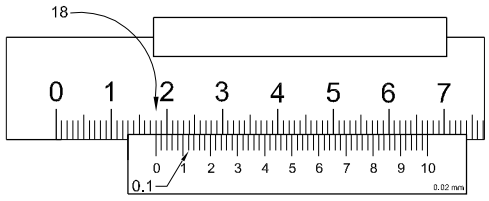
In the example: 18 mm

Find on the vernier the graduation aligned with any graduation of the main rule. (Fig 4)

In the example, it is the first graduation just after the value 1.

Fig 4



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The numbers on the vernier give tenths > 0.1 mm.

Each graduation equals 0.02 mm.

The value read on the vernier is therefore 0.1 + 0.02 = 0.12 mm.

The total reading is: 18.12 mm

Vernier calliper

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

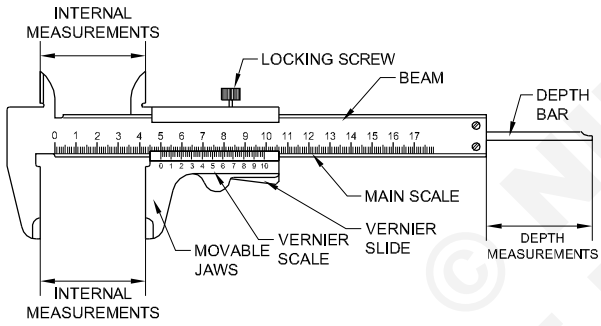
- **name the parts of a vernier callipers**
- **describe the parts of a vernier callipers**
- **state the uses of a vernier callipers.**

A vernier calliper is a precision measuring instrument. It is used to measure up to an accuracy of 0.02 mm.

Parts of a vernier callipers

Fixed jaws are part of the beam scale. One jaw is used for taking external measurements, and the other for taking internal measurements.

Fig 1



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Movable jaws are part of the vernier slide. One jaw is used for external measurements, and the other for internal measurements. (Figs 2 and 3)

Vernier slide moves over the beam and can be set in any position.

Beam: The vernier slide and the depth bar attached to it, slide over the beam. The graduations on the beam are called the main scale divisions.

The depth bar is attached to the vernier slide and is used for measurement of depth. (Fig 4)

Fig 2

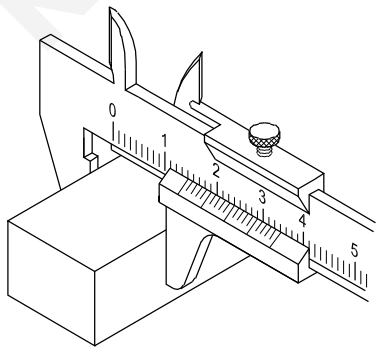

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Fig 3

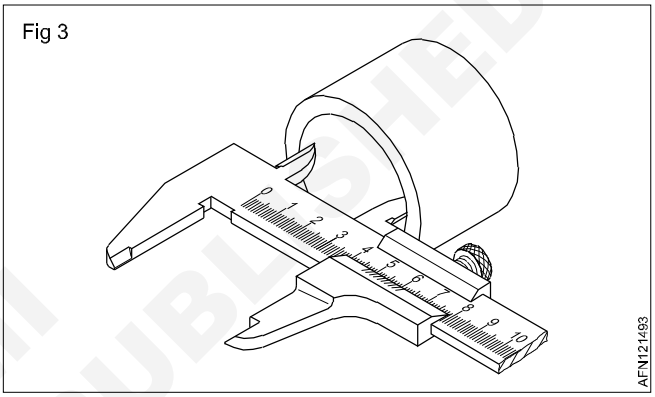

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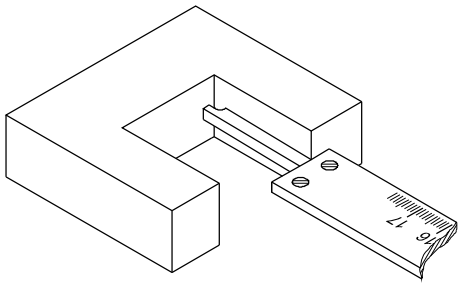
Fig 4



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The vernier scale is the graduation marked on the vernier slide. The divisions of this scale are called vernier divisions.

The **main scale** graduations or divisions are marked on the beam.

Sizes

Vernier callipers are available in sizes of 150 mm,200, 250, 300 and 600 mm. The selection of the size depends on the measurements to be taken.

Precautions

- **Vernier callipers are precision instruments, and therefore, extreme care should be taken while handling them.**
- **Never use a vernier callipers for any purpose other than measuring.**

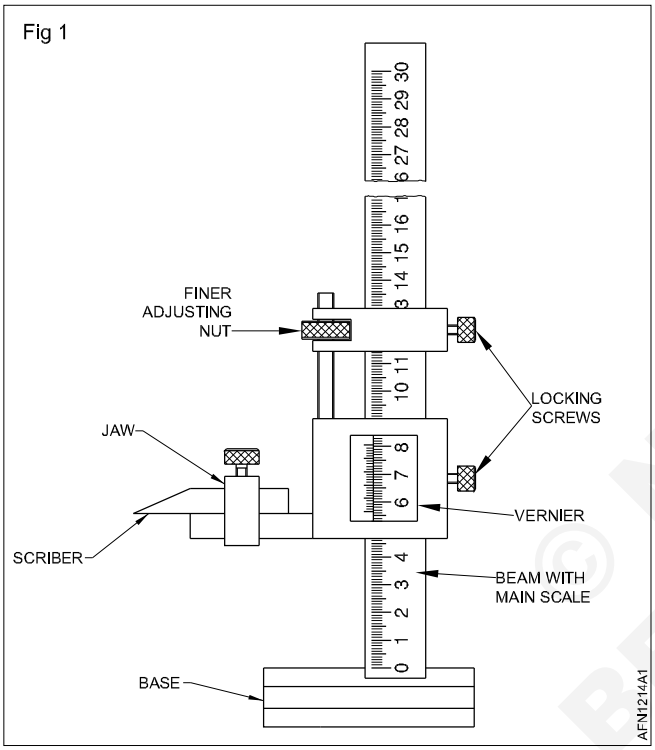
- **Vernier callipers should be used only to measure machined or filed surfaces.**
- **They should never be mixed with any other tools.**
- **Clean the instrument after use and store it in a box.**

Vernier height gauge

Objectives: At the end of this lesson you shall be able to
- **name the parts of a vernier height gauge**
- **state the constructional features of a vernier height gauge**
- **state the functional features of a vernier height gauge**
- **state the various applications of the vernier height gauge in engineering.**

Parts of a vernier height gauge (Fig 1)

Fig 1



Constructional features of a vernier height gauge

The construction of a vernier height gauge is similar to that of the vernier calliper that it is vertical with a rigid base.

It is graduated on the same vernier principle which is applied to the vernier calliper.

The beam is graduated with the main scale in mm as well as in inches. The main slide carries a jaw upon which various attachments may be clamped. The jaw is an integral part of the main slide.

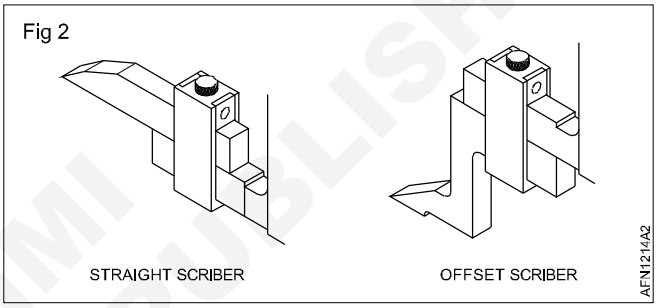
The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the finer adjusting slide.

The movable jaw is most widely used with the chisel pointed scriber blade for accurate marking out as well as for checking the height, steps etc. Care should be taken to allow for the thickness of the jaw depending on whether the attachment is clamped on the top or under the jaw for this purpose.

As like in a vernier calliper, the least count of this instrument is also 0.02 mm.

An offset scriber is also used on the movable jaw when it is required to take measurement from the lower planes. (Fig 2)

Fig 2



The complete sliding attachment along with the jaw can be arrested on the beam to the desired height with the help of the locking screws.

The vernier height gauges are available in ranges of capacities reading from zero to 1000 mm.

Functional features of the vernier height gauge

Vernier height gauges are used in conjunction with the surface plate.

In order to move the main slide, both the locking screws of the slide and the finer adjusting slide must be loosened.

The main slide along with the chisel pointed scriber has to be set by hand, for an approximate height as required.

The finer adjusting slide has to be locked in position, for an approximate height as required. To get an exact markable height, the finer adjustments have to be carried on the slider with the help of the adjusting nut. After obtaining the exact markable dimension, the main slide is also to be locked in position. (Fig 3)

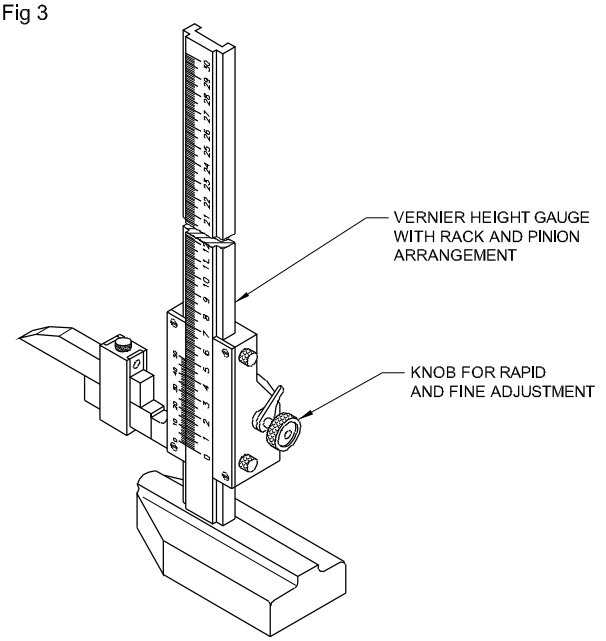
Some vernier height gauges are equipped with a sliding main scale which may be set immediately for the initial reading. This minimises the possible errors in reading the various sizes in the same setting. (Fig 4)

Various applications of a vernier height gauge

The vernier height gauge is mainly used for layout work.

It is used for measuring the width of the slot and external dimension.

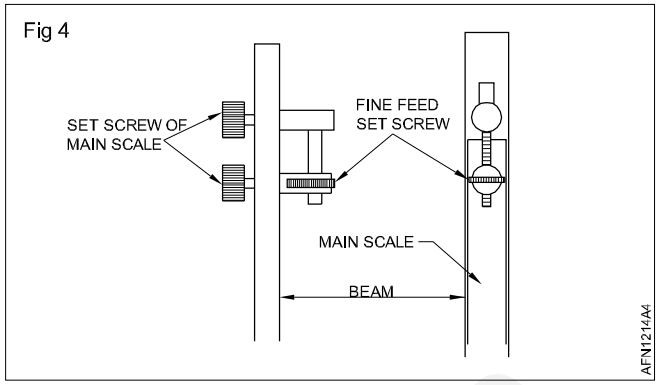
Fig 3



It is also used for measuring depth, with a depth attachment.

It is used to measure sizes from the lower plane with the help of an offset scriber.

Fig 4

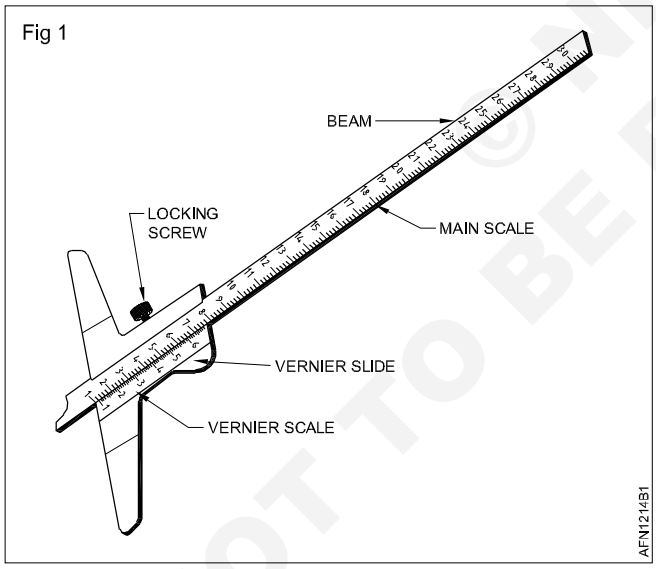


Vernier depth gauge

Objectives: At the end of this lesson you shall be able to
- **name the parts of vernier depth gauge**
- **state the uses of vernier depth gauge.**

Parts of a vernier depth gauge (Fig 1)

Fig 1



A depth gauge is a measurement device used to accurately measure the depth of cavities, recesses, grooves or other type of openings.

The depth gauges have a graduation of 0.02mm or 0.05mm.

It is composed of a base fixed to the vernier sliding on the beam.

The reading is the same as for the calliper.

Bevelled straight edge

Objectives: At the end of this lesson you shall be able to
- **state the uses of straight edge.**

Bevelled straight edge is a flat bar of steel.

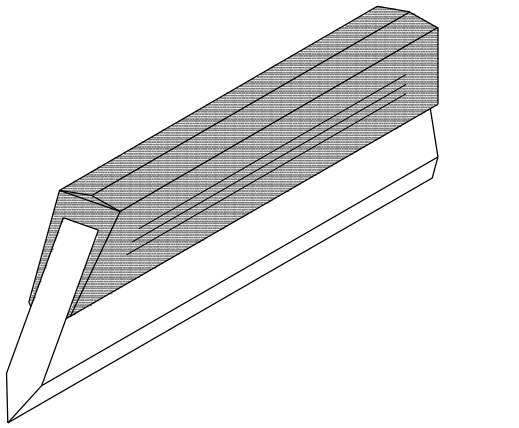
It is used to check flatness (Fig 1).

The blade is bevelled, and the upper edge is covered with a grip plate.

Note: the blade of a square can serve as a straight edge.

Burrs should be removed before any checking.

Fig 1



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Radius and fillet gauge

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

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 radius gauge and the gauges used to check the fillets are called fillet 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.

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

Some sets have provisions to check the radius and fillet on each blade. (Fig 3)

And some sets have separate sets of blades to check the radius and fillet. (Fig 4)

Fig 1

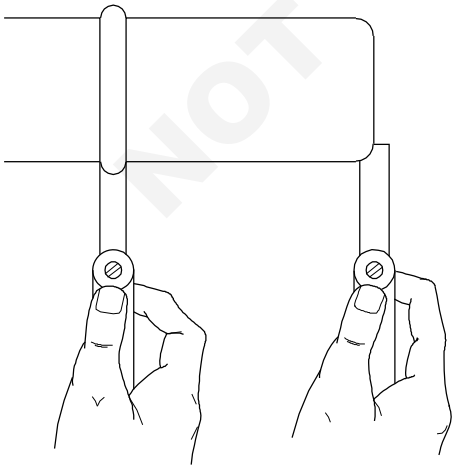

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Fig 2

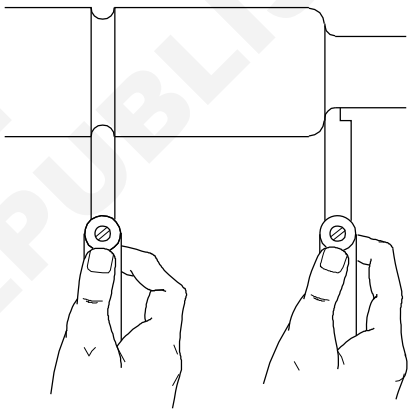

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Fig 3

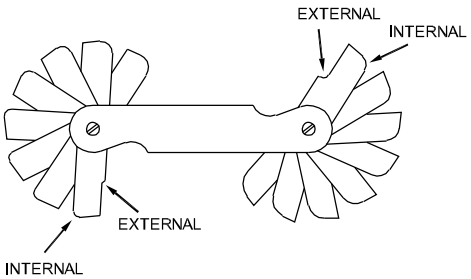

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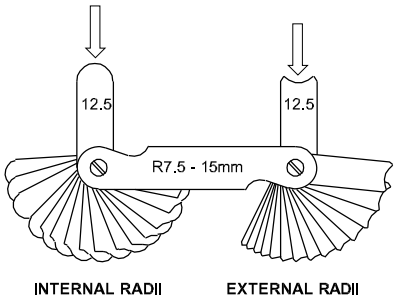
Fig 4



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Each blade can be swung out of the holder separately, and has its size engraved on it. (Fig 4)

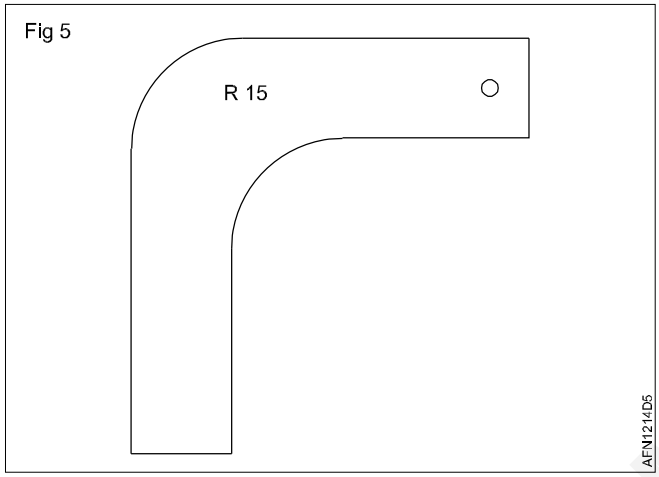
Fillet gauges are available in sets to check the radii and

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 5)

Fig 5



Use of radius and fillet gauge

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

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.

Fig 7 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 6

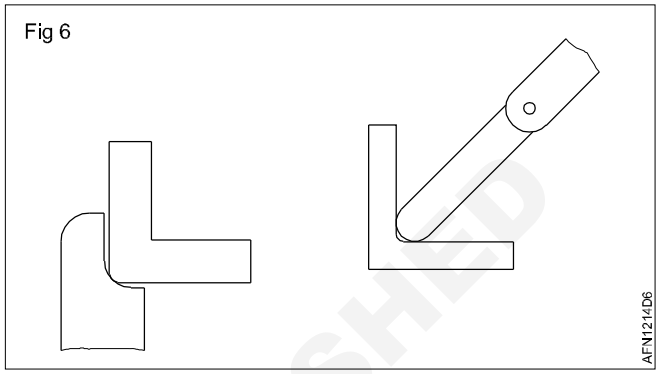
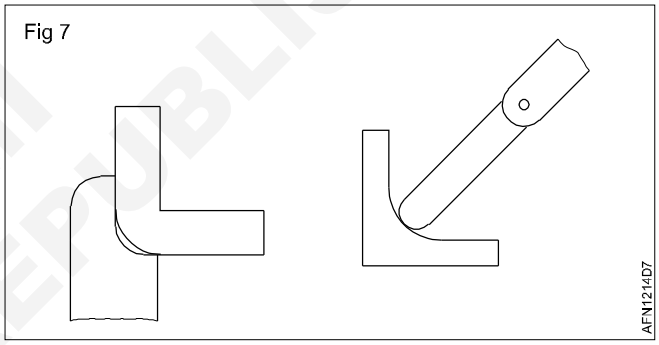


Fig 7



Metallic material - Physical & mechanical properties

Objectives: At the end of this lesson you shall be able to
- **name the different physical and mechanical properties of materials**
- **state the characteristics of the mechanical properties of metals.**

Properties of metals: Metals have different properties. Depending on the type of application, different metals are selected. Physical properties of metals;

- Colour
- Weight/Specific gravity
- Structure
- Conductivity
- Magnetic property
- Fusibility

Colour: Different metals have different colours. For example, copper is of a distinctive red colour. Mild steel is of a blue/black sheen.

Weight: Metals differ based on their weight. A metal, like aluminium, weighs lighter (specific gravity 2.8) than many others, and a metal, like lead, is heavy (specific gravity 9).

Specific gravity: It is the ratio between the weight of the metal and the weight of equal volume of water.

Structure: Generally, metals can also be differentiated by their internal microstructure. Metals like wrought iron and aluminium will have a fibrous structure, and metals like cast iron and bronze will have a granular structure.

Conductivity: Thermal conductivity and electrical conductivity are the measure of the ability of a material to conduct heat and electricity. Conductivity will vary from metal to metal.

Copper and aluminium are good conductors of heat and electricity.

Magnetic property: A metal is said to possess magnetic property, if it is attracted by a magnet.

Almost all ferrous metals, excepting some types of stainless steel, can be attracted by a magnet and all non-ferrous metals and their alloys will not be attracted by a magnet.

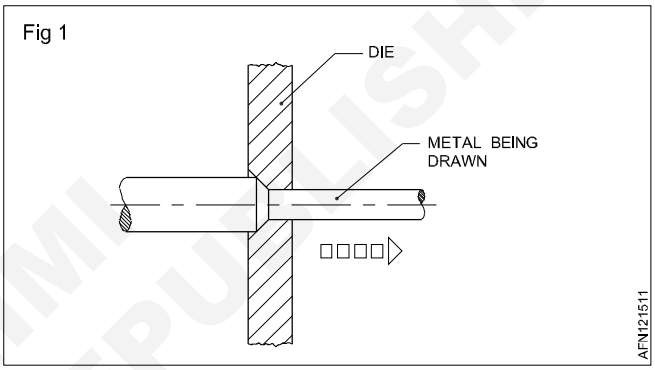
Fusibility: It is the property possessed by a metal by virtue of which it melts when heat is applied. Many materials are subject to the transformation in shape (i.e.) from solid to liquid at different temperatures. Tin has a low melting temperature (232ºC) and tungsten melts at a high temperature (3370ºC).

Mechanical properties: The mechanical properties of a metal are:

- Ductility
- Malleability
- Hardness
- Toughness
- Elasticity
- Brittleness
- Tenacity

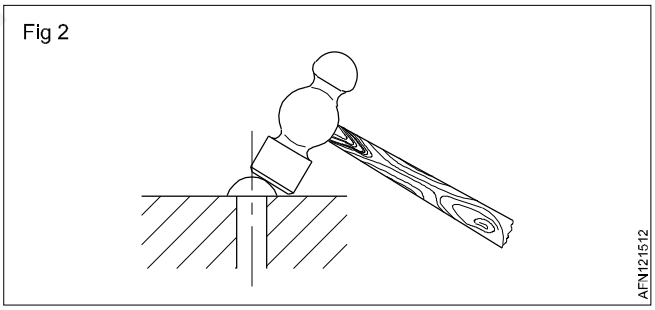
Ductility (Fig 1): A metal is said to be ductile when it may be drawn out in tension without rupture. Wire-drawing depends upon ductility for its successful operation. A ductile metal must be both strong and plastic. Copper and aluminium are good examples of ductile metals.

Fig 1



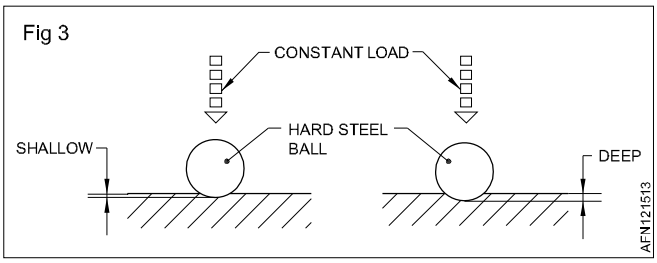
Malleability (Fig 2): Malleability is the property of permanently extending in all directions without rupture by hammering, rolling, etc. to change its size and shape. Lead is a very malleable metal.

Fig 2



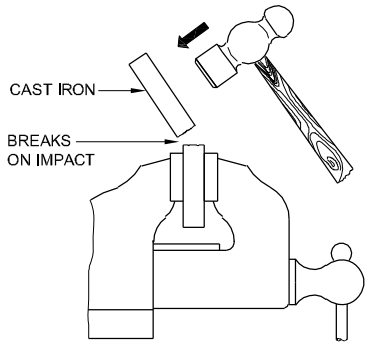
Hardness (Fig 3): Hardness is a measure of a metal's ability to withstand scratching, wear, abrasion and penetration.

Fig 3



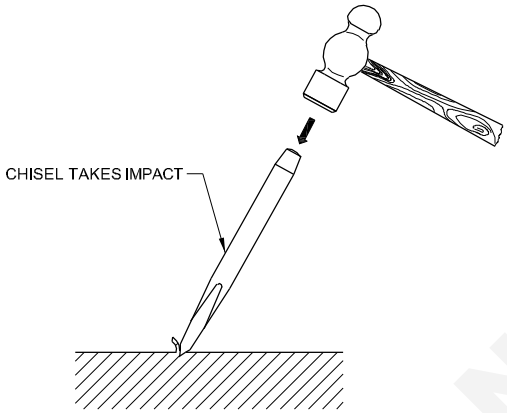
Brittleness (Fig 4): Brittleness is the property of a metal which permits no permanent distortion before breaking. Cast iron is an example of a brittle metal, and it will break rather than bend under shock or impact.

Fig 4



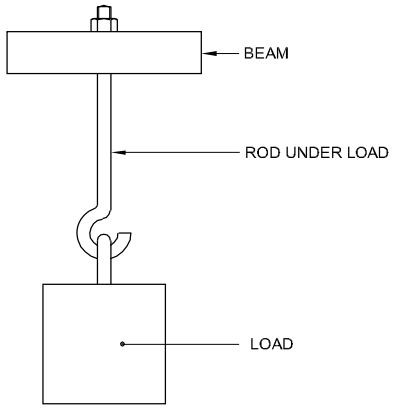
Toughness (Fig 5): Toughness is the property of a metal to withstand shock or impact. Toughness is the property opposite to brittleness. Wrought iron is an example of a tough metal.

Fig 5



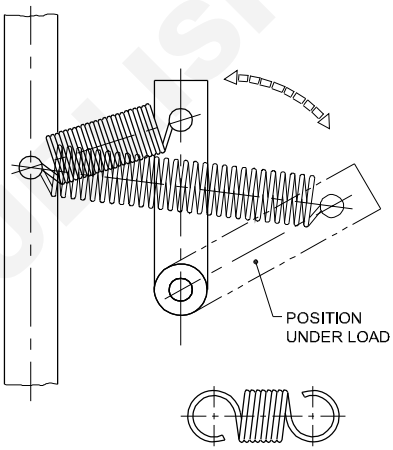
Tenacity (Fig 6): Tenacity of a metal is its ability to resist the effect of tensile forces without rupture. Mild steel wrought iron and copper are examples of tenacious metals.

Fig 6



Elasticity (Fig 7): Elasticity of a metal is its power of returning to its original shape after the applied force is released. Properly heat-treated spring is a good example of elasticity.

Fig 7



Non - Ferrous metals: Aluminium

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.**

Aluminium is a non-ferrous metal which is extracted from 'BAUXITE'.

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.

It is a remarkable metal for its lightness, its malleability (it is soft), and its resistance to corrosion, which is due to the formation of an oxidation layer.

Chemical Symbol	A
Technological Symbol	Al
Colour	Silvery-white
Melting point	660°C
Density	2.73

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 based on the principal alloying element present in an alloy.

Non - Ferrous metals: Aluminium alloys

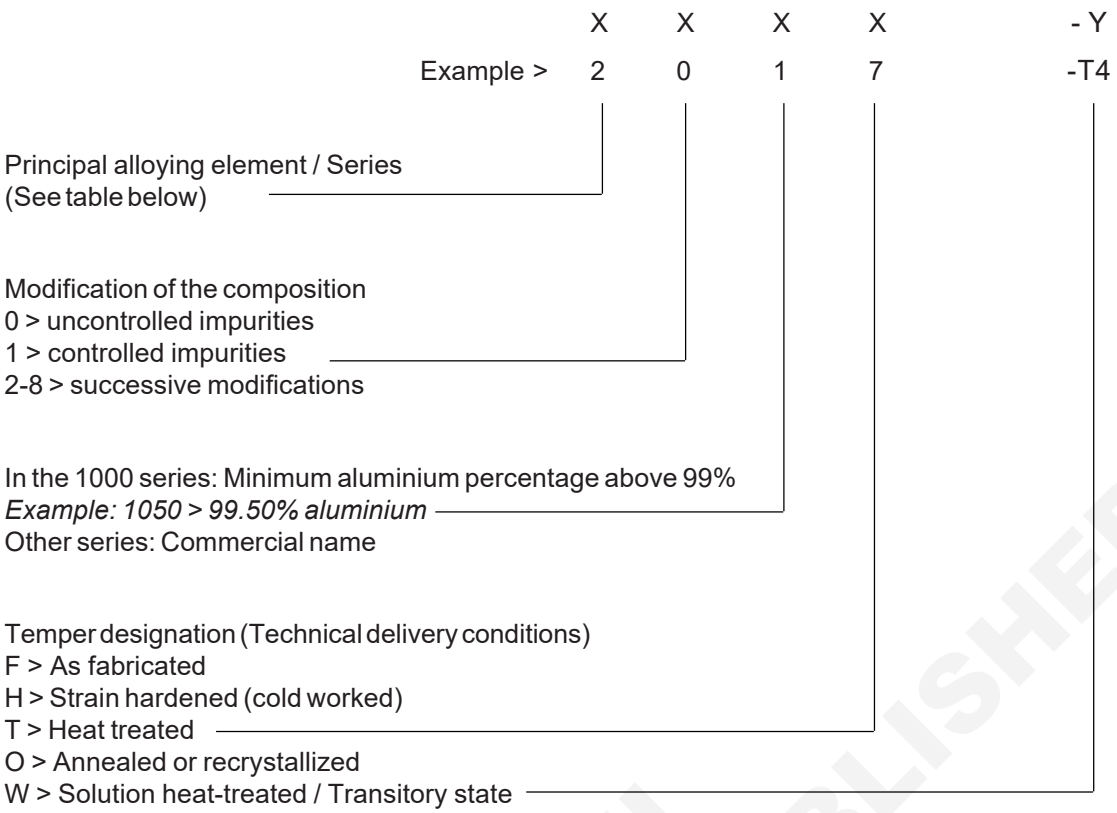
Objectives: At the end of this lesson you shall be able to
- **name the commonly used series of aluminium alloys**
- **know the designation of aluminium alloys.**

Wrought aluminium alloy numbering system

There are over 300 wrought alloys, 50 of them in common use.

Aluminium alloys are classified based on the principal alloying element present in an alloy.

Each alloy is designated with a four-digit number with a dash, a letter, and digit number.



Series of alloys: The first digit indicates the major alloying elements.

Series	Major alloying element
1000	Non-alloyed aluminium – 99% minimum
2000	Copper
3000	Manganese
4000	Silicon
5000	Magnesium
6000	Magnesium – Silicon
7000	Zinc
8000	Other aluminium alloys

There are two types of aluminium alloys depending on their hardening.

- Strain hardening, cold-working
- Precipitation or age hardening

Aluminium alloys of series 1000, 3000, 5000 are hardened by strain hardening or cold working.

The 2000, 4000, 6000 and 7000 series by precipitation hardening after heat treatment.

Aerospace aluminium alloys: The following aluminium alloys are commonly used in aircraft:

- Alloy 2014 is used for heavy-duty forgings, plates, extrusions for aircraft fittings, wheels, and major structural components. This alloy is often used for applications requiring high strength and hardness, as well as for service at elevated temperatures.
- Alloy 2017 is used for rivets.
- **Alloy 2024** is used for aircraft structures, rivets, hardware, machine screw products, and other miscellaneous structural applications. In addition, this alloy is commonly used for heat-treated parts, airfoil and fuselage skins, extrusions, and fittings.
- **Alloy 2025** is used extensively for propeller blades.
- **Alloy 5052** is used where good workability, very good corrosion resistance, high fatigue strength, weldability, and moderate static strength are desired. This alloy is used for fuel, hydraulic, and oil lines.
- **Alloy 5056** is used for making rivets and cable sheeting.
- **Alloy 6061** is commonly used for hydraulic and pneumatic tubing.
- **Alloy 7075**, although higher in strength than 2024, is used for aircraft structures, rivets, hardware, machine screw products, and other miscellaneous structural applications.

Temper designation: The temper designation follows the wrought designation number with a dash, a letter, and potentially a one to three-digit number. (2024-T4)

- **F >As Fabricated**

No special control has been performed to the heat treatment or strain hardening after the shaping process such as casting, hot working, or cold working.

- **O >Annealed:** This is the lowest strength, highest ductility temper
- **H >Strain Hardened:** Used for products that have been strengthened by strain hardening, with or without subsequent heat treatment. The designation is followed by two or more numbers as discussed below.
- **T >Heat Treated:** Used for products that have been strengthened by heat treatment, with or without subsequent strain hardening. The designation is followed by one or more numbers as discussed below.
- **W >Solution Heat Treated:** This is seldom encountered because it is an unstable temper that applies only to alloys that spontaneously age at ambient temperature after heat treatment.

H Temper subdivisions

H1 >Strain-hardened only.

H2 >Strain-hardened and partially annealed.

H3 >Strain-hardened and stabilized.

H4 >Strain-hardened and lacquered or painted.

H1X / H2X / H3X / H4X : The second digit Indicates the degree of strain-hardening as identified by the min. value of the ultimate tensile strength

HX2 = 1/4 hard

HX4 = 1/2 hard

HX6 = 3/4 hard

HX8 = full hard

HX9 = extra hard

H1xX / H2xX / H3xX / H4xX

The third digit when used indicates a variation of a second digit temper.

T Temper subdivisions

T1 >Cooled from hot working and naturally aged (at room temperature)

T2 >Cooled from hot working, cold-worked, and naturally aged

T3>Solution heat treated and cold worked

T4>Solution heat treated and naturally aged

T5>Cooled from hot working and artificially aged (at elevated temperature)

T51>Stress relieved by stretching

T52 >Stress relieved by thermal treatment

T54 >Stress Relieved by Combined Stretching & Compressing

T6>Solution heat treated and artificially aged

T7>Solution heat treated and stabilized

T8>Solution heat treated, cold worked, artificially aged

T9>Solution heat treated, artificially aged, cold worked

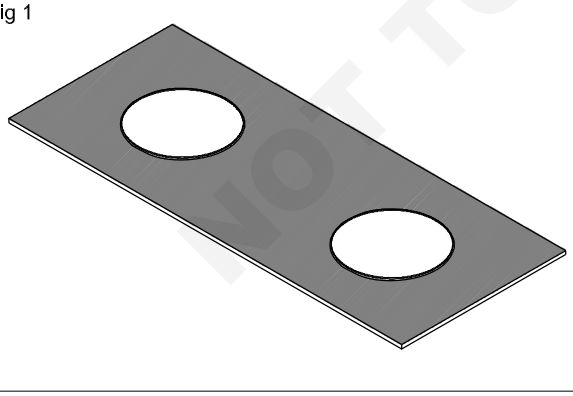
T10>Cooled from hot working, cold-worked, artificially aged

Lightning flanged holes

Objectives: At the end of this lesson you shall be able to
- **state the use of lightning flanged holes**
- **know how to make a flanged hole.**

It is a large hole whose edges have been bent to increase the strength of the sheet (Fig 1).

Fig 1



Flanged lightening holes reduce weight, they are easy to produce, induce a little stiffness to webs, and provide access.

Inspection flanges should all be the same way to assist tooling and their direction should facilitate drainage.

Flanged lightening holes are preferred in the thickness range of 0.6 mm – 2.5 mm.

It is mainly carried out on a press (manual or hydraulic).

Male and female dies are mounted on the press and made:

- punching and forming in one operation,
- forming once the punching has been done.

Fig 2

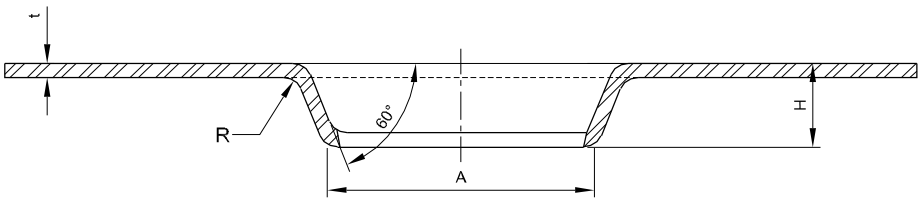


TABLE 1

FLANGED HOLE DIMENSIONS

A	H	R	PUNCHED HOLES DIAMETERS			
			t=1.2	t=1.6	t=2.0	t=2.5
30	4.5	4	26.2	26.2	-	-
40	5	5	35.6	36	36.2	-
50	5.5	6	45.2	45.8	45.8	-
60	5	7	54.7	55	55.2	55.2
70	6.5	7	64.4	64.6	65	65.2
80	7	8	73.9	74.4	74.4	74.6
90	7.5	8	83.4	83.8	83.8	84.2
100	8	8	92.8	93.2	93.4	93.6
120	9	8	111.6	111.8	112	112.4

Hydraulic press and dimple die set for flanged hole

Objectives: At the end of this lesson you shall be able to
- **know the mains components of hydraulic press**
- **state the use of dies for flanged hole.**

Hydraulic press (Fig 1): The hydraulic press is widely used in industry for forming metals and for other tasks where a large force is required. It is manufactured in a wide variety of styles and sizes

Use of workshop hydraulic press: Place the workpiece on the working table so that it is directly under the piston rod (plugger). The centre of the piston must be in alignment with the application axis.

Close release valve.

Operate the pump handle to build pressure. Pressure will be maintained until the release valve is opened.

Open release valve to release pressure.

Creating flanged hole: Cut a clean hole of the size corresponding to the die set to be used.

File any remaining burrs from the edge of the drilled hole.The hole must be clean-deburred and round.

Set male die with beveled feature up on lowerplate of press.

Place the sheet metal with drilled hole over thecenter pilot of the male die. (Fig 2)

Fig 1

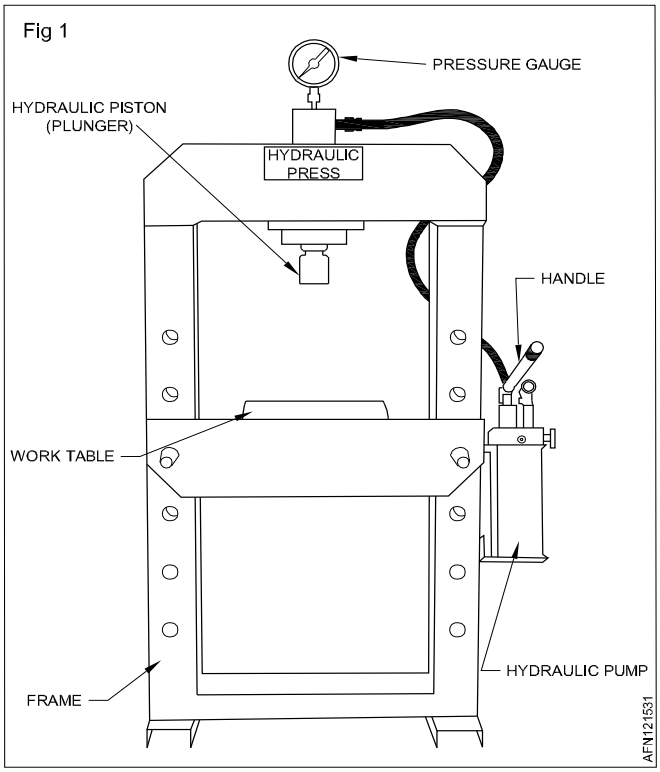
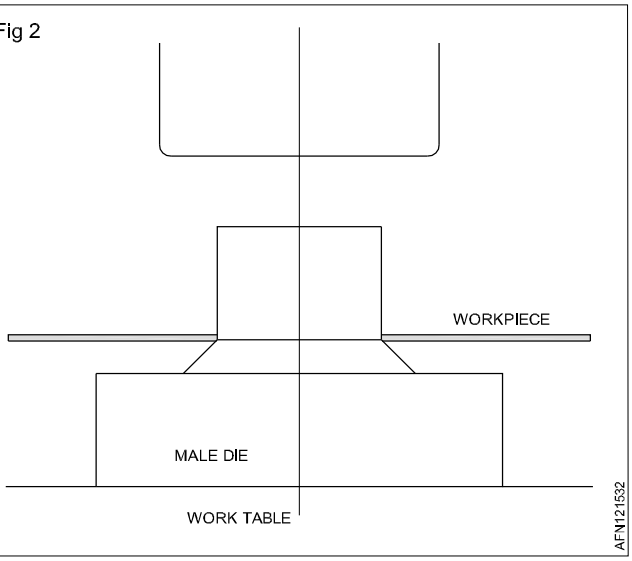


Fig 2



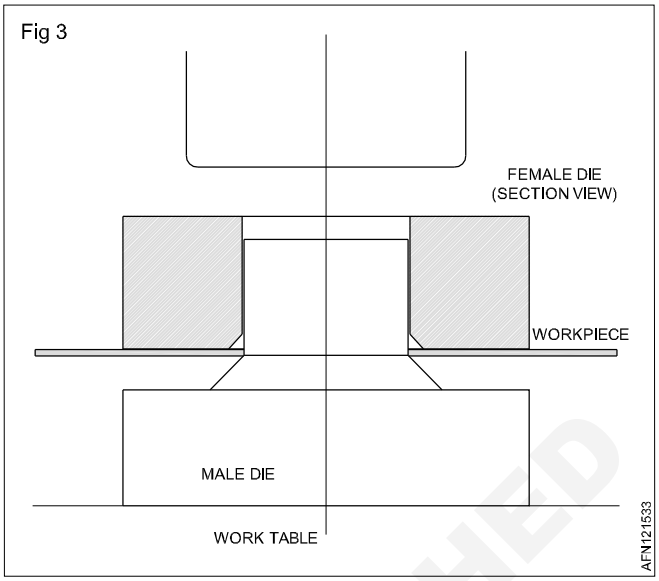
Set the female die with the beveled featurefacing down and over the male die and sheet metal. (Fig 3)

Center the press upper plate (plugger) over the female die.

Slowly activate the handle of the press exertingpressure on the female die until the metalpanel is pushed fully down against the face ofthe male die.

Release pressure on dies, remove dies and inspect finished flange.

Fig 3



Measurement of angles

Objectives: At the end of this lesson you shall be able to
- **state the units and fractional units of angles**
- **express degrees, minutes and seconds using symbols.**

The unit of an angle: For angular measurements a complete circle is divided into 360 equal parts (Fig 1)).

Each division is called a degree.

A half circle will have 180°.

Sub-divisions of an angle: For more precise angular measurements, one degree is further divided into 60 equal parts.

This division is one minute (‘). The minute is used to represent a fractional part of a degree and is written as 30° 15’.

One minute is further divided into smaller units known as seconds (“). There are 60 seconds in a minute.

An angular measurement written in degrees, minutes and seconds would read as 30° 15' 20".

Examples for angular divisions

1 complete circle 360°

1/2 circle 180° (straight angle)

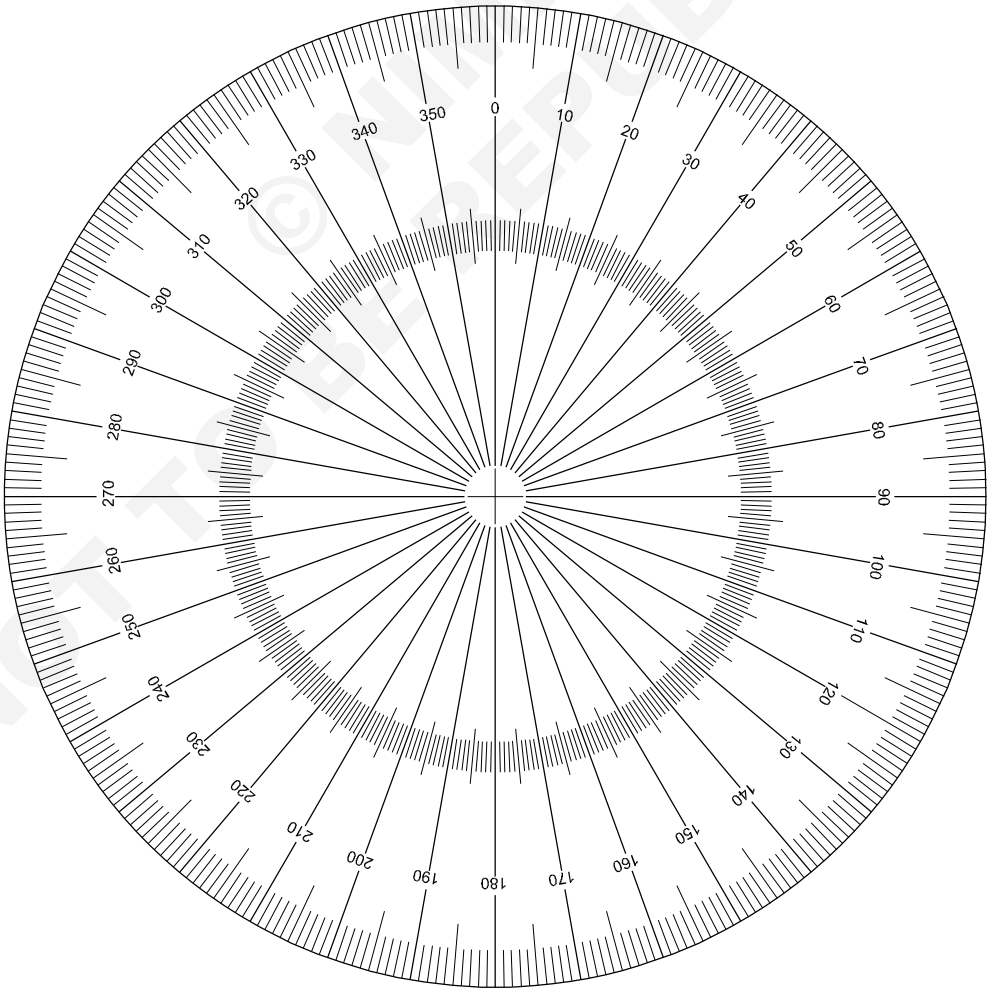
1/4 of a circle 90° (right angle)

Sub divisions

1 degree or 1° = 60 minutes or 60'

1 minute or 1' = 60 seconds or 60"

Fig 1



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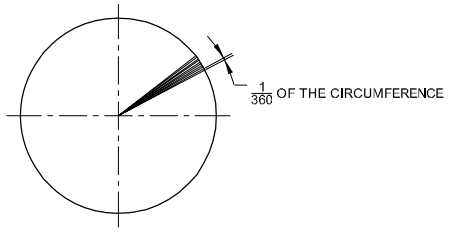
Angles properties

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

Angles: Angle is the inclination between two straight lines meeting at a point or meet when extended. AB and BC are two straight lines meeting at B. The inclination between them is called an angle. The angle is expressedin degrees or radians.

Concept of degree: When the circumference of a circle is divided into 360 equal parts and radial lines are drawn through these points, the inclination between the two adjacent radial lines is defined as one degree. Thus a circle is said to contain 360°. (Fig 1)

Fig 1



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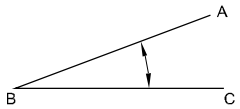
Acute angle: IF an angle which is less than 90° is called an acute angle. (Fig 2)

Fig 2

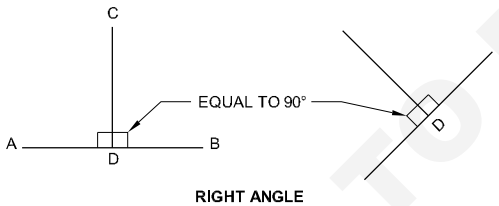


ACUTE ANGLE

AFN121622

Right angle: Angle between a reference line and a perpendicular line is called right angle. (Fig 3)

Fig 3

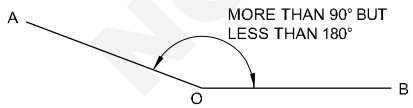


RIGHT ANGLE

AFN121623

Obtuse angle: This refer to an angle between 90° and 180°. (Fig 4)

Fig 4



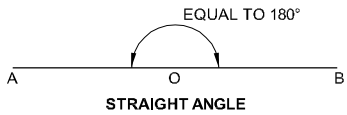
OBTUSE ANGLE

AFN121624

Straight angle: This refers to angle of 180°. This also called as the angle of a straight line. (Fig 5)

Reflex angle: It is the angle which is more than 180° (Fig 6)

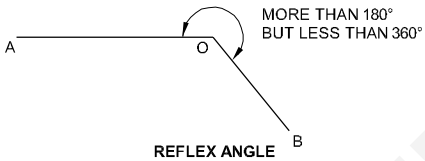
Fig 5



STRAIGHT ANGLE

AFN121625

Fig 6



REFLEX ANGLE

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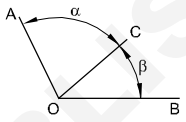
Adjacent angles: These are the angles lying on side of a line. (Fig 7)

Fig 7

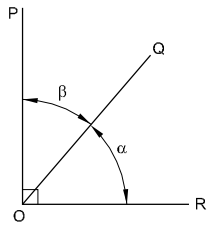


ADJACENT ANGLES

AFN121627

Complementary angles: When the sum of the two angles is equal to 90°, angle POQ + angle QOP+ angle POQ and angle QOR are complementary angles to each other. (Fig 8)

Fig 8

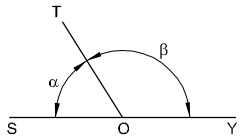


COMPLEMENTARY ANGLES

AFN121628

Supplementary angle: When the sum of the two adjacent angles is equal to 180°,example angle SOT + angle TOY = 180°, angle SOT and angle TOY are supplementary angles to each other. (Fig 9)

Fig 9



SUPPLEMENTARY ANGLES

AFN121629

Bevel proctractor

Objectives: At the end of this lesson you shall be able to
- **state the features of bevel protractors.**

Bevel protractor: The bevel protractor is a direct angular measuring instrument, and has graduation marked from 0° to 180°.

Angles can be measured within an accuracy of 1° using this instrument.

Fig 1

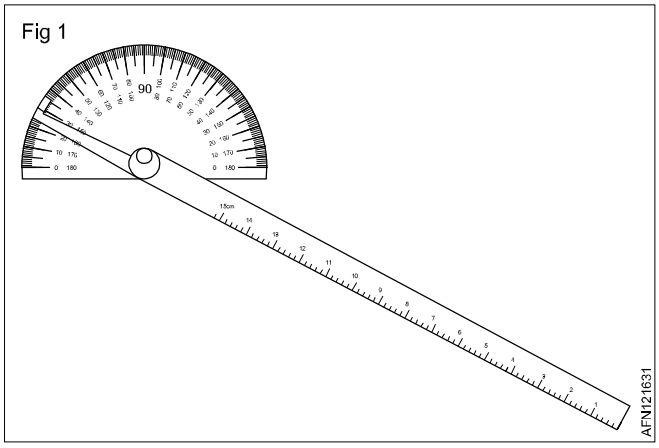
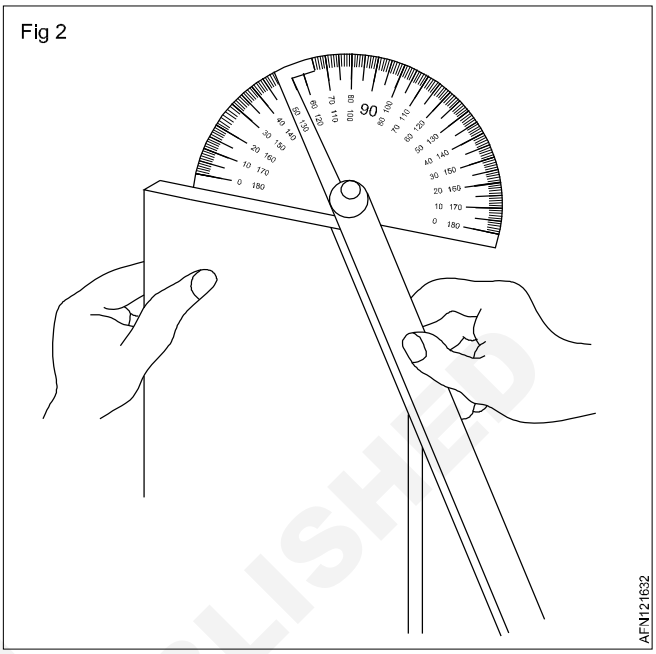


Fig 2



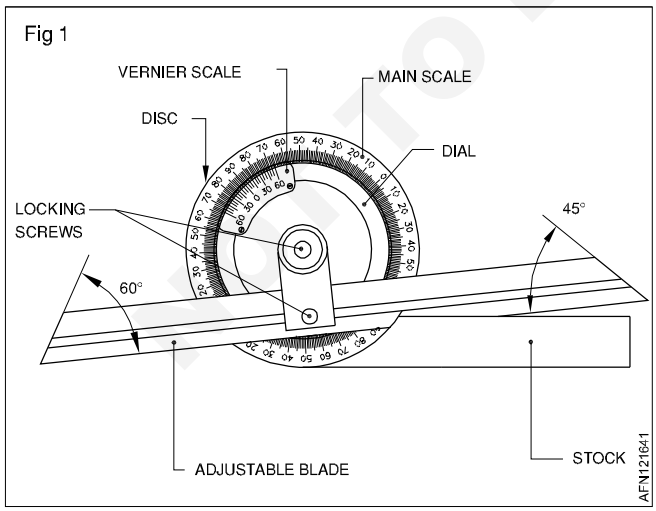
Vernier bevel protractor

Objectives: At the end of this lesson you shall be able to
- **name the parts of a vernier bevel protractor**
- **state the functions of each part**
- **list out the uses of a vernier bevel protractor.**

The vernier bevel protractor is a precision instrument meant for measuring angles to an accuracy of 5 minutes. (5')

Parts of a vernier bevel protractor: The following are the parts of a vernier bevel protractor (Fig 1).

Fig 1



Stock: This is one of the contacting surfaces during the measurement of an angle. Preferably it should be kept in contact with the datum surface from which the angle is measured.

Dial: The dial is an integrated part of the stock. It is circular in shape, and the edge is graduated in degrees.

Blade: This is the other surface of the instrument that contacts the work during measurement. It is fixed to the dial with the help of the clamping lever. A parallel groove is provided in the centre of the blade to enable it to be longitudinally positioned whenever necessary.

Locking screws: Two knurled locking screws are provided, one to lock the dial to the disc, and the other to lock the blade to the dial.

All parts are made of good quality steel and highly finished. A magnifying glass is sometimes fitted for clear reading of the graduations.

Uses of a vernier bevel protractor: Apart from being used for measuring angles a vernier bevel protractor is also used for setting work-holding devices on machine tools, work-tables etc.

The vernier bevel protractor is used to measure acute angles less than 90° obtuse angles more than 90°.

Reading vernier bevel protractor

Objectives: At the end of this lesson you shall be able to
- **state the main scale graduations on the disc**
- **state the vernier scale graduations on the dial**
- **Read a vernier bevel protractor for acute angle setting**
- **Read a vernier bevel protractor for obtuse angle setting.**

For purposes of taking angular measurements, the full circumference of the dial is graduated in degrees.

The 360° are equally divided and marked in four quadrants, from '0' degree to 90 degrees, 90 degrees to '0' degree. Every tenth division is marked longer and numbered. Each division represents 1 degree.

The graduations on the dial are known as the main scale divisions.

On the disc, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 3rd line is marked longer and numbered as 0, 15, 30, 45, 60.

This constitutes the vernier scale. Similar graduations are marked to the left of '0' also.

For any setting of the blade and stock, the reading of the acute angle and the supplementary obtuse angle is possible, and the two sets of the vernier scale graduations on the disc assist to achieve this.

For reading acute angle set up (Fig 1 and 2)

First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

Fig 1

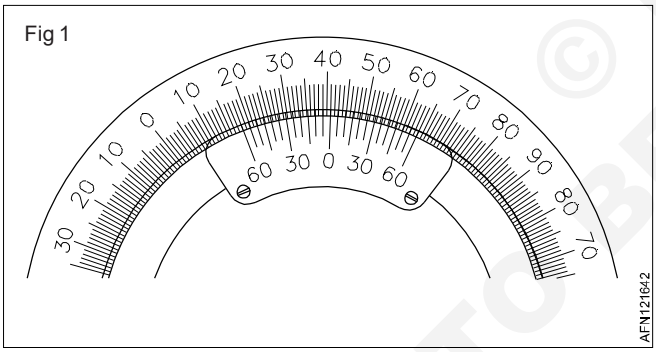
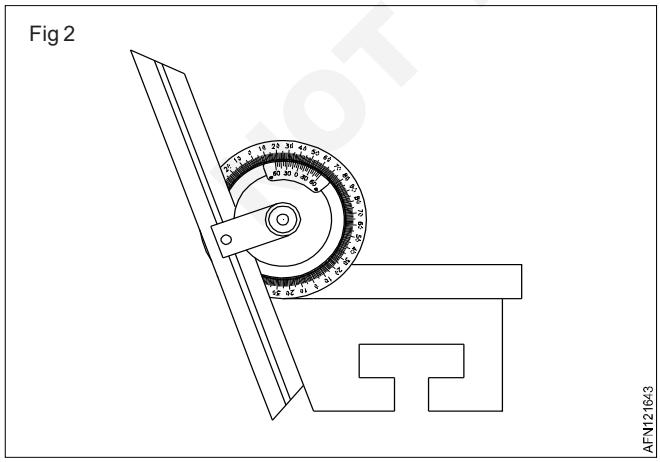


Fig 2



Note the line on the vernier scale that exactly coincides with any one of the main scale divisions and determine its value in minutes. (Fig 3 & 4)

Fig 3

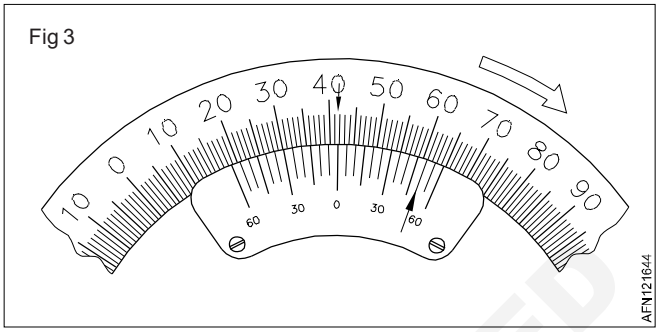
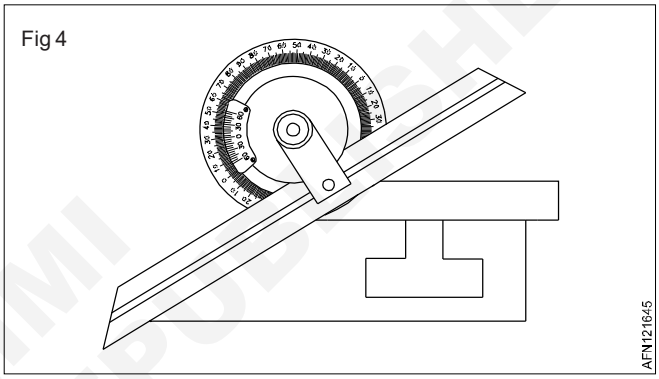


Fig 4



To take the vernier scale reading, multiply the coinciding divisions with the least count.

Example

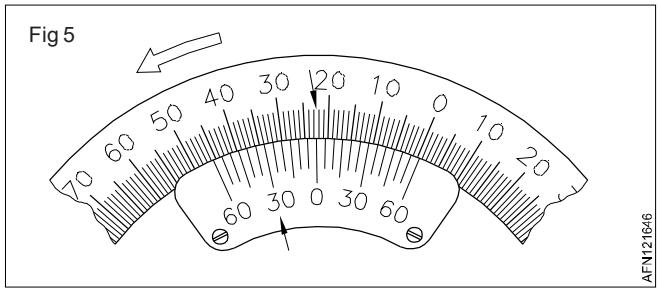
10 x 5' = 50'

Total up both the readings to get the measurements=41°50'.

If you read the main scale in an anticlockwise direction, read the vernier scale also in an anticlockwise direction from zero.

For reading obtuse angle set up (Fig 5)

Fig 5



The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 3). The reading value is subtracted from 180º to get the obtuse angle value.

Example

Reading 22º 30'

Measurement 180º-22º30'=157"30'

Care and maintenance of vernier bevel protractor

Clean the vernier bevel protractor before use.

Loosen the locking screw of dial to move the blade according to the angle measurement.

While taking a measurement apply light pressure on vernier bevel protractor

Heavy pressure will force the two scales out of parallel and show the false reading.

After using vernier bevel protractor wipe it clean and apply a thin coating of oil and keep it in safe place.

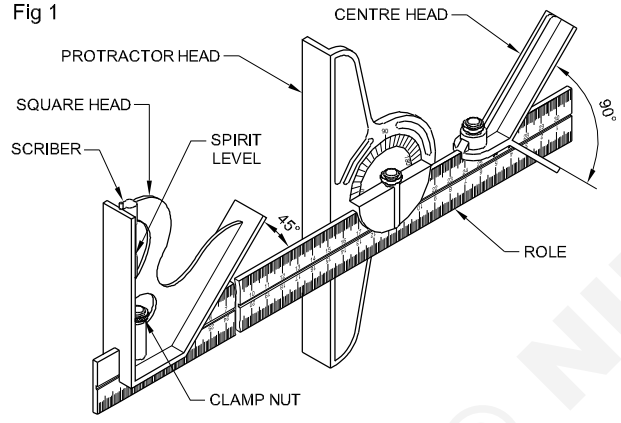
Combination square

Objectives: At the end of this lesson you shall be able to
- **name the parts of a combination set**
- **state the uses of each attachment in a combination set.**

Combination sets can be used for different types of work, like layout work, measurement and checking of angles.

The combination set (Fig 1) has a protractor head, square Head, centre head, and a rule.

Fig 1



COMBINATION SET

Protractor Head: The protractor head can be rotated and set to any required angle.

The protractor head is used for marking and measuring angles within an accuracy of 1°. The spirit level attached to this is useful for setting jobs in a horizontal plane.

Square Head: The square head has one measuring face at 90° and another at 45° to the rule.

It is used to mark and check 90° and 45° angles. It can also be used to set workpieces on the machines and measure the depth of slots. (Fig 2,3 and 4)

Centre Head: This along with the rule is used for locating the centre of cylindrical jobs. (Fig 5)

For ensuring accurate results, the combination set should be cleaned well after use and should not be mixed with cutting tools, either while using or storing.

Fig 2

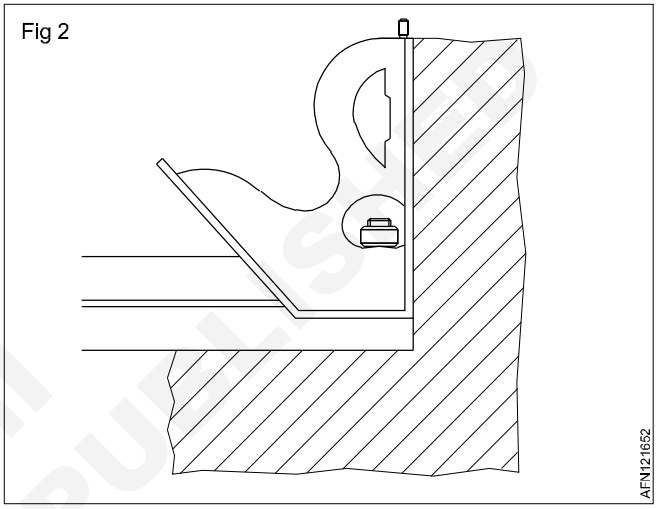


Fig 3

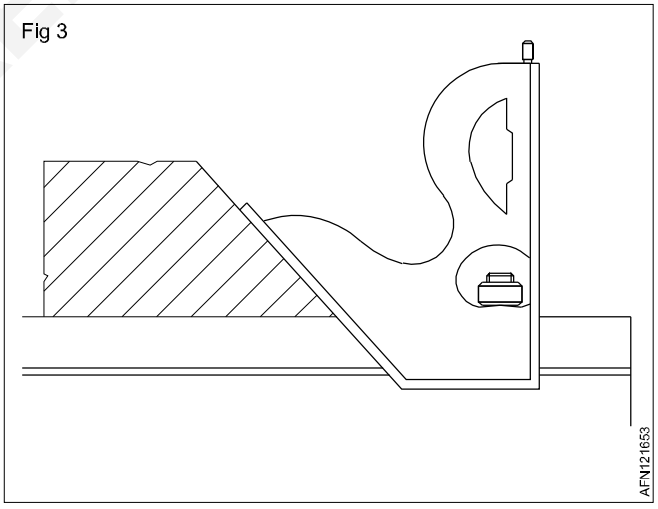


Fig 4

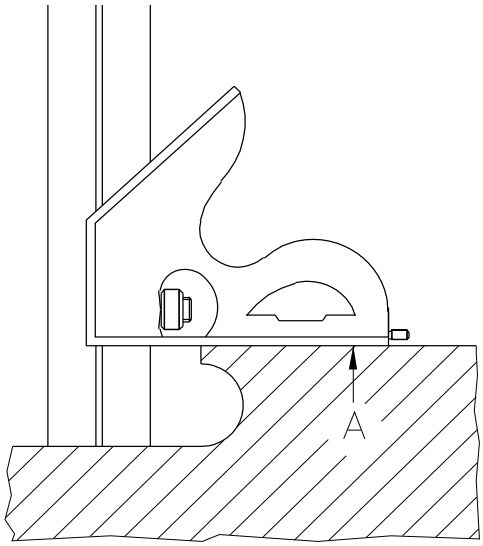


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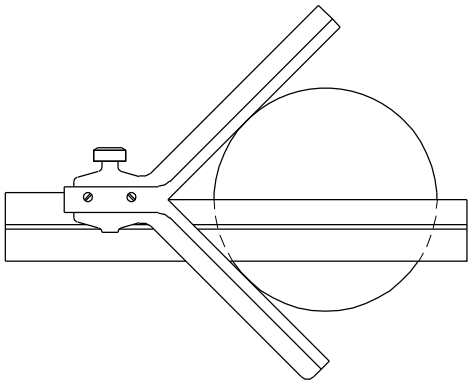
Fig 5



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Drill press

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

- **name the various types of drill press**
- **name the parts of the bench and pillar type drilling machines**
- **compare the features of the bench and pillar type drilling machines**
- **adjust the spindle speed**

A drill press is a machine that may be mounted on a stand or bolted to the floor or workbench.

They can perform drilling, countersinking, boring, counterboring, spot facing, reaming, and tapping.

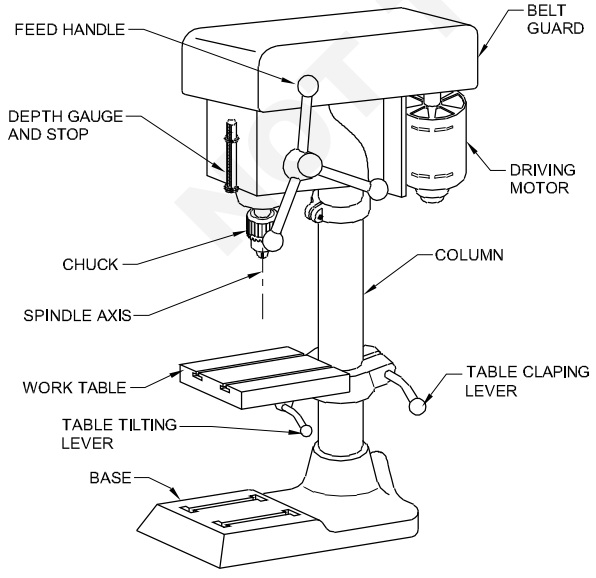
The principal types of drilling machines used are:

- Sensitive bench drilling machine.
- Pillar or column drilling machine.

The sensitive bench drilling machine (Fig 1)

The simplest type of the sensitive drilling machine is shown in the figure with its various parts marked. This is used for light duty work.

Fig 1



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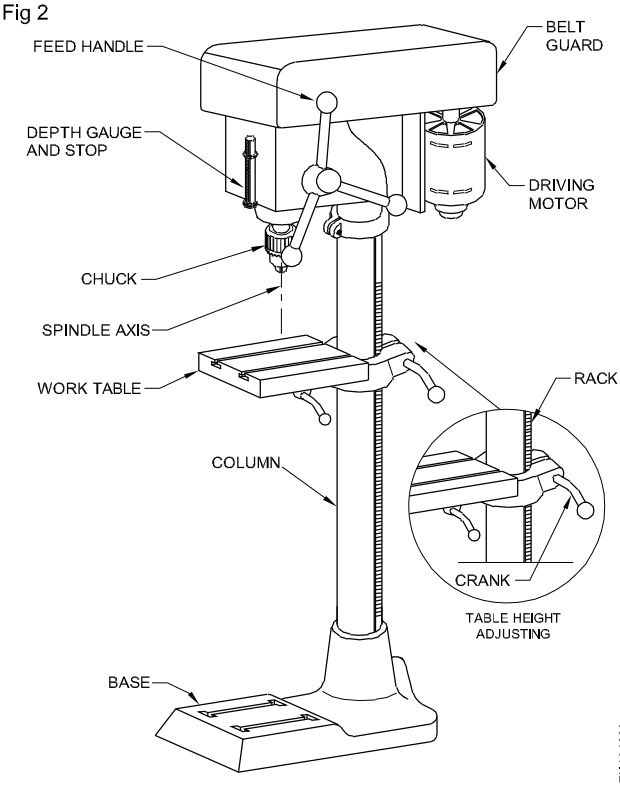
This machine is capable of drilling holes up to 12.5 mm diameter. The drills are fitted in the chuck or directly inthe tapered hole of the machine spindle.

For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted. (Fig 1)

The pillar drilling machine (Fig 2)

Fig 2



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This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounted on the floor and driven by more powerful electric motors.

They are also used for light duty work. Pillar drilling machines are available in different sizes. The larger machines are provided with a rack and pinion mechanism to raise the table for setting the work.

Both have a gauge to adjust the drilling depth (Fig 3).

Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (Fig 4 and 5)

Set the tension to approximately ½" deflection in the belt.

Fig 3

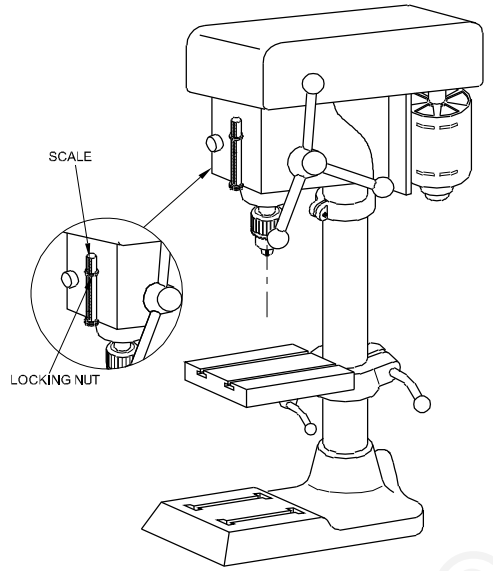


Fig 4

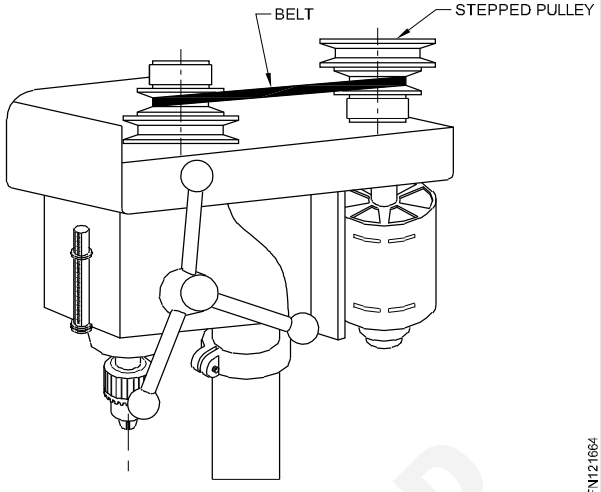
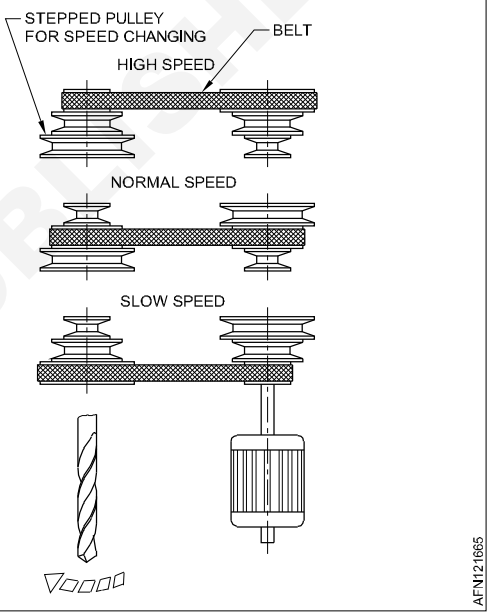


Fig 5



Holding devices

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

- **name the types of drill - holding devices**
- **state the features of drill chucks**
- **state the functions of drill sleeves**
- **state the function of drift.**

For drilling holes on materials, the drills are to be held accurately and rigidly on the on the machines.

The common drill-holding devices are drill chucks and sleeves and sockets.

Drill chuck: Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

The drill chucks are held on the machine spindle by means of an arbor fitted on the drill chuck. (Fig 1)

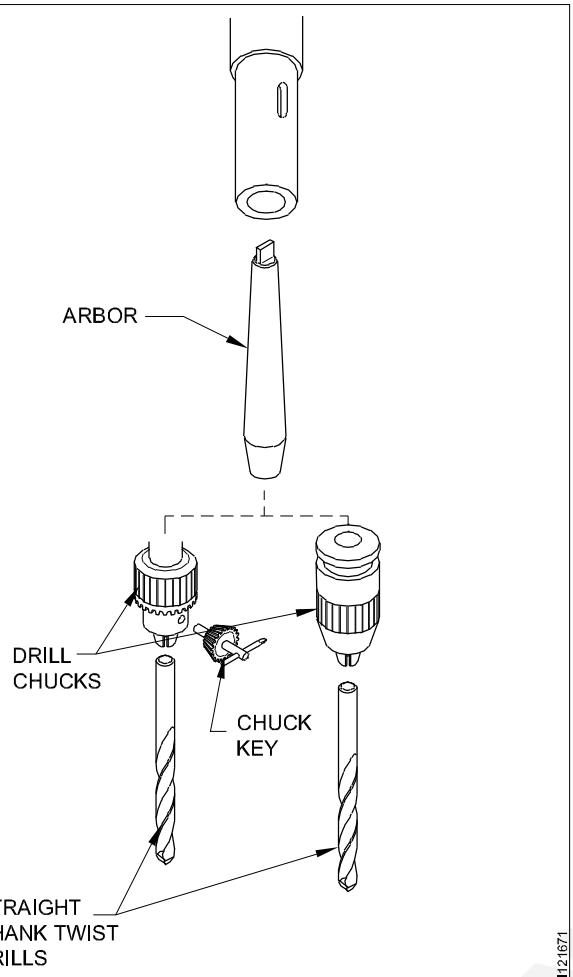
Taper Sleeves and Sockets (Fig 2): Taper shank drills have a morse taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill, when engaged, will give a good wedding action. Due to this reason morse tapers are called self-holding tapers.

Drills are provided with five different sizes of morse tapers and are numbered from MT1 to MT5.

In order to make up the difference in sizes between the shanks of the drills and the type of machine spindles, sleeves of different sizes are used. When the drill taper shank is smaller than machine spindle, taper sockets are used.

Fig 1



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

Use a drift to remove drills and sockets from the machine spindle. (Fig 3)

Fig 3

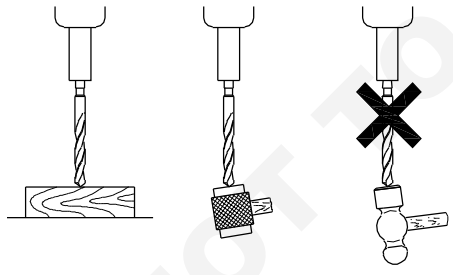
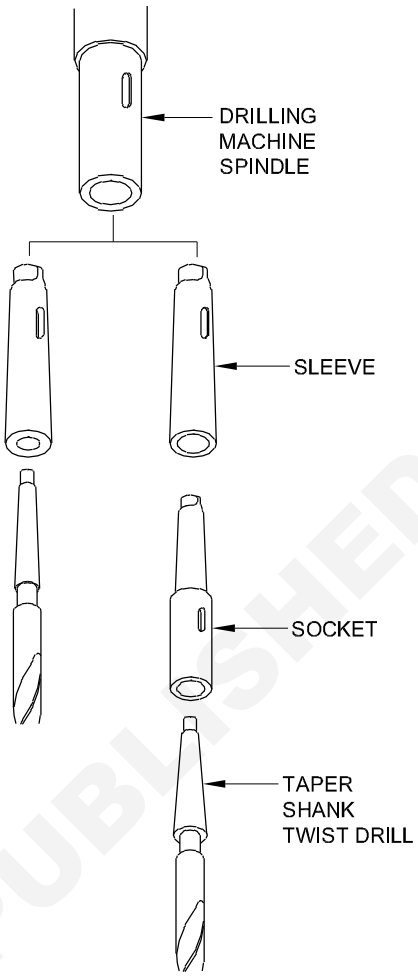
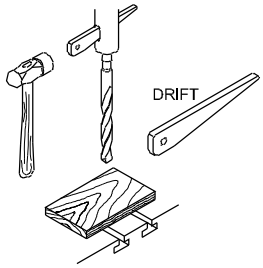


Fig 2



While removing the drill from the sockets/ sleeves, don't allow it to fall on the table or jobs. (Fig 4)

Fig 4



Cutting speed and RPM

Objectives: At the end of this lesson you shall be able to
- **define cutting speed**
- **state the factors for determining the cutting speed**
- **differentiate between cutting speed and RPM**
- **determine RPM/spindle speed**
- **select RPM for drill sizes from tables.**

For a drill to give a satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the RPM, at which a drill has to be driven, is determined.

Materials being drilled for HSS	Cutting speed (m/min)
Aluminium	70 - 100
Brass	35 - 50
Bronze(phosphor)	20 - 35
Cast iron (grey)	25 - 40
Copper	35 - 45
Steel (medium carbon/mild steel)	20 - 30
Steel (alloy,high tensile)	5 - 8
Thermosetting plastic (low speed due to abrasive properties)	20 - 30

Calculating RPM

$$v = \frac{nxdx\pi}{1000} \text{ m/min}$$

$$n = \frac{vx1000}{dx\pi} \text{ RPM}$$

n - RPM

v - cutting speed in m/min.

d - diameter of the drill in mm

ð = 3.14

Examples: Calculate the RPM for a high-speed steel drill “24 to cut mild steel.

Calculating RPM

$$n = \frac{vx1000}{\pi D}$$

$$= \frac{30x1000}{3.74x24}$$

$$= 398 \text{ RPM}$$

The cutting speed for MS is taken as 30 m/min. from the table.

It is always preferable to set the spindle speed to the nearest available lower range. The selected spindle speed Is 300 RPM.

The RPM will differ according to the diameter of the drills.

The cutting speed being the same, larger diameter drills will have lesser RPM and smaller diameter drills will have higher RPM.

The recommended cutting speeds are achieved only by actual experiments.

Feed in drilling

Objectives: At the end of this lesson you shall be able to
- **state what is meant by feed**
- **state the factors that contribute to an efficient feed rate.**

Feed is the distance (X) a drill advances into the work in one complete rotation. (Fig 1)

Feed is expressed in hundredths of a millimetre.

Example - 0.040mm

The rate of feed depends on several factors.

- Finish required
- Type of drill (drill material)
- Material to be drilled

Factors like rigidity of the machine, holding of the workpiece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table for the feed rate given here is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.

Drill diameter (mm) HSS	Rate of feed (mm/rev)
1.0 - 2.5	0.040 - 0.060
2.6 - 4.5	0.050 - 0.100
4.6 - 6.0	0.075 - 0.150
6.1 - 9.0	0.100 - 0.200
9.1 -12.0	0.150 - 0.250
12.1 - 15.0	0.200 - 0.300
15.1 - 18.0	0.230 - 0.330
18.1 - 21.0	0.260 - 0.360
21.1 - 25.0	0.280 - 0.380

Drills

Objectives: At the end of this lesson you shall be able to
- **state drilling**
- **state the necessity of drilling**
- **name the types of drills used**
- **identify the parts of a twist drill**
- **state the functions of drills**
- **state the functions of each part of a drill**
- **designate drills as per ISI recommendations.**

Drilling: Drilling is a process of making holes on workpieces. The tool used is a drill. For drilling, the drill is rotated with a downward pressure causing the tool to penetrate the material.

It is the first operation done internally for any further operation.

Twist drill: Almost all drilling operation is done using a twist drill. It is called a twist drill as it has two or more spiral or helical flutes formed along its length. The two basic types of twist drills are, parallel shank and taper shank. Parallel shank twist drills are available below 13mm size (Fig 2).

Parts of a twist drill: The various parts of a drill can be identified from figures 2, 3 and 4.

Fig 1

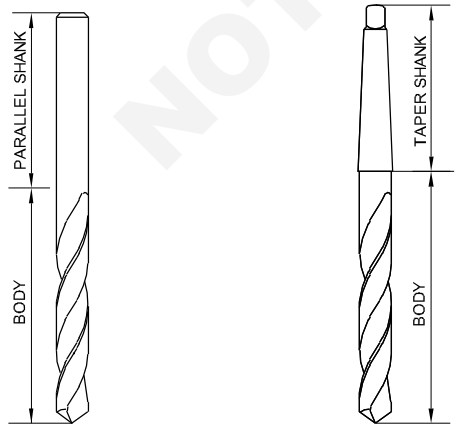
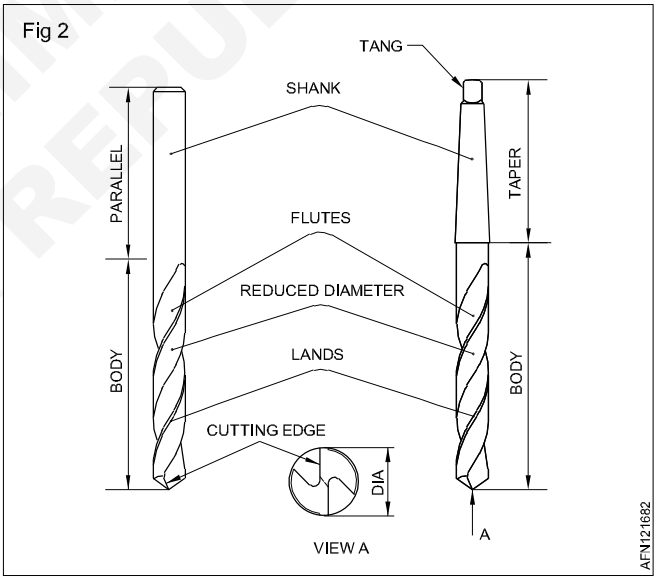


Fig 2



Point: The cone shaped end which does the cutting is called the point. It consists of a dead centre, lips or cutting edges, and a heel.

Shank: This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

Taper shank, used for larger diameter drills, and straight shank, used for smaller diameter drills.

Tang: This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Body: The portion between the point and the shank is called the body of a drill.

The parts of the body are flute, land/margin, body clearance and web.

Fig 3

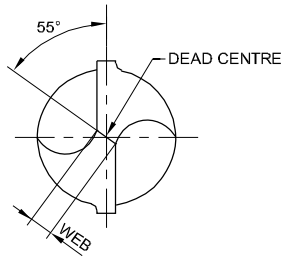
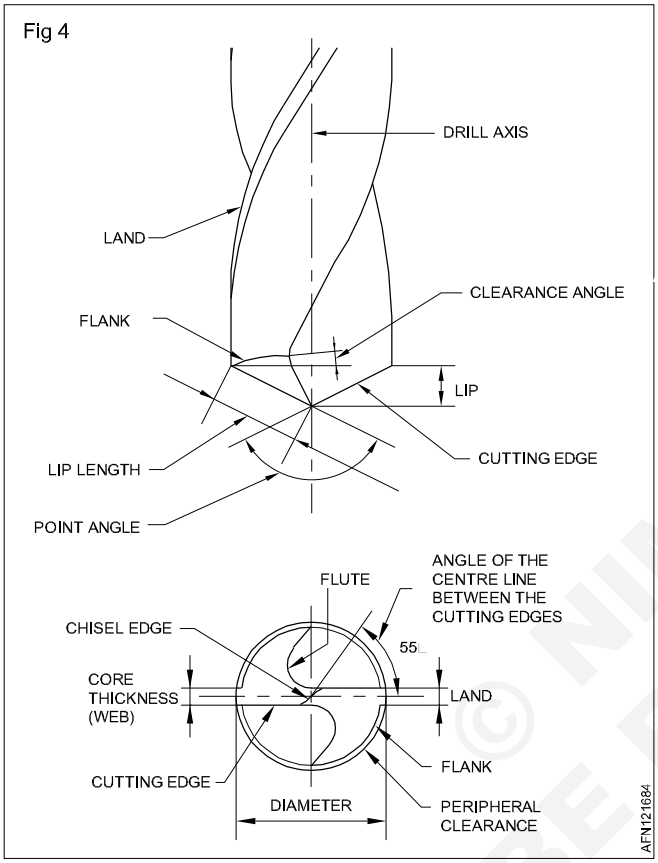


Fig 4



Flutes: Flutes are the spiral grooves which run to the length of the drill. The flutes help

- To form the cutting edges.
- To curl the chips and allow these to come out.
- The coolant to flow to the cutting edge.

Land/Margin: The land/margin is the narrow strip which extends to the entire length of the flutes.

The diameter of the drill is measured across the land/ margin.

Body clearance: Body clearance is the part of the body which is reduced in diameter to cut down the friction between the drill and the hole being drilled.

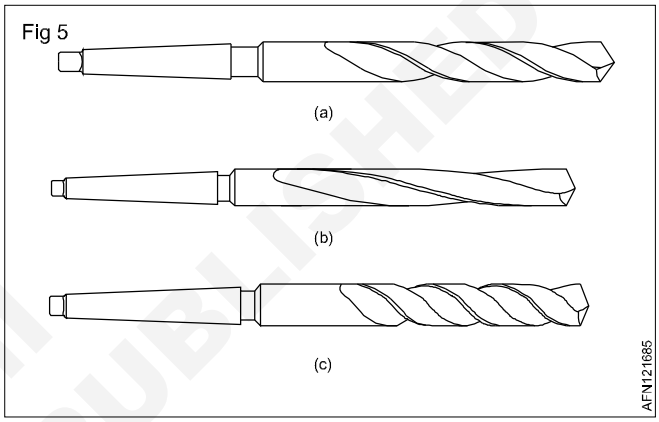
Web: Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.

Drills are manufactured with varying helix angles for drilling different materials. General purpose drills have a standard helix angle of 27 ½°. They are used on mild steel and cast iron. (Fig 5A)

A slow helix drill is used on materials like brass, gun metal, phosphor-bronze and plastics. (Fig 5B)

A quick helix drill is used for copper, aluminium and other soft metals (Fig 5C)

Fig 5



Designation of drills

Twist drills are designated by:

- Diameter
- Tool type
- Material

Example

A twist drill of 9.50 mm dia. of tool type 'H' for right hand cutting and made from HSS is designated as:

Twist drill 9.50 - H - IS5101 - HS

where H = tool type

IS5101 = IS Number

HS = tool material

9.5 = diameter of the drill.

If the tool type is not indicated in the designation, it should be taken as type 'N' tool.

Drills angles

Objectives: At the end of this lesson you shall be able to
- **identify the various angles of a twist drill**
- **state the functions of each angle**
- **list the types of helix for drills as per ISI.**
- **distinguish the features of drifferent types of drills.**

Like all cutting tools the drills are provided with certain angles for efficiency in drilling.

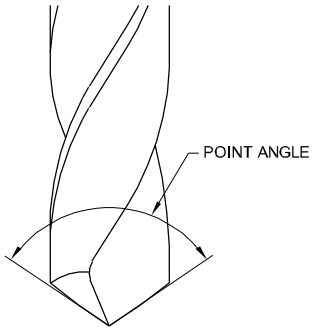
They are different angles for different purposes. They are listed below.

Point angle, helix angle, rake angle, clearance angle and chisel edge angle.

Point angle/cutting angle (Fig 1): The point angle of a general purpose (standard) drill is 118°. This is the angle between the cutting edges (lips).

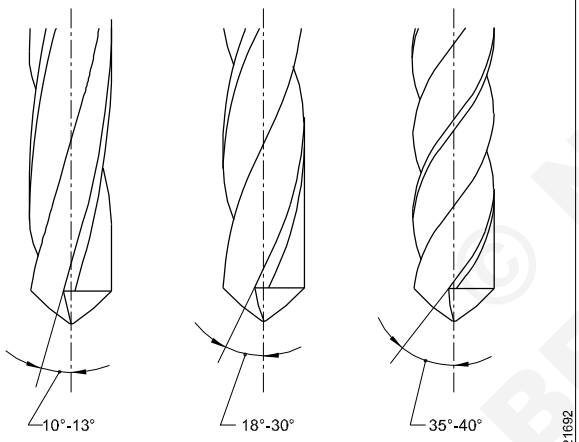
The angle varies according to the hardness of the material to be drilled.

Fig 1



Helix angle (Figs 2): Twist drills are made with different helix angles. The helix angle determines the rake angle at the cutting edge of the twist drill.

Fig 2



The helix angles vary according to the material being drilled.

According to Indian standards, three types of drills are used for drilling various materials.

Type N - For normal low carbon steel.

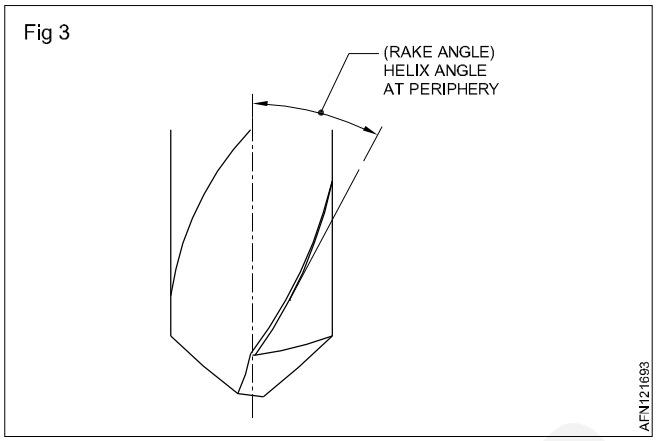
Type H - For hard and tenacious materials.

Type S - For soft and tough materials.

The type of drill used for general purpose drilling work is type N.

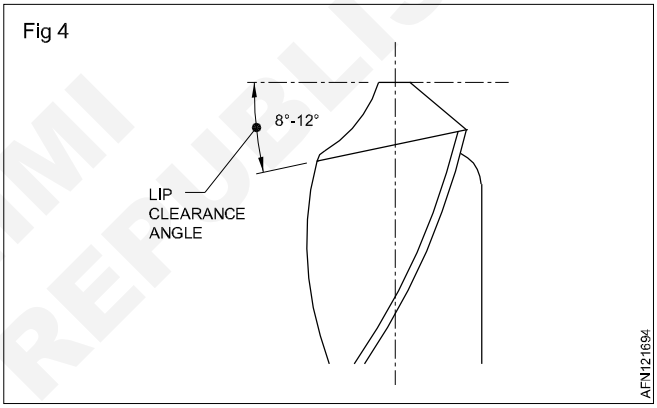
Rake angle (Fig 3): Rake angle is the angle of flute (helix angle).

Fig 3



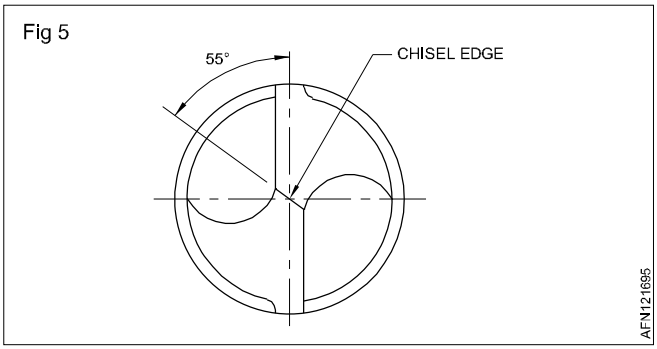
Clearance angle (Fig 4): The clearance angle is meant to prevent the friction of the tool behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much, the cutting edges will be weak, and if it is too small, the drill will not cut.

Fig 4



Chisel edge angle/web angle (Fig 5): This is the angle between the chisel edge and the cutting lip.

Fig 5



Human factor introduction - Part 1

Objectives: At the end of this lesson you shall be able to
- **know why human factor is important**
- **know the areas covered by human factor.**

Human Factor is the science of people at work. It is primarily concerned with understanding human capabilities, and then applying this knowledge to the design of tools, systems, and processes of work.

The field of Human Factors can be seen to have four main goals: enhancing safety; reducing error; enhancing comfort; and increasing productivity.

Human Factor is important because it helps make work more efficient, effective and safe. Is one of the safety barriers which is used in order to prevent accidents or incidents of aircraft.

The study of Human Factors is about understanding human behaviour and performance. When applied to aviation operations, Human Factors knowledge is used to optimize the fit between people and the systems in which they work in order to improve safety and performance.

In summary Human Factor covers three areas of influence on people at work:

- The organization
- The job
- Personal factors

Human Factor includes

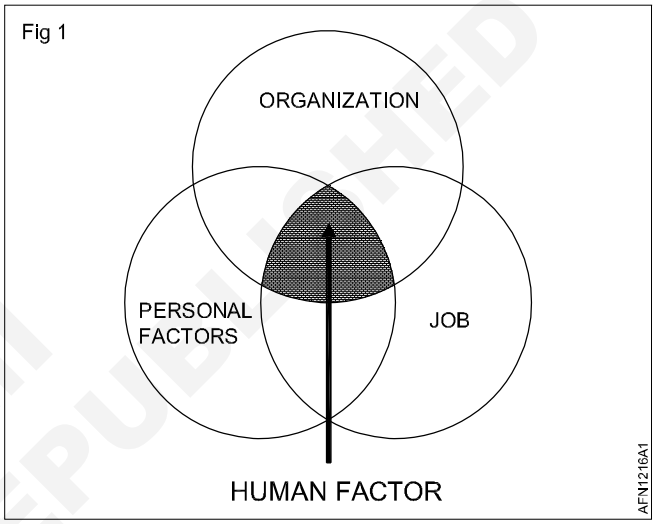
- Human physiology
- Psychology (including perception, cognition, memory, social interaction, error, etc.)
- Work place design
- Environmental conditions
- Human-machine interface
- Anthropometrics

Human Factor Training Programme: The human factor course is divided into several chapters which are:

- Human Performance and Limitations
- Social Psychology
- Factors Affecting Performance
- Physical Environment
- Physical work
- Repetitive tasks
- Visual inspection
- Complex systems
- Communication within and between teams
- Hazards in the Workplace

In this section we will discuss human performance and limitations.

Fig 1



Human performance and limitations - vision and audition

Objectives: At the end of this lesson you shall be able to
- **state the importance of the human performance and limitations**
- **name the parts of eye and ear.**

In order to be able to decide and act, the human being must perceive information of different kinds, which requires these different senses.

It is important that we are aware of these different means of information. In their possibilities, but also and above all in their limits. To do this, he will call on:

- Vision
- Audition

They are essential to stimulate attention and perception.

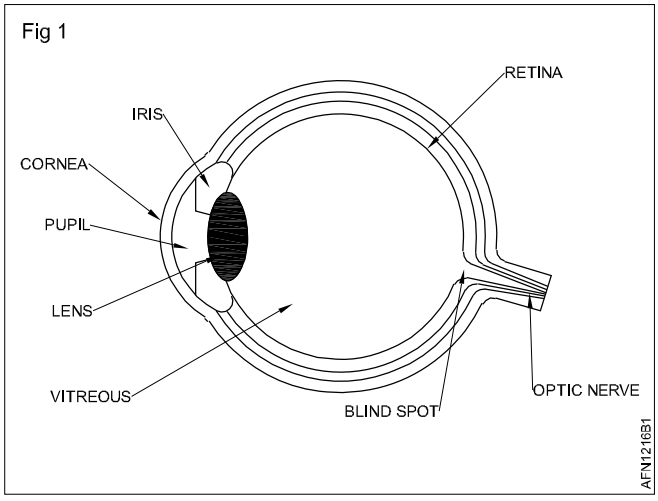
For example: to cross the road first we look to the left then to the right, then we listen to make sure that a car doesn't arrive.

Vision: More than 70% of the information processed by the human being enters through the visual channel.

The basic structure of the eye (Fig 1) is similar to a simple camera with an aperture (the iris), a lens and a light sensitive surface (the retina).

Light enters the eye through the cornea, then passes through the iris and the lens and falls on the retina.

Fig 1



Light stimulates the light-sensitive cells on the retina (rods and cones) and these pass small electrical impulses by way of the optic nerve to the visual cortex in the brain.

Electrical impulses are interpreted, and an image is perceived.

The cones are in the centre of the retina. They are at the origin of central vision, detail and colour.

The rods are on the periphery of the retina and are at the origin of peripheral vision and the perception of movement.

Various factors can affect and limit the visual acuity of the eye including physical factors, influence of foreign substances, environmental factors, and factors surrounding the object itself.

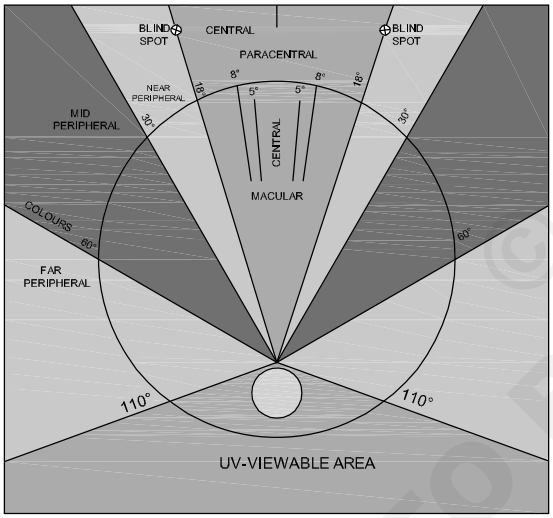
Physical factors include

- Physical imperfections in eye(s)
- Age

The influence of ingested foreign substances includes:

- Drugs
- Medication
- Alcohol
- Cigarettes

Fig 2



Environmental factors include

- Amount of light available.
- Clarity of the air (dust, mist, rain, etc.)

Factors associated with object being viewed include:

- Size and contours of the object.
- Contrast of the object with its surrounding.
- Relative motion of the object.
- Distance of the object from the viewer.
- The angle of the object from the viewer.

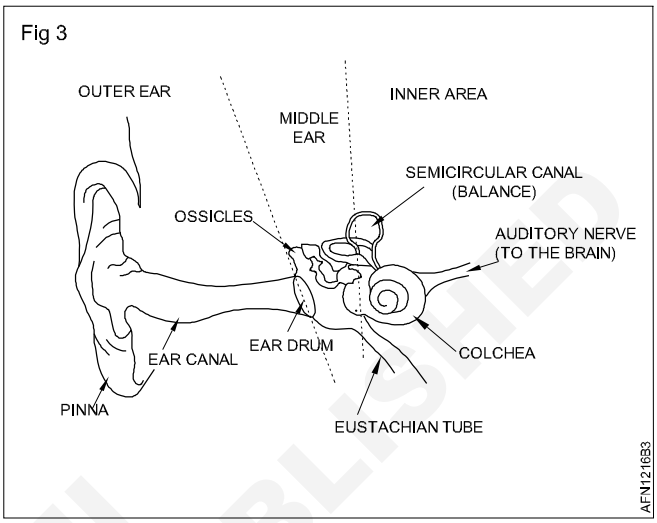
Audition (Hearing): The ear performs two quite different functions.

It is used to detect sounds by receiving vibrations in the air, and secondly, it is responsible for balance and sensing acceleration.

The ear (Fig 3) has three divisions: outer ear, middle ear, and inner ear. These act to receive vibrations from the air and turn these signals into nerve impulses that the brain can recognize as sounds.

The outer part of the ear directs sounds down the auditory canal and on to the eardrum. The sound waves will cause the eardrum to vibrate.

Fig 3



Middle Ear: Beyond the eardrum is the middle ear which transmits vibrations from the eardrum by way of three small bones known as the ossicles, to the fluid of the inner ear.

The middle ear is usually filled with air which is refreshed by way of the Eustachian tube which connects this part of the ear with the back of the nose and mouth. However, this tube can allow mucus to travel to the middle ear which can build up, interfering with normal hearing.

Inner Ear: Unlike the middle ear, the inner ear is filled with fluid. The last of the ossicles in the middle ear is connected to the cochlea. This contains a fine membrane (the basilar membrane) covered in hair-like cells which are sensitive to movement in the fluid. Any vibrations they detect cause neural impulses to be transmitted to the brain via the auditory nerve.

Impact of noise on performance: Noise can have various negative effects in the workplace. It can;

- Be annoying (e.g., sudden sounds, constant loud sound, etc.)
- Interfere with verbal communication between individuals in the workplace
- Cause accidents by masking warning signals or messages
- Be fatiguing and affect concentration, decision making, etc.
- Damage workers' hearing (either temporarily or permanently)

Human performance and limitations - information processing

Objectives: At the end of this lesson you shall be able to
- **state information processing model.**

Information processing model: Information processing can be represented as a model. This captures the main elements of the process, from receipt of information via the senses, to outputs such as decision making and actions.

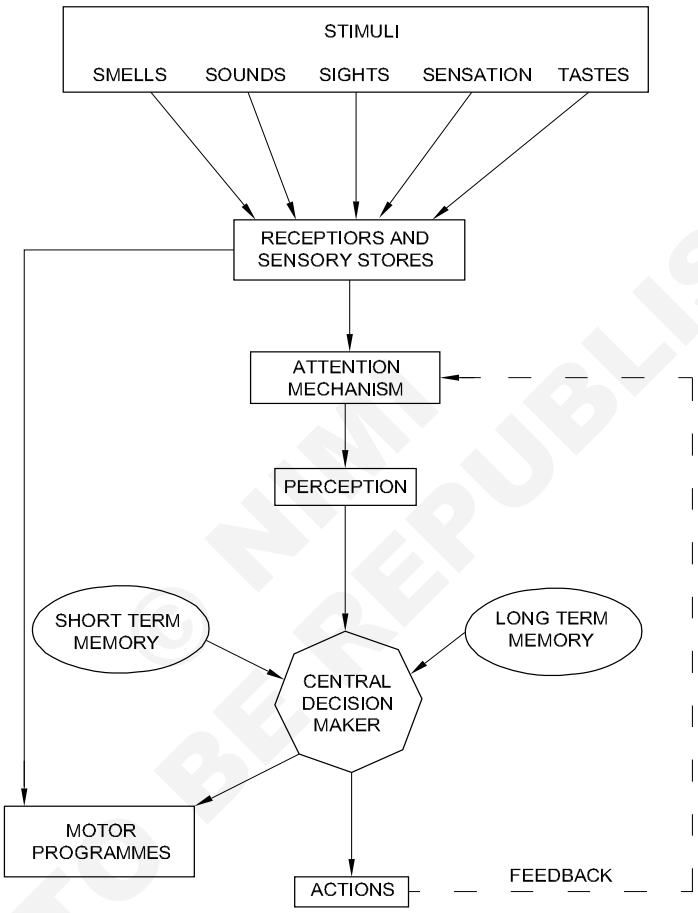
Information processing is the process of receiving information through the senses, analysing it and making it meaningful.

To act in the best possible way in their working environment, human beings collect information, analyse it, memorize it and use it to make decisions and act.

To do this, the worker appeals:

- to information processes,
- in memory.

Fig 1



Human performance and limitations - attention and preception

Objectives: At the end of this lesson you shall be able to
- **name the different attentions**
- **state the importance of attention.**

Attention: Having detected information, our mental resources are concentrated on specific elements this is attention.

Attention is the voluntary application of mental resources to the current task or object of current interest. It is the ability to focus on a message, information or task, eliminating others considered irrelevant.

Although attention can move very quickly from one item to another, it can only deal with one item at a time. Attention can take the form of:

- Selective attention
- Focused attention
- Divided attention
- Sustained attention

Selective attention occurs when a person is monitoring several sources of input, with greater attention being given to one or more sources which appear more important. A person can be consciously attending to one source whilst still sampling other sources in the background.

Distraction is the negative side of selective attention.

Divided attention refers to instances when an individual must conduct multiple tasks at the same time.

Focused attention is the brain's ability to concentrate its attention upon a single source and avoiding distraction.

Sustained attention refers to the ability to maintain attention and remain alert over long periods of time, often on one task.

Perception: Perception is a highly sophisticated mechanism and requires existing knowledge and experience to knowwhat data to keep and what to discard and how to associate the data in a meaningful manner.

Perception refers to the mechanisms by which man becomes aware of his environment.

The operator's reactions are based on what he perceives. He must therefore be in good physical and mental condition. Vision and hearing collect a very large part of the information in the operators' activities.

Fig 1

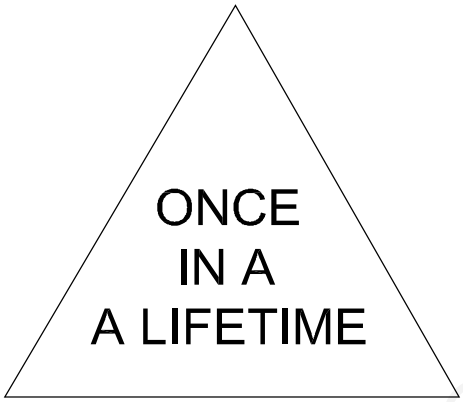
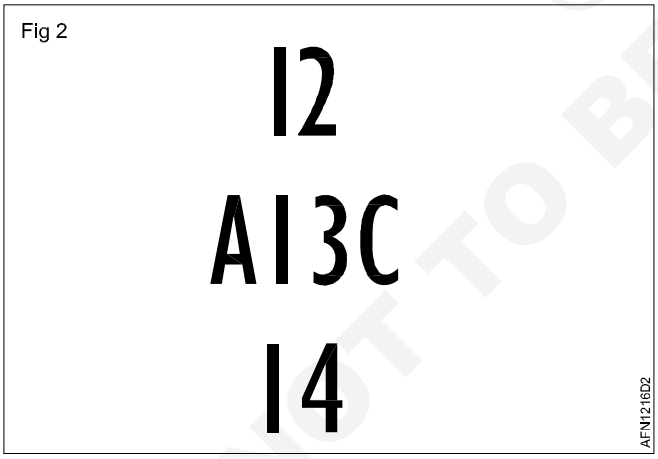


Fig 2



Expectation: In aviation, it is often necessary to consult documents with which the technician can become very familiar. It is possible that a technician can scan a document and fail to notice that subtle changes have been made. He sees only what he expects to see. (Fig 3)

Fig 4 illustrates that we can perceive the same thing quite differently (the letter "B" or the number "13"). This shows the influence of context on our information processing.

Visual illusions: There are many well-known visual illusions which illustrate the limits of human perception.

Fig 3

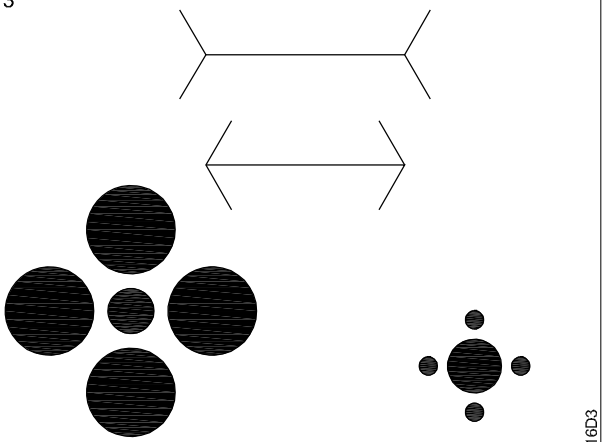


Fig 4

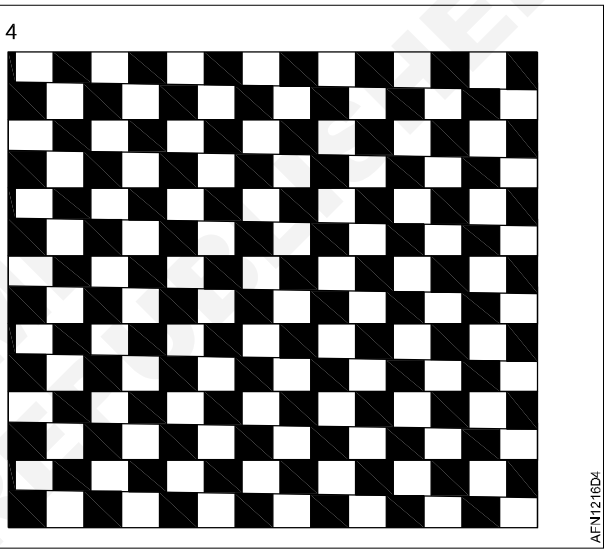


Fig 5 shows how the perceptual system can be misled into believing that one line is longer than the other the circle in the centre on the right is larger than the other one, even though a ruler will confirm that they are the same.

Fig 5

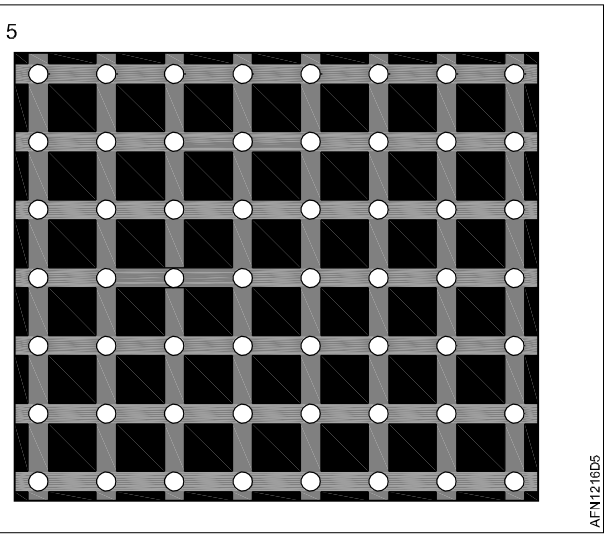


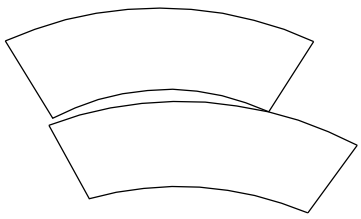
Fig 6 shows how the vertical zigzag patterns disrupt our horizontal perception. The horizontal lines are straight, even though they do not seem straight.

Fig 6 shows how your brain thinks that there is a black circle inside each white circle until you focus on that white circle. Then you realize it was never there at all.

Fig 6 shows two arcs that look different. It is because your brain compares the close elements (here, the corners).

In fact, these two arcs are identical.

Fig 6



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Human Performance and Limitations - Memory

Objectives: At the end of this lesson you shall be able to
- **state the different types of memories**
- **know the purpose of the different memories.**

Memory: Memory is the ability of human beings to record, retain and retrieve information. Memory depends on three processes;

- Registration: the input of information into memory.
- Storage: the retention of information
- Retrieval: the recovery of stored information

It is possible to distinguish between 3 forms of memory.

Ultra-short-term memory: Sensory information is stored in ultra-short-term memory just long enough to be transferred to short-term memory. It has a duration of up to 4 seconds (depending on the sense) and is used as a buffer.

Visual information is stored for up to half a second in iconic memory.

Sounds are stored between 2 and 4 seconds in echoic memory.

Haptic memory, also known as tactile memory, lasts approximately 2 seconds

Short-term memory/ Working memory

Memory that is used for short-term retention of information (usually less than twenty seconds).

It can store only a relatively small amount of information at one time, i.e. 5 to 9 items of information, for a short duration, typically 10 to 20 seconds.

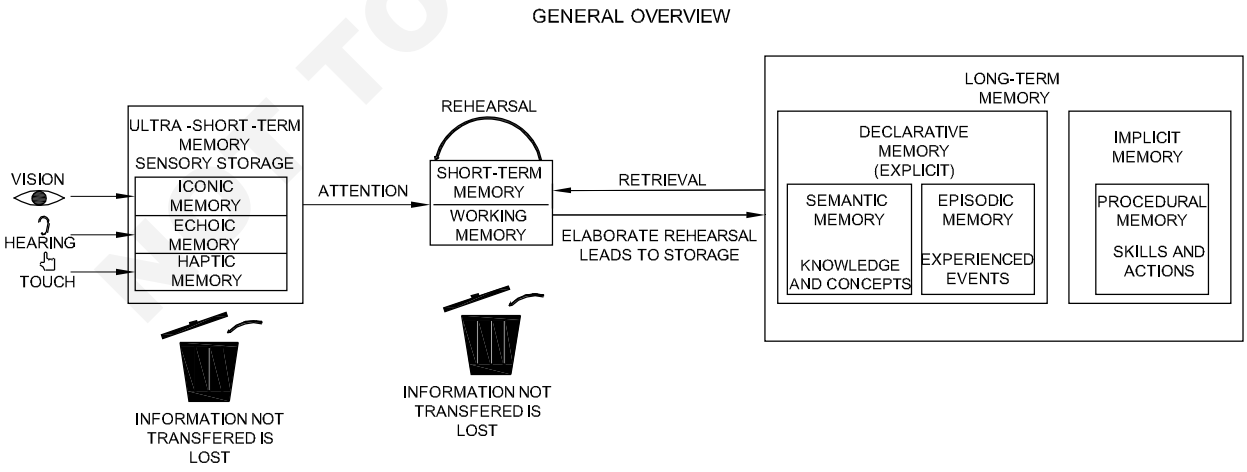
It must be updated regularly.

It can be affected by interruptions, stress, fatigue, and so on.

Long-term memory: The capacity of long-term memory appears to be unlimited. It is used to store information that is not currently being used, including:

- Knowledge of the physical world and objects within it and how these behave.
- Personal experiences.
- Beliefs about people, social norms, values, etc.
- Abilities, such as language comprehension.

Fig 1



AFN1216F1

History of aviation

Objectives: At the end of this lesson you shall be able to
- **know the main dates in the history of aviation**
- **know the main precursors of aviation**

Fig 1

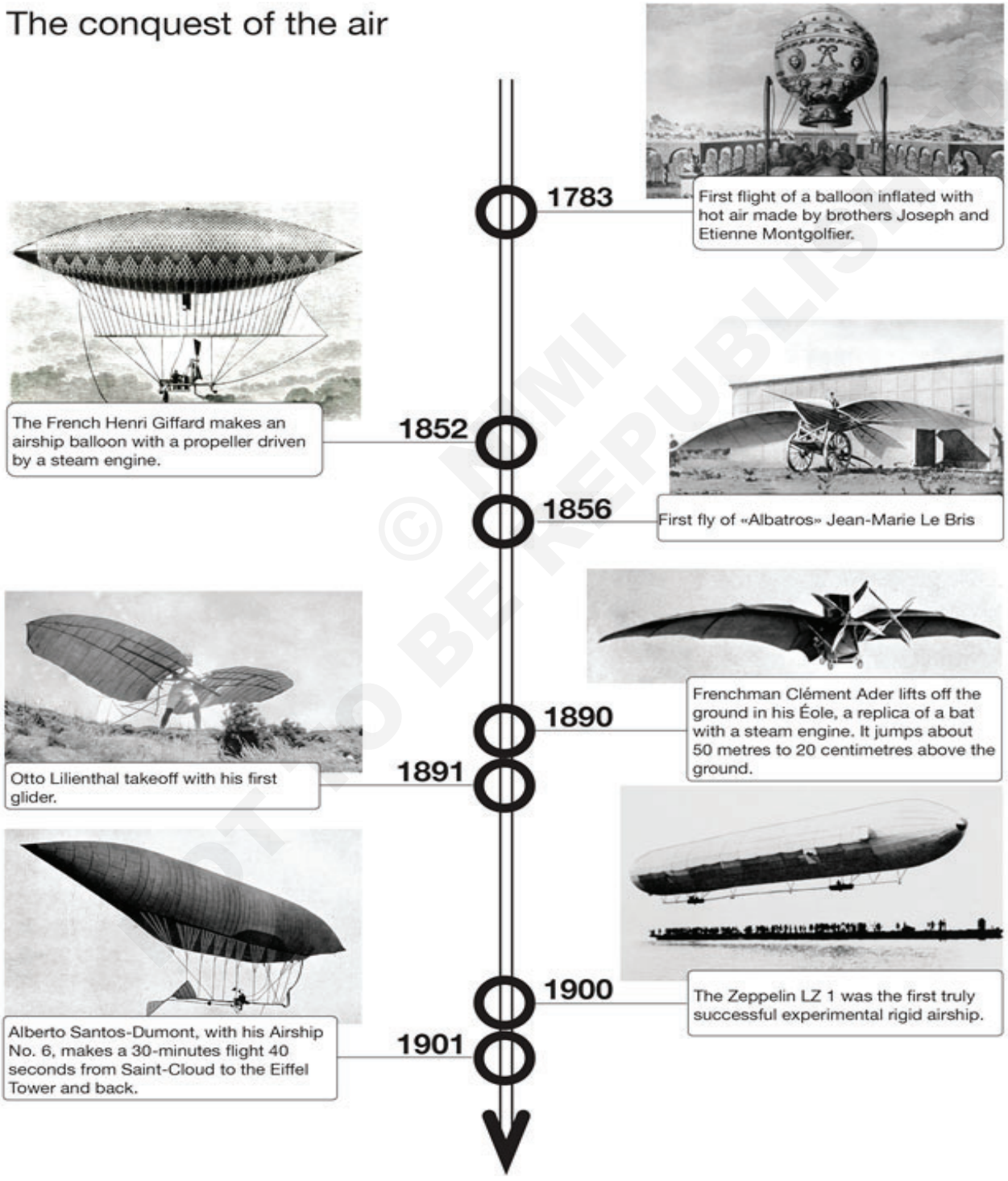


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Fig 2

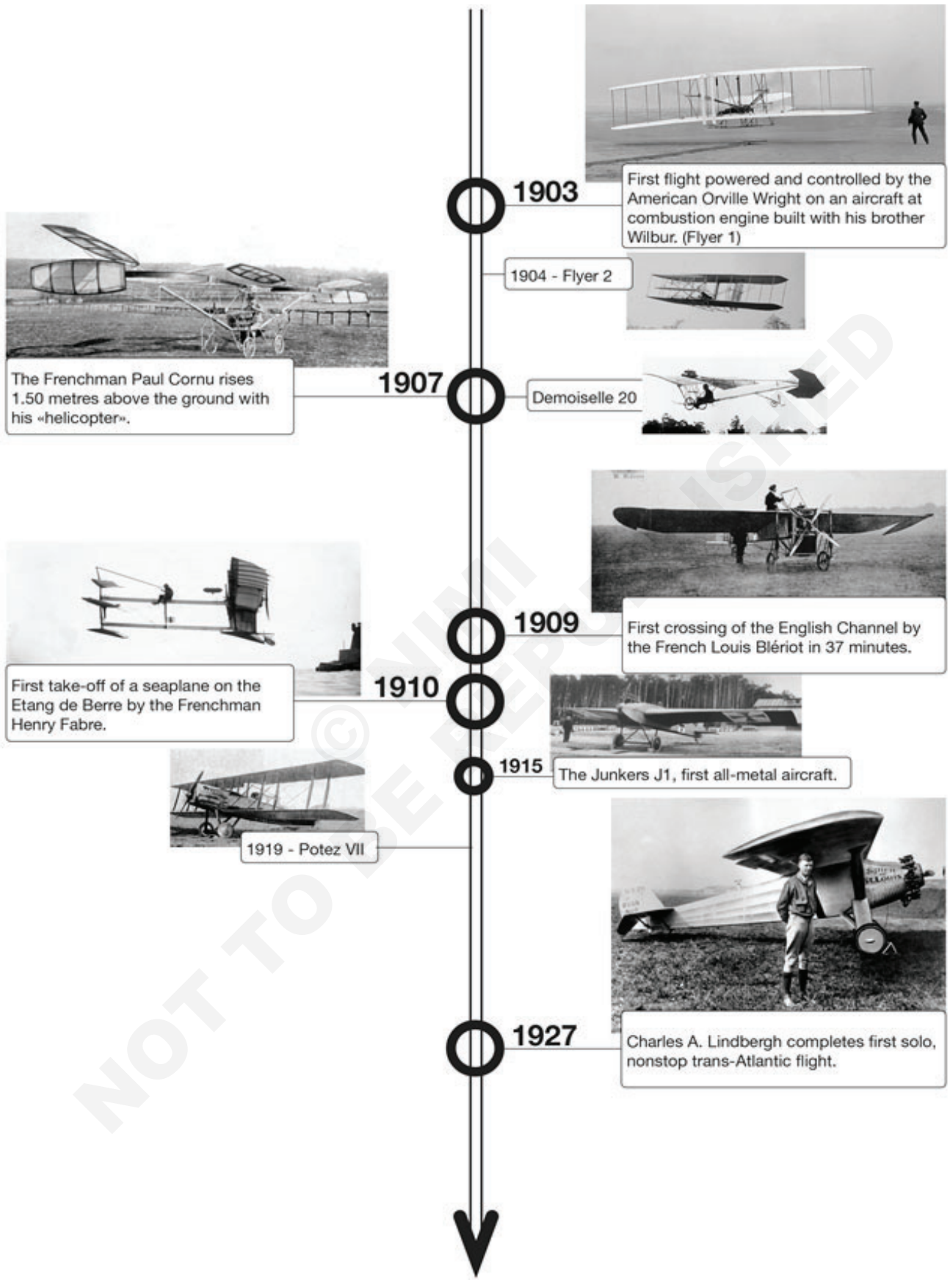

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Fig 3

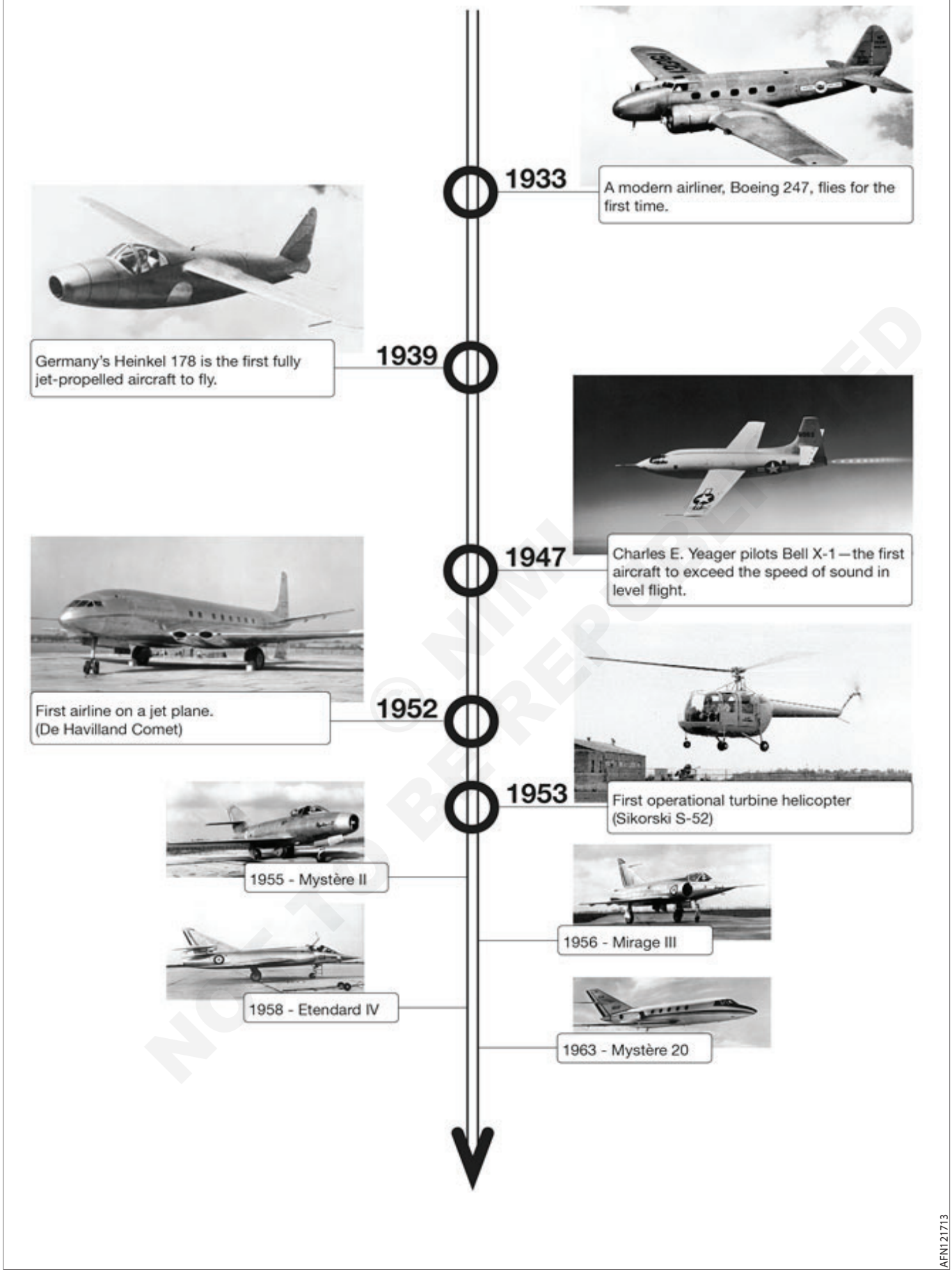
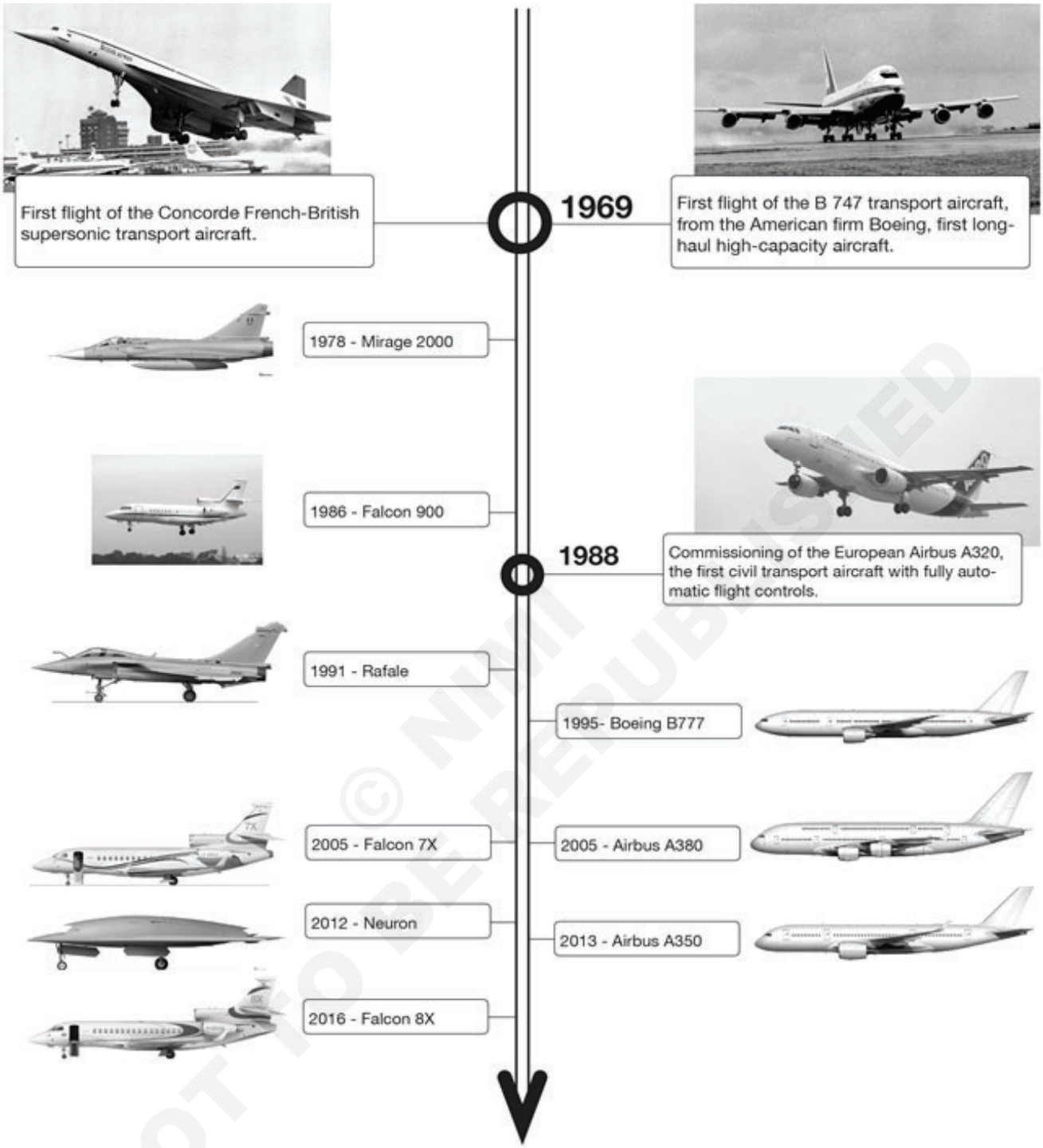


Fig 4



What is an aircraft

Objectives: At the end of this lesson you shall be able to
- **know the different type of aircafts and name them.**

An aircraft is any machine capable of atmospheric flight.

It is supported for flight in the air by buoyancy or by the dynamic action of air on its surfaces.

AEROSTATS - Lighter than air

Aerostats use buoyancy to float in the air in much the same way that ships float on the water.

They are characterized by one or more large cells filled with a relatively low-density gas such as helium or hot air.

Balloon, large airtight bag filled with hot air or a lighter-than-air gas, such as helium, to provide buoyancy so that it will rise and float in the atmosphere.

Airship, also called dirigible or dirigible balloon, a self-propelled lighter-than-air craft.

AERODYNES - Heavier-than-air

This type of aircraft must have a power source to provide the thrust necessary to obtain lift.

Aerodyne - Fixed-wing

Kite, oldest known heavier-than-air craft designed to gain lift from the wind.

Glider, non-powered heavier-than-air craft capable of sustained flight.

Hang-glider Like all other engineless aircraft, hang gliders use gravity as the source of propulsion

Para-gliders have no rigid framework, the parachute canopy acts as a wing.

Airplane (also known as an airplane or simply a plane) is a powered fixed-wing aircraft that is propelled forward by thrust from a jet engine or propeller.

Seaplane is a fixed-wing aircraft capable of taking off and landing on water.

Aerodyne - Rotorcraft

Rotorcraft, or rotary-wing aircraft, use a spinning rotor with aerofoil section blades (a rotary wing) to provide lift.

A helicopter, or chopper, is a type of rotorcraft in which lift and thrust are supplied by rotors.

An autogyro, also known as a gyroplane or gyrocopter, is a type of rotorcraft that uses an unpowered rotor to develop lift. Forward thrust is provided independently, by an engine-driven propeller.

General airplane main description

Objectives: At the end of this lesson you shall be able to
- **name the main components of an aircraft**
- **know the purpose of the main components of an aircraft.**

An aircraft is composed of different main elements:

- The fuselage.
- The wing.
- The empennage.
- The powerplant.
- The doors.
- The windows.

The fuselage is the envelope of an aircraft that receives passengers, cargo, crew, etc.

The wings are the element that will ensure the aircraft's lift.

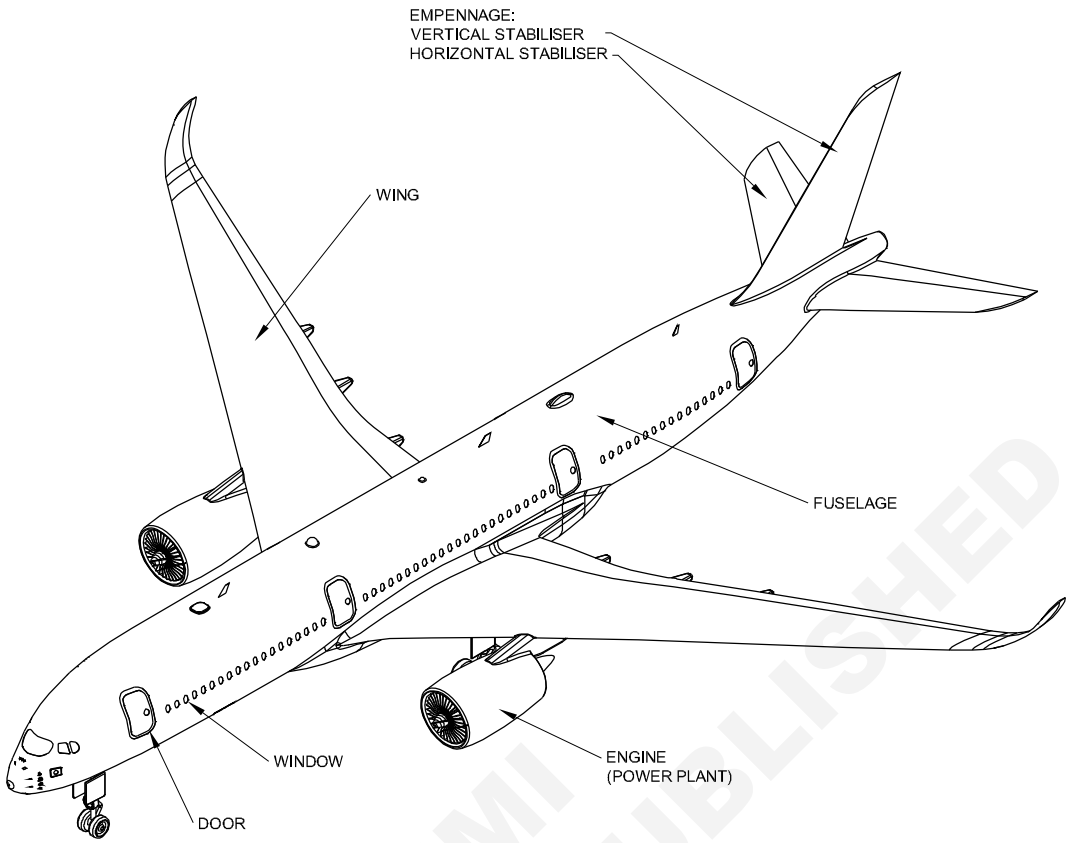
Located on both sides of the aircraft, it can take different shapes and positions.The wings support some operating and hyper-lifters components.

The empennage, as on the arrows, ensures the stability of the aircraft during the flight.

It is also on this element that two of the three operating elements are located.

The powerplant is an element that will provide the thrust that allows the aircraft to move. The engines can be locatedin different places such as the wings or the tail.

Fig 1



AIRBUS A320 MAIN COMPONENTS

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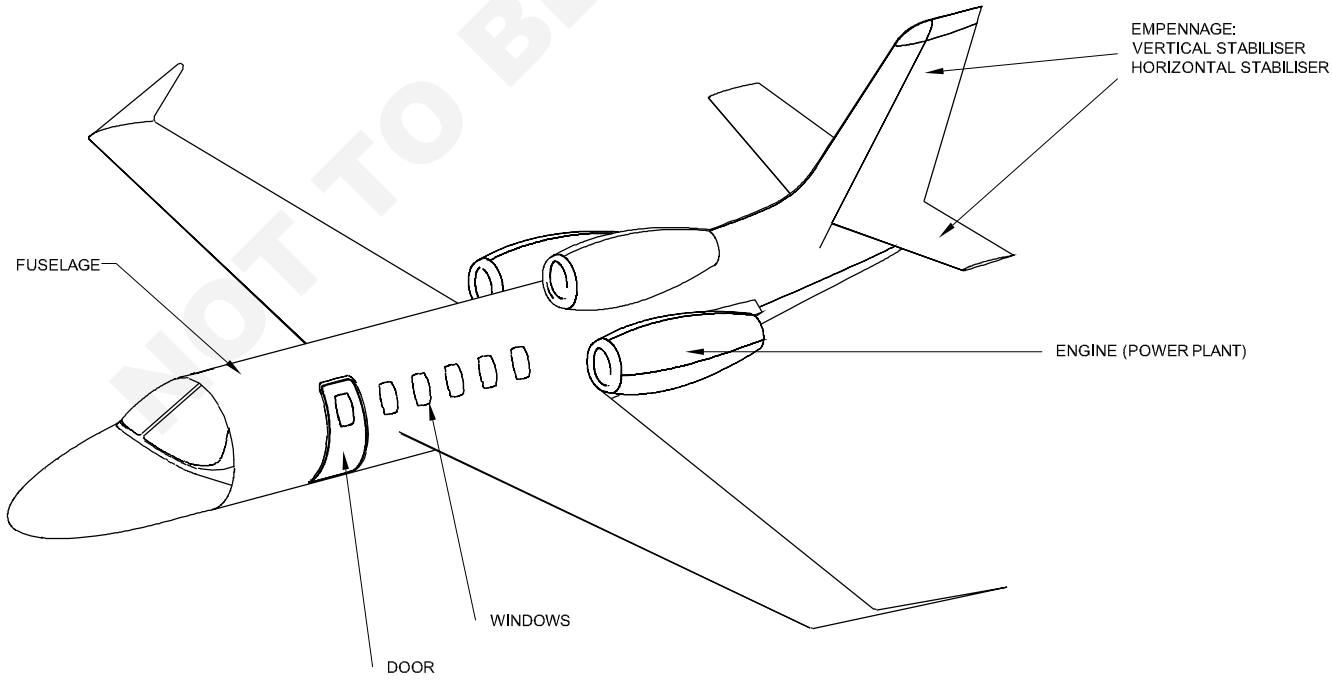
Fig 2



DASSAULT FALCON 8X MAIN COMPONENTS

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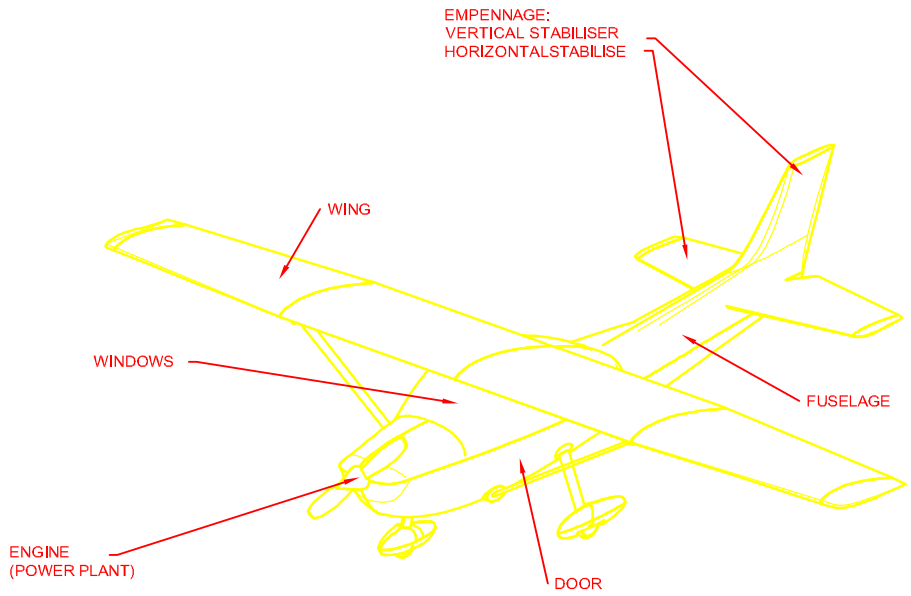
Fig 3



Aerodynamic notions

Objectives: At the end of this lesson you shall be able to
- **know the forces of the fly**
- **state the physicals laws making the fly possible.**

Four forces of flight: During flight, there are four forces acting on an airplane.

These forces are (Fig 1)

- **Lift:** the forcecreated by the wing that pushes an airplane upwards.

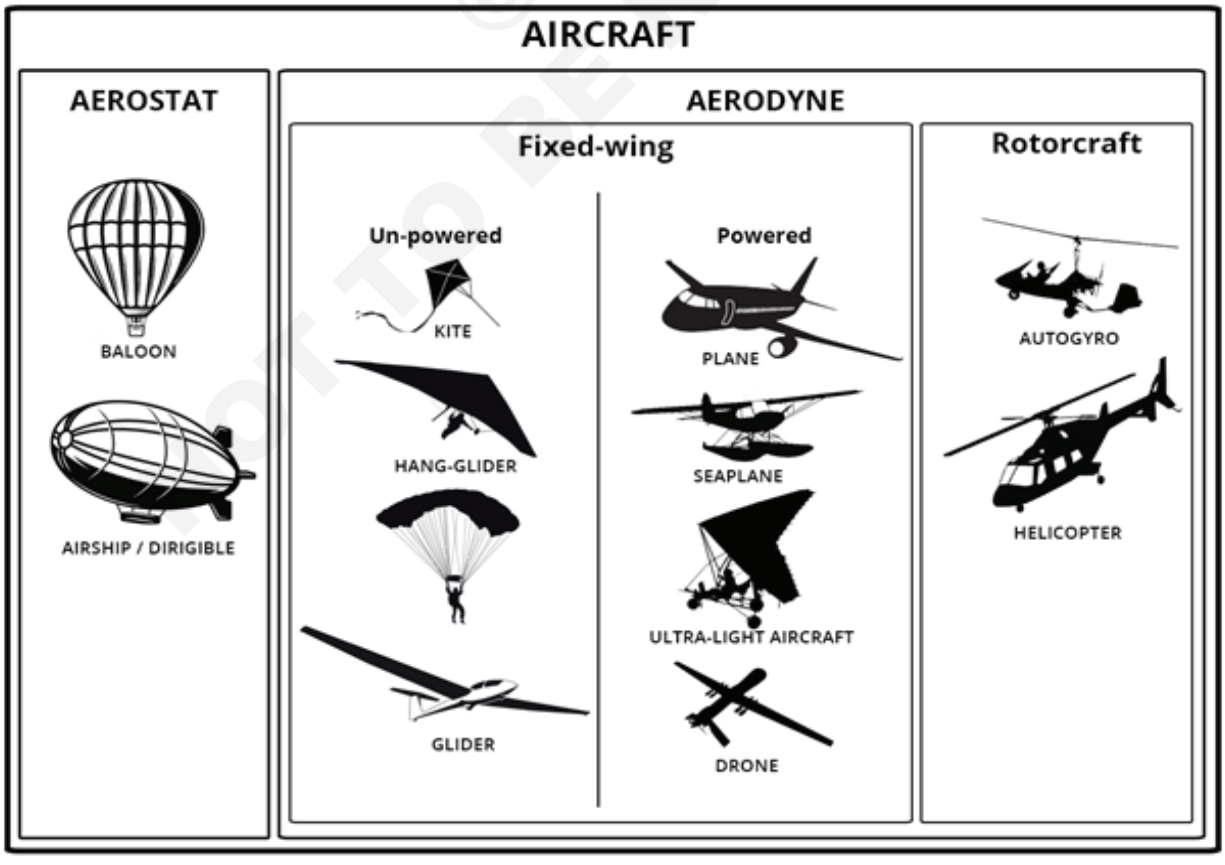
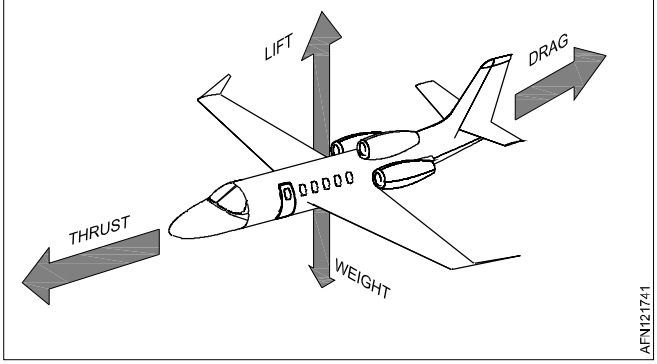


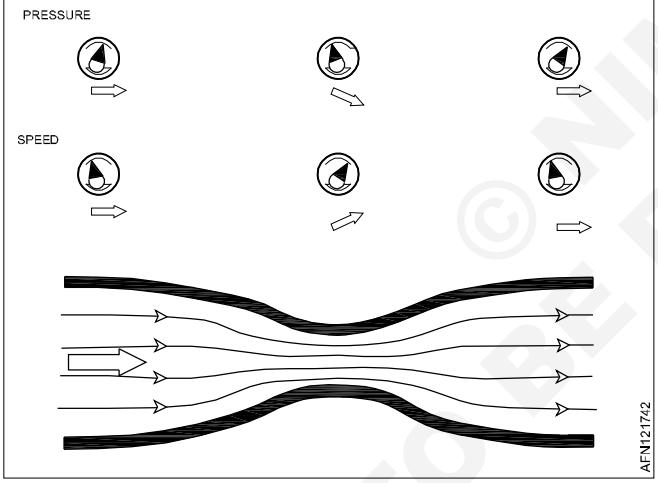
Fig 1



- **Weight:** the downward force (gravity) that opposes lift.
- **Thrust:** the forcecreated by the airplane's propeller or turbine engine that moves an airplane forward.
- **Drag:** the friction that resists the airplane as it moves forward

Bernoulli's Principle: Bernoulli's principle states that "as the velocity of a fluid increases, the static pressure of that fluid will decrease, provided there is no energy added or energy taken away." (Fig 2)

Fig 2



As the air flows over the upper surface of an airfoil, its velocity increases and its pressure decreases. An area of low pressure is formed.

There is an area of greater pressure on the lower surface of the airfoil, and this greater pressure tends to move the wing upward.

In other words, air below the wing pushes on the wing more than air above the wing.

Conservation of mass: Streamlines and stream tubes around an airfoil generating lift. Observe the narrower stream tubes above and the wider stream tubes below (Fig 3).

Mass conservation indicates that the flow velocity should increase as the surface area of the flow tube decreases.

From Bernoulli's principle, the pressure on the upper surface where the flow is moving faster is lower than the pressure on the lower surface where it is moving slower. This pressure difference creates a net aerodynamic force, pointing upward. (Fig 4)

Fig 3

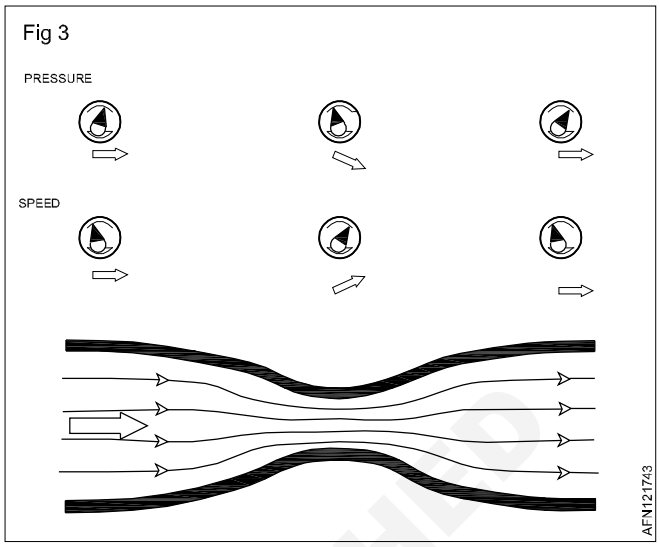
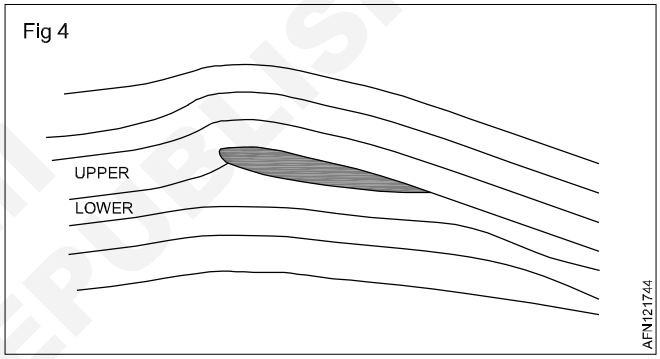
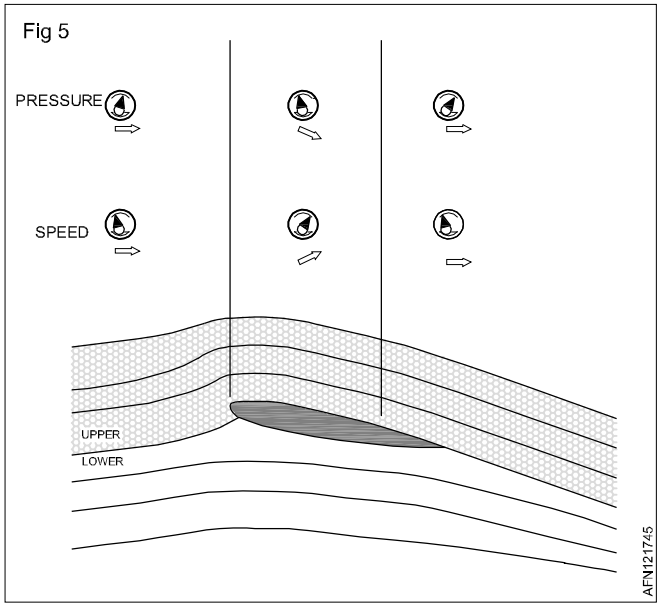


Fig 4



Coandã effect: The Coandã effect is the tendency of a fluid flow to stay attached to a convex surface. (Fig 5)

Fig 5



Lift and Newton's Third Law

Newton's third law identifies that for every force there is an equal and opposite reacting force. In addition to Bernoulli's principle, Newton's third law can also be used to explain the lift being created by a wing.

Based on this law, wings are forced upwards because they are tilted, pushing air downwards so the wings get pushed upwards.

As air flows over the surface of a wing, it sticks slightly to the surface it is flowing past and follows the shape. The air is deflected downwards. (Coandã effect)

When an airfoil deflects air downwards, Newton's third law requires that the air must exert an equal upward reaction on the airfoil (Fig 6)

Fig 6

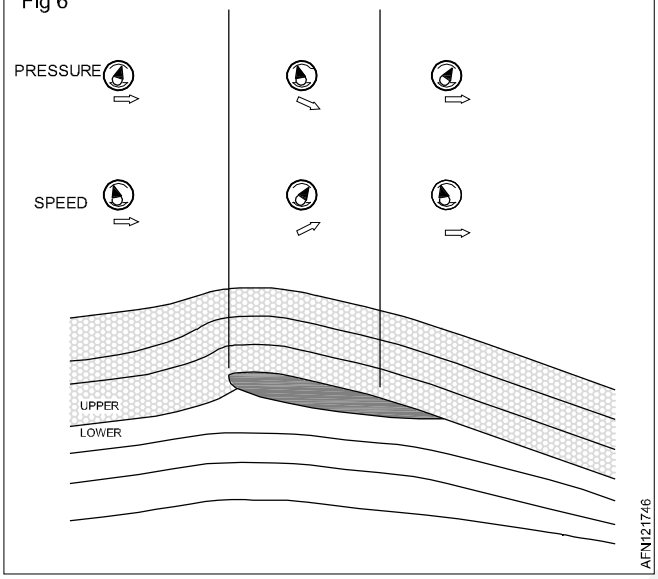


Fig 7

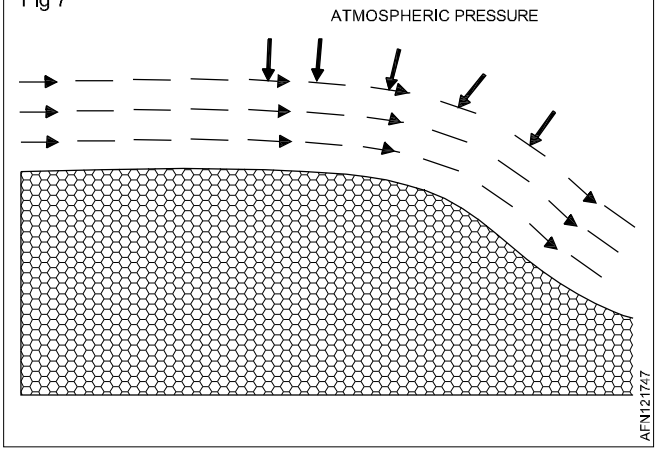
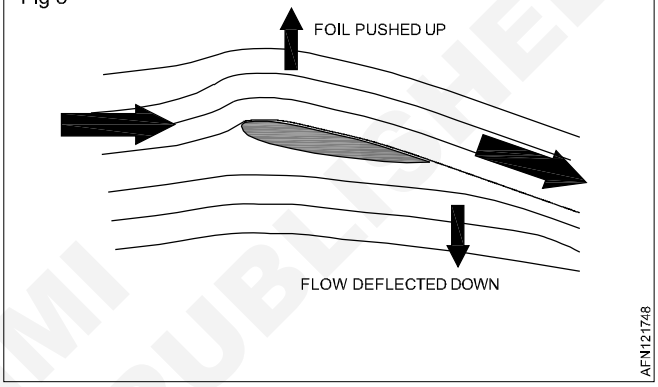


Fig 8



The lift on the wing as described by Bernoulli's principle, and lift on the wing as described by Newton's third law, are not separate or independent of each other. (Fig 7 & 8)

How does an aircraft fly?

Objectives: At the end of this lesson you shall be able to
- **name the axis and operating elements of an aircarft**
- **know the function of the different elements on the flight of an aircraft.**

How is controlling an airplane?

The purpose of flight controls is to allow the pilot tocontrol the airplane from the time it starts the takeoff roll until it lands.

Flight controls are associated with the wing and the vertical and horizontal stabilizers.

In flight, and to some extent on the ground, flight controls provide the airplane with the ability to move around one or more of the three axes; (Fig 1)

- Roll
- Pitch
- Yaw

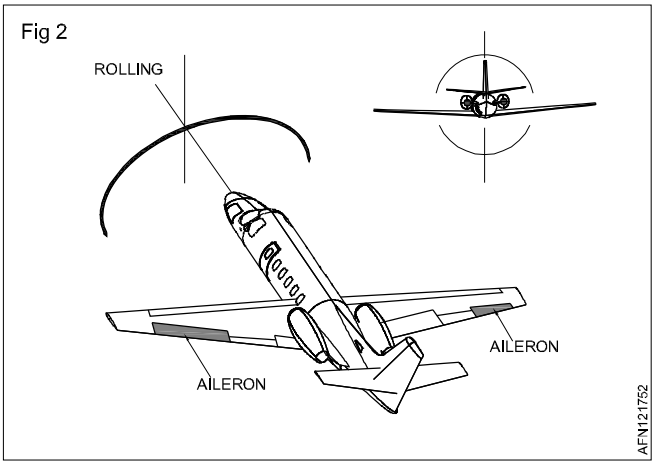
Flight controls function by changing the shape or aerodynamic characteristics of the surface they are attached to.

The ailerons control the rolling (Fig 2&3): On the outer rear edge of each wing, the two ailerons move in opposite directions, up and down, decreasing lift on one wing while increasing it on the other.

This causes the airplane to roll to the left or right. To turn the airplane, the pilot uses the ailerons to tilt the wings in the desired direction.

The elevator controls the pitching (Fig 4&5): On the horizontal tail surface, the elevator tilts up or down, decreasing or increasing lift on the tail.

Fig 2



This tilts the nose of the airplane up and down.

The rudder controls the Yawing (Fig 6&7): On the vertical tail fin, the rudder swivels from side to side, pushing the tail in a left or right direction.

A pilot usually uses the rudder along with the ailerons to turn the airplane.

Fig 1

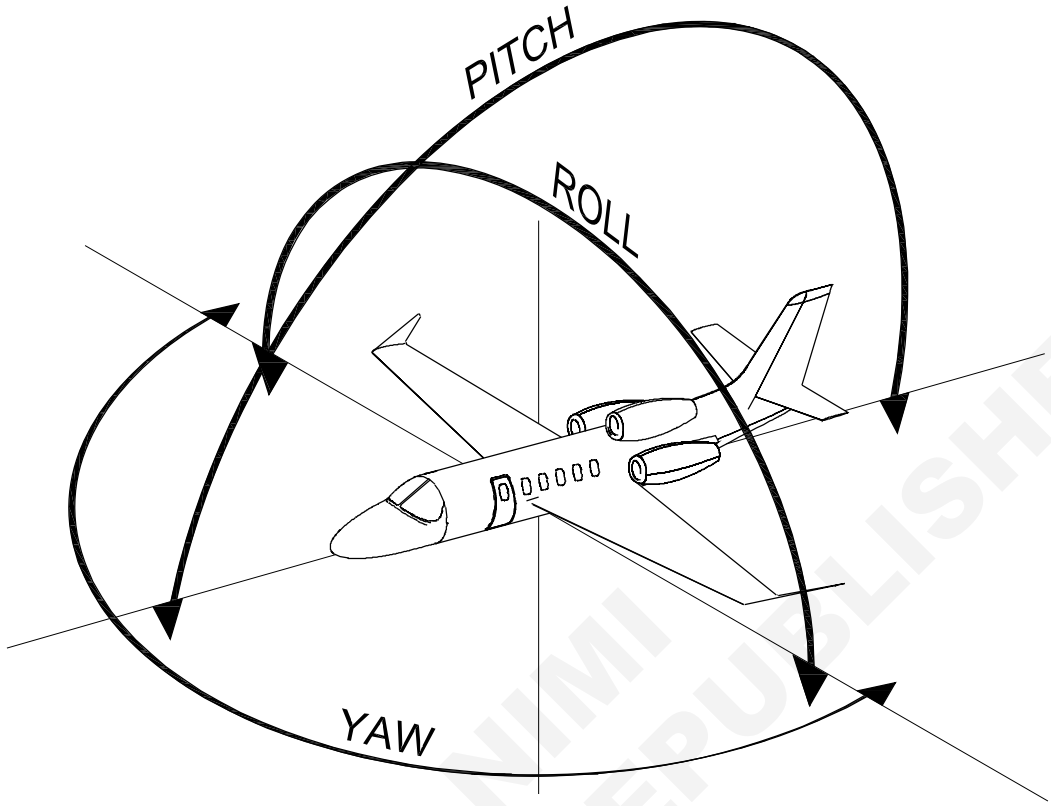


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Fig 3

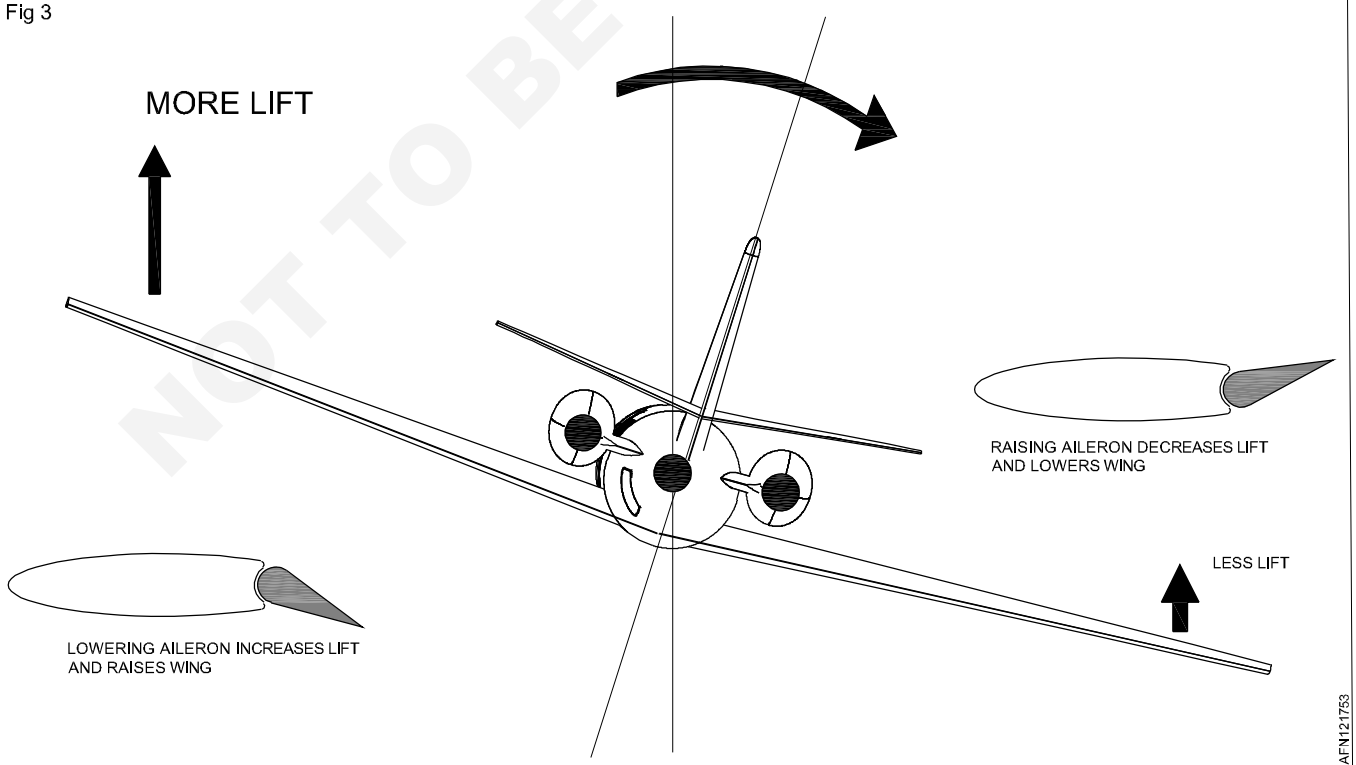

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Fig 4

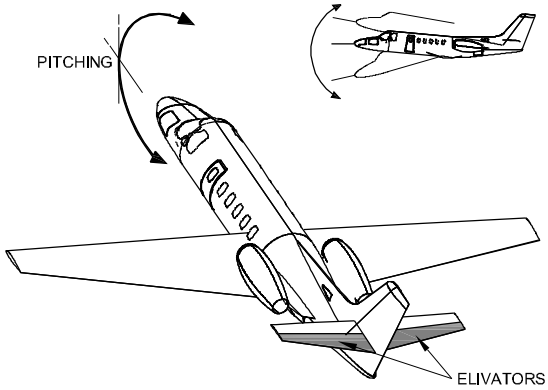


Fig 6

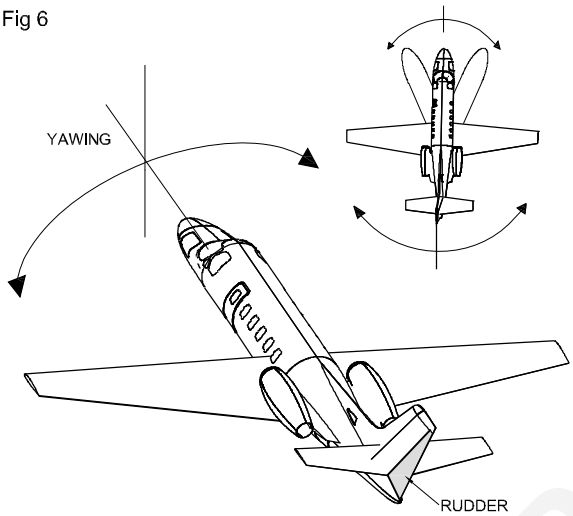


Fig 5

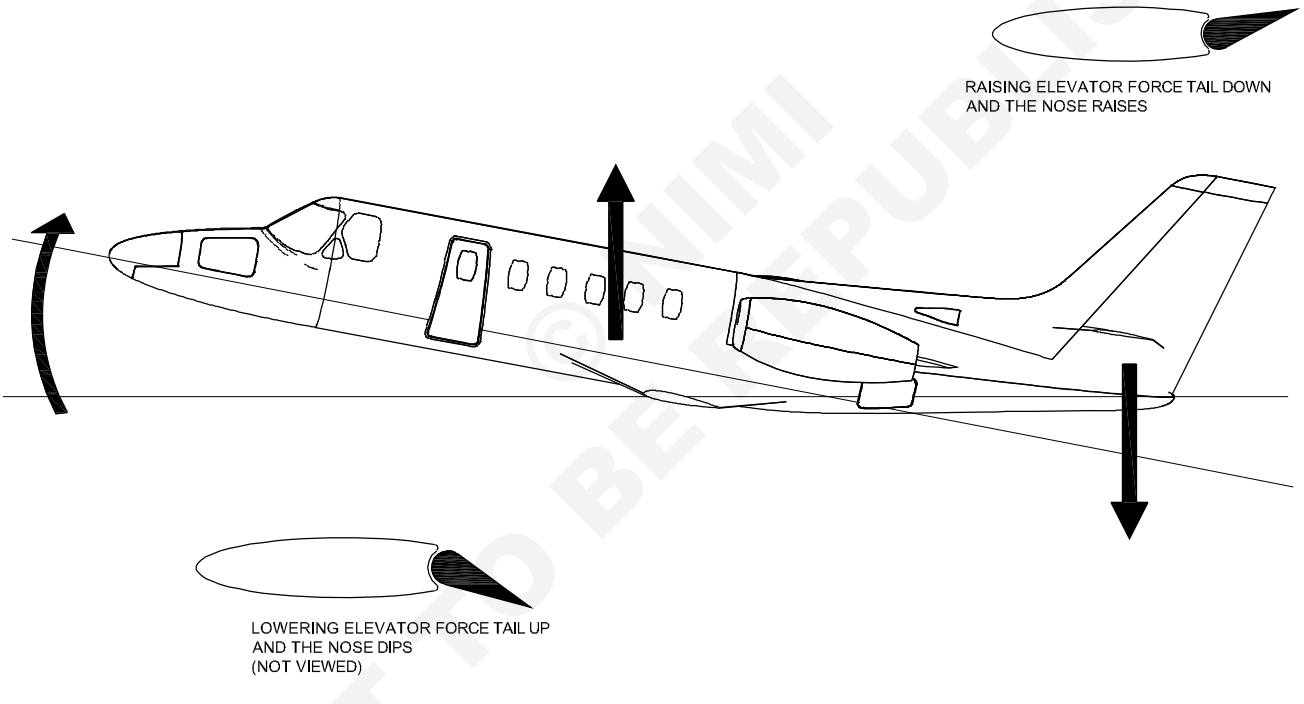
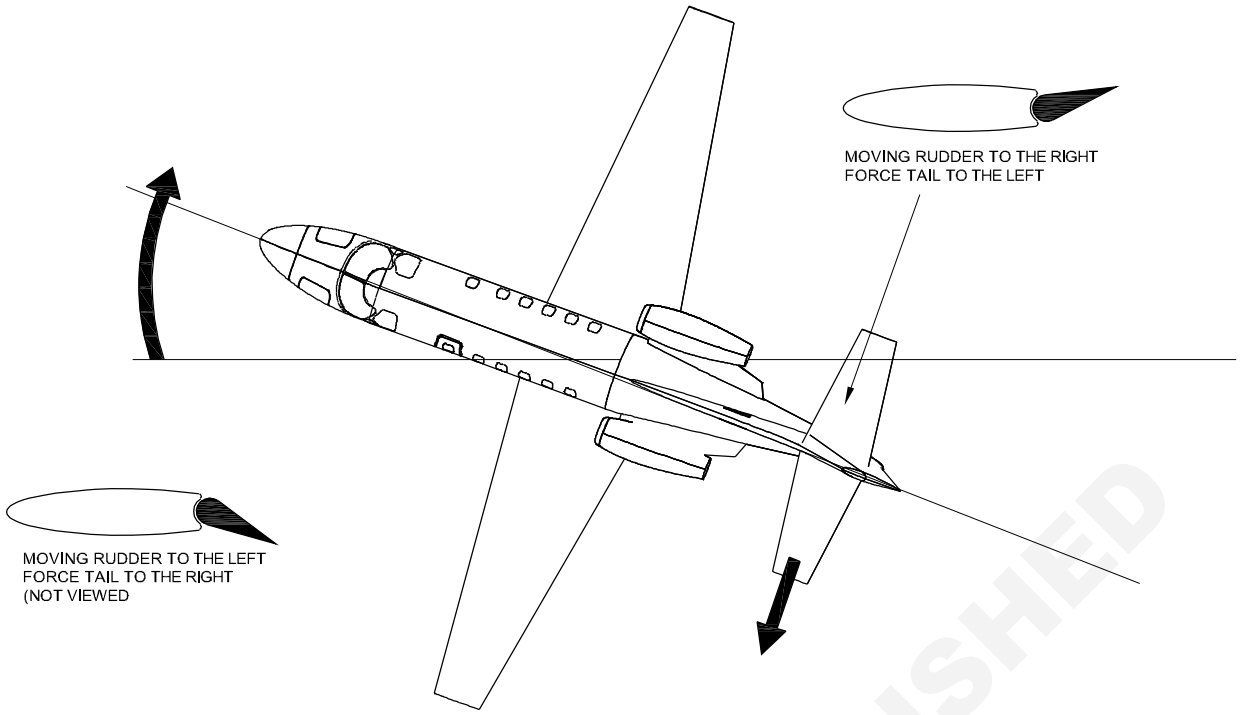


Fig 7



Deburring and chamfering holes

Objectives: At the end of this lesson you shall be able to
- **state the type of deburring hole tools**
- **state deburring hole.**

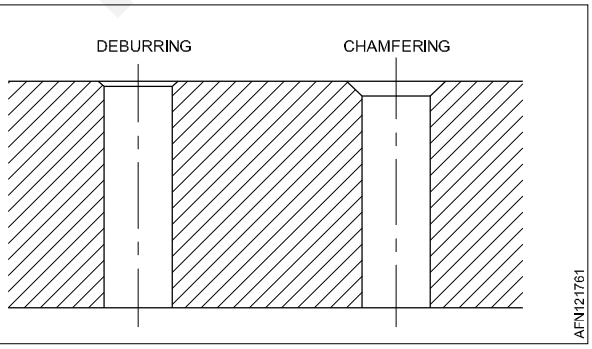
Burrs can impact an enclosure's functionality, longevity, safety, and effectiveness. The burrs can cause the following issues:

- Decreased resistance to fractures due to increased stress.
- Improper seating of fasteners, causing damage to the fastener or assembly.
- Material failure due to cracks.
- Increased risk of corrosion.
- Unsafe handling.

A deburring tool is designed to remove sharp edges and burrs from drilled holes.

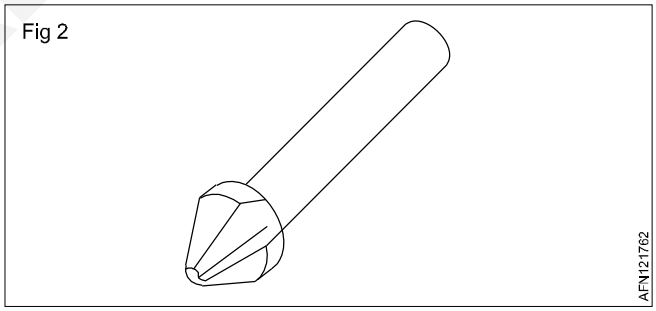
Deburring and chamfering tools: These tools are using to deburr a hole after drilling and to chamfer the ends of holes for thread cutting and other machining processes.

Fig 1



3 Flutes countersink cutter

Fig 2



Single Flute Countersinks: It is a cone-shaped tool with a cutting edge provided by a hole that goes through the side of the cone.

They are suitable to perform deburring on all materials which require a surface free from vibration.

Are particularly suitable for light alloys.

Cross-hole countersink cutter

It is more particularly designed for use with light metals and plastics.

The surface obtained is smooth and without burrs.

Tungsten Carbide countersink cutter

It is designed for use on hard metal and composite.

Fig 3

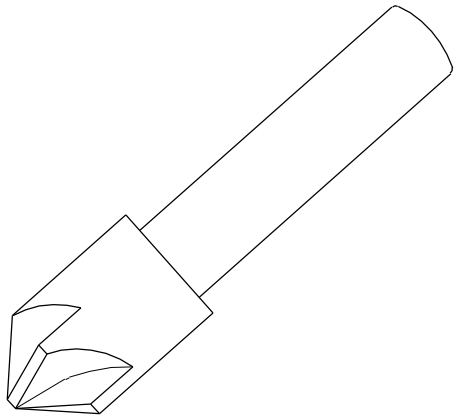


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Fig 4

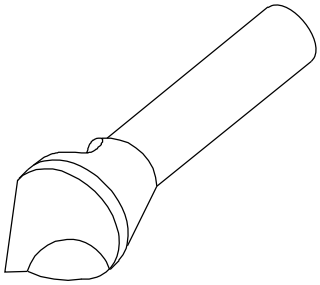

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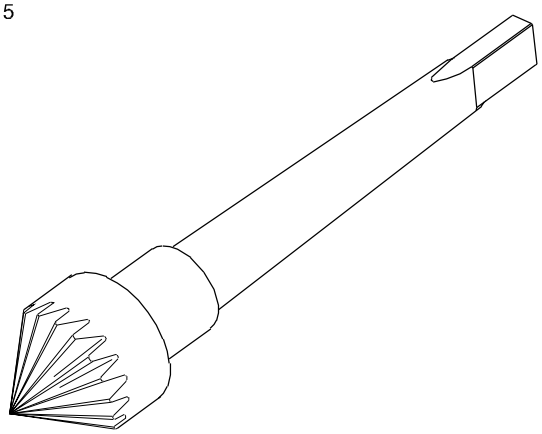
Fig 5



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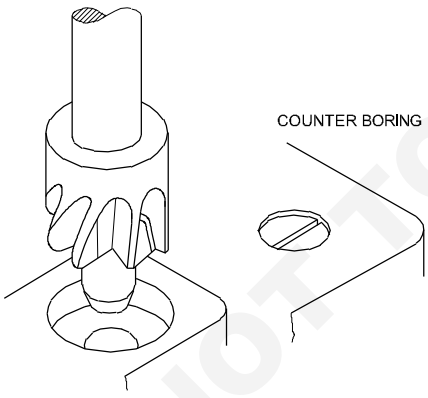
Counter boring and spot facing

Objectives: At the end of this lesson you shall be able to
- **differentiate counter boaring and spot facing.**

Counter boring: Counter boring is an operation of enlarging a hole to a given depth, to house heads of socket heads or cap screws with the help of a counter bore tool. (Fig 1)

Fig 1



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Counterbore (Fig 2)

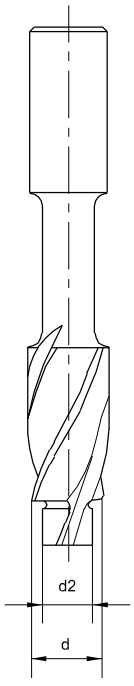
The tool used for counterboring is called a counterbore.

Counterbores will have two or more cutting edges.

At the cutting end, a pilot is provided to guide the tool concentric to the previously drilled hole. The pilot also helps to avoid chattering while counterboring.

Counterbores are available with solid pilots or with interchangeable pilots. The interchangeable pilot provides flexibility of counterboring on different diameters of holes.

Fig 2



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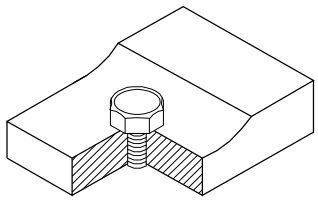
Spot facing

Spot facing is a machining operation for producing a flat seat for bolt head, washer or nut at the opening of a drilled hole. The tool is called a spot facer or a spot facing tool.

Spot facing is similar to counterboring, except that it is shallower. Tools that are used for counterboring can be used for spot facing as well. (Fig 3)

Spot facing is also done by fly cutters by end-cutting action. The cutter blade is inserted in the slot of the holder, which can be mounted on to the spindle.

Fig 3



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Countersinking

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

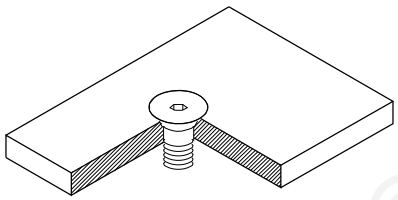
- **state countersinking**
- **list the purposes of countersinking**
- **state the angles of countersinking for the different applications**
- **name the different types of countersinks.**

What is countersinking?

Countersinking is an operation of bevelling the end of a drilled hole. The tool used is called a countersink cutter.

Countersinking is carried out to provide a recess for the head of a countersink screw, solid rivet or other fastener, so that it is flush with the surface after fixing. (Fig 1) Angles for countersinking.

Fig 1



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Countersinks in aerospace are available in different angles for different uses.

- 90° countersink head screws (ISO, DIN metric) and deburring.
- 82° countersink head screws (UNC, UNF inch)
- 100° aerospace countersink riveting (metric and inch)
- 120° chamfering ends of holes to be threaded or other machining processes.

Countersinks: Countersinks of different types are available.

The cutter used to deburr can be use to countersinking.

For countersinking small diameter holes special countersinks with two or one flute are available. This will reduce the vibration while cutting.

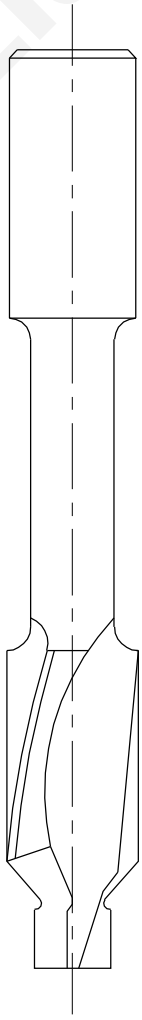
Countersinks with Pilot (Fig 2): For precision countersinking, needed for machine tool assembling and after machining process, countersinks with pilots are used.

They are particularly useful for heavy duty work.

The pilot is provided at the end for guiding the countersink concentric to the hole.

Countersinks with pilots are available with interchangeable and solid pilots.

Fig 2



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Screw thread and elements

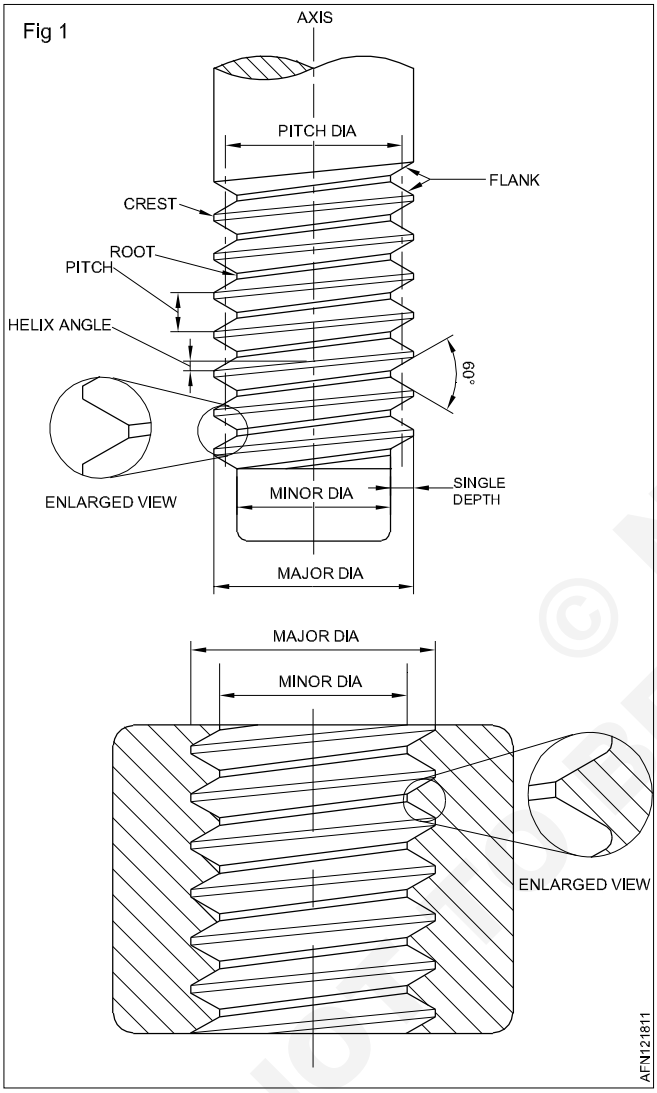
Objectives: At the end of this lesson you shall be able to
- **state the terminology of screw threads**
- **state the types of screw threads.**

Screw thread terminology

Parts of screw thread (Fig 1)

Crest: The top surface joining the two sides of a thread.

Fig 1



Root: The bottom surface joining the two sides of adjacent threads.

Flank: The surface joining the crest and the root.

Thread angle: The included angle between the flanks of adjacent threads.

Depth: The perpendicular distance between the roots and crest of the thread.

Major Diameter: In the case of external threads, it is the diameter of the blank on which the threads are cut and in the case of internal threads it is the largest diameter after the threads are cut that are known as the major diameter.

This is the diameter by which the sizes of screws are stated.

Minor Diameter: For external threads, the minor diameter is the smallest diameter after cutting the full thread. In the case of internal threads, it is the diameter of the hole drilled for forming the thread which is the minor diameter.

Pitch Diameter (effective diameter): The diameter of the thread at which the thread thickness is equal to one half of the pitch.

Pitch: It is the distance from a point on one thread to a corresponding point on the adjacent thread measured parallel to the axis.

Lead: Lead is the distance of a threaded component moves along the matching component during one complete revolution.

For a single start thread the lead is equal to the pitch.

Helix Angle: The angle of inclination of the thread to the imaginary perpendicular line.

Hand: The direction in which the thread is turned to advance. A right-hand thread is turned clockwise to advance, while a left-hand thread is turned anticlockwise.

Thread standards used in aerospace industry

Objectives: At the end of this lesson you shall be able to
- **state the different standards of V threads used in aerospace industry**
- **indicate the angle and the relation between the pitch with the other elements of the thread**
- **read the designation of the threads.**

ISO and ANSI/ASME B1.1profiles (the most frequently used in aircraft assembly) have the same basic profile (equilateral triangle). The screw thread is characterized by having a flat tip and a round root. (Fig 1)

ISO Unified thread – Millimetre series

ISO metric screw thread profile: The "M" designation for metric screws indicates the nominal outer diameter of the screw, in millimetres (e.g. M6 screw has a nominal outer diameter of 6 millimetres).

Grades 3 to 9 indicate quality, which is lowest at 3 and highest at 9.

e, f, g, h> external threads

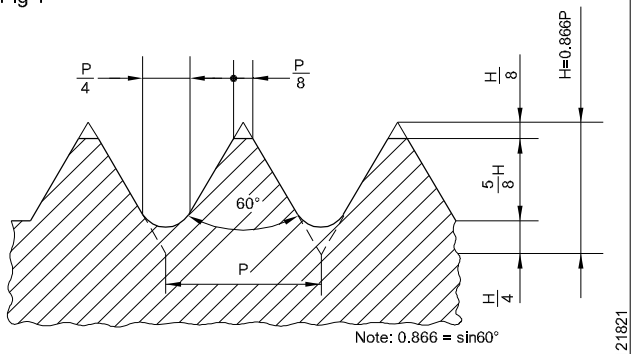
G, H> internal threads

Examples

M8x1.25-g6(screw, g6 type, d = 8 mm normal pitch – 1.25mm the annotation of pitch is optional).

M10x1.25-H9 (internal threaded hole; H9 type, diameter = 10 mm, 1.25 mm fine pitch)

Fig 1



ISO METRIC THREAD, UNIFIED INCH SERIES THREAD

ANSI/ASME B1.1– Inch series

The basic profile of this threads is the same as that of all ISO metric screw threads, but the characteristic dimensions of each thread (outer diameter and pitch) were chosen as an inch fraction rather than a millimeter value.

Grades 1 to 3 indicate quality, which is lowest at 1 and highest at 3.

1A, 2A, 3A> external threads

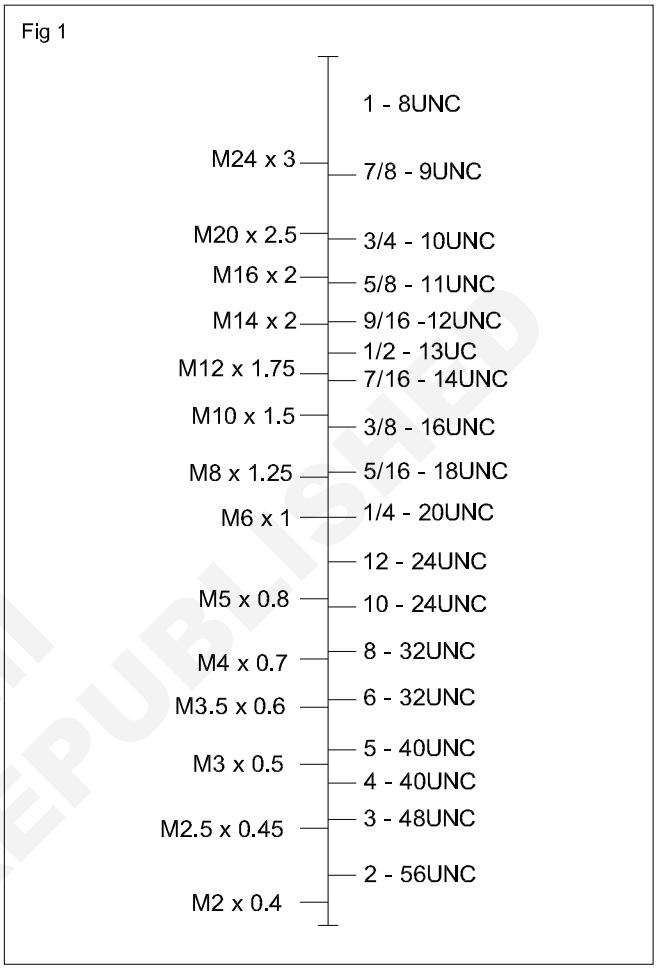
1B, 2B, 3B> internal threads

Examples

6-32 UNC-2A LH (screw, class 2A, nominal d = 0.138 in, 32 threads/in, LH = left-hand screw thread).

3/8-24 UNF-2B (internal threaded hole, class 2B, nominal d = 3/8 in, 24 threads/in, fine pitch).

Fig 1



Hand taps

Objectives: At the end of this lesson you shall be able to
- **state the uses of threading hand taps**
- **state the features of hand taps**
- **distinguish between different taps in a set.**

Use of hand taps: Hand taps are used for internal threading of components.

Features (Fig 1): They are made from high carbon steel or high-speed steel, hardened and ground.

Threads are cut on the surface and are accurately finished.

To form the cutting edges, the flutes are cut across the thread.

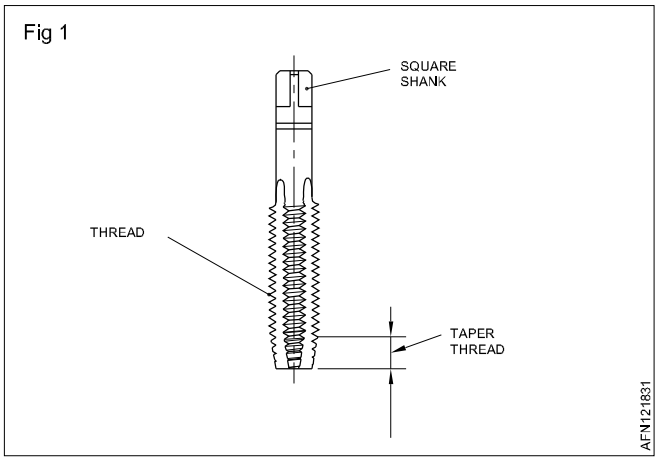
For holding and turning the taps while cutting threads, the ends of the shanks are squared.

The ends of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.

The size of the taps, the thread standard, the pitch of the thread, the dia. of the tapping hole are usually marked on the shank.

In certain cases, the pitch of the thread will also be marked.

Fig 1



Markings are also made to indicate the type of tap i.e. first, second or plug.

Types of Taps in a set: Hand taps for a thread are available as a set consisting of three pieces. (Fig 2) These are;

- First tap or taper tap (Fig 2A)
- Second tap or intermediate tap (Fig 2B)
- Plug or bottoming tap (Fig 2C)

These taps are identical in all features except in the tap lead.

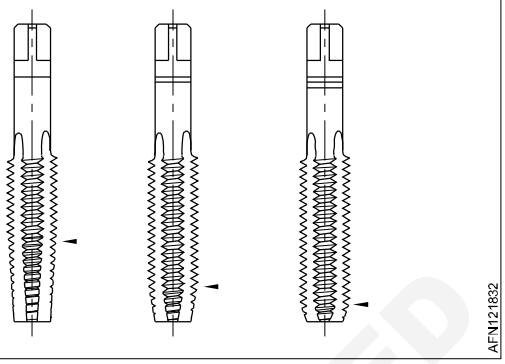
The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

For identifying the type of taps quickly - the taps are either numbered as 1, 2 and 3 or rings are marked on the shank.

The taper tap has one ring, the intermediate tap has two rings and the bottoming tap has three rings. (Fig 2)

Fig 2



Hand taps wrenches

Objectives: At the end of this lesson you shall be able to
- **name the different types of tap wrenches**
- **stat the uses of different types of wrenches.**

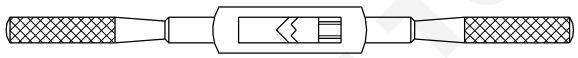
Tap wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap wrenches are of different types:

- Double ended adjustable wrench.
- T-handle tap wrench.
- Solid type tap wrench.

Double-ended adjustable tap wrench or bar type tap wrench (Fig 1): This is the most commonly used type of tap wrench. It is available in various sizes. These tap wrenches are more suitable for large diameter taps and can be used in open places where there is no obstruction to turn the tap. It is important to select the correct size of wrench.

Fig 1

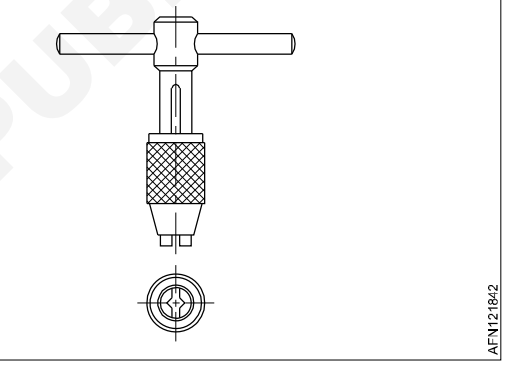


T-Handle tap wrench (Fig 2): These are small adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places and is turned with one hand only.

This wrench is not available for holding large diameter taps.

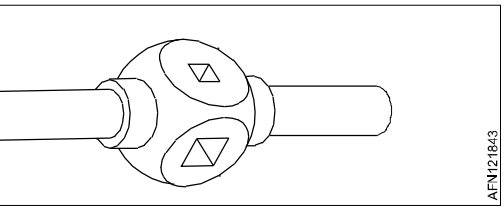
Fig 2



Solid type tap wrench (Fig 3): These wrenches are not adjustable.

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches, and thus prevents damage to the taps.

Fig 3



Tap drill size

Objectives: At the end of this lesson you shall be able to
- **state what is tap drill size**
- **choose the tap drill sizes of different threads from tables.**
- **calculate the tap drill sizes for ISO metric and ANSI/ASME B1.1 inch.**

What is a tap drill size?

Before a tap is used for cutting internal threads, a hole is to be drilled. The diameter of the hole should be such that it should have enough material in the hole for the tap to cut the thread.

Calculation of the drilling diameter

DIAMETER – PITCH

The depth of any 60-degree metric/UNC/UNF thread is pitch x 0.6134

Metric Thread

Tapping drill size for M10 x 1.5 thread

Minor diameter = Major diameter – 2 x depth

Depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

= 1.226 x 1.5 mm = 1.839 mm

Minor diameter (D1)=10 mm – 1.839 mm

= 8.161mm or 8.2 mm

This tap drill will produce 100% thread because this is equal to the minor diameter of the thread. For mostfastening purposes, a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread.

Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size = Major diameter – pitch

= 10 mm - 1.5 mm

= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

Inch (Unified) threads Formula

Tap Drill size =

$$\text{Major diameter} - \frac{1}{\text{Number of threads per inch}}$$

For calculating the tap drill size for 5/8" UNC thread

Tap drill size = 5/8" – 1/11"

= 0.625" – 0.091"

= 0.534"

The next drill size is 17/32" (0.531 inches)

Compare this with the table of drill sizes for unified inch threads.

TABLE FOR TAP DRILL SIZES- ISO METRIC THREADS

ISO METRIC PROFILE (mm)				
Diameter	**Coarse pitch**	**Available fine pitches**		
1.6	0.35	0.20		
2	0.40	0.25		
2.5	0.45	0.35		
3	0.50	0.35		
4	0.70	0.50		
5	0.80	0.50		
6	1.00	0.75		
8	1.25	0.75	1.00	
10	1.50	0.75	1.00	1.25
12	1.75	1.00	1.25	1.50
(14)	2.00	1.00	1.25	1.50
16	2.00	1.00	1.50	
(18)	2.50	1.00	1.50	2.00
20	2.50	1.00	1.50	2.00

COMMERCIAL DRILL SIZES ISO INCH (UNIFIED) THREAD (1/2)

Designation	Diameter			Threads/inch (T.P.I)	Pitch		Hole (in mm)
	Code	inch	mm		mm	inch	
1-64 UNC	1	0.073	1.87	64	0.396	.0629	1.46
2-56 UNC	2	0.086	2.18	56	0.453	.0744	1.74
3-48 UNC	3	0.099	2.51	48	0.528	0.855	1.99
4-40 UNC	4	0.112	2.84	40	0.634	.0858	2.22
5-40 UNC	5	0.125	3.17	40	0.634	.1088	2.54
6-32 UNC	6	0.138	3.50	32	0.794	.1177	2.71
8-32 UNC	8	0.164	4.16	32	0.794	.1437	3.38
10-24 UNC	10	0.190	4.83	24	1.057	.1629	3.80
12-24 UNC	12	0.216	5.49	24	1.057	.1889	4.44
1/4-20 UNC	1/4	0.250	6.35	20	1.269	.2175	5.10
5/16 -18 UNC	5/16	0.312	7.94	18	1.411	.2764	6.55
3/8-16 UNC	3/8	0.375	9.52	16	1.587	.3344	7.97
7/16-14 UNC	7/16	0.437	11.11	14	1.813	.3911	9.35
1/2-13 UNC	1/2	0.500	12.70	13	1.953	.4500	10.79

COMMERCIAL DRILL SIZES ISO INCH (UNIFIED) THREAD (2/2)

Designation	Diameter			Threads/inch	Pitch (in mm)		Hole in (mm)
	Code	inch	mm	(T.P.I)	mm	inch	1.51
1-64 UNF	1	.073	1.87	72	0.352	.0640	1.51
2-64 UNF	2	.086	2.18	64	0.396	.0759	1.90
3-48 UNF	3	0.99	2.51	56	0.453	.0874	2.07
4-40 UNF	4	.112	2.84	48	0.528	.0985	2.33
5-40 UNF	5	.125	3.17	44	0.577	.1102	2.61
6-32 UNF	6	.138	3.50	40	0.634	.1218	2.90
8-32 UNF	8	.164	4.16	36	0.705	.1460	3.48
10-24 UNF	10	.190	4.83	32	0.794	.1697	4.06
12-24 UNF	12	.216	5.49	28	0.906	.1928	4.60
1/4-20 UNF	1/4	.250	6.35	28	0.906	.2268	5.46
5/16-18 UNF	5/16	.312	7.94	24	1.057	.2854	6.91
3/8-16 UNF	3/8	.375	9.52	24	1.057	.3479	8.48
7/16-14 UNF	7/16	.437	11.11	20	1.269	.4050	9.85
1/2-13 UNF	1/2	.500	12.70	20	1.269	.4675	11.45

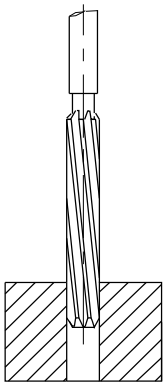
Reamers

Objectives: At the end of this lesson you shall be able to
- **state the use of reamers**
- **state the advantages of reaming**
- **distinguish between hand and machine reaming**
- **name the elements of a reamer and state their functions.**

What is a reamer?

A reamer is a multipoint cutting tool used for enlarging by finishing previously drilled holes to accurate sizes. (Fig 1)

Fig 1



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Advantages of reaming

- Reaming produces
- High quality surface finish
- Dimensional accuracy to close limits.

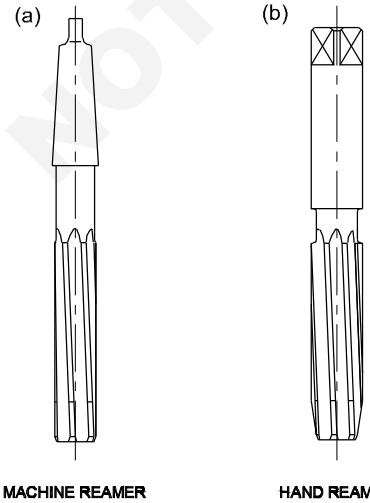
Classification of reamers

Reamers are classified as hand reamers and machine reamers. (Figs 2a & 2b)

Reaming by using hand reamers is done manually for which great skill is needed.

Machine reamers are fitted on spindles of machine tools and rotated for reaming.

Fig 2



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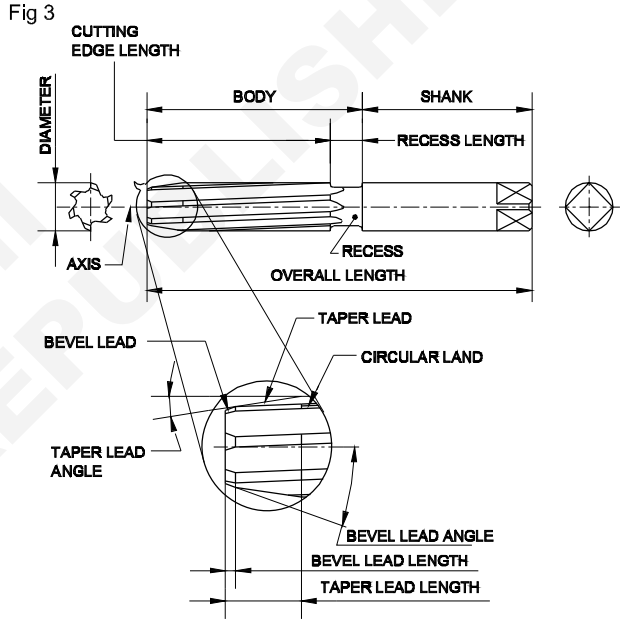
Machine reamers are provided with morse taper shanks for holding on machine spindles.

Hand reamers have straight shanks with 'square' at the end, for holding with tap wrenches. (Figs 2 (a) and (b)

Parts of a hand reamer: The parts of a hand reamer are listed hereunder. Refer to Fig 3.

Fig 3



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Axis: The longitudinal centre line of the reamer.

Body: The portion of the reamer extending from the entering end of the reamer to the commencement of the shank.

Recess: The portion of the body which is reduced in diameter below the cutting edges, pilot or guide diameters.

Shank: The portion of the reamer which is held and driven. It can be parallel or taper.

Circular land: The cylindrically ground surface adjacent to the cutting edge on the leading edge of the land.

Bevel lead: The bevel lead cutting portion at the entering end of the reamer cutting its way into the hole. It is not provided with a circular land.

Taper lead

The tapered cutting portion at the entering end to facilitate cutting and finishing of the hole. It is not provided with a circular land.

Bevel lead angle: The angle formed by the cutting edges of the bevel lead and the reamer axis.

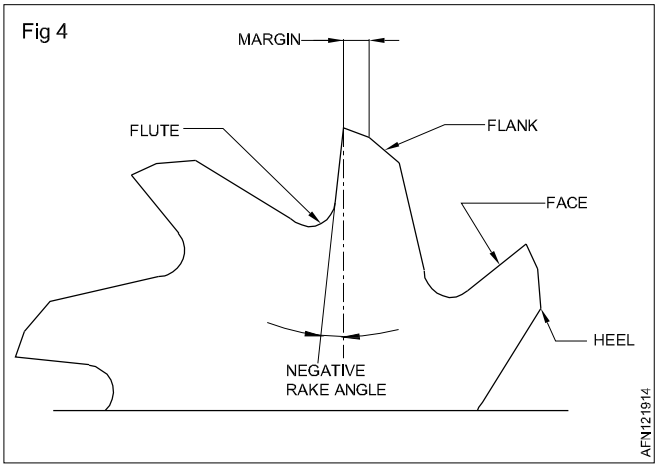
Taper lead angle: The angle formed by the cutting edges of the taper and the reamer axis.

Terms relating to cutting geometry

Flutes: The grooves in the body of the reamer to provide cutting edges, to permit the removal of chips, and to allow the cutting fluid to reach the cutting edges. (Fig 4)

Heel: The edge formed by the intersection of the surface left by the provision of a secondary clearance and the flute. (Fig 4)

Fig 4



Cutting edge: The edge formed by the intersection of the face and the circular land or the surface left by the provision of primary clearance. (Fig 4)

Face: The portion of the flute surface adjacent to the cutting edge on which the chip impinges as it is cut from the work. (Fig 4)

Rake angles: The angles in a diametral plane formed by the face and a radial line from the cutting edge. (Fig 5)

Clearance angle: The angles formed by the primary or secondary clearances and the tangent to the periphery of the reamer at the cutting edge. They are called primary clearance angle and secondary clearance angle respectively. (Fig 6)

Fig 5

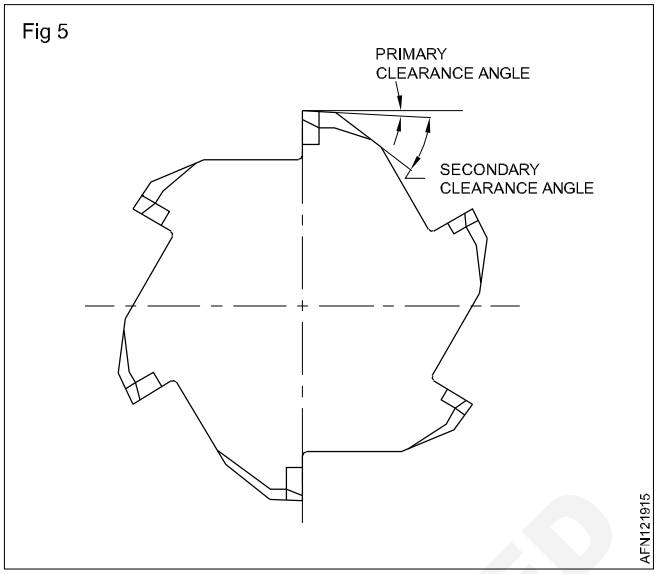
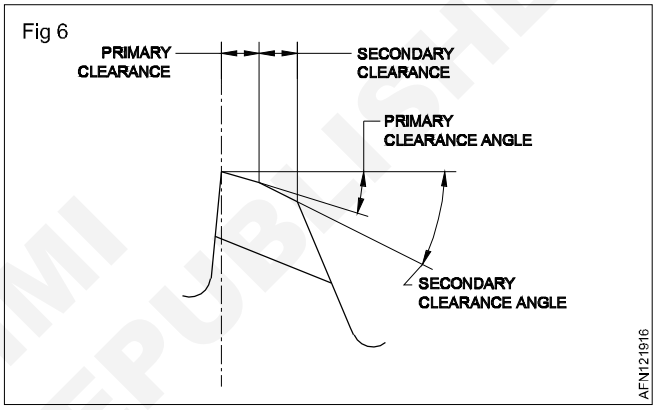
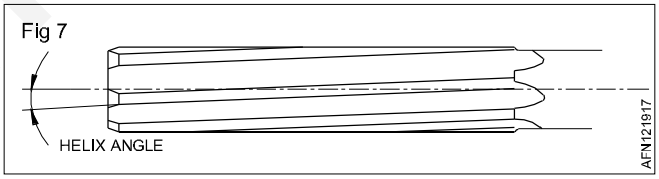


Fig 6



Helix angle: The angle between the edge and the reamer axis. (Fig 7)

Fig 7



Hand reamers

Objectives: At the end of this lesson you shall be able to
- **state the general features of hand reamers**
- **identify the types of hand reamers**
- **distinguish between the uses of straight fluted and helical fluted reamers**
- **name the materials from which reamers are made and specify reamers.**

General features of hand reamers (Fig 1): Hand reamers are used to ream holes manually using tap wrenches.

These reamers have a long taper lead. (Fig 2) This allows to start the reamer straight and in alignment with the hole being reamed.

Most hand reamers are for right hand cutting.

Helical fluted hand reamers have left hand helix.

The left hand helix will produce smooth cutting action and finish.

Most reamers, machine or hand, have uneven spacing of teeth. This feature of reamers helps to reduce chattering while reaming.

Types, features and functions: Hand reamers with different features are available for meeting different reaming conditions. The commonly used types are listed here under:

Fig 1

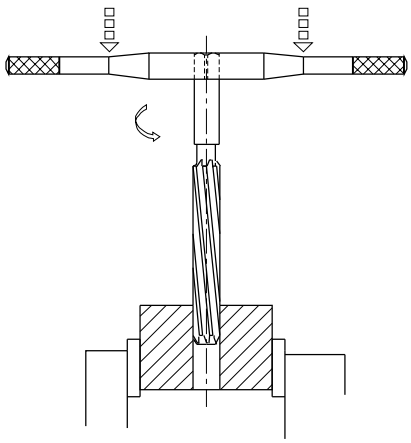


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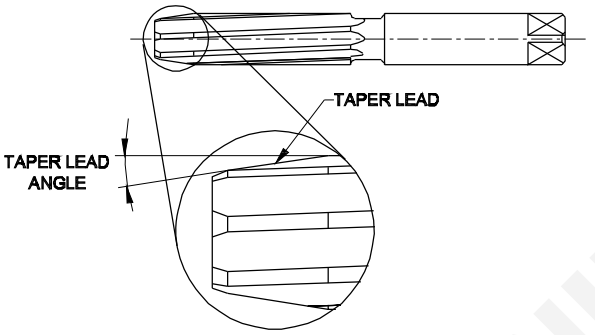
Fig 2



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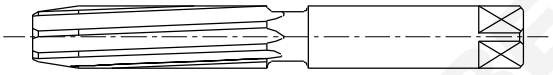
Parallel hand reamer with parallel shank (Fig 3)

Fig 3



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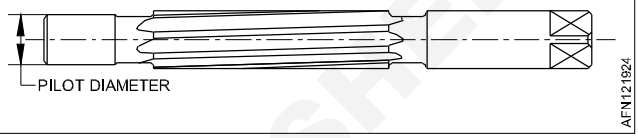
A reamer which has virtually parallel cutting edges with taper and bevel lead. The body of the reamer is integral with a shank. The shank has the nominal diameter of the cutting edges. One end of the shank is square shaped for tuning it with a tap wrench. Parallel reamers are available with straight and helical flutes. This is the commonly used hand reamer for reaming holes with parallel sides.

Reamers commonly used in workshop produce H7 holes.

Hand reamer with pilot (Fig 4): For this type of reamer, a portion of the body is cylindrically ground to form a pilot at the entering end. The pilot keeps the reamer concentric with the hole being reamed.

The helical flutes will bridge the gap and reduce binding and chattering.

Fig 4



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Material of hand reamers: When the reamers are made as a one-piece construction, high speed steel is used. When they are made as two-piece construction then the cutting portion is made of high-speed steel while the shank portion is made of carbon steel. They are butt-welded together before manufacturing.

Specifications of a reamer: To specify a reamer the following data is to be given.

Type, Flute, Shank end, Size.

Example: Hand reamer, Straight flute, Parallel shank of Ø 20 mm.

Drill size of reaming

Objectives: At the end of this lesson you shall be able to
- **determine the hole size for reaming.**

For reaming with a hand or a machine reamer, the hole drilled should be smaller than the reamer size.

The drilled hole should have sufficient metal for finishing with the reamer. Excessive metal will impose a strain on the cutting edge of the reamer and damage it.

Calculating drill size for reamer: A method generally practiced in workshop is by applying the following formula.

Drill size = Reamed size – (Undersize + Oversize)

Finished size

Finished size is the diameter of the reamer.

Undersize: Undersize is the recommended reduction in size for different ranges of drill diameter. (Table 1)

TABLE 1

Undersize for reaming

Diameter of ready reamed hole (mm)	Undersize of rough bored hole (mm)
Under 5	0.1 / 0.2
5 to 20	0.2 / 0.3
21 to 50	0.3 / 0.5
50	0.5 / 1.0

Oversize: It is generally considered that a twist drill will make a hole larger than its diameter. The oversize for calculationpurposes is taken as 0.05 mm - for all diameters of drills.

For light metals the undersize will be chosen 50% larger.

Example

A hole is to be reamed on mild steel with a 10 mm reamer.

What will be the diameter of the drill for drilling the hole before reaming?

Drill size = Reamed size – (Undersize + Oversize)

(Finished size) = 10 mm

Undersize as per

Table = 0.2 mm

Oversize = 0.05 mm

Drill size = 10 mm — 0.25 mm

Drill size = 9.75 mm

Note: If the reamed hole is undersize, the cause is that the reamer is worn out.

Always inspect the condition of the reamer before commencing reaming.

For obtaining good surface finish: Use a coolant while reaming. Remove metal chips from the reamer frequently.

Advance the reamer slowly into the work.

Defects in reaming - Causes and Remedies

Reamed hole undersize

- If a worn-out reamer is used, it may result in the reamed hole bearing undersize. Do not use such reamers.
- Always inspect the condition of the reamer before using.

Surface finish rough

- The causes may be any one of the following or a combination thereof.
- Incorrect application
- Swarf accumulated in reamer flutes.
- Inadequate flow of coolant.
- Feed rate too fast.
- While reaming applies a steady and slow feed-rate.
- Ensure a continuous supply of the coolant.
- Do not turn the reamer in the reverse direction.

Determining the drill size for reaming

Use the formula,

Drill diameter = reamed hole size. (undersize + oversize)

Reaming

Objectives: At the end of this lesson you shall be able to
- **state the procedure for hand reaming and machine reaming.**

Reaming: Reaming is the operation of finishing and sizing a hole which has been previously drilled, bored, casted holes.

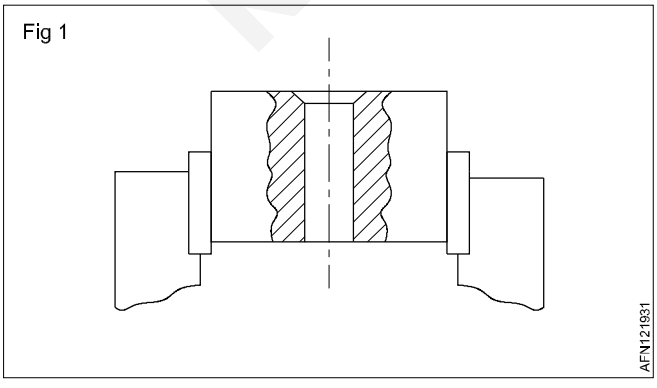
The tool used is called a reamer, which has multiple cutting edges. Manually it is held in a tap wrench and reamed.

Machine reamer are used in drilling machine using sleeves (or) socket. Normally the speed for reaming will be 1/3rd speed of drilling.

Hand Reaming: Drill holes for reaming as per the sizes determined.

Place the work on parallels while setting on the machine vice.

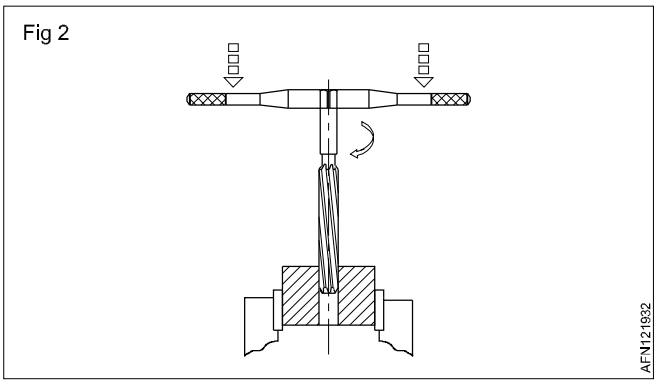
Fig 1



Chamfer the hole ends slightly. This removes burrs and will also help to align the reamer vertically.

Fix the work in the bench vice.Ensure that the job is horizontal. (Fig 2)

Fig 2



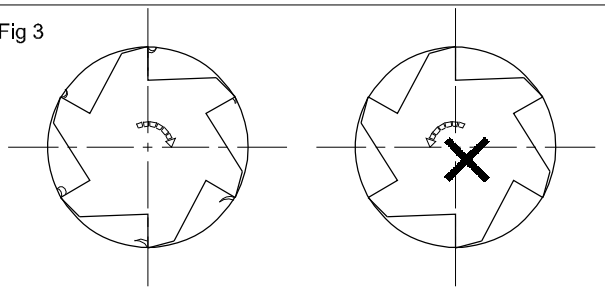
Fix the tap wrench on the square end and place the reamer vertically in the hole. Check the alignment with a try square.

Make corrections, If necessary. Turn the tap wrench in a clockwise direction applying a slight downward pressure at the same time. (Fig 3) Apply pressure evenly at both ends of the tap wrench.

Apply cutting force

Turn the tap wrench steadily and slowly, maintaining the downward pressure.

Fig 3



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

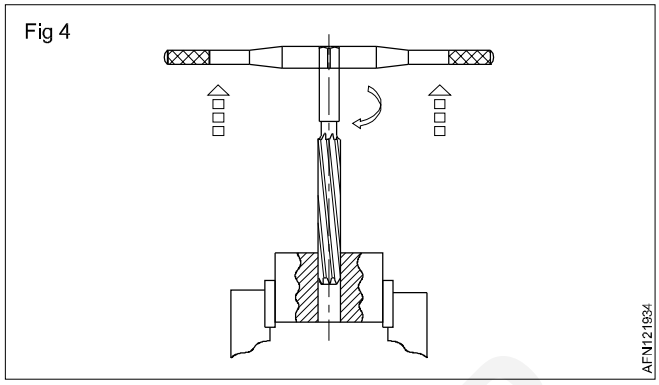
Ream the hole through, ensure that the taper lead length of the reamer comes out well and clear from the bottom of the work. Do not allow the end of the reamer to strike on the vice. Remove the reamer with an upward pull until the reamer is clear of the hole.

Remove the burrs from the bottom of the reamed hole.

Clean the hole.

Check the accuracy with the plug gauge supplied.

Fig 4



Plug gauges: Go/No-Go gaguge

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.**

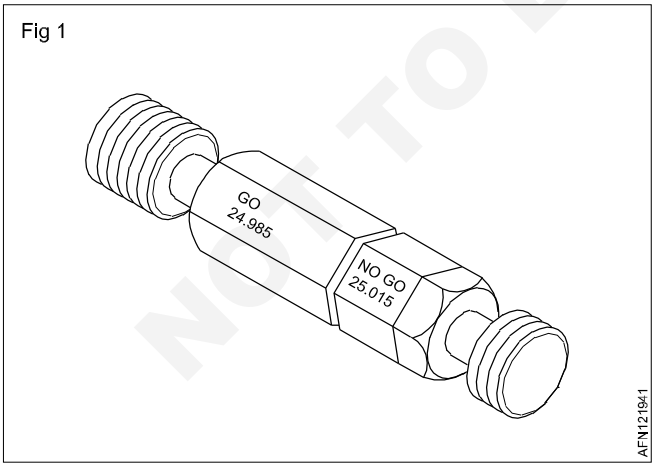
Plug gauge is an inspection tool used to check diameter dimension with reference to its maximum and minimum acceptable limits. It is, generally, used to segregate acceptable and non-acceptable products in mass production, without the exact dimensions. It is made of tool steel and is heat treated.

Types of cylindrical plug gauges

Double-ended plug gauge

Progressive plug gauge (Fig 1): 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 1

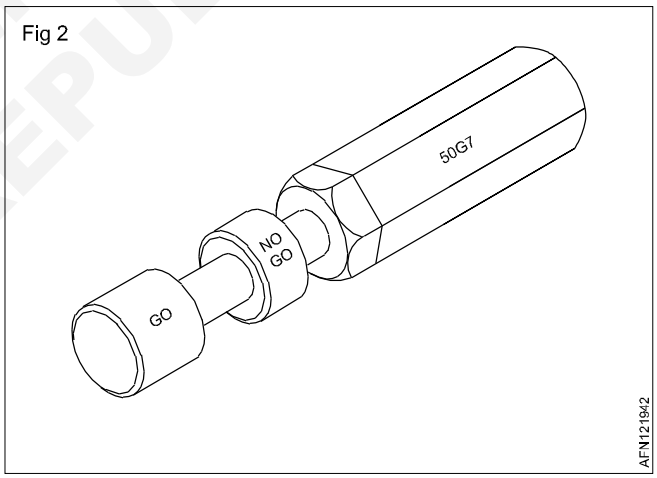


Go and No - Go principle (Fig 2): The Go / No-Go principle of gauging is that the Go-end of the gauge must go into the feature of the component being checked and the No-Go end must not go into the same feature.

The dimensions of the Go / No-Goends 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 permissible dimension and that of the No-Go end is equal to the maximum permissible dimension.

Fig 2



Essential Features

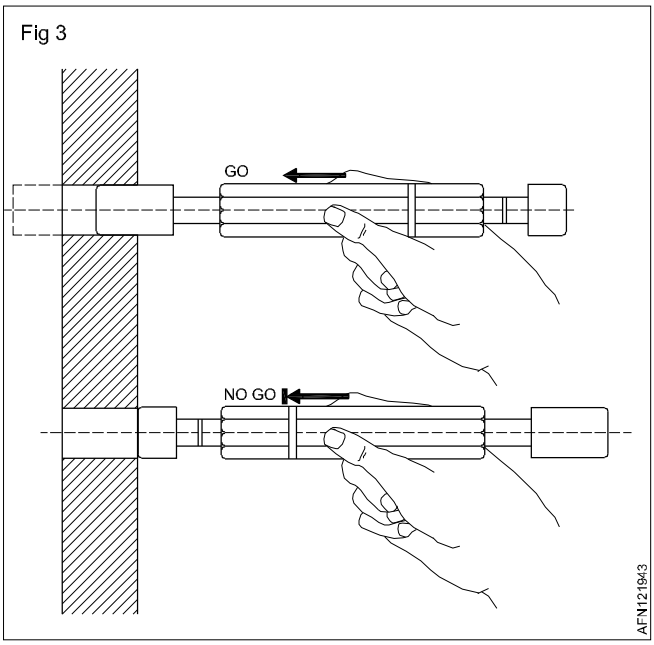
These gauges are easy to handle and are accurately finished. They are generally finished to one tenth of the tolerance they are designed to control. For example, if the tolerance to be maintained is at 0.02mm, then the gauge must be finished to within 0.002mm, of the required size.

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 dimensions of these gauges are usually stamped on them.

Fig 3



Necessity of interchangeablility

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

- **state the advantages and disadvantages of mass production**
- **outling the meaning of the term intechangeability.**

Mass production: Mass production means production of a unit, component or part in large numbers.

Advantages of mass production

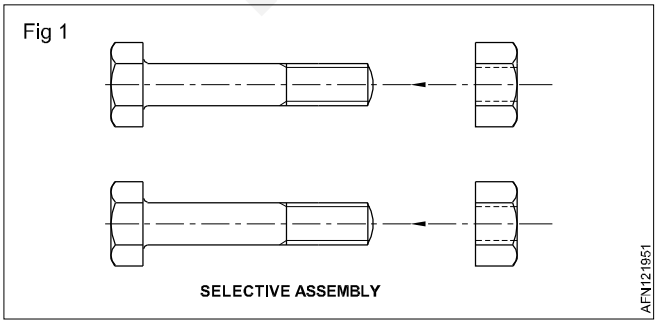
- Time for the manufacture of components is reduced.
- The cost of a piece is reduced.
- Spare parts can be quickly made available.

Disadvantages of mass production

- Special purpose machines are necessary.
- Jigs and fixtures are needed.
- Gauges are to be used instead of conventional precision instruments.
- Initial expenditure will be very high

Selective assembly: The figures illustrate the difference between a selective assembly and a non-selective assembly. It will be seen in (Fig 1) that each nut fits only one bolt. Such an assembly is slow and costly, and maintenance is difficult because spares must be individually manufactured.

Fig 1



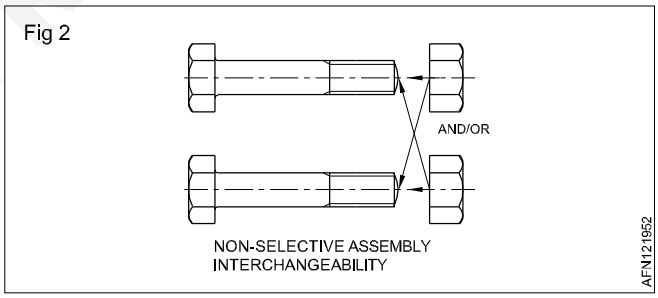
Non-selective assembly

Any nut fits any bolt 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 2)

Fig 2



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 circumstances, selective assembly is still justified.

Interchangeability

When components are mass-produced, unless they are interchangeable, the purpose of mass production is not fulfilled. By interchangeability, we mean that identical components, manufactured by different personnel under different environments, can be assembled and replaced without any further rectification during the assembly stage, without affecting the functioning of the component when assembled.

Necessity of the limit system: If components are to be interchangeable, they need to be manufactured to the same size which is not possible, when they are mass-produced. Hence, it becomes necessary to permit the operator to deviate by a small margin from the exact size which he is not able to maintain for all the components. At the same time, the deviated size should not affect the quality of the assembly. This sort of dimensioning is known as limit dimensioning.

A system of limits is to be followed as a standard for the limit dimensioning of components.

Various standard systems of limits and fits are followed by different countries based on the ISO (International Standards Organisation) specifications.

The system of limits and fits followed in our country is stipulated by the BIS (Bureau of Indian Standards) based on ISO.

The ISO and BIS system of limits & fits - Terminology

Objectives: At the end of this lesson you shall be able to
- **state the terms under the ISO and BIS system of limits and fits**
- **define each term under the ISO and BIS system of limits and fits.**

Fig 1

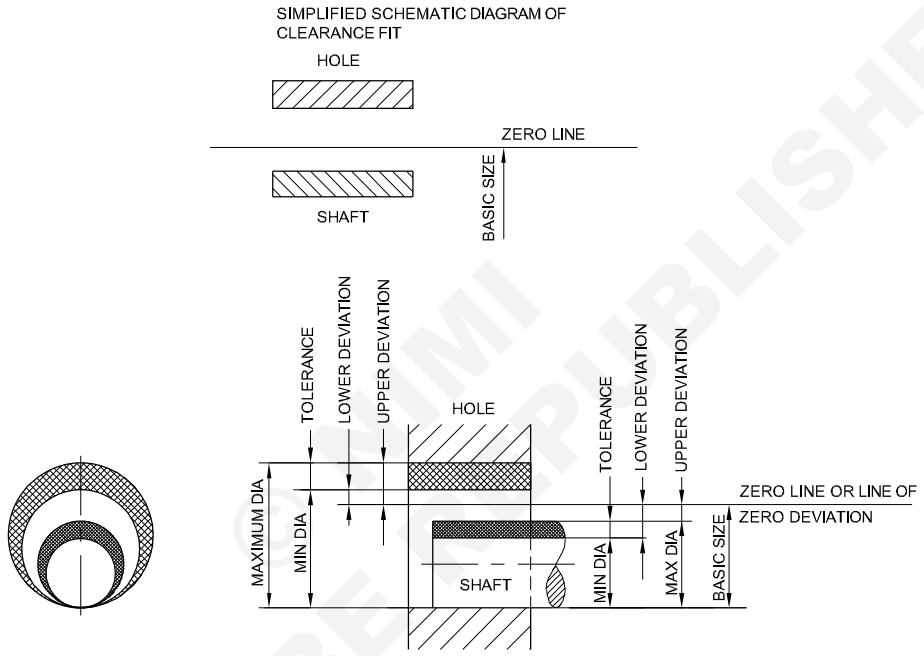
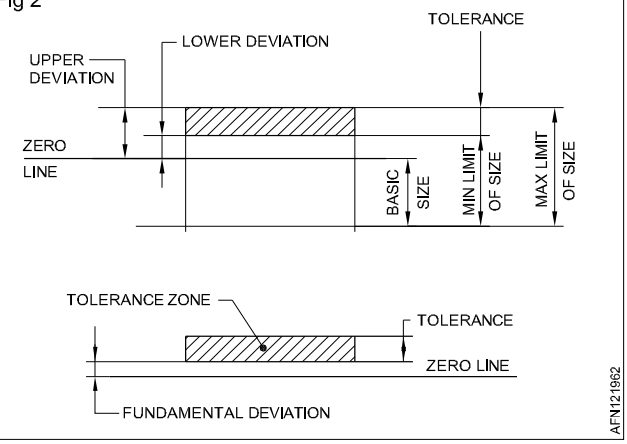


Table 1 (Examples)

SL. NO.	Size of component	Upper Deviation	Lower Deviation	Max-Limit of size	MIN-LIMIT OF SIZE
1	+ 0.008 20 - 0.005	+ 0.008	- 0.005	20.008	19.995
2	+ 0.028 20 + 0.007	+ 0.028	+ 0.007	20.028	20.007
3	- 0.012 20 - 0.021	- 0.012	- 0.021	19.988	19.979

Fig 2



Size: It is a number expressed in a unit in the measurement of length.

Basic size: It is the size based on which the dimensional deviations are given.

Actual size: It is the size of the component by actual measurement after it is manufactured. It should lie between the two limits of size if the component is to be accepted.

Limits of size: These are the extreme permissible sizes within which the operator is expected to make the component.

Maximum limit of size: It is the greater of the two limit sizes.

Minimum limit of size: It is the smaller of the two limits of size.

Hole: In the ISO and BIS system of limits & fits, all internal features of a component including those which are not cylindrical are designated as ' hole'.

Shaft: In the ISO and BIS system of limits & fits, all external features of a component including those which are not cylindrical are designated as shaft.

Deviation: It is the algebraic difference between a size, to its corresponding basic size. It may be positive, negative or zero.

Upper deviation: It is the algebraic difference between the maximum limit of size and its corresponding basic size.

Lower deviation: It is the algebraic difference between the minimum limit of size and its corresponding basic size.

Upper deviation: It is the deviation which gives the maximum limit of size. Lower deviation is the deviation which gives the minimum limit of size.

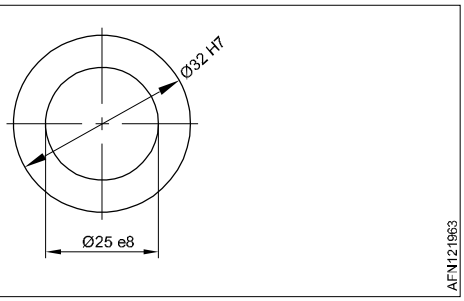
Actual deviation: It is the algebraic difference between the actual size and its corresponding basic size.

Tolerance: It is the difference between the maximum limit of size and the minimum limit of size. It is always positive and is expressed only as a number without a sign.

Zero line: In graphical representation of the above terms, the zero line represents the basic size. This line is also called as the line of zero deviation.

Fundamental deviation: There are 25 fundamental deviations in the BIS system represented by letter symbols (capital letters for holes and small letters for shafts), i.e for holes - ABCD....Z excluding I,L,O,Q & W. (Fig 3)

Fig 3



In addition to the above, four sets of letters JS, ZA, ZB & ZC are included. For fine mechanisms CD, EF and FG are added.

For shafts, the same 25 letter symbols but in small letters are used. (Fig 3)

The position of tolerance zone with respect to the zero line is shown in Figs 4 and 5.

The fundamental deviations are for achieving the different classes of fits.

Fig 4

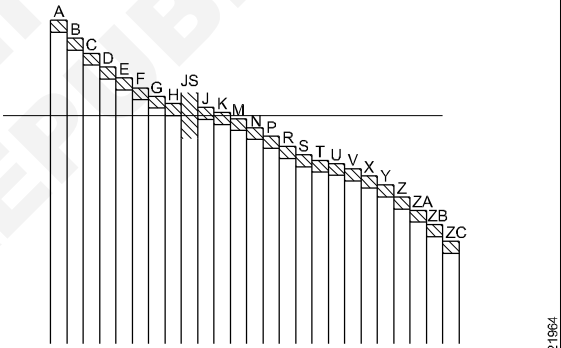
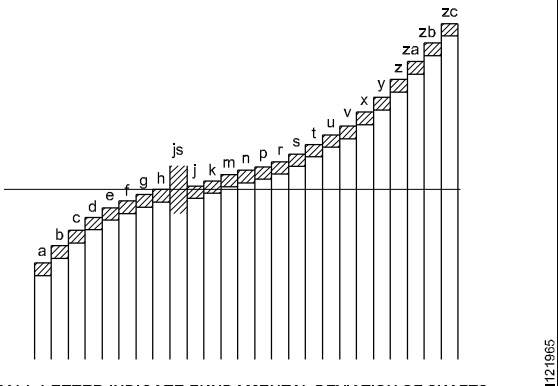
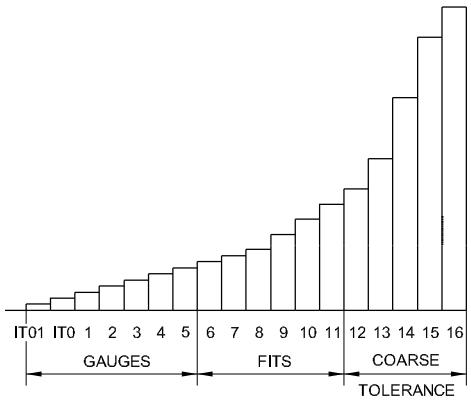


Fig 5



Fundamental tolerance: This is also called as 'grade of tolerance'. In the Indian Standard System, there are 18 grades of tolerances represented by number symbols, both for hole and shaft, denoted as IT01, IT0, IT1....to IT16. A high number gives a large tolerance zone.

Fig 6



Grade of tolerance: The grade of tolerance refers to the accuracy of manufacture.

In a standard chart, the upper and lower deviations for each combination of fundamental deviation and fundamental tolerance are indicated for sizes ranging up to 500 mm.

Toleranced size: This includes the basic size, the fundamental deviation and the grade of tolerance.

Example

25 H7 - toleranced size of a hole whose basic size is 25.

Fundamental deviation: The fundamental deviation is represented by the letter symbol (i.e. H) and the grade of tolerance is represented by the number symbol (i.e. 7).

25 e8 - is the toleranced size of a shaft whose basic size is 25. The fundamental deviation is represented by the letter symbol e and the grade of tolerance is represented by the number 8.

A very wide range of selection can be made by the combination of the 25 fundamental deviations and 18 grades of tolerances.

Example

In Fig 7, a hole is shown as 25 ± 0.2 which means that 25 mm is the basic dimension and ± 0.2 is the deviation.

As pointed out earlier, the permissible variation from the basic dimension is called 'DEVIATION'.

The deviation is mostly given on the drawing with the dimensions.

In the example 25 ± 0.2, ± 0.2 is the deviation of the hole of 25 mm diameter. (Fig 7) This means that the hole is of acceptable size if its dimension is between:

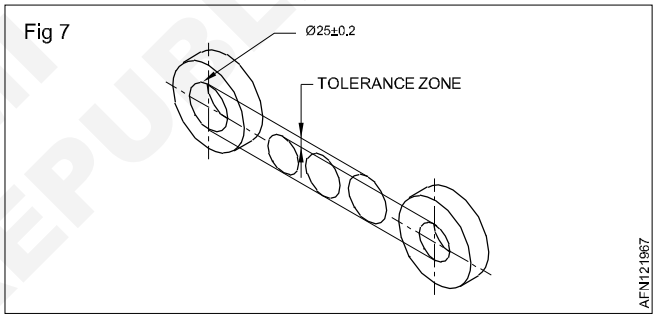
25 + 0.2 = 25.2 mm

or 25 - 0.2 = 24.8 mm.

All dimensions of the hole within the tolerance zone are of acceptable size as in Fig 7.

As per IS 696, while dimensioning the components as a drawing convention, the deviations are expressed as tolerances.

Fig 7



Fits and their classification as per ISO and the Indian standard

Objectives: At the end of this lesson you shall be able to
- **define 'Fit' as per the India standard**
- **list out the terms used in limits and fits as per the India standard**
- **state examples for each class of fit**
- **interpret the graphical representation of different classes of fits.**

Fit: It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional differences before assembly.

Expression of a fit: A fit is expressed by writing the basic size of the fit first, (the basic size which is common to both the hole and the shaft,) followed by the symbol for the hole, and by the symbol for the shaft.

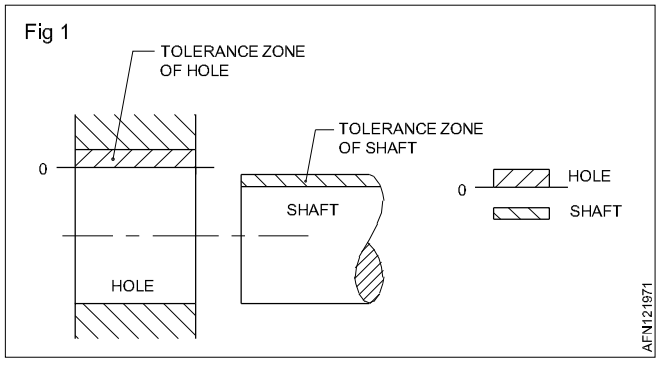
Example: 30 H7/g6 or 30 H7-g6

Clearance: In a fit the clearance is the difference between the size of the hole and the size of the shaft which is always positive.

Clearance fit: It is a fit which always provides clearance. Here the tolerance zone of the hole will be above the tolerance zone of the shaft. (Fig 1)

Example: 20 H7/g6

Fig 1



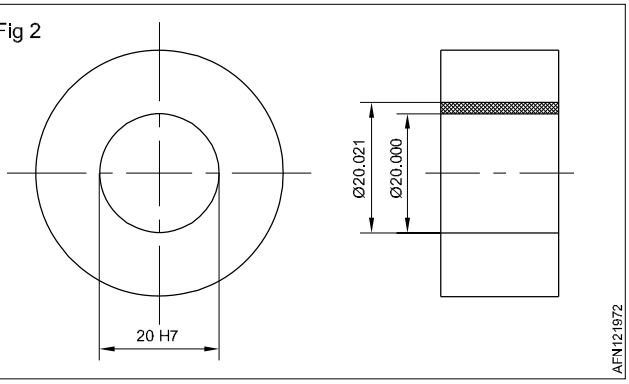
With the fit given, we can find the deviations from the chart.

For a hole 20 H7 we find in the table + 21 +0.

These numbers indicate the deviations in microns.

(1 micrometre = 0.001 mm)

Fig 2

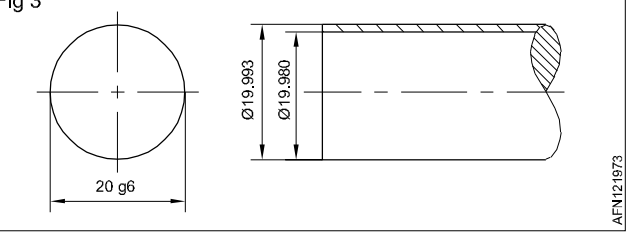


The limits of the hole are 20 + 0.021 = 20.021 mm and 20 + 0 = 20.000mm. (Fig 2)

For a shaft 20 g6 we find in the table – 7 – 20.

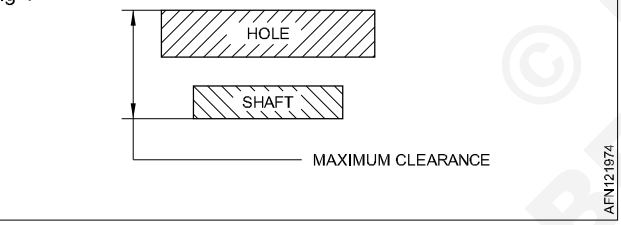
So the limits of the shaft are 20 – 0.007 =19.993 mm and 20 – 0.020 =19.980mm. (Fig 3)

Fig 3



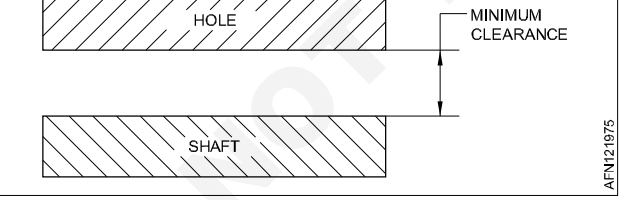
Maximum clearance: In a clearance fit or transition fit, it is the difference between the maximum hole and minimum shaft. (Fig 4)

Fig 4



Minimum Clearance: In a clearance fit, it is the difference between the minimum hole and the maximum shaft. (Fig 5)

Fig 5



The minimum clearance is 20.000 - 19.993 = 0.007mm. (Fig 6)

The maximum clearance is 20.021 - 19.980 = 0.041 mm.

There is always a clearance between the hole and the shaft. This is the clearance fit.

Interference (Fig 7)

It is the difference between the size of the hole and the shaft before assembly, and this is negative. In this case, the shaft is always larger than the hole size.

Fig 6

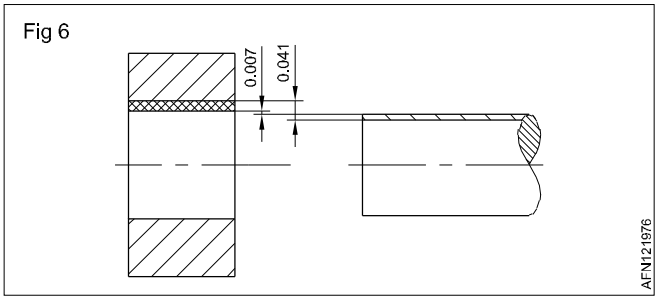
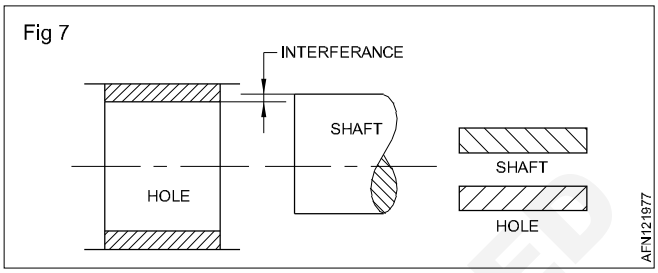


Fig 7

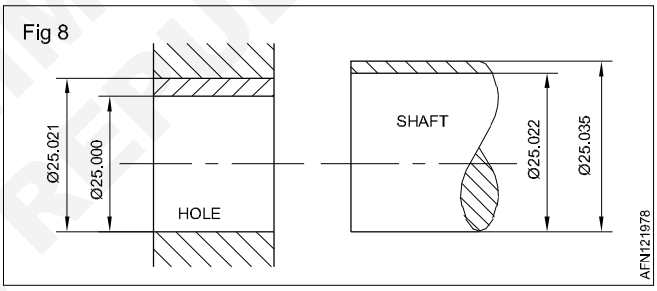


Interference Fit: It is a fit which always provides interference. Here the tolerance zone of the hole will be below the tolerance zone of the shaft. (Fig 8)

Example: Fit 25 H7/p6 (Fig 8)

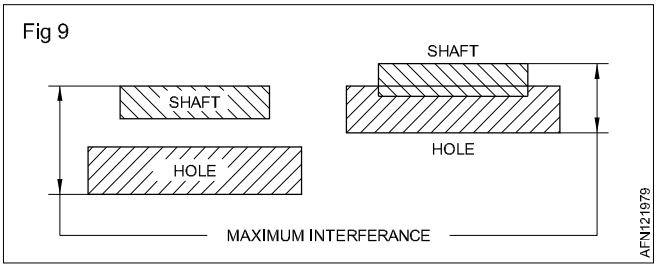
The limits of hole are 25.000 and 25.021 mm and the limits of the shaft 25.022 and 25.035 mm. The shaft is always bigger than the hole. This is an interference fit.

Fig 8



Maximum interference: In an interference fit or transition fit, it is the algebraic difference between the minimum hole and the maximum shaft. (Fig 9)

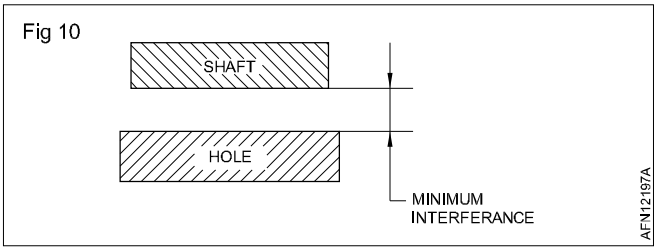
Fig 9



Minimum interference: In an interference fit, it is the algebraic difference between the maximum hole and the minimum shaft. (Fig 10)

In the example shown in figure 8

Fig 10

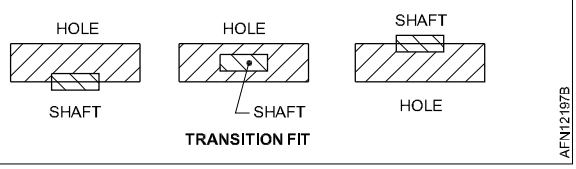


The maximum interference is = 25.035 – 25.000 = 0.035

The minimum interference is = 25.022 – 25.021 = 0.001

Transition fit: It is a fit which may sometimes provide clearance, and sometimes interference. When this class of fit is represented graphically, the tolerance zones of the hole and shaft will overlap each other. (Fig 11)

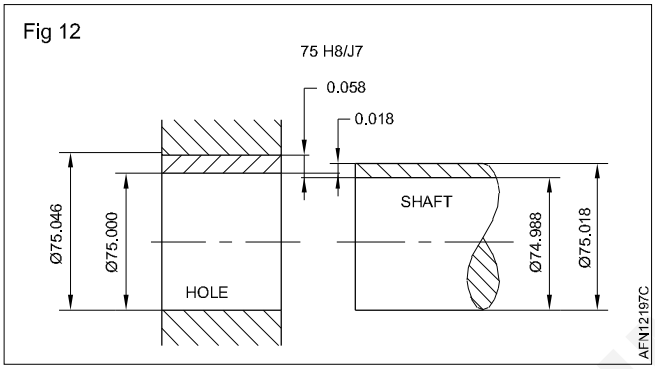
Fig 11



Example Fit 75 H8/j7 (Fig 12)

The limits of the hole are 75.000 and 75.046 mm and those of the shaft are 75.018 and 74.988 mm.

Fig 12



Maximum Clearance = 75.046 - 74.988 = 0.058 mm.

If the hole is 75.000 and the shaft 75.018 mm, the shaft is 0.018 mm, bigger than the hole. This results in interference.

This is a transition fit because it can result in a clearance fit or an interference fit.

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'.

Shaft basis system: 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 followed. 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 tooling..

The ISO and BIS system of limits and fits - Reading the standard chart

Objectives: At the end of this lesson you shall be able to
- **refer to the standard limit system chart and determine the limits of sizes.**

The standard chart covers sizes up to 500 mm for both holes and shafts. It specifies the upper and lower deviations for a certain range of sizes for all combinations of the 25 fundamental deviations, and 18 fundamental tolerances.

The upper deviation of the hole is denoted as "ES" and the lower deviation of the hole is denoted as "EI". The upper deviation of the shaft is denoted as "es" and the lower deviation of the shaft is denoted as "ei".

"ES is expanded as "ECART SUPERIEUR"

(UPPER DEVIATION in French)

"EI" as ECART INFERIEUR

(LOWER DEVIATION in French).

Determining the limits from the chart

Note whether it is an internal measurement or an external measurement.

Note the basic size.

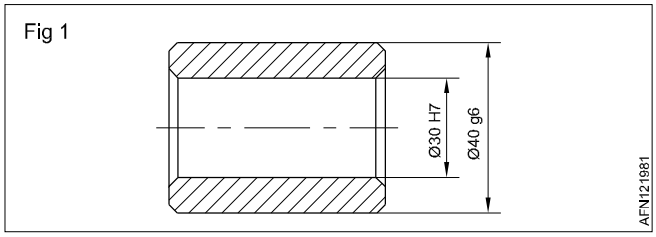
Note the combination of the fundamental deviation and the grade of tolerance.

Then refer to the chart and note the upper and lower deviations which are given in microns, with the sign.

Accordingly add or subtract from the basic size and determine the limits of size of the components.

Example: 30 H7 (Fig 1)

Fig 1



It is an internal measurement. So, we must refer to the chart for 'holes'.

The basic size is 30 mm. See the range 30 to 40.

Look for ES, and EI values in microns for H7 combination for 30 mm basic size.

It is given as

Therefore, the maximum limit of the hole is 30 + 0.025 = 30.025mm.

The minimum limit of the hole is 30 + 0.000 = 30.000mm.

Refer to the chart and note the values of 40 g6.

The table for tolerance zones and limits as per IS 2709 is attached.

ISO system of limits and fits

Fundamental tolerances

Nominal dimension in mm		Micrometre (1/1000 mm)											Millimetre						
over	up to	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
-	3	0.8	1.2	2	3	4	6	10	14	25	40	60	0.1	0.14	0.25	0.4	0.6	1.0	1.4
3	6	1	1.5	2.5	4	5	8	12	18	30	48	75	0.12	0.18	0.3	0.48	0.75	1.2	1.8
6	10	1	1.5	2.5	4	6	9	15	22	36	58	90	0.15	0.22	0.36	0.58	0.9	1.5	2.2
10	18	1.2	2	3	5	8	11	18	27	43	70	110	0.18	0.27	0.43	0.7	1.1	1.8	2.7
18	30	1.5	2.5	4	6	9	13	21	33	52	84	130	0.21	0.33	0.52	0.84	1.3	2.1	3.3
30	50	1.5	2.5	4	7	11	16	25	39	62	100	160	0.25	0.39	0.62	1.0	1.6	2.5	3.9
50	80	2	3	5	8	13	19	30	46	74	120	190	0.3	0.46	0.74	1.2	1.9	3.0	4.6
80	120	2.5	4	6	10	15	22	35	54	87	140	220	0.35	0.54	0.87	1.4	2.2	3.5	5.4
120	180	3.5	5	8	12	18	25	40	63	100	160	250	0.4	0.63	1.0	1.6	2.5	4.0	6.3
180	250	4.5	7	10	14	20	29	46	72	115	185	290	0.46	0.72	1.15	1.85	2.9	4.6	7.2
250	315	6	8	12	16	23	32	52	81	130	210	320	0.52	0.81	1.3	2.1	3.2	5.2	8.1
315	400	7	9	13	18	25	36	57	89	140	230	360	0.57	0.89	1.4	2.3	3.6	5.7	8.9
400	500	8	10	15	20	27	40	63	97	155	250	400	0.63	0.97	1.55	2.5	4.0	6.3	9.7
500	630	9	11	16	22	32	44	70	110	175	280	440	0.7	1.1	1.75	2.8	4.4	7.0	11.0
630	800	10	13	18	25	36	50	80	125	200	320	500	0.8	1.25	2.0	3.2	5.0	8.0	12.5
800	1000	11	15	21	28	40	56	90	140	230	360	560	0.9	1.4	2.3	3.6	5.6	9.0	14.0
1000	1250	13	18	24	33	47	66	105	165	260	420	660	1.05	1.65	2.6	4.2	6.6	10.5	16.5
1250	1600	15	21	29	39	55	78	125	195	310	500	780	1.25	1.95	3.1	5.0	7.8	12.5	19.5
1600	2000	18	25	35	46	65	92	150	230	370	600	920	1.5	2.3	3.7	6.0	9.2	15.0	23.0
2000	2500	22	30	41	55	78	110	175	280	440	700	1100	1.75	2.8	4.4	7.0	11.0	17.5	28.0
2500	3150	26	36	50	68	96	135	210	330	540	860	1350	2.1	3.3	5.4	8.6	13.5	21.0	33.0

ISO system of limits and fits - SHAFTS

Upper and lower limits in micrometer (0.001 mm)

over	up to	d9	e8	f7	g6	h5	h6	h7	h8	h9	h11	js5	js6	js13	js14	k5	k6	m5	m6	n5	n6	p6	r6	s6	s7
-	3	- 20 - 45	- 14 - 28	- 6 - 16	- 2 - 8	0 - 4	0 - 6	0 - 10	0 - 14	0 - 25	0 - 60	+ 2 - 2	+ 3 - 3	+ 70 - 70	+ 125 - 125	+ 4 0	+ 6 0	+ 6 + 2	+ 8 + 2	+ 8 + 4	+ 10 + 4	+ 12 + 6	+ 16 + 10	+ 20 + 14	+ 24 + 14
3	6	- 30 - 60	- 20 -38	- 10 - 22	- 4 -12	0 - 5	0 - 8	0 - 12	0 - 18	0 -30	0 - 75	+ 2.5 - 2.5	+ 4 - 4	+ 90 - 90	+ 150 - 150	+ 6 + 1	+ 9 + 1	+ 9 + 4	+ 12 + 4	+13 + 8	+ 16 + 8	+ 20 + 12	+ 23 + 15	+ 27 + 19	+ 31 + 19
6	10	- 40 - 76	- 25 - 47	- 13 - 28	- 5 - 14	0 - 6	0 - 9	0 - 15	0 - 22	0 - 36	0 - 90	+ 3 - 3	+ 4.5 - 4.5	+ 110 -110	+ 180 - 180	+ 7 + 1	+ 10 + 1	+ 12 + 6	+ 15 + 6	+ 16 + 10	+ 19 + 10	+ 24 + 15	+ 28 + 19	+ 32 + 23	+ 38 +23
10	18	- 50 - 93	- 32 - 59	- 16 - 34	- 6 - 17	0 - 8	0 - 11	0 - 18	0 - 27	0 - 43	0 - 110	+ 4 - 4	+ 5.5 - 5.5	+ 135 - 135	+ 215 - 215	+ 9 + 1	+ 12 + 1	+ 15 + 7	+ 18 + 7	+ 20 + 12	+ 23 + 12	+ 29 + 18	+ 34 + 23	+ 39 + 28	+ 46 +28
18	30	- 65 -117	- 40 - 73	- 20 - 41	- 7 - 20	0 - 9	0 - 13	0 - 21	0 - 33	0 - 52	0 - 130	+ 4.5 - 4.5	+ 6.5 - 6.5	+ 165 - 165	+ 260 - 260	+ 11 + 2	+ 15 + 2	+ 17 + 8	+ 21 + 8	+ 24 + 15	+ 28 + 15	+ 35 + 22	+ 41 + 28	+ 48 + 35	+ 56 + 35
30	50	- 80 - 142	- 50 - 89	- 25 - 50	- 9 - 25	0 - 11	0 - 16	0 - 25	0 - 39	0 - 62	0 - 160	+ 5.5 - 5.5	+ 8 - 8	+ 195 - 195	+ 310 - 310	+ 13 + 2	+ 18 + 2	+ 20 + 9	+ 25 + 9	+ 28 + 17	+ 33 + 17	+ 42 + 26	+ 50 + 34	+ 59 + 43	+ 68 + 43
50	65	- 100 - 174	- 60 - 106	- 30 - 60	- 10 - 29	0 - 13	0 - 19	0 - 30	0 - 46	0 - 74	0 - 190	+ 6.5 - 6.5	+ 9.5 - 9.5	+ 230 - 230	+ 370 - 370	+ 15 + 2	+ 21 + 2	+ 24 + 11	+ 30 + 11	+ 33 + 20	+ 39 + 20	+ 51 + 32	+ 60 + 41	+ 72 + 53	+ 83 + 53
65	80	- 100 - 174	- 60 - 106	- 30 - 60	- 10 - 29	0 - 13	0 - 19	0 - 30	0 - 46	0 - 74	0 - 190	+ 6.5 - 6.5	+ 9.5 - 9.5	+ 230 - 230	+ 370 - 370	+ 15 + 2	+ 21 + 2	+ 24 + 11	+ 30 + 11	+ 33 + 20	+ 39 + 20	+ 51 + 32	+ 62 + 43	+ 78 + 59	+ 89 + 59
80	100	- 120 - 207	- 72 - 126	- 36 - 71	- 12 - 34	0 - 15	0 - 22	0 - 35	0 - 54	0 - 87	0 - 220	+ 7.5 - 7.5	+ 11 - 11	+ 270 - 270	+ 435 - 435	+ 18 + 3	+ 25 + 3	+ 28 + 13	+ 35 + 13	+ 38 + 23	+ 45 + 23	+ 59 + 37	+ 73 + 51	+ 93 + 71	+ 106 + 71
100	120	- 120 - 207	- 72 - 126	- 36 - 71	- 12 - 34	0 - 15	0 - 22	0 - 35	0 - 54	0 - 87	0 - 220	+ 7.5 - 7.5	+ 11 - 11	+ 270 - 270	+ 435 - 435	+ 18 + 3	+ 25 + 3	+ 28 + 13	+ 35 + 13	+ 38 + 23	+ 45 + 23	+ 59 + 37	+ 76 + 54	+ 101 + 79	+ 114 + 79
120	140	-145 - 245	- 85 - 148	- 43 - 83	- 14 - 39	0 - 18	0 - 25	0 - 40	0 - 63	0 - 100	0 - 250	+ 9 - 9	+ 12.5 - 12.5	+ 315 - 315	+ 500 - 500	+ 21 + 3	+ 28 + 3	+ 33 + 15	+ 40 + 15	+ 45 + 27	+ 52 + 27	+ 68 + 43	+ 88 + 63	+ 117 + 92	+ 132 + 92
140	160																						+ 90 + 65	+ 125 + 100	+ 140 + 100
160	180																						+ 93 + 68	+ 133 + 108	+ 148 + 108
180	200	- 170 - 285	- 100 - 172	- 50 - 96	- 15 - 44	0 - 20	0 - 29	0 - 46	0 - 72	0 - 115	0 - 290	+ 10 - 10	+ 14.5 - 14.5	+ 360 - 360	+ 575 - 575	+ 24 + 4	+ 33 + 4	+ 37 + 17	+ 46 + 17	+ 51 + 31	+ 60 + 31	+ 79 + 50	+ 106 + 77	+ 151 + 122	+ 168 + 122
200	225																						+ 109 + 80	+ 159 + 130	+ 176 + 130
225	250																						+ 113 + 84	+ 169 + 140	+ 186 + 140
250	280	-190 - 320	- 110 - 191	- 56 - 108	- 17 - 49	0 - 23	0 - 32	0 - 52	0 - 81	0 - 130	0 - 320	+ 11.5 - 11.5	+ 16 - 16	+ 405 - 405	+ 650 - 650	+ 27 + 4	+ 36 + 4	+ 43 + 20	+ 52 + 20	+ 57 + 34	+ 66 + 34	+ 88 + 56	+ 126 + 94	+ 190 + 158	+ 210 + 158
280	315																						+ 130 + 98	+ 202 + 170	+ 222 + 170
315	355	- 210 -350	- 125 - 214	- 62 - 119	- 18 - 54	0 - 25	0 - 36	0 - 57	0 - 89	0 - 140	0 - 360	+ 12.5 - 12.5	+ 18 - 18	+ 445 - 445	+ 700 - 700	+ 29 + 4	+ 40 + 4	+ 46 + 21	+ 57 + 21	+ 62 + 37	+ 73 + 37	+ 98 + 62	+ 144 + 108	+ 226 + 190	+ 247 + 190
355	400																						+ 150 + 114	+ 244 + 208	+ 265 + 208

ISO system of limits and fits - HOLES

Upper and lower limits in micrometer (0.001 mm)

over	up to	D10	E9	F7	F8	G7	G9	H6	H7	H8	H9	H11	H12	H13	JS7	JS9	K6	K7	M6	M7	N7	N9	P7	P9	R7
-	3	+ 60 + 20	+ 39 + 14	+ 16 + 6	+ 20 + 10	+ 12 + 2	+ 27 + 2	+ 6 0	+ 10 0	+ 14 0	+ 25 0	+ 60 0	+ 100 0	+ 140 0	+5 - 5	+ 12.5 - 12.5	0 - 6	0 - 10	- 2 - 8	- 2 - 12	- 4 - 14	- 4 - 29	- 6 - 16	- 6 - 31	- 10 - 20
3	6	+ 78 + 30	+ 50 + 20	+ 22 + 10	+ 28 + 10	+ 16 + 4	+ 34 + 4	+ 8 0	+ 12 0	+ 18 0	+ 30 0	+ 75 0	+ 120 0	+ 180 0	+ 6 - 6	+ 15 - 15	+ 2 - 6	+ 3 - 9	- 1 - 9	0 - 12	- 4 - 16	0 - 30	- 8 - 20	- 12 - 42	- 11 - 23
6	10	+ 98 + 40	+ 61 + 25	+ 28 + 13	+ 35 + 13	+ 20 + 5	+ 41 + 5	+ 9 0	+ 15 0	+ 22 0	+ 36 0	+ 90 0	+ 150 0	+ 220 0	+ 7.5 - 7.5	+ 18 -18	+ 2 - 7	+ 5 - 10	- 3 - 12	0 - 15	- 4 - 19	0 - 36	- 9 - 24	- 15 - 51	- 13 - 28
10	18	+ 120 + 50	+ 75 + 32	+ 34 + 16	+ 43 + 16	+ 24 + 6	+ 49 + 6	+ 11 0	+ 18 0	+ 27 0	+ 43 0	+ 110 0	+ 180 0	+ 270 0	+ 9 - 9	+ 21.5 - 21.5	+ 2 - 9	+ 6 - 12	- 4 -15	0 - 18	- 5 - 23	0 - 43	- 11 - 29	- 18 - 61	- 16 - 34
18	30	+ 149 + 65	+ 92 + 40	+ 41 + 20	+ 53 + 20	+ 28 + 7	+ 59 + 7	+ 13 0	+ 21 0	+ 33 0	+ 52 0	+ 130 0	+ 210 0	+ 330 0	+ 10.5 - 10.5	+ 26 - 26	+ 2 - 11	+ 6 - 15	- 4 - 17	0 - 21	- 7 - 28	0 - 52	- 14 - 35	- 22 - 74	- 20 - 41
30	50	+ 180 +80	+ 112 + 50	+ 50 + 25	+ 64 + 25	+ 34 + 9	+ 71 + 9	+ 16 0	+ 25 0	+ 39 0	+ 62 0	+ 160 0	+ 250 0	+ 390 0	+ 12.5 - 12.5	+ 31 - 31	+ 3 - 13	+ 7 - 18	- 4 - 20	0 - 25	- 8 -33	0 - 62	- 17 - 42	- 26 - 88	- 25 -50
50	65	+ 220 + 100	+ 134 + 60	+ 60 + 30	+ 76 + 30	+ 40 + 10		+ 19 0	+ 30 0	+ 46 0	+ 74 0	+ 190 0	+ 300 0	+ 460 0	+ 15 - 15	+ 37 - 37	+ 4 - 15	+ 9 - 21	- 5 - 24	0 - 30	- 9 - 39	0 - 74	- 21 - 51	- 32 - 106	- 30 - 60
65	80	+ 220 + 100	+ 134 + 60	+ 60 + 30	+ 76 + 30	+ 40 + 10		+ 19 0	+ 30 0	+ 46 0	+ 74 0	+ 190 0	+ 300 0	+ 460 0	+ 15 - 15	+ 37 - 37	+ 4 - 15	+ 9 - 21	- 5 - 24	0 - 30	- 9 - 39	0 - 74	- 21 - 51	- 32 - 106	- 32 - 62
80	100	+ 260 + 120	+ 159 + 72	+ 71 + 36	+ 90 + 36	+ 47 + 12		+ 22 0	+ 35 0	+ 54 0	+ 87 0	+ 220 0	+ 350 0	+ 540 0	+ 17.5 - 17.5	+ 43.5 - 43.5	+ 4 - 18	+ 10 - 25	- 6 - 28	0 - 35	- 10 - 45	0 - 87	- 24 - 59	- 37 - 124	- 38 - 73
100	120	+ 260 + 120	+ 159 + 72	+ 71 + 36	+ 90 + 36	+ 47 + 12		+ 22 0	+ 35 0	+ 54 0	+ 87 0	+ 220 0	+ 350 0	+ 540 0	+ 17.5 - 17.5	+ 43.5 - 43.5	+ 4 - 18	+ 10 - 25	- 6 - 28	0 - 35	- 10 - 45	0 - 87	- 24 - 59	- 37 - 124	- 41 - 76
120	140	+ 305 + 145	+ 185 + 85	+ 83 + 43	+ 106 + 43	+ 54 + 14		+ 25 0	+ 40 0	+ 63 0	+ 100 0	+ 250 0	+ 400 0	+ 630 0	+ 20 - 20	+ 50 - 50	+ 4 - 21	+ 12 - 28	- 8 - 33	0 - 40	- 12 - 52	0 - 100	- 28 - 68	- 43 - 143	- 48 - 88
140	160																								- 50 - 90
160	180																								- 53 - 93
180	200	+ 335 + 170	+ 215 + 110	+ 96 + 50	+ 122 + 50	+ 61 + 15		+ 29 0	+ 46 0	+ 72 0	+ 115 0	+ 290 0	+ 460 0	+ 720 0	+ 23 - 23	+ 57.5 - 57.5	+ 5 - 24	+ 13 - 33	- 8 - 37	0 - 46	- 14 - 60	0 - 115	- 33 - 79	- 50 - 165	- 60 - 106
200	225																								- 63 - 109
225	250																								- 67 - 113
250	280	+ 400 + 190	+ 240 + 110	+ 108 + 56	+ 137 + 56	+ 69 + 17		+ 32 0	+ 52 0	+ 81 0	+ 130 0	+ 320 0	+ 520 0	+ 810 0	+ 26 - 26	+ 65 - 65	+ 5 - 27	+ 16 - 36	- 9 - 41	0 - 52	- 14 - 66	0 - 130	- 36 - 88	- 56 - 186	- 74 - 126
280	315																								- 78 - 130
315	355	+ 440 + 210	+ 265 + 125	+ 119 + 62	+ 151 + 62	+ 75 + 18		+ 36 0	+ 57 0	+ 89 0	+ 140 0	+ 360 0	+ 570 0	+ 890 0	+ 28.5 - 28.5	+ 70 - 70	+ 7 - 29	+ 17 - 40	-10 - 46	0 - 57	- 16 - 73	0 - 140	- 41 - 98	- 62 - 202	- 87 - 144
355	400																								- 93 - 150

Types of Ferrous & Non-Ferrous metals

Objectives: At the end of this lesson you shall be able to·
- **differentiate ferrous and Non-Ferrous metals**
- **name metals commonly used for making alloy steels**
- **explain the properties of non-ferrous metals and alloys.**

Introduction

Metals are divided into two classes, ferrous and nonferrous. Ferrous metals are those in the iron class and magnetic in nature. These metals are of iron, steel, and the alloys related to them. Nonferrous metals are metals that contain little or no ferrous metals and include aluminium, copper, magnesium, and titanium.

Metals and Alloys

Iron, aluminium, copper, magnesium, and titanium have proven to be very useful metals.

Alloys, however, increase their usefulness by altering their physical characteristics, and producing much more versatile and practical materials for aircraft structures

Alloying

An alloy is a metallic mixture composed of two or more elements of which at least one is a metal However, a metal is not designated an “alloy” based on elements used in its manufacture.

For example, iron, carbon, manganese, silicon, phosphorous, sulphur, oxygen, nitrogen, and hydrogen are used in the manufacture of plain carbon steel. It does not become an “alloy steel” until the elements are increased beyond regular composition or until other elements are added in significant amounts for a specific purpose.

Industrial Alloys

Steel, aluminium, and titanium are the primary metals which are alloyed for use in aircraft structures.

Steel alloys

Carbon is used in varying amounts up to 1.05 percent to produce carbon steels which range from mild to very hard Silicon, manganese, nickel, vanadium, tungsten, molybdenum, and chromium are most commonly used to produce alloy steels. Each element imparts special properties to the alloy in which it is used, and they are used alone or in certain combinations for alloys which have specific qualities.

Steel

Iron obtained directly from the smelting process contains an excess of carbon and impurities which render it undesirable for commercial use. After refining, only small amounts of carbon and impurities remain in the iron. This presence of limited quantities of carbon greatly affects the useful properties of iron. If carbon is added in percentages ranging up to approximately 1 percent, the product will be vastly superior to iron in toughness, strength, and hardness and is classified as carbon steel. Numerous types of carbon steels, ranging from mild to very hard, can be produced by heat treating these metals.

Metals commonly used for making alloy steels

Nickel (Ni)

This is a hard metal and is resistant to many types of corrosion rust.

It is used in industrial applications like nickel, cadmium batteries, boiler tubes, valves of internal combustion engines),engine spark plugs etc. The melting point of nickelis 1450°C. Nickel can be magnetised. In the manufacture of permanent magnets, a special nickel steel alloy is used.

Nickel is also used for electroplating. Invar steel contains about 36% nickel. It is tough and corrosion resistant.

Nickel-steel alloys are available containing nickel from 2%to 50%.

Chromium (Cr)

Chromium, when added to steel, improves the corrosion resistance, toughness and hardenability of steel. Chromium steels are available which may contain chromiumup to 30%.

Chromium, nickel, tungsten and molybdenum are alloyed for making automobile components and cutting tools. Chromium is also used for electroplating components.

Cylinder liners are chrome-plated inside to have wear resistance properties. Stainless steel contains about 13%chromium. Chromium-nickel steel is used for bearings.

Chrome-vanadium steel is used for making hand tools like spanners and wrenches.

Manganese (Mn)

Addition of manganese to steel increases hardness and strength but decreases the cooling rate.

Manganese steel can be used to harden the outer surface for providing a wear resisting surface with a tough core.

Manganese steel containing about 14% manganese isaued for making agricultural equipment like ploughs and blades.

Silicon (Si): Addition of silicon for alloying with steel improves resistance to high temperature oxidation.

This also improves elasticity, and resistance again stcorrosion. Silicon alloyed steels are used in manufacturings prings and certain types of steel, due to its resistance to corrosion. Cast iron contains silicon about 2.5%. It helps in the formation of free graphite which promotes the machine-ability of cast iron.

Tungsten (W)

The melting temperature of tungsten is 3380° C. This can be drawn into thin wires.

Due to this reason it is used to make filaments of electric lamps.

Tungsten is used as an alloying metal to produce high-speed cutting tools. High speed steel is an alloy of18% tungsten, 4% chromium and 1% vanadium.

Satellite is an alloy of 30% chromium, 20% tungsten, 1 to 4% carbon and the balance cobalt.

Vanadium (Va)

This improves the toughness of steel. Vanadium steel is used in the manufacture of gears, tools etc. Vanadium helps in providing a fine grain structure in tool steels.

Chrome-vanadium steel contains 0.5% to 1.5% chromium,0.15% to 0.3% vanadium, 0.13% to 1.10% carbon.

This alloy has high tensile strength, elastic limit and ductility. It is used in the manufacture of springs, gears,shafts and drop forged components.

Vanadium high speed steel contains 0.70% carbon and about 10% vanadium. This is considered as a superior high-speed steel.

Cobalt (Co)

The melting point of cobalt is 1495°C. This can retain magnetic properties and wear- resistance at very high temperatures. Cobalt is used in the manufacture of magnets, ball bearings, cutting tools etc. Cobalt high-speed steel (sometimes known as super H.S.S.) contains about 5 to 8% cobalt. This has better hardness and wear resistance properties than the 18% tungsten H.S.S.

Molybdenum (Mo)

The melting point of molybdenum is 2620°C. This gives high resistance against softening when heated. Molybdenum high speed steel contains 6% of molybdenum, 6%tungsten, 4% chromium and 2% vanadium. This high-speed steel is very tough and has good cutting ability.

Cadmium (cd)

The melting point of cadmium is 320°C. This is used for coating steel components.

Non-ferrous Metals And Alloys

Copper and its alloys

Metals without iron are called non-ferrous metals. For example, 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 sheetsor wires.

It is a good conductor of electricity. Copper is extensively used as electrical cables and parts of electrical apparatus which conduct electric current.

Copper is a good conductor of heat and 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 1083o C.

The tensile strength of copper can be increased by hammering or rolling.

Copper Alloys

Brass

It is an alloy of copper and zinc. For certain types of bras ssmall 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 from880 to 930oC.

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. Sometimeszinc is also added for achieving certain special properties.

Its colour ranges from red to yellow. The melting point ofbronze is about 1005°C. It is harder than brass. It can be easily machined with sharp tools. The chip produced isgranular. Special bronze alloys are used as brazing rods.

Bronze of different compositions are available for various applications.

Lead and its alloys

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.

Lead Alloys

Babbitt metal

Babbitt 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'.

Zinc and its alloys

Zinc is a commonly used metal for coating on steel toprevent corrosion. Examples are steel buckets, galvanized roofing sheets, etc.

Zinc is obtained from the ore-calamine or blender.

Its melting point is 420o C.

It is brittle and softens on heating; it is also corrosion resistant.

It is due to this reason it is used for batterycontainers and is coated on roofing sheets etc.

Galvanized iron sheets are coated with zinc.

Tin and tin alloys

Tin

Tin is produced from cassiterite or tinstone. It is silvery white in appearance, and the melting point is 231o C. It is soft and highly corrosion-resistant.

It is mainly used as a coating on steel sheets to produce food containers. It is also used with other metals, to form alloys.

Aluminium alloys

Aluminium alloys are made when aluminium is combined with copper, manganese, and magnesium. These alloys are lightweight and strong but require treatment to have the same corrosion resistance as pure aluminium.

Titanium alloy

Titanium alloy can contain small amounts of aluminium and vanadium. It is light, strong, and corrosion resistant.

Table of symbols and densities of commons elements

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

- **state the chemical symbol of commons elements**
- **state the technological symbol of commons elements.**

Element	Chemical Symbol	Technological Symbol	Bulk density (Kg/dm3)	Funsion Temperature (°C)
Aluminum	Al	A	2.73	658
Antimony	Sb	R	6.62	630
Beryllium	Be	Be	1.83	1280
Boron	B	-	2.30	2500
Cadmium	Cd	Cd	8.65	321
Carbon	C	-	2.23	3600
Chromium	Cr	C	7.19	1890
Cobalt	Co	K	8.85	1495
Copper	Cu	U	8.96	1083
Gold	Au	-	19.32	1063
Iron	Fe	Fe	7.86	1535
Lead	pb	pb	11.35	327
Magnesium	Mg	G	1.73	651
Manganese	Mn	M	7.43	1245
Mercury	Hg	-	13.55	38
Molybdenum	mo	D	10.22	2625
Nickel	Ni	N	8.90	1452
Niobium	Nb	Nb	8.60	2470
Platinum	Pt	-	21.45	1770
Silicon	Si	S	2.33	1410
Silver	Ag	-	10.49	961
TIN	Sn	E	7.30	232
Titanium	Ti	T	4.52	1690
Tungsten	W	W	19.30	3430
Zinc	Zn	Z	7.13	420

Introduction of iron and cast iron

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

• explain the difference between Iron, steel and Cast iron, Alloy steel, carbon steel, stainless steel.

Ferrous Metals

Metals which contain iron as a major content are called ferrous metals. Ferrous metals of different properties are used for various purposes.

Introduction of Iron, Cast Iron, wrought Iron and steel

The ferrous metals and alloys used commonly are:

- Pig-iron
- Cast Iron
- Wrought Iron
- Steels and Alloy steels

Different processes are used to produce iron and steel.

Pig-iron (Manufacturing process)

Pig-iron is obtained by the chemical reduction of iron ore.

This process of reduction of the iron ore to Pig-iron is known as SMELTING.

The main raw materials required for producing Pig-iron are:

- Iron ore
- Coke
- Flux

Iron ore

The chief iron ores used are:

- magnetite
- hematite
- limonite
- carbonate.

These ores contain iron in different proportions and are naturally available.

Coke

Coke is the fuel used to give the necessary heat to carryon the reducing action. The carbon from the coke in the form of carbon monoxide combines with the iron ore to reduce it to iron.

Flux

This is the mineral substance charged into a blast furnace to lower the melting point of the ore, and it combines with the non-metallic portion of the ore to form a molten slag.

Limestone is the most commonly used flux in the blast furnace.

Properties and use of Pig-iron

Pig-iron is, therefore, refined and used to produce other varieties of iron and steel.

Cast Iron (Manufacturing process)

The pig-iron which is tapped from the blast furnace is the crude form of raw material for the cupola and should be further refined for making castings. This refining iscarriedout in the cupola furnace which is a small form of a blast furnace.

Generally, cupolas are not worked continuously like blastfurnaces but are run only as and when required.

Cast Iron (Types)

Cast iron is an alloy of iron, carbon and silicon. The carbon content ranges from 2 to 4%.

Types of cast iron

The following are the types of cast iron.

- Grey cast iron
- White cast iron
- Malleable cast iron
- Nodular cast iron

Grey cast iron

This is widely used for the casting of machinery parts and can be machined easily.

Machine base, tables, slide ways are made of cast iron because it is dimensionally stable after a period of aging.

Because of its graphite content, cast iron provides an excellent bearing and sliding surface.

The melting point is lower than that of steel and as grey cast iron possesses good fluidity, intricate casting can be made.

Grey cast iron is widely used for machine tools because of its ability to reduce vibration and minimize tool chatter.

Grey cast iron, when not alloyed, is quite brittle and has relatively low tensile strength. Due to this reason it is not used for making components subjected to high stress or impact loads.

Grey cast iron is often alloyed with nickel, chromium, vanadium or copper to make it tough.

Grey cast iron is wieldable but the base metal needs preheating.

White cast iron

This is very hard and is very difficult to machine, and for this reason, it is used in components which should be abrasion resistant.

White cast iron is produced by lowering the silicon content and by rapid cooling. When cooled in this manner, it is called chilled cast iron.

White cast iron cannot be welded.

Malleable cast iron

Malleable cast iron has increased ductility, tensile strength and toughness when compared with grey cast iron.

Malleable cast iron is produced from white cast iron by aprolonged heat-treatment process lasting for about 30hours.

Nodular cast iron

This is very similar to malleable cast iron. But this is produced without any heat treatment. Nodular cast iron is also known as: Nodular Iron - Ductile Iron - Spheroid

Graphite Iron

This has good machinability, cast ability, resistance to wear, low melting point and hardness.

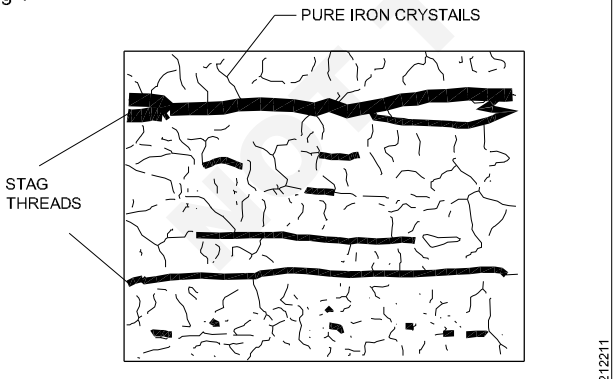
Malleable and nodular castings are used for machine parts where there is a higher tensile stress and moderate impact loading. These castings are less expensive and arena alternative to steel castings.

Wrought Iron (Manufacturing process) (Fig 1)

Wrought iron is the purest form of iron. The analysis of wrought iron shows as much as 99.9% of iron. (Fig 1)

When heated, wrought iron does not melt, but only becomes pasty and in this form, it can be forged to any shape.

Fig 1



MICROSTRUCTURE OF WROUGHT IRON

Modern methods used to produce wrought iron in large quantities are the

- paddling process
- Aston or Byers process

Steel

This is pure iron. Carbon content is more. Due to excessive carbon it is harder and tougher. Carbon content is from 0.15 to 1.5%. Besides there are other impurities like sulphur, phosphorous etc. are there which cannot be separated. This is hardened and tempered by heating it to a definite temperature and cooling it in oil or water.

The following methods are adopted for making different types of steel:

- Cementation process
- Crucible process
- Bessemer process
- Open hearth process
- Electro thermo process
- High frequency process.

Alloy Steel

When the steel is mixed with other metals like vinoleum, manganese tungsten etc., it is called an alloy steel. Alloy steel has properties of its ingredients.

Types of Alloy Steel

Two types of alloy steel are:

1 Low alloy steel

2 High alloy steel

Low Alloy steel:

Besides carbon other metals are in lesser quantity. Its tensile strength is more. The welding can work on it. This can also be hardened and tempered. It is used in manufacturing various

parts of an aeroplane and cam shaft etc.

High Alloy Steel:

Besides carbon it has a high percentage of the metals higher than low steel alloy.

This is classified into following types:

High Speed Steel

It is also called high tungsten alloy steel because it has more quantity of tungsten.

According to the quantity of tungsten it is classified into three types:

- 1 Tungsten 22%, Chromium4%, Vanadium 1%
- 2 Tungsten 18%, Chromium 4%, Vanadium 1%
- 3 Tungsten 14%, Chromium 4%, Vanadium 1%

Cutting tools are made from it because it is very hard but becomes soft at low critical temperature.

This temperature is raised out of cutting process of tool, then the cutting tool becomes useless and is unfit for work. But due to high percentage oftungsten it keeps working up to high temperature. It is used for cutting tools, drills, cutters, reamers, hacksaw blades etc.

Nickel Steel

In this 0.3% carbon and 0.25 to0.35% nickel is present. Due to nickel its tensile strength, elastic limit and hardness is increased. It does not catch rust. Its cutting resistance increases 6 times more than plain carbon and steeldue to 0.35% nickel present in it. This is used for making rivets, pipes, axle shafting, parts of buses and aeroplanes. If 5% of cobalt is mixed with 30-35% nickel, it becomes invar steel. It is mainly used for making precious instruments.

Vanadium Steel

It contains 1.5% carbon 12.5%tungsten, 4.5% chromium, 5% vanadium and 5%cobalt. Its elastic limit, tensile strength and ductility is more. It has strength to bear sharp jerks. It is mainly used to manufacture of tools.

Manganese Steel

It is also called special high alloy steel. It contains 1.6 to 1.9% of manganese and 0.4 to 0.5% carbon. It is hard and less wear. It is not affected by magnet. It is used in grinders and rail points etc.

Stainless Steel

Along with iron it contains 0.2 to90.6% carbon, 12 to 18% chromium, 8% nickel and2% molybdenum. It is used for making knives, scissors, utensils, parts of aeroplane, wires, pipes and gears etc.

Properties of stainless steel:

- Higher corrosion resistance
- Higher cryogenic toughness
- Higher work hardening rate
- Higher hot strength
- Higher ductility
- Higher strength and hardness
- More attractive appearance
- Lower maintenance

Silicon Steel

It contains 14% of silicon. It's usesare multiferroic according to the percentage of silicon. 0.5% to 1% silicon, 0.7 to 0.95% manganese mixture is used for construction work. 2.5 to 4%silicon content mixture is used for manufacturing electric motors, generators, laminations of transformers. In chemical industries 14% silicon content mixture is used.

Cobalt Steel

High carbon steel contains 5 to 35%cobalt. Toughness and tenacity are high. It has magnetic property therefore used to make permanent magnets.

Designation of steels – AISI/SAE numerical system

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

- **describe the AISI/SAE numerical system.**

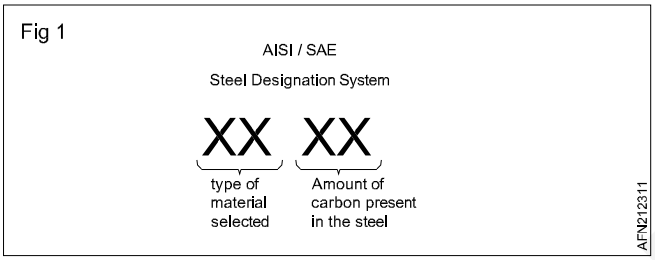
Steel stock can be identified by the Society of Automotive Engineers (SAE) numbering system.

AISI/SAE numbering system

A numeral index system is used to identify the compositions of the SAE steels, which makes it possible to use numerals that are partially descriptive of the composition of material covered by such numbers.

The SAE system uses a basic four-digit system to designate the chemical composition of carbon and alloy steels. The simplest system for designation of steel is schematically shown in Fig 1.

Fig 1



The first digit indicates the type to which the steel belongs; for example, “1” indicates a carbon steel, “2” a nickel steel, and “3” a nickel chromium steel in the case of the simple alloy steels. Table 1 shows these numbers.

Table 1 - Major classifications of steel

S.No	Types of Steel
1XXX	Carbon steels
2XXX	Nickel steels
3XXX	Nickel-chromium steels
4XXX	Molybdenum steels
5XXX	Chromium steels
6XXX	Chromium-vanadium steels
7XXX	Tungsten steels
8XXX	Nickel-chromium-molybdenum steels
9XXX	Silicon-manganese steels

The second digit generally indicates the approximate percentage of the predominant alloying element.

Table 2 shows these numbers.

Usually the last two or three digits indicate the approximate average carbon content in “points” or hundredths of 1 percent.

Thus “2340” indicates a nickel steel of approximately 3 percent nickel (3.25 to 3.75) and 0.40 percent carbon (0.38 to 0.43). In some instances, in order to avoid confusion, it has been found necessary to depart from this system of identifying the approximate alloy composition of a steel by varying the second and third digits of the number.

An instance of such departure is the steel numbers selected for several of the corrosion and heat resisting alloys.

Example: AISI/SAE No. 1020

- The first digit indicates that this is plain carbon steel.
- The second digit indicates there are no alloying elements.
- The last two digits indicates that the steel contains approximately 0.20 percent carbon.

Example: AISI/SAE No. 4340

- The first two digits indicates a Nickel-Chromium-Molybdenum alloy steel.
- The last two digits indicates carbon content roughly 0.4 percent.

Table 2 - Carbon and alloy steel grades

10XX	Carbon steels	Plain carbon, Mn 1.00% max
11XX		Resulfurized free machining
12XX		Resulfurized / rephosphorized free machining
15XX		Plain carbon, Mn 1.00-1.65%
13XX	Manganese steel	Mn 1.75%
23XX	Nickel steels	Ni 3.50%
25XX		Ni 5.00%
31XX	Nickel-chromium steels	Ni 1.25%, Cr 0.65-0.80%
32XX		Ni 1.75%, Cr 1.07%
33XX		Ni 3.50%, Cr 1.50-1.57%
34XX		Ni 3.00%, Cr 0.77%
40XX	Molybdenumsteels	Mo 0.20-0.25%
44XX		Mo 0.40-0.52%
41XX	Chromium-molybdenum steels	Cr 0.50-0.95%, Mo 0.12-0.30%
43XX	Nickel-chromium-molybdenum steels	Ni1.82%,Cr0.500.80%, Mo 0.25%
47XX		Ni 1.05%, Cr 0.45%, Mo 0.20-0.35%
46XX	Nickel-molybdenum steels	Ni 0.85-1.82%, Mo 0.20-0.25%
48XX		Ni 3.50%, Mo 0.25%
50XX	Chromiumsteels	Cr 0.27-0.65%
51XX		Cr 0.80-1.05%
50XXX		Cr 0.50%, C 1.00% min
51XXX		Cr 1.02%, C 1.00% min
52XXX		Cr 1.45%, C 1.00% min
61XX	Chromium-vanadium steels	Cr 0.60-0.95%, V 0.10-0.15%
72XX	Tungsten-chromium steels	W 1.75%, Cr 0.75%
81XX	Nickel-chromium-molybdenumsteels	Ni .30%, Cr 0.40%, Mo 0.12%
86XX		Ni .55%, Cr 0.50%, Mo 0.20%
87XX		Ni .55%, Cr 0.50%, Mo 0.25%
88XX		Ni .55%, Cr 0.50%, Mo 0.35%
92XX	Silicon-manganese steels	Si 1.40-2.00%, Mn 0.65-0.85%, Cr 0-0.65%
93XX	Nickel-chromium-molybdenumsteels	Ni 3.25%, Cr 1.20%, Mo 0.12%
94XX		Ni 0.45%, Cr 0.40%, Mo 0.12%
97XX		Ni 0.55%, Cr 0.20%, Mo 0.20%
98XX		Ni 1.00%, Cr 0.80%, Mo 0.25%

Designation of steels – European standard steel grades

Objective: At the end of this lesson you shall be able to
- **state the European standard steel grade EN 10027-1 &2.**

European standard steel grade names fall into two categories:

- Category 1: EN 10027-1 -Steel specified by purpose of use and mechanical properties.
- Category 2: EN 10027-2 - Steel specified by chemical composition.

Category 1

Basic grade designations for group 1 steels consist of a single letter then a number signifying the mechanical property dictated in the standard for that application designation. For some application designations another letter is included before the property value, this number is used to indicate any special requirements or conditions.

These additional letters and values depend entirely on the application of the steel and are specified in the standard and far too numerous to mention here.

Symbolic designation

G S 235 JR ……+… G = cast steel Indicate the application Mechanical property, often yield strength in mega pascals Impact resistance end testing temperature First group of additional-type symbols Second group of additional-type symbols Supplementary information

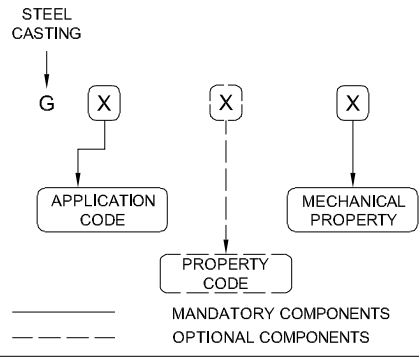
Application	
B	Steels for reinforcing concrete
D	Flat products for cold forming (except H)
E	Engineering steels
H	Cold rolled flat products of high strength steels for cold forming
M	Electrical steels
P	Pressure vessel steels
R	Steels for or in the form of rails
S	Structural steels
T	Tin mill products (tin plate, black iron electrolytic chromium coated steel)
Y	Steels for prestressing concrete

Impact resistance	
J	Testing strength 27 J/Cm^2 JR at 20 °C, j0 at °C, J2 at °C, ...,J6 at -60 °C
K	Testing strength 40 J/cm2 KR at 20 **°C,** K0 at 0 °C, K2 at -20 °C,..,L6 at -60°C
L	Testing strength 60 J/cm2 LR at 20 °C, L0 at 0 °C, L2 at -20 °C,.., L6 at 60 °C

First group of additional-types symbols	
G	Other characteristics
G1	Not killed steel
G2	Not killed Steel not allowed
G3	Normalized or normalized rolled
G4	Choice for normalizing up to the manufacturer
M	Thermo mechanically rolled
N	Normalized or normalized rolled
Q	Quenched and tempered

Second group of additional- type symbols	
C	Cold worked or strain hardened
D	Galvanized
F	Forging
H	Hollow profile
L	For low temperature applications
M	Thermo mechanically rolled
N	Normalized or normalized rolled
O	For application in high sea
Q	Quenched and tempered
S	For shipbuilding application
T	Steel for tubes
W	Weather resistant steel

Fig 1

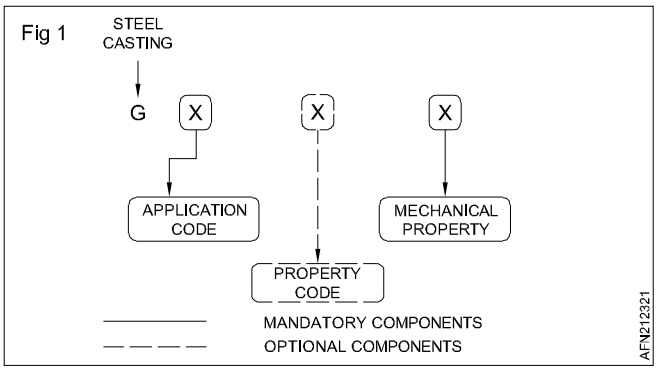


Category 2

In addition to the descriptive steel grade naming system indicated above, within EN 10027-2 is defined a system for creating unique steel grade numbers. While less descriptive and intuitive than the grand names they are easier to tabulate and use in data processing applications.

No type code signifies non-alloy steel with Mn > 1% or alloy steel with all alloying elements composing > 5% by weight.

Fig 1



The order of alloying elements is that of decreasing concentration.

The order of the adjustment values is the same.

If no adjustment value is present, then that material's percentage in unknown.

The adjustment value is divided by the adjustment factor to find the percentage of alloying element.

Element adjustment factor

4 = Cr, Co, Mn, Ni, Si, W

10 = Al, Be, Cu, Mo, Nb, Ta, Ti, V, Zr

100 = Ce, N, P, S

1000 = B

Steel grade numbering

Basic steels = 1.00xx or 1.90xx

Quality steels = 1.01xx thru 1.07xx / 1.91xx thru 1.97xx

Special steels = 1.10xx thru 1.13xx

Tool steels = 1.15xx thru 1.18xx

Tensile testing of metallic materials definitions

Objective: At the end of this lesson you shall be able to·
- **explain the terminology of tensile testing.**

Definitions

Gauge length (L)

Length of the cylindrical or parallel portion of the test piece on which elongation shall be measured. A distinction is made between:

Original gauge length (L_o)

Gauge length before application of force.

Length between gauge length marks on the test piece measured at room temperature before the test.

Final gauge length after fracture (L_u)

Gauge length after rupture of the test piece.

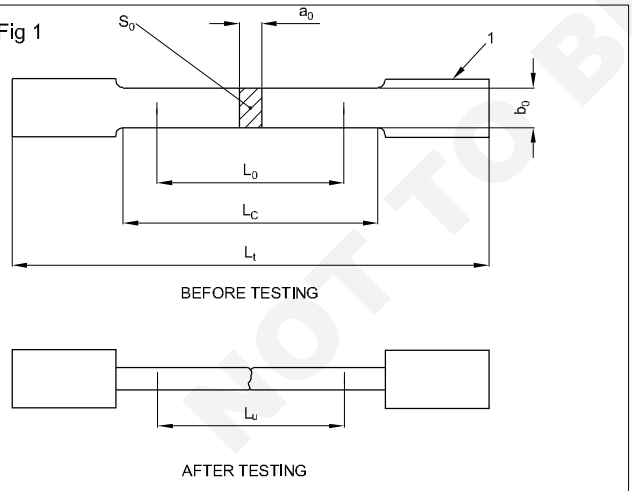
Length between gauge length marks on the test piece measured after rupture, at room temperature, the two pieces having been carefully fitted back together so that their axes lie in a straight line.

Parallel length (L_c)

Length of the parallel reduced section of the test piece

The concept of parallel length is replaced by the concept of distance between grips for unmachined test pieces.

Fig 1



a_0 - ORIGINAL THICKNESS OF A FLAT TEST PIECE OR WALL THICKNESS OF A TUBE
b_0 - ORIGINAL WIDTH OF THE PARALLEL LENGTH OF A FLAT TEST PIECE
L_c - PARALLEL LENGTH
L_t - TOTAL LENGTH OF TEST PIECE
L_u - FINAL GAUGE LENGTH AFTER FRACTURE
S_0 - ORIGINAL CROSS - SECTIONAL AREA OF THE PARALLEL LENGTH
1 - GRIPPED ENDS

Elongation

Increase in the original gauge length (L_o) at any moment during the test.

Percentage elongation

Elongation expressed as a percentage of the original gauge length.

Percentage permanent elongation

Increase in the original gauge length of a test piece after removal of a specified stress, expressed as a percentage of the original gauge length (L_o).

Percentage elongation after fracture(A)

Permanent elongation of the gauge length after fracture, (L_u " L_o), expressed as a percentage of the original gauge length (L_o).

Percentage total elongation at fracture (A_t)

Total elongation {elastic elongation plus plastic elongation) of the gauge length at the moment of fracture expressed as a percentage of the original gauge length (L_o).

Percentage elongation at maximum force(A_{gt})

Increase in the gauge length of the test piece at maximum force, expressed as a percentage of the original gauge length (L_o).

Extensometer gauge length (L_e):

Length of the parallel portion of the test piece used for the measurement of extension by means of an extensometer.

Extension

Increase in the extensometer gauge length (L_o) at a given moment of the test.

Percentage permanent extension

Increase in the extensometer gauge length, after removal of a specified stress from the test piece, expressed as a percentage of the extensometer gauge length (L_e).

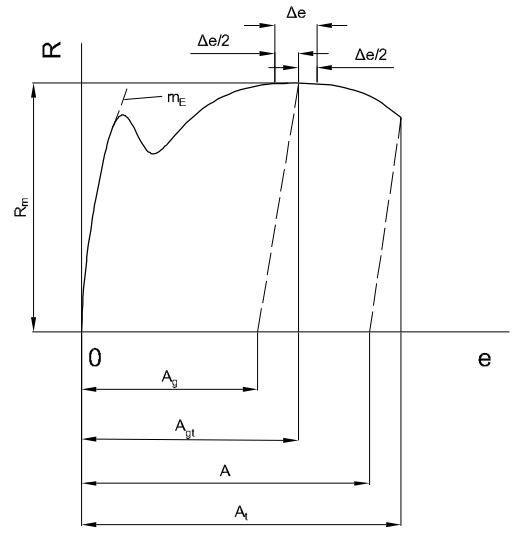
Percentage yield point extension (A_e)

In discontinuous yielding materials, the extension between the start of yielding and the start of uniform work hardening. It is expressed as a percentage of the extensometer gauge length (L_e).

Percentage reduction of area (Z)

Maximum change in cross-sectional area (S_o–S_u) which has occurred during the test expressed as a percentage of the original cross-sectional area (S_o).

Fig 2



A - PERCENTAGE ELONGATION AFTER FRACTURE
A_g - PERCENTAGE PLASTIC EXTENSION AT MAXIMUM FORCE
A_{gt} - PERCENTAGE TOTAL EXTENSION AT MAXIMUM FORCE
A_t - PERCENTAGE TOTAL EXTENSION AT MAXIMUM FRACTURE
R - STRESS
R_m - TENSILE STRENGTH

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Maximum force (F_m)

The greatest force which the test piece withstands during the test once the yield point has been passed.

For materials, without yield point, it is the maximum value during the test.

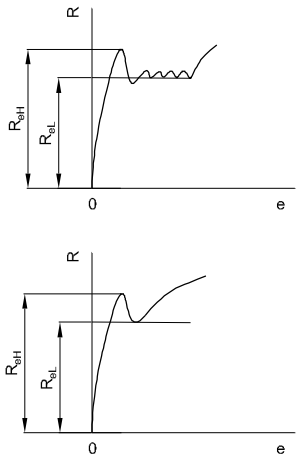
Stress

At any moment during the test, force divided by the original cross-sectional area (S_o) of the test piece.

Tensile strength (R_m)

Stress corresponding to the maximum force (F_m).

Fig 3



e - PERCENTAGE EXTENSION
R - STRESS
R_{eH} - UPPER YIELD STRENGTH
R_{eL} - LOWER YIELD STRENGTH
a - INITIAL TRANSIENT EFFECT

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Yield strength

When the metallic material exhibits a yield phenomenon, a point is reached during the test at which plastic deformation occurs without any increase in the force.

A distinction is made between:

Upper yield strength (R_{eH})

Value of stress at the moment when the first decrease in force is observed.

Lower yield strength (R_{eL})

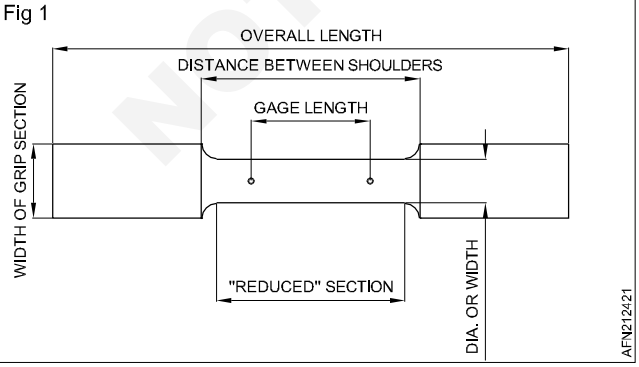
Lowest value of stress during plastic yielding, ignoring any initial transient effects

Tensile testing – Specimen, test piece

Objectives: At the end of this lesson you shall be able to
- **explain about the shapes and dimensions of the test pieces.**
- **determine the dimensions of the test piece.**

Parts of test piece (Fig. 1)

Fig 1



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Shape and dimensions

The shape and dimensions of the test pieces depend on the shape and dimensions of the metallic product from which the test pieces are taken.

The test piece is usually obtained by machining a sample from the product or a pressed blank or casting. However, products of constant cross-section (sections, bars, wires, etc.) and as-cast test pieces (i.e. cast irons and non-ferrous alloys) may be tested without being machined.

The cross-section of the test pieces may be circular, square, rectangular, annular or, in special cases, of some other shape.

Machined test pieces shall incorporate a transition curve between the gripped ends and the parallel length if these have different dimensions.

The gripped ends may be of any shape to suit the grips of the testing machine. The axis of the test piece shall coincide with or be parallel to the axis of application of the force.

The parallel length (L_c) or, in the case where the test piece has no transition curve, the free length between the grips, shall always be greater than the original gauge length (L_o).

Marking the original gauge length (L_o)

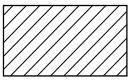
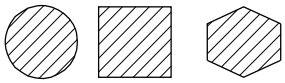
Each end of the original gauge length shall be marked by means of fine marks or scribed lines, but not by notches which could result in premature fracture.

Type of specimens

The main types of test pieces are defined according to the shape and type of product,as shown in Table 1. Other types of test pieces can be specified in product standards.

Table 1

Type of product

Sheets - plates - Flats	Wire - Bars - Sections
	
Thickness	**Diameter or side**
a 0.1<a<3 – a ≥3	 – <4 ≥4

Types of test pieces to be used for thin products: sheets, strips, and flats between 0,1 mm and 3 mm thick

Generally, the test piece has gripped ends which are wider than the parallel length. The parallel length, L_c, shall be connected to the ends by means of transition curves with a radius of at least 20 mm. The width of these ends should be e"1,2b_o, where b_o is the original width.

Three different non-proportional test piece geometries are widely used (see table 2 below).

The parallel length shall not be less than $L_o + b_o/2$.

For parallel side test pieces less than 20 mm wide, and unless otherwise specified in the product standard, the original gauge length, Lo, shall be equal to 50 mm. For this type of test piece, the free length between the grips shall be equal to $L_o + 3b_o$.

Table 2

Width b_o	Original Free length	Parallel length L_c Minimum	Parallel length L_c Recommade	Free length between the grips for parallel sided test piece
12,5±1	50	57	75	87,5
20±1	80	90	120	140
25 ±1	50	60	-	Not defined

Preparation of test pieces

The test pieces shall be prepared so as not to affect the properties of the sample. Any areas which have been hardened by shearing or punching, if it affects the properties, shall be removed by machining.

These test pieces are predominantly prepared from sheet or strip.

Tensile testing - Tensile testing machine

Objectives: At the end of this lesson you shall be able to
- **name the parts of tensile testing machine.**
- **explain how to grip the test piece.**

Tensile testing is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure.

Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area.

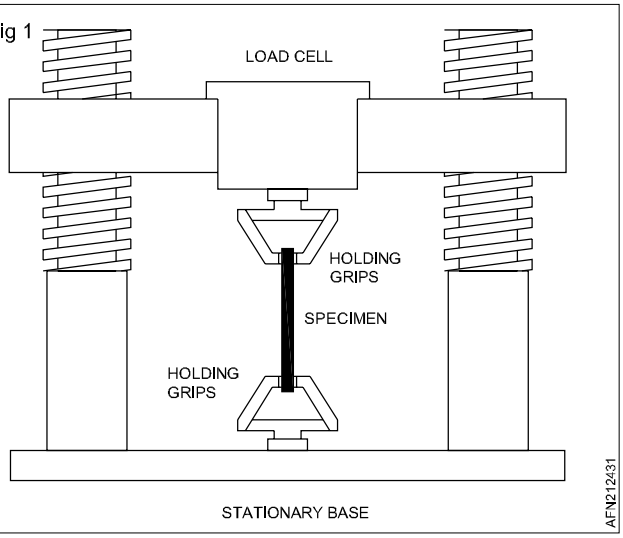
Tensile testing is also known as tension testing.

Tensile testing machine

A tensile testing machine is used to test the tensile strength of materials. An earlier name for a tensile testing machine is atensiometer.

The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held.

Fig 1



However, this method not only records the change in length of the specimen but also all other extending/elastic components of the testing machine and it sdrive systems including any slipping of the specimen in the grips.

Setting the force zero point

The force-measuring system shall be set to zero after the testing loading train has been assembled, but before the test piece is gripped at both ends. Once the force zero point has been set, the force measuring system shall not be changed in any way during the test.

Method of gripping

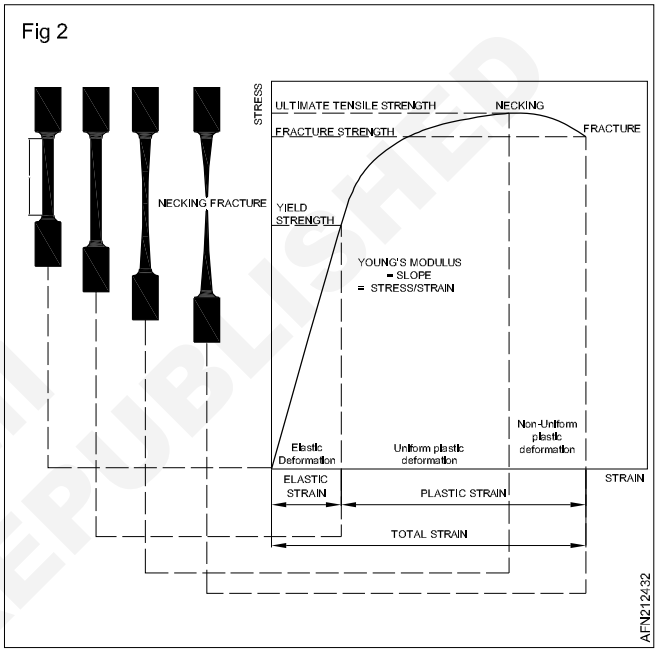
The test pieces shall be gripped by suitable means, such as wedges, screwed grips, parallel jaw faces, or shouldered holders.

Every endeavor should be made to ensure that test pieces are held in such a way that the force is applied as axially as possible, in order to minimize bending

Testing

The test process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force.

Fig 2



Pneumatic drills

Objective: At the end of this lesson you shall be able to
- **name the different type of pneumatic drill and their uses.**

Drilling holes is a common operation in the airframe workshop.

Once the basic knowledge of drilling is known (speed, feed, perpendicularity, etc.), drilling holes for rivets and bolts on light metal is not difficult. While a small portable power drill is usually the most practical tool for this common operation in airframe metalwork.

Pneumatic Drills

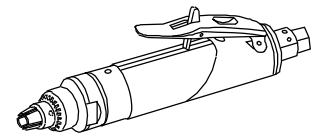
Aerospace portable power drills operate by compressed air.

Pneumatic drill motors are the most common type of drill motor in airframe workshop.

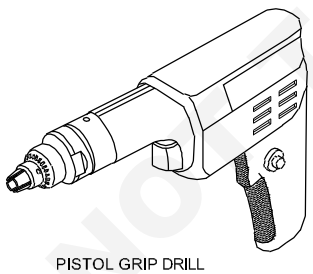
They are light weight and have enough power and good speed control. Drill motors are available in many different sizes and models. Most drill motors used for aircraft sheet metal work are rated from 3,200 to 5,200 rpm, but if drilling deep holes, drilling in hard materials or reaming, a drill motor with more torque and lower rpm should be selected to prevent damage to tools and materials.

Straight/inline and pistol grip drills (Fig. 1)

Fig 1



STRAIGHT / INLINE DRILL



PISTOL GRIP DRILL

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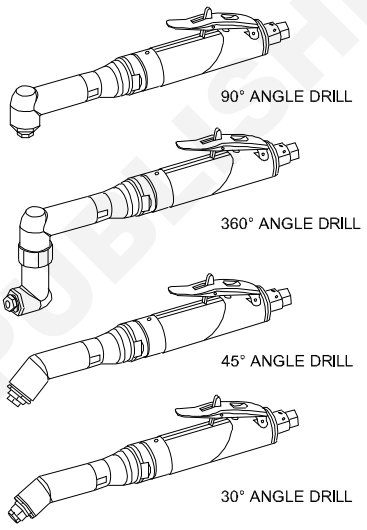
Angle drills (Fig. 2)

Right angle, 45°, 30° and offset (360°) drills are used for positions that are not accessible with a pistol grip or straight drill. Most right-angle drill motors use threaded drill bits that are available in several lengths or normal drill bit with cullet.

Fig 2



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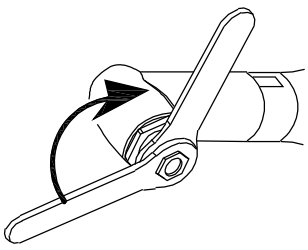
Usually, the drill bit is mounted in a cullet and screwed onto the drill using two wrenches. (Fig. 3)

Fig 3



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Type of drill bits

Objective: At the end of this lesson you shall be able to
- **name the different type of drill bits and their uses.**

Twist Drill Bits

Easily the most popular drill bit type, the twist drill bit has spiral grooves or flutes running along its working length. This drill bit comes in a single-fluted, two-fluted, three-fluted, and four-fluted styles. Single-fluted and two-fluted drill bits (most commonly available) are used for originating holes. Three-fluted and four-fluted drill bits are used interchangeably to enlarge existing holes. Twist drill bits are available in a wide choice of tooling materials and lengths with the variations targeting specific projects.

The standard twist drill bits used for drilling aluminium are made from HSS and have a 135° split point. Drill bits for titanium are made from cobalt vanadium for increased wear resistance.

Cobalt Alloy Drill Bits

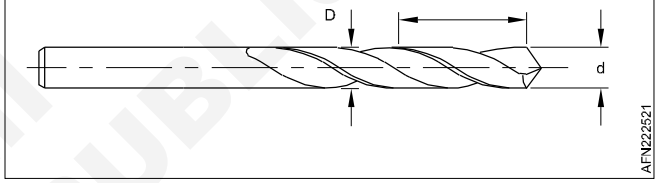
Cobalt alloy drill bits are designed for hard, tough metals like corrosion-resistant steel and titanium. It is important for the aircraft technician to note the difference between HSS and cobalt, because HSS drill bits wear out quickly when drilling titanium or stainless. Cobalt drill bits are excellent for drilling titanium or stainless steel, but do not produce a quality hole in aluminium alloys. Cobalt drill bits can be recognized by thicker webs and a taper at the end of the drill shank.

Step Drill Bits (Fig. 1)

Typically, the procedure for drilling holes larger than 4,8mm (3D 16 inch) in sheet metal is to drill a pilot hole and then to oversize with a larger drill bit to the correct size. The step drill combines these two functions into one step. The step drill bit consists of a smaller pilot drill point that drills the initial small hole. When the drill bit is advanced further into the material, the second step of the drill bit enlarges the hole to the desired size.

Step drill bits are designed to drill round holes in most metals, plastic, and wood. Commonly used in general construction and plumbing, they work best on softer materials, such as plywood, but can be used on very thin sheet metal. Step drill bits can also be used to debar holes left by other bits.

Fig 1



Holding devices

Objectives: At the end of this lesson you shall be able to·
- **name the types of drill-holding devices**
- **state the features of drill chucks**
- **state the functions of drill sleeves**
- **state the function of drift.**

For drilling holes on materials, the drills are to be held accurately and rigidly on the on the machines.

The common drill-holding devices are drill chucks and sleeves and sockets.

Drill Chuck

Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

The drill chucks are held on the machine spindle by means of an arbour fitted on the drill chuck. (Fig 1)

Taper Sleeves and Sockets (Fig 2)

Taper shank drills have a mores taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill, when engaged, will give a good wedding action. Due to this reason mores tapers are called self-holding tapers.

Drills are provided with five different sizes of mores tapers and are numbered from MT1 to MT5.

In order to make up the difference in sizes between the shanks of the drills and the type of machine spindles, sleeves of different sizes are used. When the drill taper shank is bigger than machine spindle, taper sockets are used.

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

Fig 1

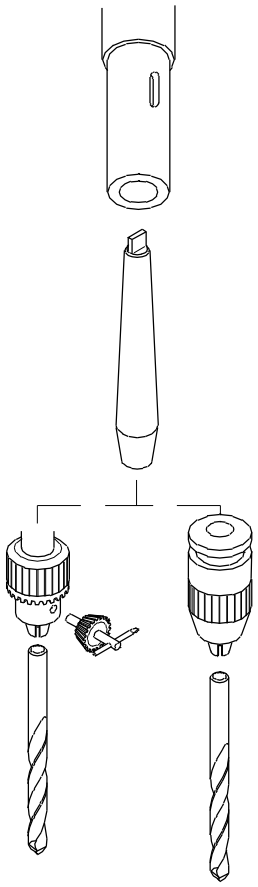


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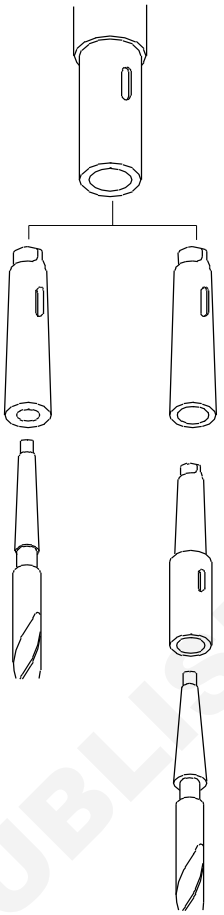
Fig 2



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Cutting speed and RPM

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

- **define cutting speed**
- **state the factors for determining the cutting speed**
- **differentiate between cutting speed and RPM.**
- **determine RPM/spindle speed.**
- **select RPM for drill sizes from tables.**

For a drill to give a satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the RPM, at which a drill has to be driven, is determined.

Materials being drilled	**Cutting speed (m/min) for HSS**
Aluminium	70 - 100
Brass	35 - 50
Bronze (phosphor)	20 - 35
Cast iron (grey)	25 - 40
Copper	35 - 45
Steel (medium carbon/mild steel)	20 - 30
Steel (alloy,high tensile)	5 - 8
Thermo setting plastic (low speed due to abrasive properties)	20 - 30

Calculating RPM

$$v = \frac{n \times d \times \pi}{1000} \text{m/min}$$

$$n = \frac{v \times 1000}{d \times \pi} \text{RPM}$$

n - RPM

v - cutting speed in m/min.

d - diameter of the drill in mm

ð = 3.14

Examples: Calculate the RPM for a high-speed steel drill " 24 to cut mild steel.

The cutting speed for MS is taken as 30 m/min. from the table.

It is always preferable to set the spindle speed to the nearest available lower range. The selected spindle speed Is 300 RPM.

The RPM will differ according to the diameter of the drills.

The cutting speed being the same, larger diameter drills will have lesser RPM and smaller diameter drills will have higher RPM.

The recommended cutting speeds are achieved only by actual experiments.

Feed in drilling

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

- **State what is meant by feed**
- **State the factors that contribute to an efficient feed rate.**

Feed is the distance (X) a drill advances into the work in one complete rotation. (Fig 1)

Feed is expressed in hundredths of a millimetre.

Example - 0.040mm

The rate of feed depends on several factors.

- Finish required
- Type of drill (drill material)
- Material to be drilled

Factors like rigidity of the machine, holding of the work piece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table for the feed rate given here is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

Drill diameter	Rate of feed (mm/rev)
1.0 - 2.5	0.040 - 0.060
2.6. - 4.5	0.050 - 0.100
4.6 - 6.0	0.075 - 0.150
6.1 - 9.0	0.100 - 0.200
9.1 - 12.0	0.150 - 0.250
12.1 - 15.0	0.200 - 0.300
15.1 - 18.0	0.230 - 0.330
18.1 - 21.0	0.260 - 0.360
21.1 - 25.0	0.280 - 0.380

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.

Drills

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

- **state drilling**
- **state the necessity of drilling**
- **name the types of drills used**
- **Identify the parts of a twist drill**
- **state the functions of drills.**
- **state the functions of each part of a drill.**
- **designate drills as per ISI recommendations.**

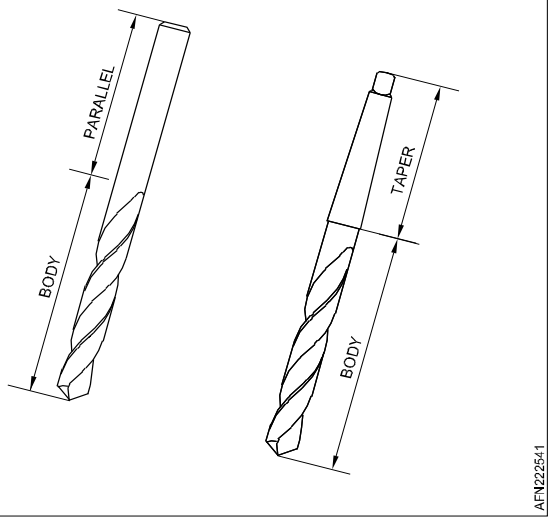
Drilling: Drilling is a process of making holes on work pieces. The tool used is a drill. For drilling, the drill is rotated with a downward pressure causing the tool to penetrate the material.

It is the first operation done internally for any further operation.

Twist drill

Almost all drilling operation is done using a twist drill. It is called a twist drill as it has two or more spiral or helical flutes formed along its length. The two basic types of twist drills are, parallel shank and taper shank. Parallel shank twist drills are available below 13mm size (Fig 1).

Fig 1



Parts of a twist drill; The various parts of a drill can be identified from figures 2, 3 and 4.

Point: The cone shaped end which does the cutting is called the point. It consists of a dead centre, lips or cutting edges, and a heel.

Fig 2

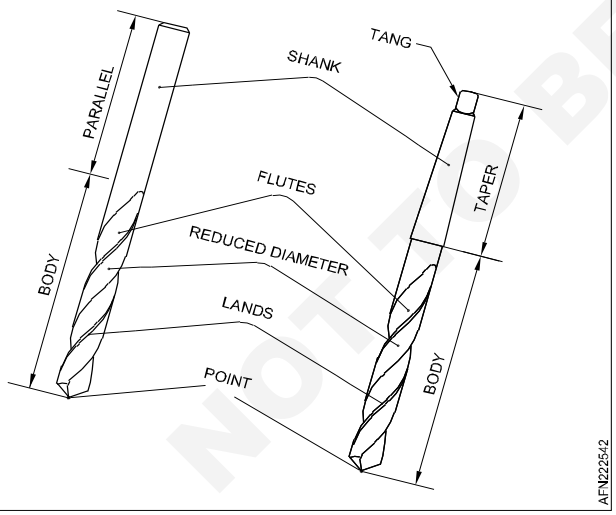


Fig 3

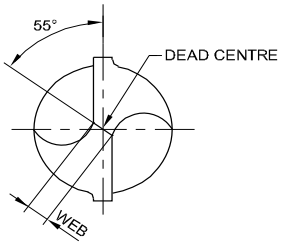
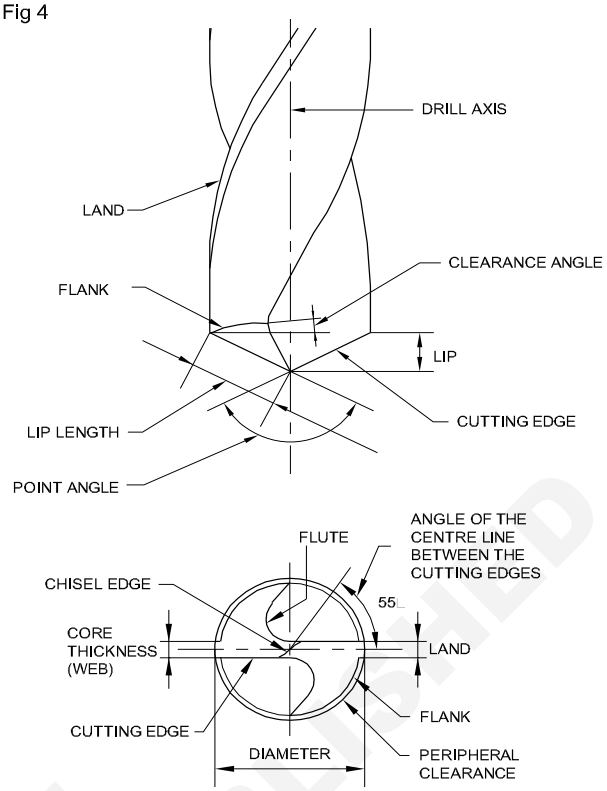


Fig 4



Shank: This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

Taper shank, used for larger diameter drills, and straight shank, used for smaller diameter drills.

Tang: This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Body: The portion between the point and the shank is called the body of a drill.

The parts of the body are flute, land/margin, body clearance and web.

Flutes: Flutes are the spiral grooves which run to the length of the drill. The flutes help

- To form the cutting edges.
- To curl the chips and allow these to come out.
- The coolant to flow to the cutting edge.

Land/Margin: The land/margin is the narrow strip which extends to the entire length of the flutes.

The diameter of the drill is measured across the land/ margin.

Body clearance: Body clearance is the part of the body which is reduced in diameter to cut down the friction between the drill and the hole being drilled.

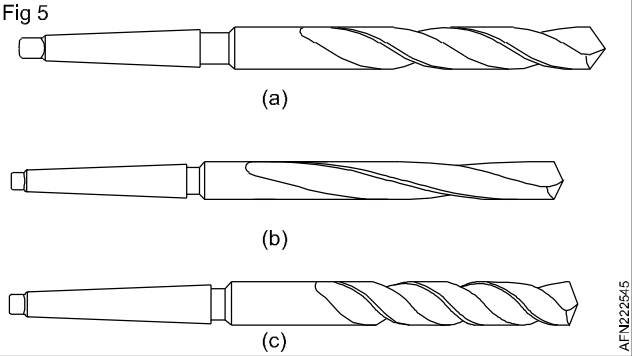
Web: Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.

Drills are manufactured with varying helix angles for drilling different materials. General purpose drills have a standard helix angle of 27 1/2°. They are used on mild steel and cast iron. (Fig 5A)

A slow helix drill is used on materials like brass, gun metal, phosphor-bronze and plastics. (Fig 5B)

A quick helix drill is used for copper, aluminium and other soft metals (Fig 5C)

Fig 5



Designation of drills

Twist drills are designated by:

- Diameter.
- Tool type.
- Material.

Example

A twist drill of 9.50 mm dia. of tool type 'H' for right hand cutting and made from HSS is designated as:

Twist drill 9.50 - H - IS5101 - HS

where H = tool type

IS5101 = IS Number

HS = tool material

9.5 = diameter of the drill.

If the tool type is not indicated in the designation, it should be taken as type 'N' tool.

Drills angles

Objectives: At the end of this lesson you shall be able to·
- **identify the various angles of a twist drill**
- **state the functions of each angle**
- **list the types of helix for drills as per ISI**
- **Distinguish the features of different types of drills.**

Like all cutting tools the drills are provided with certain angles for efficiency in drilling.

They are different angles for different purposes. They are listed below.

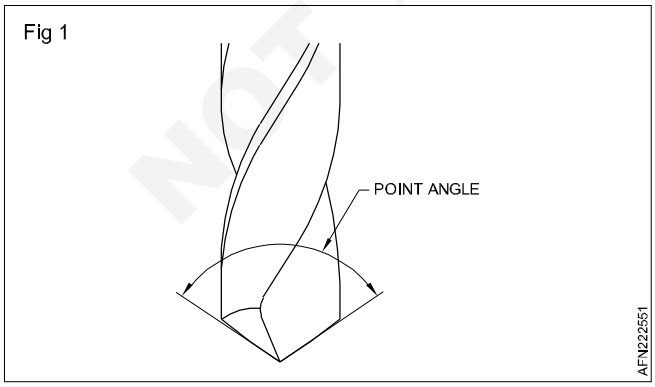
Point angle, helix angle, rake angle, clearance angle and chisel edge angle.

Point angle/cutting angle (Fig 1)

The point angle of a general purpose (standard) drill is 118°. This is the angle between the cutting edges (lips).

The angle varies according to the hardness of the material to be drilled.

Fig 1



Helix angle (Figs 2)

Twist drills are made with different helix angles. The helix angle determines the rake angle at the cutting edge of the twist drill.

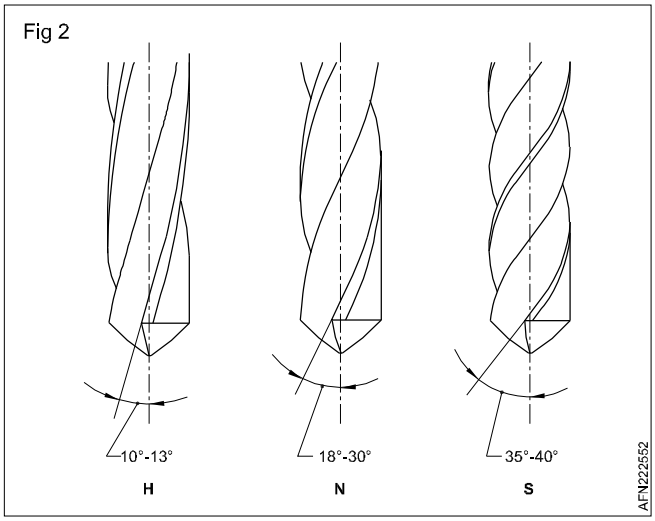
The helix angles vary according to the material being drilled.

According to Indian standards, three types of drills are used for drilling various materials.

- Type N - For normal low carbon steel.
- Type H - For hard and tenacious materials.
- Type S - For soft and tough materials.

The type of drill used for general purpose drilling work is type N.

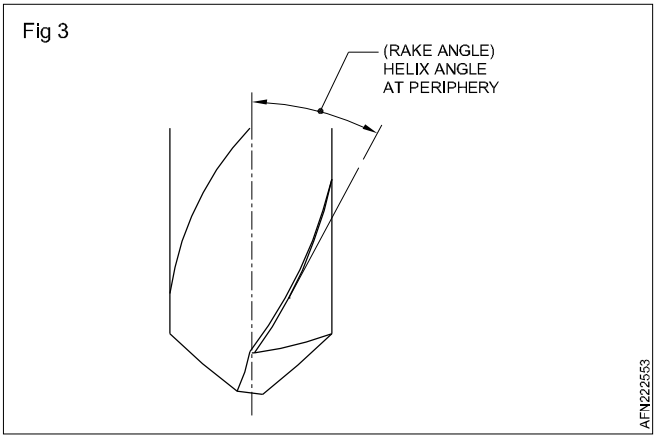
Fig 2



Rake angle (Fig 3)

Rake angle is the angle of flute (helix angle).

Fig 3



Clearance angle (Fig 4)

The clearance angle is meant to prevent the friction of the tool behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much, the cutting edges will be weak, and if it is too small, the drill will not cut.

Chisel edge angle/web angle (Fig 5)

This is the angle between the chisel edge and the cutting lip.

Fig 4

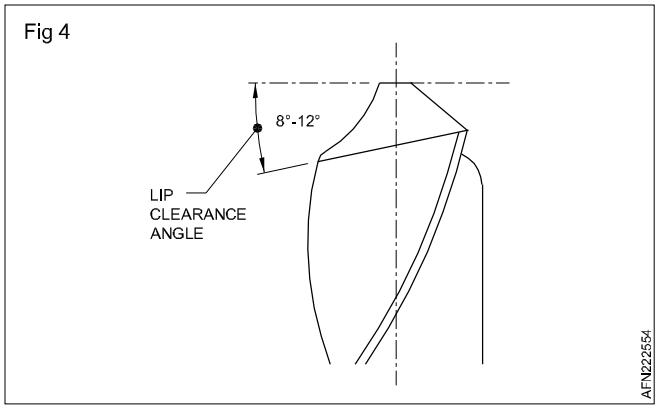
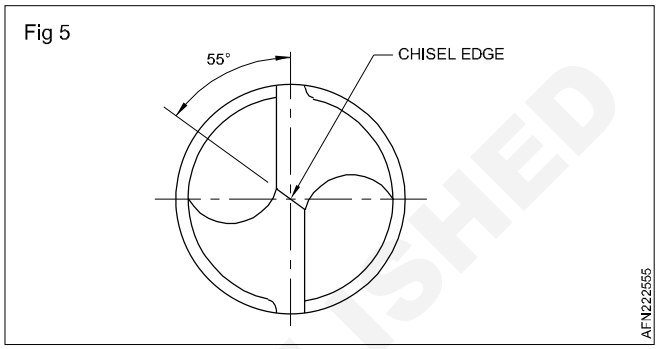


Fig 5



Edge distance and edge margin

Objectives: At the end of this lesson you shall be able to·
- **state the difference between edge margin and edge distance**
- **state the importance of the edge distance**
- **edge margin calculation.**

Definitions

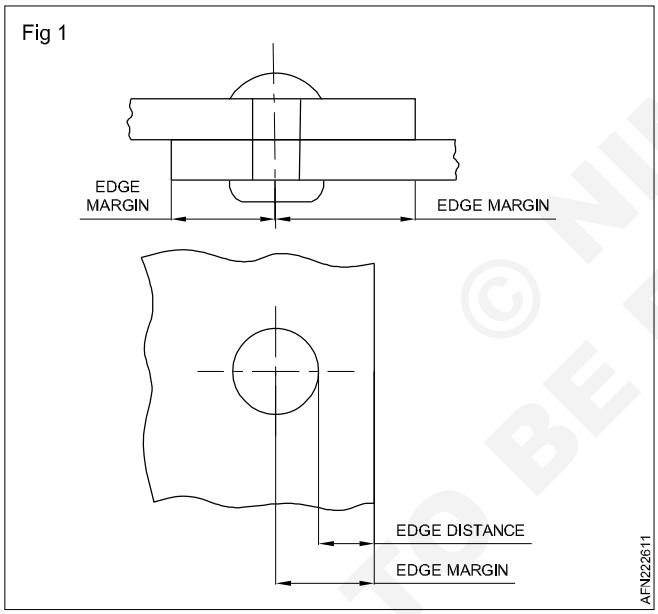
An edge margin is the distance from the center line of a fastener or fastener hole to the edge of the part. (Fig 1)

An edge distance is the distance from the edge of the fastener hole to the nearest edge of the part. (Fig 1)

If rivets are placed too close to the edge of the sheet, the sheet may crack or pull away from the rivets.

If they are spaced too far from the edge, the sheet is likely to turn up at the edges.

Fig 1



Calculation – General case

Edge margin for metallic joints

The edge margin values are calculated based on the nominal rivet shank diameter “D”.

The recommended edge values for metallic joints with protruding head rivet are 2D minimum, 2.5D with countersunk rivets.

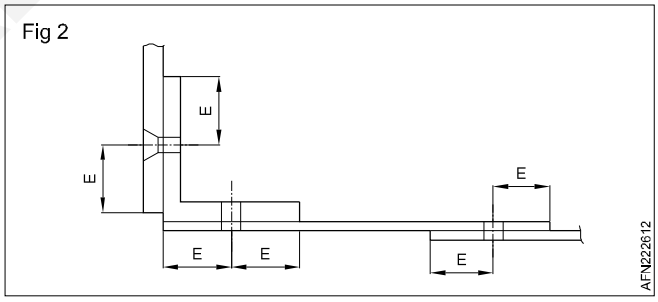
Edge margin for non-metallic joints

The recommended minimum edge margin in non-metallic joints is 2.5D unless otherwise specified by the job order.

It is good practice to lay out the rivets a little further from the edge so that the rivet holes can be over sized without violating the edge distance minimums.

The edge margin and hole pitch (chapter below) must be checked to ensure they comply, after oversizing, with the minimum values. (Fig 2)

Fig 2



Holes pitch or holes spacing

Objectives: At the end of this lesson you shall be able to·
- **explain the importance of the holes pitch**
- **hole pitch calculation.**

Rivet spacing is measured between the center lines of rivets in the same row. (Fig 1)

Calculation

The hole pitch values are calculated based on the nominal rivet shank diameter “D”.

The minimum spacing between fasteners in metallic joints shall not be less than 3D.

The average hole pitch values are:

- Pressure tight joint - 4D to 5D
- Non-pressure tight joints - 4D minimum

In non-metallic joints the recommended minimum hole pitch is 5D. (Fig 2)

Fig 1

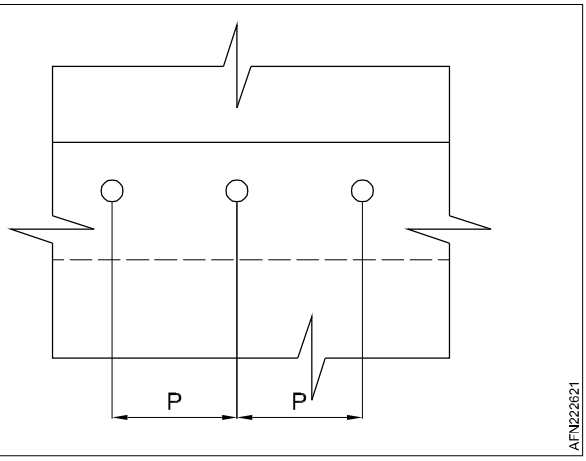
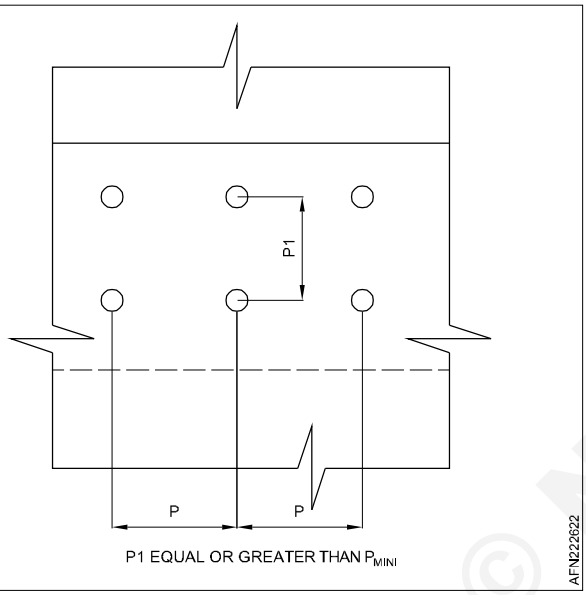


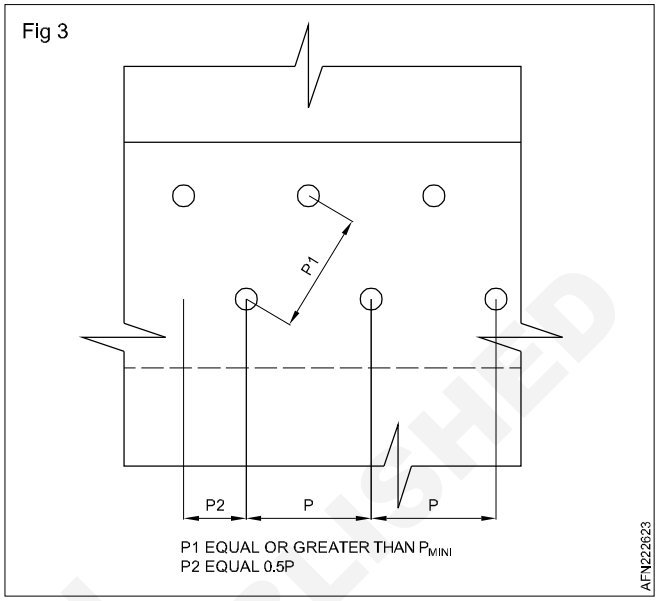
Fig 2



Rivet spacing on parts that are subjected to bending moments is often closer to the minimum spacing to prevent buckling of the skin between the rivets. (Fig 3)

The minimum pitch also depends on the number of rows of rivets.

Fig 3



Sheet metal forming terminology

Objective: At the end of this lesson you shall be able to
- **describe the terms commonly used in sheet metal bending.**

The following terms are commonly used in sheet metal forming and flat pattern layout.

Familiarity with these terms aids in understanding how bend calculations are used in a bending operation. Fig 1 to 3 illustrates most of these terms.

Fig 1

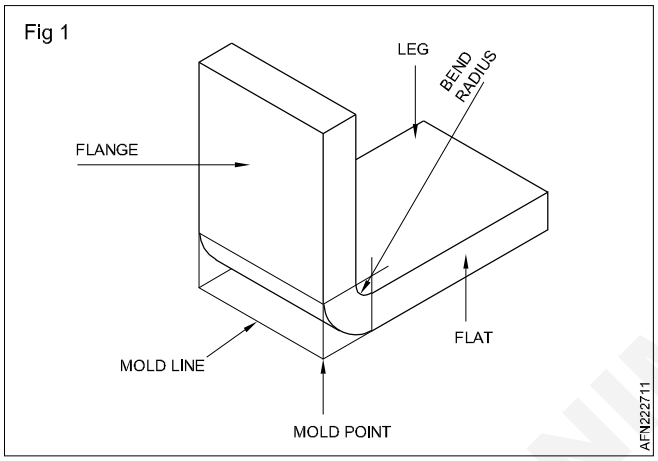
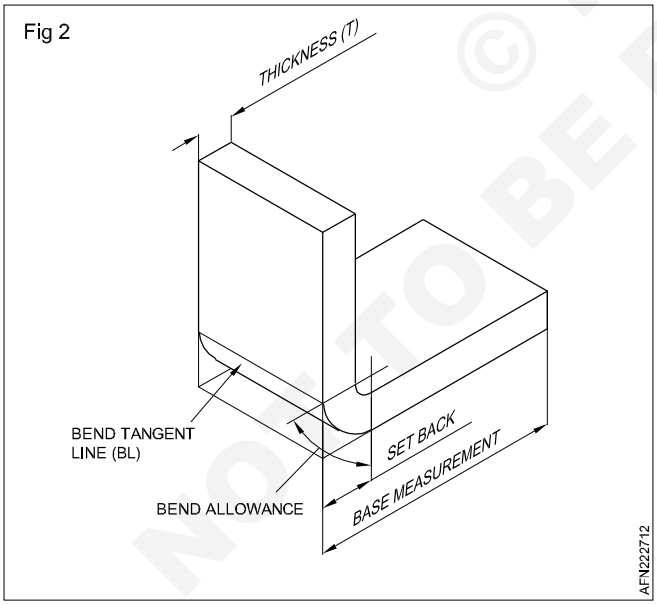


Fig 2

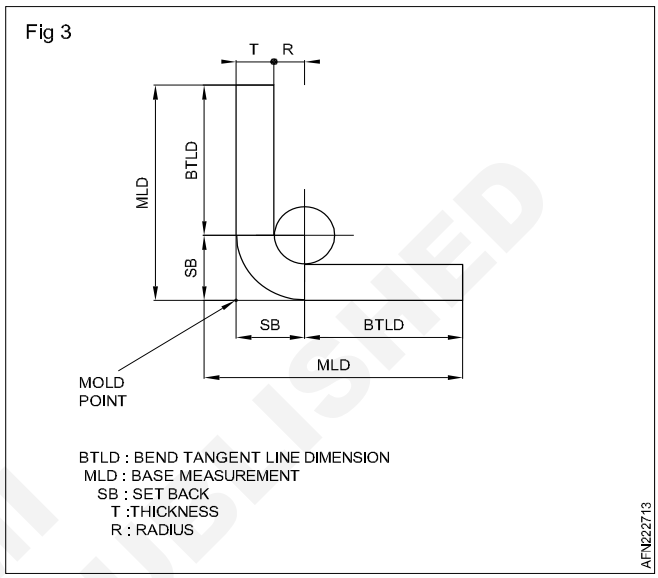


Leg; The longer part of a formed angle.

Flange: The shorter part of a formed angle the opposite of leg. If each side of the angle is the same length, then each is known as a leg.

Flat: That portion of a part that is not included in the bend. It is equal to the base measurement (MLD) minus the setback (SB).Flat = MLD – SB

Fig 3



Mould line (ML)

An extension of the flat side of a part beyond the radius.

Mould point

The point of intersection of the mold lines. The mould point would be the outside corner of the part if there were no radius.

Bend radius

The arc is formed when sheet metal is bent. This arc is called the bend radius. The bend radius is measured from a radius center to the inside surface of the metal. The minimum bend radius depends on the temper, thickness, and type of material. Always use a Minimum Bend Radius Table to determine the minimum bend radius for the alloy that is going to be used. Minimum bend radius charts can be found in manufacturer's manuals.

Bend allowance (BA)

Refers to the curved section of metal within the bend (the portion of metal that is curved in bending). The bend allowance may be considered as being the length of the curved portion of the neutral line.

Mould line dimension (MLD)

The dimension of a part made by the intersection of mould lines. It is the dimension the part would have if its corners had no radius.

Setback (SB)

The distance the jaws of a brake must be setback from the mould line to form a bend.

In a 90° bend, SB = R + T (radius of the bend plus thickness of the metal).

The setback dimension must be determined prior to making the bend because setback is used in determining the location of the beginning bend tangent line.

When a part has more than one bend, setback must be subtracted for each bend.

Bend tangent line (BL)

The location at which the metal starts to bend and the line at which the metal stops curving. All the space between the band tangent lines is the bend allowance.

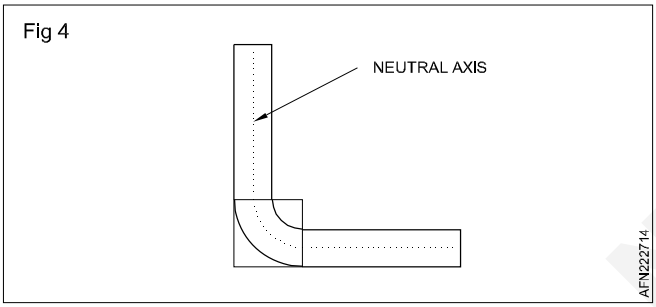
Base measurement

The outside dimensions of a formed part. Base measurement is given on the drawing or blueprint or may be obtained from the original part.

Neutral axis (Fig. 4)

An imaginary line that has the same length after bending as it had before bending.

Fig 4



After bending, the bend area is 10 to 15 percent thinner than before bending. This thinning of the bend area moves the neutral line of the metal in towards the radius center.

For calculation purposes, it is often assumed that the neutral axis is located at the center of the material, although the neutral axis is not exactly in the center of the material.

However, the amount of error incurred is so slight that, for most work, assuming it is at the center is satisfactory.

Other terms

Closed angle

An angle that is less than 90° when measured between legs, or more than 90° when the amount of bend is measured.

Open angle

An angle that is more than 90° when measured between legs, or less than 90° when the amount of bend is measured.

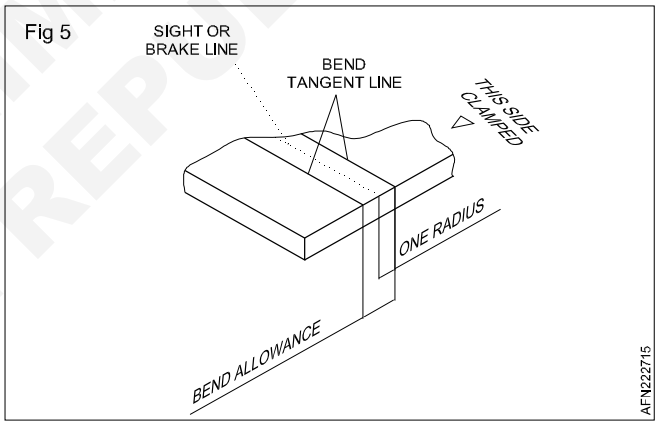
Total developed width (TDW)

The width of material measured around the bends from edge to edge. Finding the TDW is necessary to determine the size of material to be cut. The TDW is less than the sum of mold line dimensions since the metal is bent on a radius and not to a square corner as mold line dimensions indicate.

Sight (brake) line (Fig. 5)

Also called the bend or brake line, it is the layout line on the metal being formed that is set even with the nose of the brake and serves as a guide in bending the work.

Fig 5



Bending calculation – Bending table

Objective: At the end of this lesson you shall be able to·
• determine the correct bend radius.

Minimum bend radius charts are found in manufacturers' manuals. Below you can see an extract of a table.

A radius that is too sharp cracks the material during the bending process.

Typically, the drawing indicates the radius to use, but it is a good practice to double check.

Table 1 – Minimum bend radius for commons alloys

		THICKNESS	W	T3 / T4	T6
		In mm			
	2014	0 > 1.2	2.5 x thickness	3 x thickness	
		1.2 > 3.2	2.5 x thickness	4 x thickness	4 x thickness
		3.2 > 6	3 x thickness	5 x thickness	5 x thickness
ALUMINIUM ALLOYS	2017	0 > 1.2	2.5 x thickness	3 x thickness	3 x thickness
		1.2 > 3.2	2.5 x thickness	4 x thickness	4 x thickness
		3.2 > 6	3 x thickness	5 x thickness	5 x thickness
	2024	0 > 1.2	3 x thickness	3 x thickness	3 x thickness
		1.2 > 3.2	4 x thickness	4 x thickness	4 x thickness
		3.2 > 6	5 x thickness	5 x thickness	5 x thickness
	6061	0 > 6	-	3 x thickness	3 x thickness
	7075	0 > 1.2	3 x thickness	-	7 x thickness
		1.2 > 3.2	-	-	7 x thickness
		3.2 > 6	-	-	7 x thickness
		THICKNESSIn mm	**O**	**H111**	-
	5086	0 > 1.6	2.5 x thickness	2.5 x thickness	-
		1.6 > 3.25	3 x thickness	3 x thickness	-
		3.25 > 6	4 x thickness	4 x thickness	-
TITANIUM		**THICKNESSIn mm**	**Cold bending**	**Hot bending**	-
	T35	0 > 1.2	2 x thickness	-	-
		1.2 > 3.25	2.5 x thickness	-	-
	T40	0 > 1.2	3 x thickness	2 x thickness	-
		1.2 > 3.25	4 x thickness	3 x thickness	-
	T60	0 > 1.2	4 x thickness	3 x thickness	-
		1.2 > 3.25	5 x thickness	4 x thickness	-
	TU2	0 > 1.2	2.5 x thickness	2 x thickness	-
		1.2 > 3.25	4 x thickness	3 x thickness	-

Bending calculation - Bend allowance

Objective: At the end of this lesson you shall be able to·
• calculate the bend allowance.

Find the bend allowance

When making a bend or fold in a piece of metal, the bend allowance or length of material required for the bend, must be calculated.

The bend allowance changes with:

- The dimension of the bend radius “R”,
- The internal bend angle “a”,
- The sheet thickness “T”.

The radius of the bend is generally proportional to the thickness of the material. Furthermore, the sharper the radius of bend, the less the material that is needed for the bend. The type of material is also important. If the material is soft, it can be bent very sharply; but if it is hard, the radius of bend is greater, and the bend allowance is greater. The degree of bend affects the overall length of the metal, whereas the thickness influences the radius of bend.

Bending a piece of metal compresses the material on the inside of the curve and stretches the material on the outside of the curve. However, at some distance between these two extremes lies a space which is not affected by either force. This is known as the neutral line or neutral axis

The length of this neutral axis must be determined so that enough material can be provided for the bend. This is called the bend allowance. This amount must be added to the overall length of the layout pattern to ensure adequate material for the bend. To save time in calculation of the bend allowance, formulas and charts for various angles, radii of bends, material thicknesses, and other factors have been developed.

The bend allowance is negative when the bend angles internal = 0° to 115°

The bend allowance can be positive or negative when the bend angles internal = 115° to 180°

Calculation of bend allowance for a 90° bend

To the radius of bend (R) add 1D 2 the thickness of the metal (1D 2T). This gives R + 1D 2T, or the radius of the circle of the neutral axis.

Compute the circumference of this circle by multiplying the radius of the neutral line (R + 1D 2T) by 2ð

Since a 90° bend is a quarter of the circle, divide the circumference by 4.

This gives:

(2x PI x(Radius + ½ thickness)) / 4 = (PI x Diameter + thickness) / 4

Example, Calculation of BC:

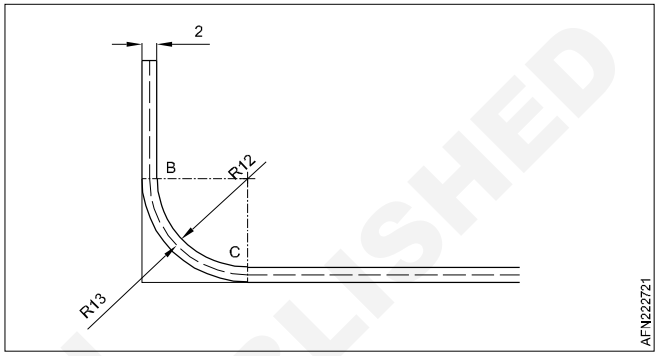
Bend allowance BC is calculated at the axis or median line.

R’ = 13 mm

It is a quarter of a circumference, so:

BC = (À x ¦)/4 ¦ = 2 x 13 = 26 mm

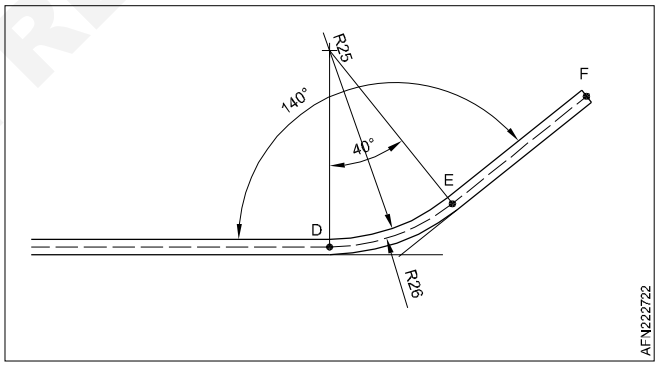
BC = (À x 26)/4 BC = 20.42 mm



Calculation of bend allowance for all angle bend

Using arc formula, you can calculate the bend allowance.

$$ARC = \frac{\pi \times R \times a}{180}$$



Example:

Bend allowance DE is calculated at the axis or median line.

DE = (À x diameter x internal angle) / 360

The internal angle is that opposite to 140°, i.e. 40° (180-140)

Diameter = (25 + ½ thickness) x 2 or (2 x radius) + thickness

R=52 mm

DE = (À x 52 x 40) / 360

DE = 18.15 mm

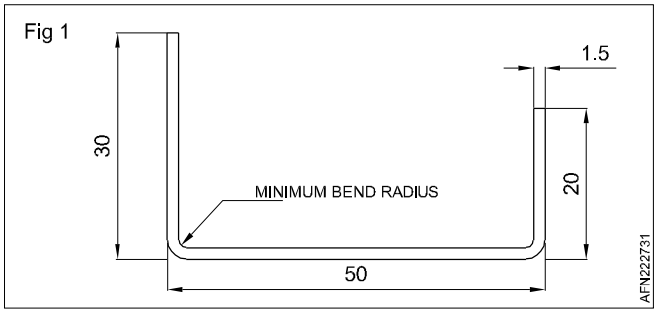
Bending calculation - Total developed width calculation

Objective: At the end of this lesson you shall be able to·
- **calculate the total developed width for bending.**

Total developed width for angles 90° and minimum bend radius – Approximate values

In this case simply subtract twice the thickness for each bend to the sum product of the external side length(or sum up the inner side length).

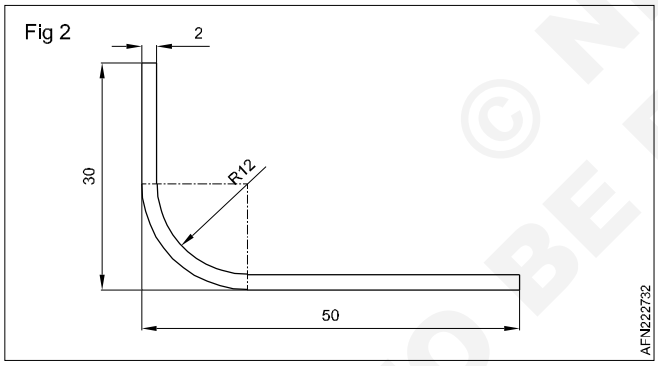
Example:



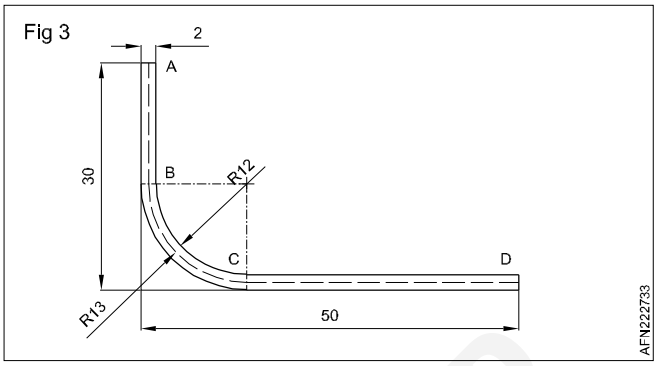
Developed length = 30 + 50 + 20 - (4 x 1.5)

Developed length = 94 mm

Total developed width for angles 90° and any bend radius



Trace the neutral axis and name the points to calculate setback (SB), Bend tangent line dimension (BTLD) and bend allowance (BA). (Fig. 3)



In this case, calculate the length of the flat piece and add the value of the arc at the neutral axis. The neutral axis is located at approximately 50% of the metal thickness.

Developed length = AB + BC + CD

Calculation of AB

AB = BASE MEASUREMENT – SETBACK

AB = 30 - thickness - radius

AB = 30 - 2 - 12 AB = 16 mm

Calculation of CD

AB = BASE MEASUREMENT – SETBACK

CD = 50 - thickness- radius

CD = 50 - 2 - 12 CD = 36 mm

Calculation of BC

Bend allowance BC is calculated at the axis or median line.

R' = 13 mm

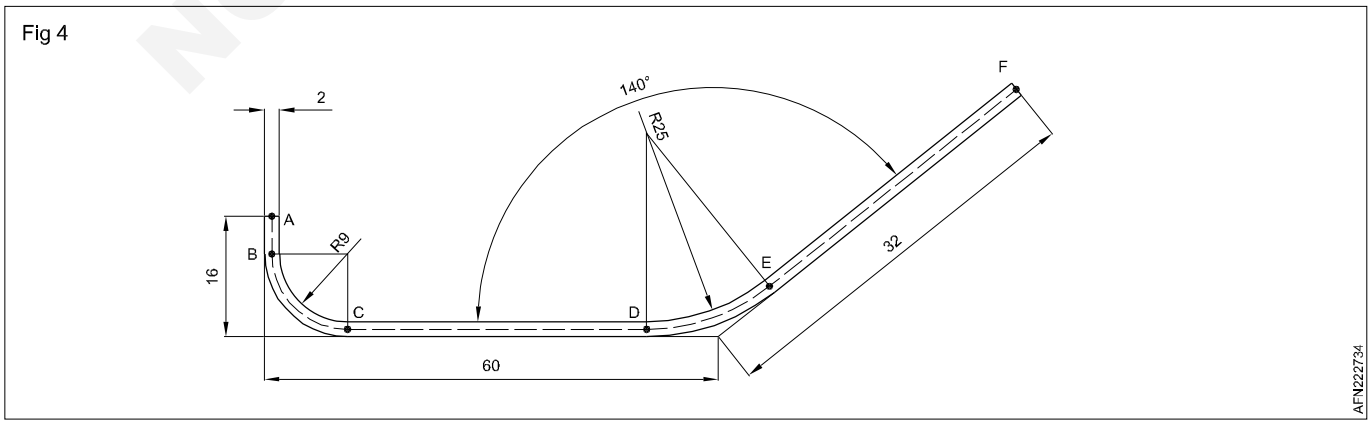
It is a quarter of a circumference, so:

BC = (À x ¦)/4 or ¦ = 2 x 13 = 26 mm

BC = (À x 26)/4 BC = 20.42 mm

Developed length = 16 + 36 + 20.42 = 72.42 mm

Total developed width for any angles and bend radius



Example:

Developed length: AB + BC + CD + DE + EF

Calculation of AB

AB = 16 - thickness - radius

AB = 16 - 2 - 9

AB = 5 mm

Calculation of the BC ARC

BC = (À x diameter) / 4

Diameter = (9 + ½ thickness) x 2

or(2xradius)+thickness

BC = (À x 20) / 4

BC = 15.71 mm

Calculation of the DE ARC

DE = (À x diameter x internal angle) / 360

The internal angle is that opposite to 140°, i.e. 40° (180-140)

Diameter = (25 + ½ thickness) x 2

or (2 x radius) + thickness

DE = (À x 52 x 40) / 360

DE = 18.15 mm

Calculation of EF

EF = 32 - E'O'

E'O' = D'O' (see calculation for CD)

EF = 32 - 9,83

EF = 22.17 mm

Calculation of CD

CD = 60 - thickness - radius - D'O'

CD = 60 - 2 - 9 - D'O'

Calculation of D'O' (Fig 5)

In the square triangle OD'O' square in D'

D'O' is the side opposite to the 20° angle

Value for OD' is known (25+2 = 27 mm) – Adjacent side to 20°

Tan20 = D'O' / 27

D'O' = Tan20 x 27

D'O' = 9.83 mm

CD = 60 - 2 - 9 - 9,83

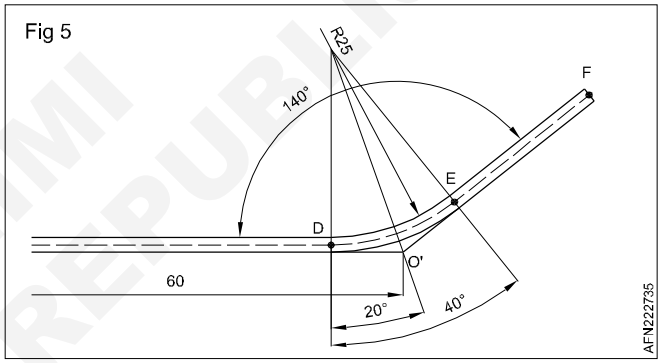
CD = 39.17 mm

The developed length is:

AB + BC + CD + DE + EF

5 + 15.71 + 39.17 + 18.15 + 22.17 = 100.2 mm

Fig 5



Holding and clamping devices

Objective: At the end of this lesson you shall be able to
- **explain about the clamping tools commonly used.**

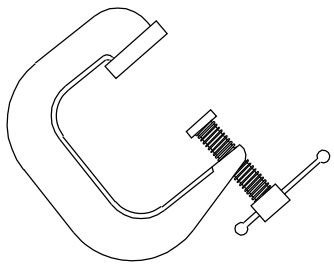
In order to work with sheet metal during the fabrication process, the aeronautical structure fitter uses a variety of holding devices, such as clamps and fasteners to hold the work together.

The type of operation being performed, and the type of metal being used determine what type of the holding device is needed.

C-Clamps and locking C-Clamps

The C-clamp is shaped like a large C and has three main parts: threaded screw, jaw, and swivel head. (Fig. 1)

Fig 1

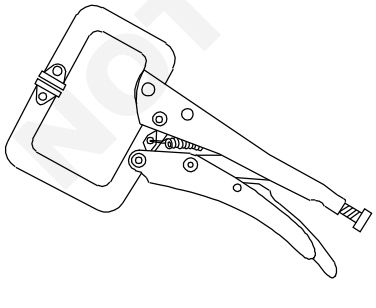


The swivel plate or flat end of the screw prevents the end from turning directly against the material being clamped. The distance from the center line of the screw to the inside edge of the frame or the depth of throat is also an important consideration when using this clamp.

The locking C-clamp is a locking plier. (Fig. 2)

Since C-clamps can leave marks on aluminium, protect the aircraft covering with masking tape at the places where the C-clamp is used.

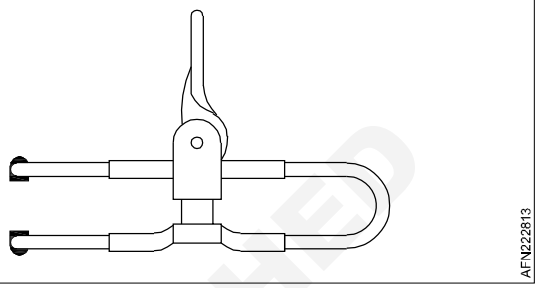
Fig 2



Handy clamps (Fig. 3)

Versatile clamps for complete range of surfaces, shapes, material. Hand installation.

Fig 3



Reusable Sheet Metal Fasteners

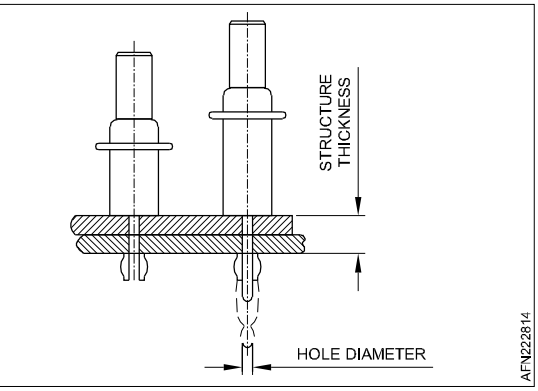
Reusable sheet metal fasteners temporarily hold drilled sheet metal parts accurately in position for riveting or drilling. If sheet metal parts are not held tightly together, they separate while being riveted or drilled.

The Cleco (also spelled Cleco) fastener is the most commonly used sheet metal holder.

Cleco type Fasteners

The Cleco fastener consists of a steel cylinder body with a plunger on the top, a spring, a pair of step-cut locks, and a spreader bar (Fig. 4).

Fig 4



These fasteners come in six different sizes:

- 2,4mm (3D 32"),
- 3,2mm (1D 8"),
- 4,0mm (5D 32"),
- 4,8mm (3D 16"),
- Etc.

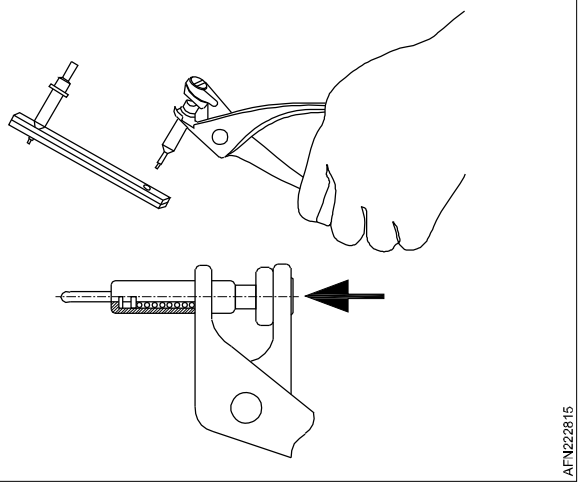
Color coding allows for easy size recognition.

- 2,4mm (3D 32")> ZINC
- 3,2mm (1D 8")> COPPER
- 4,0mm (5D 32")> BLACK
- 4,8mm (3D 16")> BRASS
- Etc.

A special type of plier fits the different sizes (Fig. 5).

When installed correctly, the reusable Cleco fastener keeps the holes in the separate sheets aligned.

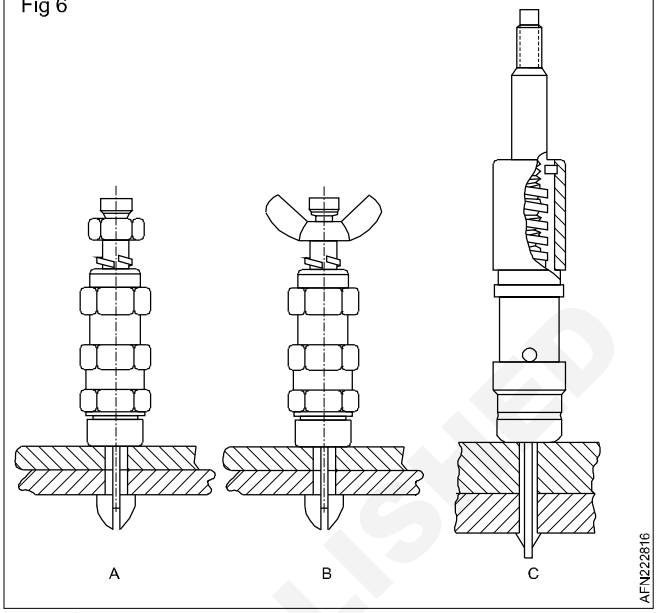
Fig 5



Powered Temporary Sheet Fasteners

Hex nut (Fig. 6-A), wing nut (Fig. 6-B) and cylindrical(Fig. 6-C) fasteners are used to temporarily fasten sheets of metal when higher clamp up pressure is required.

Fig 6



Solid rivets - Introduction

Objectives: At the end of this lesson you shall be able to·
- **name the parts of solid shank rivets**
- **explain the different rivet head shapes and their uses.**

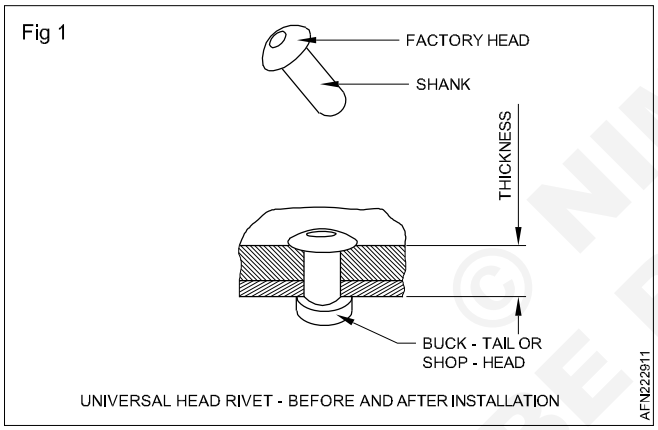
The solid rivet is the most common type of rivet used in aircraft construction. Used to join aircraft structures, solid shank rivets are one of the oldest and most reliable types of fastener.

Widely used in the aircraft manufacturing industry, solid shank rivets are relatively low-cost, permanently installed fasteners. They are faster to install than bolts and nuts.

Description (Fig 1)

Before installation, the solid rivet consists of a cylindrical shaft with a factory head on one end. The opposite end is called the buck-tail or shop-head.

Fig 1



UNIVERSAL HEAD RIVET - BEFORE AND AFTER INSTALLATION

To secure two or more pieces of sheet metal together, the rivet is placed into a hole just a bit larger in diameter than the rivet itself.

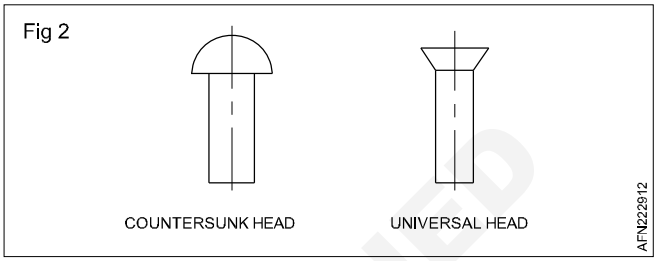
Once placed in this predrilled hole, the buck tail is upset or deformed by any of several methods from hand-held hammers to pneumatically driven squeezing tools. This action causes the rivet to expand the original shaft diameter, forming a second head that firmly holds the material in place.

Universal head rivet - Before and after installation

Rivet Head Shape (Fig 2)

Solid rivets are available in several head shapes, but the universal and the 100° countersunk head are the most commonly used in aircraft structures.

Fig 2



Universal head rivets were developed specifically for the aircraft industry and designed as a replacement for both the round and brazier head rivets. These rivets replaced all protruding head rivets and are used primarily where the protruding head has no aerodynamic significant. They have a flat area on the head.

The **countersunk head** angle can vary from 60° to 120°, but the 100° has been adopted as standard because this head style provides the best possible compromise between tension/shear strength and flushness requirements.

This rivet is used where flushness is required because the rivet is flat-topped and undercut to allow the head to fit into a countersunk or dimpled hole.

The countersunk rivet is primarily intended for use when aerodynamics smoothness is critical, such as on the external surface of a high-speed aircraft.

Materials

Typically, rivets are fabricated from aluminium alloys, such as 2017, 2024, 2117, 7050, and 5056. Titanium, nickel-based alloys, such as Monel (corrosion-resistant steel).

Mild steel or iron, and copper rivets are also used for rivets in certain cases.

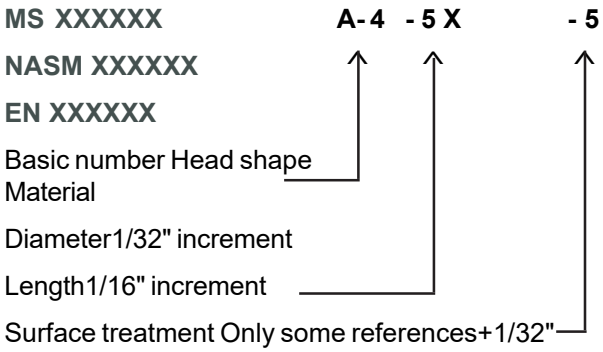
Solid rivets - MS, NASM and EN inch series designations

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

- **read MS, NASM inch series solid rivet designations.**

Inch series rivet diameters are commonly measured in 1D 32-inch incrementsand their lengths in 1D 16-inch increments, expressed as “dash numbers” at the end of the rivet identification number.

Designation



Rivet type and head shapes

MS20426 Superseded by **NASM20426**	100° countersunk head rivet Aluminium alloy and titanium columbium alloy
MS20427 Superseded by **NASM20427**	100° countersunk head rivet Carbon Steel, Corrosion-Resistant Steel, Monel, Copper and Brass
MS20470 Superseded by **NASM20470**	Universal head rivet Aluminium alloy and titanium columbium alloy
MS20613 Superseded by **NASM20613**	Universal head rivet Carbon Steel, Corrosion-Resistant Steel
MS20615 Superseded by **NASM20615**	Universal head Monel, Copper and Brass
EN6101	Close tolerance 100° countersunk head rivet
EN6080	Normal 100° countersunk head rivet
EN6069	Reduced 100° countersunk head rivet
EN6081	Universal head rivet

Material and head marking

Makings on the rivet head, such as small raised or depressed dimples or small raised bars indicate the rivet’s alloy.

Code	Material	Mark
A	1100-F Aluminium	No Head Mark
AD	2117-T4 Aluminium	Dimple dot
B	5056-H32 Aluminium	Raised Cross
D	2017-T4 Aluminium	Raised Dot
DD	2024-T4 Aluminium	Raised Double Dash
K	2219-T81 Aluminium	Indented Square
E	7050-T73 Aluminium	Indented Ring
T	45Cb Titanium	Indented Diamond
J	2219-T62 Aluminium	Indented Triangle
C	300 series stainless steel	Head Mark Varies
M	N-U30 Monel	Head Mark Varies

Diameters

Code diameter	Shank diameter	Metric conversion
- 2	1/16"	1,6 mm
- 3	3/32"	2,4 mm
- 4	1/8"	3,2 mm
- 5	5/32"	4,0 mm
- 6	3/16"	4,8 mm
- 8	1/4"	6,35 mm
- 10	5/16"	8,0 mm
- 12	3/8"	9,5 mm

Solid rivets - Metric series designations

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

- **read metric series solid rivet designations.**

Metric series rivet diameters are commonly measured in 1D 10 mm increments and their lengths in 1 mm increments, expressed as “dash numbers” at the end of the rivet identification number.

Designation

NF-L XXXX **A** **- 4** **- 5**

Basic number Head shape

Material

Diameter 1/10 mm increment

Length1mm increment

Rivet type and head shapes

NF-L21217	100° countersunk head rivet
NF-L21215	Universal head rivet

Material and head marking

Makings on the rivet head, such as small raised or depressed dimples or small raised bars indicate the rivet’s alloy.

CODE	MATERIAL	MARK
DC	2117-T4 Aluminium	Dimple dot
DE	2017-T4 Aluminium	Without
DX	2017-T4 Aluminium	Raised Double Dash
DK	7075-T73 Aluminium	Indented Ring
TS	T40 Titanium	Indented Diamond
TB	N-U30 Monel	Two Raised Dot

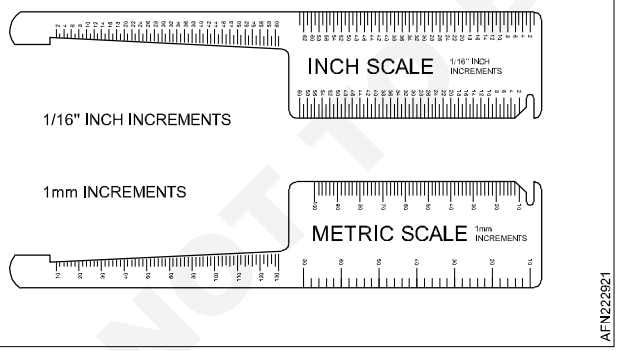
Solid rivets - Length calculation

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

- **calculate the correct length of the rivet.**

To determine the total length of a rivet to be installed, the combined thickness of the materials to be joined must first be known. This measurement is known as the grip length scale. (Fig 1)

Fig 1



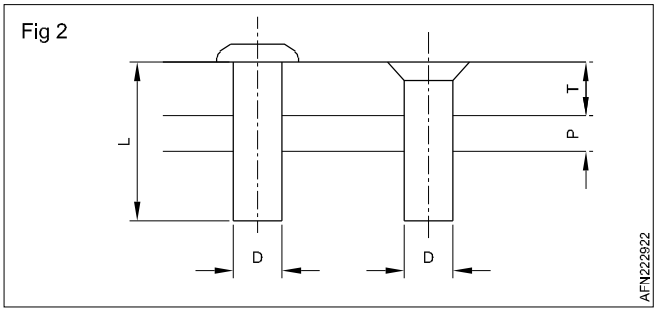
The total length of the rivet equals the grip length plus the amount of rivet shank needed to form a proper shop head.

The latter equals one and a half times the diameter of the rivet shank.

Where L is total rivet length, T is grip length, and P is the length of the material needed to form a shop head, this formula can be represented as L = T + P.

P = D x Factor

Fig 2



Factors

Hard aluminium alloy rivets for assembly of all material types (factor 1.3D)

Diameter D	mm	2.4	3.2	4.0	4.8	5.6
	inch	3/32	1/8	5/32	3/16	7/32
Protrusion P	mm	3.6	4.8	6.0	7.2	7.3

Aluminium alloy rivets for assembly of all material types (Factor 1.5D)

Diameter D	mm	2.4	3.2	4.0	4.8	5.6
	inch	3/32	1/8	5/32	3/16	7/32
Protrusion P	mm	3.6	4.8	6.0	7.2	7.3

Monel and titanium rivets for assembly of aluminium parts (Factor 1D)

Diameter D	mm	2.4	3.2	4.0	4.8	5.6
	inch	3/32	1/8	5/32	3/16	7/32
Protrusion P	mm	2.4	3.2	4.0	4.8	5.6

Monel and titanium rivets for assembly of steel or titanium parts (Factor 0.8D)

Diameter D	mm	2.4	3.2	4.0	4.8	5.6
	inch	3/32	1/8	5/32	3/16	7/32
Protrusion P	mm	1.9	2.6	3.2	3.8	4.5

Fasteners symbolisation - NAS523 standard

Objectives: At the end of this lesson you shall be able to·
- **understand the symbol of the fastener and read the information**
- **search in the table the correct fastener.**

The symbol includes a single cross whose intersection is at the location of the fastener.

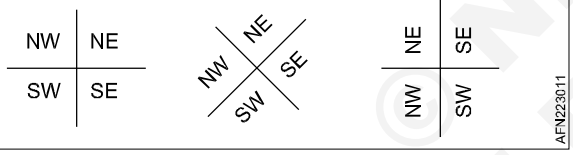
When space does not permit, the symbol may be located off to the side and the location of the fastener indicated by an arrow.

Fastener identity, size, installation requirements etc. shall be indicated by a letter-numeric coding within the quadrants of the cross as defined herein.

Quadrant orientation of the symbol is determined by the direction of the letter-numeric coding as written within the symbol. When the symbol is viewed in a position such that the letters are upright, the upper-left-hand quadrant is NW etc.

The following examples illustrate the basic symbol and quadrant identity (Fig. 1).

Fig 1



Northwest (NW) (Fig 2)

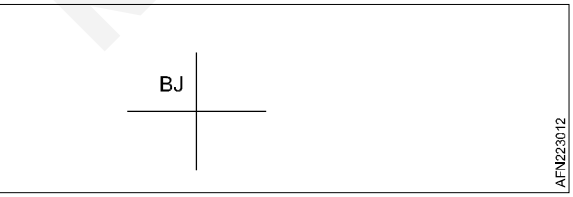
Fastener identity

He identity of the fastener is shown in the NW quadrant by a letter code as listed herein (see Annexure 1: extract of NAS523 standard).

The code is made up of non-significant letters and defines all features of the fasteners except diameter and grip. The code letters are assigned in sequence with the = exception of the letters G, I, Q and U and the combinations AD, AN and DO.

These letters shall not be used in the fastener symbol.

Fig 2



Northeast quadrant (NE) (Fig 3)

Fastener Diameter and Location of the Manufactured Head

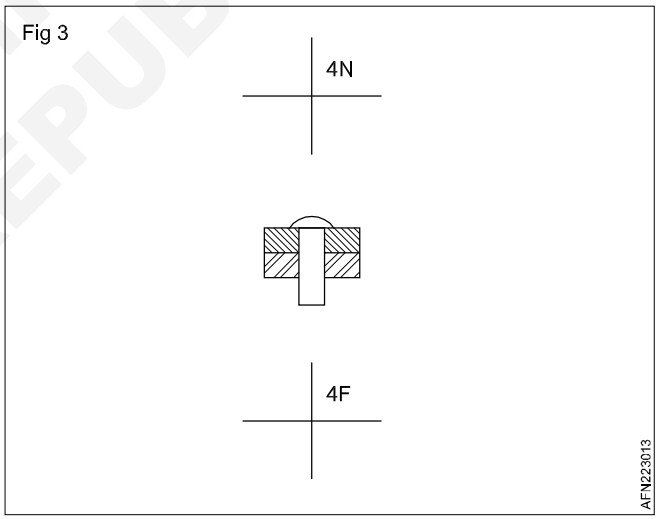
The fastener diameter and location of the manufactured head is shown in the NE quadrant by a numeric-letter as defined below.

The fastener diameter is shown by a number which is the dash number that represents the diameter in the full part number. If the diameter is designated by digits of the basic part number, then the significant digits shall be shown.

The location of the manufactured (preformed, factory) head of the fastener is defined by the code letter “F” for “Far Side” and “N” for “Near Side”.

When the location of the manufactured head is insignificant or otherwise determined by the drawing itself, the code letter may be omitted.

Fig 3



Southeast quadrant (SE) (Fig. 4)

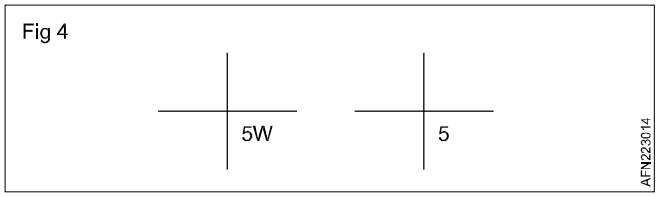
Length and Spot Weld Alternate

The length and permission to spot weld as an alternative assembly method is shown in the SE quadrant by a numeric-letter code as defined below.

The length is shown by a number which is the dash number that represents the length in the full part number.

Engineering permission to spot weld in lieu of using the fastener called for is denoted by the letter “W’.

Fig 4

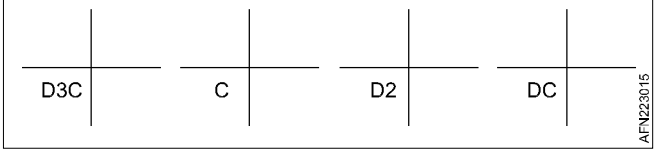


Southwest quadrant (NW)

Dimple and Countersink Data

The sheets to be dimpled or countersunk are shown in the SW quadrant by a numeric-letter code as defined below, not to exceed three digits per line. Unless otherwise noted the nominal angle for the dimple or countersink shall be the same as the angle of the manufactured rivet head.

Fig 5



The letter “0” is used to show a “dimpling” (form countersinking) operation and when more than one sheet is dimpled a number follows the “0” to show how many sheets are dimpled.

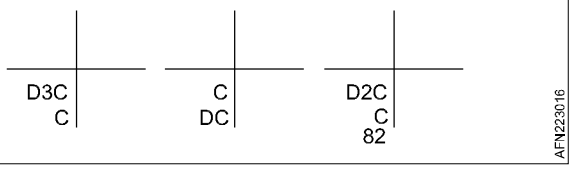
The letter “C” is used to show a countersinking (machine countersinking) operation.

No number is used, after the countersinking designation because it is the responsibility of the individual designer to see that the thickness of materials to be countersunk for a flush condition will not violate applicable company requirements.

The flush both sides condition may be indicated by placing the numeric-letter code on separate lines where:

- The first line indicates the dimple or countersink operation for the manufactured head.
- The second line indicates the dimple or countersink operation for the upset end.
- The third line indicates the nominal angle for the upset end when different than the angle of the manufactured head.

Fig 6

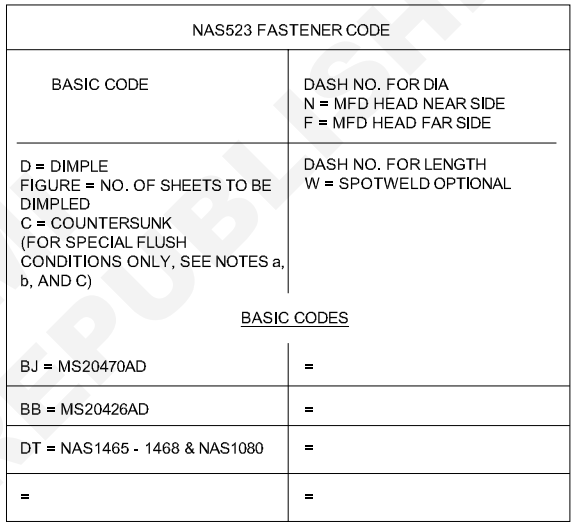


Application

The Alphabetical Part Number Listing is used by the Engineering Department to obtain the basic code designation of a given fastener for use in the northwest quadrant. (see Annexure 1: extract of NAS523 standard).

A general note or decal (stamp or stick-on) similar to the Sample Decal Layout shown in Fig 7 can be added to the drawing giving a cross reference to the codes used so that the identity of the fasteners may be determined on each drawing itself.

Fig 7



Annexure 1: Extract of NAS523 standard ia as flow

NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number
AA	MS20600AD	CE	P	EB	ALPPH-T	FW	RV203
AB	MS20600B	~~CF~~	~~NAS177~~	EB	ALPPN-T	~~FX~~	~~MS20450A( )C~~
AC	MS20601AD	~~CH~~	~~NAS177~~	EC	ALSF-T	~~FY~~	~~MS20450D~~
AE	MS20601B	~~CJ~~	~~NAS178~~	ED	ACT509N-T	~~FZ~~	~~MS20450D( )B~~
AF	MS20602D( )P	~~CK~~	~~NAS178~~	EE	ASCT509-T	~~HA~~	~~MS20450D( )M~~
AH	MS20603D( )P	CL	MS20427-( )C	EF	HS2R7C	~~HB~~	~~PN( )100~~
AJ	MS20603B( )P	~~CM~~	~~MS20450C( )AD~~	EH	HS23	~~HC~~	~~PN( )A~~
AK	CR517	~~CN~~	~~MS20450C( )B~~	EJ	HS25	HD	BB352
AL	CR563	~~CQ~~	~~MS20450D( )AD~~	EK	CR1984	HE	BB351
AM	ALP509H-E	CP	NAS1516-1522	EL	CR126	HF	MS20427C
AM	ALP509N-E	CR	ACT509H-T	EM	CR127	~~HH~~	~~MS20435CU~~
AO	MS20602B( )P	CR	ACT509W-T	EN	CR163	~~HJ~~	~~RV590~~
AP	ALP509H-T	CS	NAS1525-1532	EO	CR157	~~HK~~	~~RV591~~
AP	ALP509N-T	CT	ALPPH-T	EP	CR162	~~HL~~	~~RV290~~
AR	CR178	CT	ALPPN-T	ER	CR156	~~HM~~	~~RV291~~
~~AS~~	~~MS20435 ( )C~~	CV	NAS1555-1562	~~ES~~	~~RV201~~	HN	HS47
~~AT~~	~~MS20435M~~	CW	NAS1546-1552	~~ET~~	~~RV251~~	HO	HS48
AV	6950-S	CX	MS20470DD	~~EV~~	~~RV250~~	HP	HS67
AW	6951-S	CY	MS20426DD	~~EW~~	~~RV200~~	HR	HS68
AX	CR116	CZ	OS	~~EX~~	~~9SP-B-A~~	HS	7950-H-C
AY	CR117	DA	ALSF-T	~~EY~~	~~9SP-100-A~~	HT	7951-H-C
BA	MS20426A	DB	ASCT509-T	~~EZ~~	~~DR ( ) 100~~	HV	860-065
BB	MS20426AD	DC	11101ADJ4( )	~~FA~~	~~56S ( ) 100~~	~~HW~~	~~AN427M-0~~
BC	MS20426B	DE	44401ADJ4( )	~~FB~~	~~DR ( ) A~~	~~HX~~	~~MS20435M( )C~~
BD	MS20426D	~~DF~~	~~MS20435F~~	~~FC~~	~~56S ( )A~~	~~HY~~	~~CD PN( )100~~
BE	MS20426D	DH	MS20427F	FD	860-015	~~HZ~~	~~CD PN( )A~~
BF	MS20427M	DJ	NAS1535-1542	FE	HS26	JA	HS127
BH	MS20470A	~~DK~~	~~F~~	FF	CR174	JB	HS127
BJ	MS20470AD	~~DL~~	~~FA~~	FH	CR176	JC	HS128
BK	MS20470B	DM	ACT509H-T	FJ	CR175	JD	HS128
BL	MS20470D	DN	HS68	~~FK~~	~~P 56S ( ) 100~~	~~JE~~	~~NAS1466-1472~~
BM	MS20470D	DO	RV800	~~FL~~	~~P 56S ( )A~~	~~JF~~	~~NAS1456-1462~~
BO	NAS508M	DP	HS67	FM	R1028H-T	JH	NAS1475-1478
BP	CR516	~~DR~~	~~P~~	FM	R1028N-T	JH	NAS1480-1482
BR	CR562	DS	NAS1465-1472	FN	R1028H-T	~~JJ~~	~~R3014~~
BS	NAS525	DT	NAS1465-1468	FN	R1028N-T	JK	RV5033
BT	NAS529	DT	NAS1470-1472	~~FQ~~	~~MS20450C~~	JL	CR6634
BV	NAS525	DV	NAS1456-1462	FP	R1029H-T	~~JM~~	~~N( )A~~
BW	NAS529	DW	NAS1456-1458	FP	R1029N-T	JN	CR6624
BY	HS37P	DW	NAS1460-1462	FR	R1029H-T	~~JQ~~	~~N( )100~~
BZ	HS38P	DX	NAS1446-1452	FR	R1029N-T	~~JR~~	~~P( )A~~
CA	HS47	DY	NAS1424-1432	~~FS~~	~~RV550~~	JR	F ( ) A
CB	HS48	DZ	NAS1436-1442	~~FT~~	~~RV551~~	JS	MS20600M
CC	BL	EA	NAS1414-1422	FV	CR317	JT	MS20601M
CD	100-V						

NAS523 Code	Basic Part Number
JV	NAS1446-1452
JW	NAS1424-1432
JX	NAS1436-1442
JY	NAS1414-1422
JZ	NAS1054
KA	NAS1054
KB	NAS1055
KC	NAS1055
KD	HL18
KE	HL19
KF	NAS1806-1816
KH	NAS1806-1816
KJ	NAS1906-1916
KK	NAS1906-1916
KL	NAS2006-2010
KM	NAS2106-2110
KN	NAS2206-2210
KO	NAS2306-2310
KP	NAS2406-2412
KR	NAS2506-2512
KS	NAS2606-2612
KT	NAS2706-2712
KV	MS20600MP
KW	MS20601MP
~~KX~~	~~PA286( )A~~
~~KY~~	~~PA286( )100~~
KZ	MS20604B
LA	MS20604M
LB	MS20604MP
LC	MS20605B
LD	MS20605M
LE	MS20605MP
LF	MS20606B
LH	MS20606M
LJ	MS20606MP
~~LK~~	~~MS20613~~
LL	MS20613-( )P
LM	MS20613-( )C
LN	MS20615-( )M
LO	MS20615-( )CU
LP	HL51
LR	HL50
LS	2LPT
LT	2L426T

NAS523 Code	Basic Part Number
LV	HL26
LW	HL30
LX	HL27
LY	HL31
LZ	NAS1097AD
MA	NAS1097B
MB	NAS1097D
MC	NAS1097DD
MD	BB160
ME	BB159
MF	HS11
~~MH~~	~~MS20604AD~~
~~MJ~~	~~MS20605AD~~
MK	NAS1097D
ML	CR6636
MM	NAS1198
MN	NAS1199
MO	NAS1200
MP	CR6626
MR	HL22
MS	HL23
MT	10LP-T
MV	10LP-T
MW	10L509
MX	10L509
~~MY~~	~~HL20~~
~~MZ~~	~~HL21~~
NA	HL21
NB	SSP
NC	SSF
ND	RV850
NE	CR863
NF	RV801
NH	RV841
NJ	RV8841
NK	RV851
~~NL~~	~~A-286 ( ) 100~~
NM	860-615
NN	860-660
NO	HL10V
NP	HL31
NR	HL350
NS	HL351
NT	MS20605AD( )W

NAS523 Code	Basic Part Number
NV	MS20605AD( )C
NW	1204
NX	RV202
NY	RV502
NZ	7232
OA	MS20604AD( )C
OB	1202
OC	NAS525
OD	HS61
OE	HS61
OF	HS91
OH	HS91
OJ	NAS529
OK	HS62
OL	HS62
OM	HS92
ON	HS92
OO	NAS1436-1442
OP	NAS1414-1422
OR	NAS1446-1452
OS	NAS1424-1432
~~OT~~	~~F ( ) ALS~~
~~OV~~	~~SHFA~~
OW	BB363
~~OX~~	~~PA~~
~~OY~~	~~PDR ( ) 100 ( )~~
~~OZ~~	~~HL18~~
~~PA~~	~~HL19~~
PB	MS20604AD( )W
~~PC~~	~~HL31~~
~~PD~~	~~CR2263~~
~~PE~~	~~NAS1465~~
~~PF~~	~~NAS1475~~
PH	HL20
PJ	HL21
~~PK~~	~~CR2262~~
PL	HL350
PM	HL51
PN	HL351
PO	CR763
PP	HL50
~~PR~~	~~CR2162~~
~~PS~~	~~CR2562R~~
~~PT~~	~~CR2662~~
~~PV~~	~~CR2248~~

NAS523 Code	Basic Part Number
NV	MS20605AD( )C
NW	1204
NX	RV202
NY	RV502
NZ	7232
OA	MS20604AD( )C
OB	1202
OC	NAS525
OD	HS61
OE	HS61
OF	HS91
OH	HS91
OJ	NAS529
OK	HS62
OL	HS62
OM	HS92
ON	HS92
OO	NAS1436-1442
OP	NAS1414-1422
OR	NAS1446-1452
OS	NAS1424-1432
~~OT~~	~~F ( ) ALS~~
~~OV~~	~~SHFA~~
OW	BB363
~~OX~~	~~PA~~
~~OY~~	~~PDR ( ) 100 ( )~~
~~OZ~~	~~HL18~~
~~PA~~	~~HL19~~
PB	MS20604AD( )W
~~PC~~	~~HL31~~
~~PD~~	~~CR2263~~
~~PE~~	~~NAS1465~~
~~PF~~	~~NAS1475~~
PH	HL20
PJ	HL21
~~PK~~	~~CR2262~~
PL	HL350
PM	HL51
PN	HL351
PO	CR763
PP	HL50
~~PR~~	~~CR2162~~
~~PS~~	~~CR2562R~~
~~PT~~	~~CR2662~~
~~PV~~	~~CR2248~~

NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number
SX	HS149	VY	HL432	YZ	HL641	ABA	HS39PB
SY	HS150	~~VZ~~	~~CR2548~~	ZA	HL641	ABB	HS41PB
SZ	HS150	~~WA~~	~~CR2548P~~	ZB	HL617B	ABC	2LP-EU(6,8)
TA	HL222	~~WB~~	~~CR2549~~	ZC	HL617	ABD	2LP-EU(10,12)
TB	HL223	~~WC~~	~~CR2549P~~	ZD	HL649	ABE	HL10V
TC	HL550	WD	NAS1919M-( )	ZE	2LS426T	ABF	HL718
TD	HL550	WE	NAS1919C-( )	~~ZF~~	~~NAS1669~~	ABG	HL718
TE	HL552	WF	NAS1921M-( )	~~ZH~~	~~NAS1671~~	ABH	HL11V
TF	HL551	WH	NAS1921C-( )	~~ZJ~~	~~NAS1673~~	ABJ	HL719
TH	HL551	WJ	HL414	~~ZK~~	~~NAS1670~~	ABK	HL719
TJ	HL553	WK	HL416	~~ZL~~	~~NAS1672~~	ABL	HLT410
TK	NAS1398MW	WL	HL415	~~ZM~~	~~NAS1674~~	ABM	HLT412
TL	NAS1398MS	WM	HL417	ZN	NAS1054	~~ABN~~	~~HLT314~~
TM	NAS1398CW	WN	HL14	ZO	NAS1055	ABO	HLT411
TN	NAS1398CS	WO	HL15	ZP	NAS525	ABP	HLT413
TO	NAS1399MW	WP	NAS1054	ZR	NAS529	~~ABR~~	~~HLT315~~
TP	NAS1399MS	WR	NAS1055	~~ZS~~	~~CR2538~~	ABS	HLT410
TR	NAS1399CW	WS	ALP426-T	~~ZT~~	~~CR2538P~~	ABT	HLT411
TS	NAS1399CS	WT	MS9318	~~ZV~~	~~CR2539~~	ABV	HLT318
TT	RV840	WV	MS9460	~~ZW~~	~~CR2539P~~	ABW	HLT319
TV	RV890	WW	MS9319	ZX	HL10V	ABX	HLT318
TW	RV891	WX	MS9403	ZY	HL11	ABY	HLT319
TX	MS90354	WY	HL19PB	ZZ	F( )ANS	ABZ	MS20604ML
TY	MS90353	WZ	HL19PB	AAA	P( )ANS	ACA	MS20605ML
TZ	HS149	YA	HL18PB	AAB	HL10V	ACB	NAS1398B( )A
VA	HS150	YB	HL18PB	AAC	HL11V	ACC	NAS1398D( )A
VB	MS16535	YC	NAS2506-2512	AAD	MS20427M( )C	ACD	NAS1398MW( )A
VC	MS16536	YD	NAS2706-2712	AAE	HS92	ACE	NAS1399B( )A
VD	HS92	YE	HL10V	AAF	HS62	ACF	NAS1399D( )A
VE	HS91	YF	HL11V	AAH	HS91	ACH	CR2245
VF	HL10V	YH	HL11	AAJ	HS61	ACJ	CR2235
VH	HL11	YJ	BB371	AAK	CR2249NS	ACK	NAS1399MW( )A
VJ	HL12V	YK	HL16	AAL	CR2248NS	ACL	HLT410
~~VK~~	~~HL13~~	YL	HL16	~~AAM~~	~~CR2239~~	ACM	HLT411
VL	NAS1321AD	YM	HL17	~~AAN~~	~~CR2238~~	ACN	MS21141
VM	NAS1321DD	YN	HL17	AAO	NAS1738B	ACO	MS21140
~~VN~~	~~RR~~	YO	HL614B	AAP	NAS1738E	ACP	CR2551
~~VO~~	~~RRA~~	YP	HL614	AAR	NAS1738M	ACR	NAS1398M( )A
~~VP~~	~~FF~~	YR	HL640	AAS	NAS1738MW	ACS	NAS1398MS( )A
VR	FFA	YS	HL640	AAT	NAS1739B	ACT	NAS1399M( )A
VS	9SP-B-R	YT	HL616B	AAV	NAS1739E	ACV	NAS1399MS( )A
VT	9SP-100-R	YV	HL616	AAW	NAS1739M	ACW	NAS1398C( )A
VV	AF007M( )C	YW	HL648	AAX	NAS1739MW	ACX	NAS1399C( )A
VW	AF007M	YX	HL615B	AAY	HS40PB	ACY	CR2653
~~VX~~	~~SSHFA~~	YY	HL615	AAZ	HS42PB	ACZ	CR2743

NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number
ADA	CR2943	AFB	CR2251	~~AJC~~	~~HLT366~~	ALD	RV1100
ADB	CR2839	AFC	NAS1398CW( )A	~~AJD~~	~~HLT367~~	ALE	RV1101
ADC	CR2264	AFD	NAS1398CS( )A	~~AJE~~	~~HLT367~~	ALF	HL40
ADD	CR2164	AFE	NAS1399CW( )A	AJF	CSR914	ALH	HL41
ADE	CR2564	AFF	NAS1399CS( )A	AJH	CSR915	ALJ	HL40
ADF	CR2664	AFH	NAS1921B	AJJ	110680	ALK	HL41
ADH	CR2944	AFJ	NAS1919B	AJK	110674	ALL	NAS1750-( )DL
ADJ	CR2838	AFK	CR9163	AJL	NAS2005V-2012V	ALM	NAS1751-( )DL
ADK	CR2545	AFL	HLT44	AJM	NAS2105V-2112V	ALN	NAS1752-( )DL
ADL	CR2540	AFM	HLT44	AJN	CR2A38	ALO	NAS1753-( )DL
ADM	CR2840	AFN	HLT318	AJO	HLT412	ALP	CR2A39
ADN	HL41	AFO	HLT319	AJP	HLT413	ALR	HL40
ADO	HL11V	AFP	NAS2005V-2012V	AJR	HLT30	ALS	HL41
ADP	HL40	AFR	HL644LL	AJS	HLT31	ALT	HL40
ADR	HL10V	AFS	HL644LL	AJT	HLT412	ALV	HL41
ADS	HL49	AFT	HL13V	AJV	NAS2406V-2412V	ALW	NAS1919C-( )W
ADT	HL13V	AFV	HL49	AJW	NAS2506V-2512V	ALX	NAS1919M-( )W
ADV	HL48	AFW	HL12V	AJX	HL644LL	ALY	NAS1921C-( )W
ADW	HL12V	AFX	HL48	AJY	HL645LL	ALZ	NAS1921M-( )W
ADX	NAS2706-2712	AFY	NAS2105V-2112V	AJZ	HLT319	AMA	HL10V
ADY	NAS2606-2612	AFZ	HL11V	AKA	HL646LL	AMB	HL11V
ADZ	NAS2706-2712	AHA	HL11V	AKB	HL647LL	AMC	CCR264SS
AEA	NAS2606-2612	AHB	HL41	AKC	CSR912	AMD	NAS2406V-2412V
AEB	H2705V	AHC	HL10V	AKD	CR2A62	AME	NAS2506V-2512V
AEC	H2605V	AHD	HL10V	AKE	CR2A63	AMF	HLT45
AED	H2705V	AHE	HL40	AKF	CR2A64	AMH	RB1002NP
AEE	H2605V	AHF	HL645LL	AKH	HL644LL	AMJ	HLT110
AEF	SLS100-EU	AHH	HL645LL	AKJ	HL645LL	AMK	HLT210
AEH	SLSP-EU	AHJ	SLS100CT-EU	AKK	HL644LL	AML	HLT109
AEJ	NAS2506V-2512V	AHK	SLSPCT-EU	AKL	HL645LL	AMM	HLT209
AEK	NAS2406V-2412V	AHL	NAS2606V-2612V	AKM	HL646LL	AMN	CSR922
AEL	HLT54	AHM	2605V	AKN	HL647LL	AMO	CSR924
AEM	HLT56	AHN	NAS2706V-2712V	AKO	HL12V	AMP	CSR925
AEN	HLT316	AHO	2705V	AKP	HL13V	AMR	HLT30
AEO	HLT317	AHP	SLS100CT-EU	AKR	HL12V	AMS	HLT317
~~AEP~~	~~HLT366~~	AHR	SLSPCT-EU	AKS	HL13V	AMT	CCR264CS
~~AER~~	~~HLT366~~	AHS	HL12V	AKT	HLT318	AMV	HLT410
~~AES~~	~~HLT367~~	AHT	HL20PB	AKV	NAS1670-( )L	AMW	HLT411
~~AET~~	~~HLT367~~	AHV	HL21PB	AKW	NAS1672-( )L	AMX	CSR904B
~~AEV~~	~~FL( )~~	AHW	HL523	AKX	NAS1669-( )L	AMY	CSR903B
~~AEW~~	~~PL( )~~	AHX	HL525	AKY	NAS1671-( )L	AMZ	HLT614
~~AEX~~	~~FL( )ALS~~	AHY	HS128	AKZ	NAS1673-( )L	ANA	HLT615
~~AEY~~	~~PL( )A~~	AHZ	HLT314	ALA	NAS1674-( )L	ANB	HL50
AEZ	HL645LL	AJA	HLT315	ALB	RV1020	ANC	HL51
AFA	HL644LL	~~AJB~~	~~HLT366~~	ALC	RV1021	AND	HL20

NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number	NAS523 Code	Basic Part Number
ANE	CSR902B	APF	HL413V	ASE	HL30	AVA	MS20470T
ANF	HL29	APG	HL11V	ASF	NAS1738A	AVB	NAS4452H
ANH	HLT315	APH	HL11V	ASG	NAS1739A	AVC	MS20426T
ANJ	HLT314	APJ	CR2A38A	ASH	CR2162A	AVD	MS20426E
ANK	NAS1414H-1422H	APK	CR2A39A	ASJ	CR2163A	AVE	MS14218AD
ANL	NAS1414H-1422H	APL	CR2A62A	ASK	CR3214	~~AVF~~	~~MS14218T~~
ANM	NAS2705VH-2712VH	APM	CR2A63A	ASL	HL227	AVG	NAS2106V-2112V
ANN	NAS2705VH-2712VH	APN	CR2A64A	ASM	HL233	AVH	NAS2005V
ANO	NAS1424H-1432H	APO	MS21140-( )P	ASN	RV1203	AVJ	NAS2105V
ANP	NAS1424H-1432H	APP	MS21141-( )P	ASO	RV1293	AVK	NAS2005V
ANR	NAS2605VH-2612VH	APR	NAS1200M	ASP	RV1293M	AVL	NAS2106V-2112V
ANS	NAS2605VH-2612VH	APS	NAS1200M( )P	ASR	MS14218E	AVM	NAS2006V-2012V
ANT	NAS1436H-1442H	APT	HLT416	ASS	NAS1097KE	AVN	NAS2006V-2012V
ANV	NAS2506VH-2512VH	APV	NAS1241AD	AST	NAS1738C	AVO	NAS2105V
ANW	NAS7024H-7025H	APW	NAS1241B	ASU	NAS1739C	AVP	NAS1738CW
ANX	NAS1446H-1452H	APX	NAS1241D	ASV	NAS4450H	AVR	NAS1739CW
ANY	NAS2406VH-2412VH	APY	NAS1241DD	ASW	NAS1424-1432	AVS	NAS1321KE
ANZ	NAS7034H-7035H	APZ	NAS1242AD	~~ASX~~	~~NAS1097KE~~	~~AVT~~	~~M7885/4~~
AOA	NAS4452H	ARA	NAS1242B	ASY	NAS1720H	~~AVV~~	~~M7885/5~~
AOB	NAS4452V	ARB	NAS1242D	ASZ	NAS1720KE	~~AVW~~	~~MS14218E~~
AOC	NAS4452S	ARC	NAS1242DD	ATA	NAS1720V	AVX	MS14219AD
AOD	NAS4450H	ARD	M7885/7	ATA	NAS2406V-2412V	AVY	NAS6946-6952
AOE	NAS4450V	ARE	M7885/6	ATB	NAS1721C	~~AVZ~~	~~NAS1097U~~
AOF	NAS4450S	ARF	M7885/9	ATB	NAS2406V-2412V	AWA	MS14218B
AOH	HLT314	ARG	M7885/8	ATC	NAS1721H	AWB	NAS6910
AOJ	HLT315	ARH	HLT415	ATC	NAS2406V-2412V	AWC	NAS6910
AOK	HLT315	ARJ	HL12V	ATD	NAS1721KE	AWD	NAS6911
AOL	HLT414	ARK	HL13V	ATE	NAS1721V	AWE	NAS6911
AOM	NAS1768D	ARL	HL12V	ATF	NAS2506V-2512V	AWF	NAS6911
AON	NAS1768MW	ARM	M7885/3	ATG	NAS2506V-2512V	AWH	NAS6912
AOO	NAS1768M	ARN	M7885/2	ATH	NAS2506V-2512V	AWJ	NAS6912
AOP	NAS1769D	ARO	CR3252	ATJ	CR3224	AWK	NAS6912
AOR	NAS1769MW	ARP	CR3253	ATK	CR3245	AWL	NAS6913
AOS	NAS1769M	ARR	HL41	ATL	M7885/5	AWM	NAS6913
AOT	HL112V	ARS	HL21PN	ATM	M7885/4	AWN	NAS6914
AOV	HL112V	ART	HL32	ATN	NAS1769CW	AWO	NAS6914
AOW	HL113V	ARV	HL40	ATP	NAS4452S	AWP	HL12VTA
AOX	HL113V	ARW	NAS4600-4616	ATR	HSR200D	AWR	HL13VTA
AOY	HL12V	ARX	NAS5200-5206	ATS	MS14218T	AWS	LGPL9SP-V( )B
AOZ	HL12V	ARY	CSR924F	ATT	NAS4450H	AWT	HLGPL9SP-V( )B
APA	HL13V	ARZ	CSR925F	ATV	NAS4452H	AWV	LGPL8FC-V( )B
APB	HL13V	ASA	CSR945F	ATW	NAS1097E	AWW	HLGPL8FC-V( )B
APC	HL412V	ASB	HLT110	~~ATX~~	~~NAS1097KE~~	AWX	860-515
APD	HL412V	~~ASC~~	~~M7885/4~~	ATY	NAS1097U	AWY	MS21140U
APE	HL413V	~~ASD~~	~~M7885/5~~	ATZ	MS20470E	AWZ	MS21140U( )P

NAS523 Code	Basic Part Number
AXA	MS21141U
AXB	MS21141U( )P
AXC	MS90353U
AXD	MS90353U( )D
AXE	MS90354U
AXF	MS90354U( )D
AXH	MS14219AD
AXJ	MS20604S( )W( )
AXK	MS20604R( )W( )
AXL	MS20604H( )W( )
AXM	MS20605S( )W( )
AXN	MS20605R( )W( )
AXO	MS20605H( )W( )
~~AXP~~	~~M7885/4~~
~~AXR~~	~~M7885/5~~
~~AXS~~	~~M7885/6~~
~~AXT~~	~~M7885/7~~
AXV	MS14219AD
~~AXW~~	~~NAS1097U~~
~~AXX~~	~~NAS1321KE~~
AXY	CCR264CS( )IT
AXZ	NAS6956-6962
AYA	NAS6966-6972
AYB	NAS1754-( )DL
AYC	NAS1755-( )DL
AYD	NAS9301B
AYE	NAS9301E
AYF	NAS9302B
AYH	NAS9302E
AYJ	NAS9303B
AYK	NAS9303E
AYL	NAS9304B
AYM	NAS9304E
AYN	NAS9305B
AYO	NAS9305E
AYP	NAS9306B
AYR	NAS9306E
AYS	NAS9307M
AYT	NAS9307MP
AYV	NAS9308M
AYW	NAS9308MP
AYX	NAS9309M
AYY	NAS9309MP
AYZ	NAS9310C
AZA	NAS9310M

NAS523 Code	Basic Part Number
AZB	NAS9310MP
AZC	NAS9311C
AZD	NAS9311M
AZE	NAS9311MP
AZF	NAS9312M
AZH	NAS9312MP
AZJ	NAS1669-( )DL
AZK	NAS1670-( )DL
AZL	NAS1671-( )DL
AZM	NAS1672-( )DL
AZN	NAS1673-( )DL
AZO	NAS1674-( )DL
AZX	NAS1719C
AZY	NAS1720C
AZZ	NAS2005V-2012V
BAA	NAS2005V-2012V
BAB	NAS2105V-2112V
BAC	NAS2105V-2112V
BAD	MS20426K
BAE	MS20470K
BAF	HST10YV
BAG	HST315YV
BAH	HST10YV
BAJ	HST315YV
BAK	HST12YW
BAL	HST13YW
BAM	MBF3003
BAN	MBF3005
BAO	HST11VAZ-( )-( )
BAP	MBF3006
BAR	NAS1719H
BAS	NAS1719KE
BAT	HL220
BAV	MS90353S( )D
BAW	MS90354S( )D
BAX	NAS1398C( )AB( )
BAY	NAS1398CW( )AB( )
BAZ	NAS1399C( )AB( )
BBA	NAS1399CW( )AB( )
BBB	NAS9307ML-( )-( )
BBC	NAS9307MN-( )-( )
BBD	NAS9308ML-( )-( )
BBE	NAS9308MN-( )-( )
BBF	HST12VAZ-( )-( )
BBG	NAS1919B( )S( )FC

NAS523 Code	Basic Part Number
BBH	NAS1919C( )S( )
BBJ	NAS1919C( )S( )U
BBK	NAS1919M( )S( )
BBL	NAS1921B( )S( )FC
BBM	NAS1921C( )S( )
BBN	NAS1921C( )S( )U
BBP	NAS1921M( )S( )
BBR	HST11AG-( )-( )
BBS	MBF3011PL-( )-( )
BBT	HL19PB-( )-( )
BBV	NAS9301EH-( )-( )
BBW	NAS9303EH-( )-( )
BBX	NAS1398B( )AB( )
BBY	NAS1398M( )AB( )
BBZ	NAS1398MW( )AB( )
BCA	NAS1399B( )AB( )
BCB	NAS1399M( )AB( )
BCC	NAS1399MW( )AB( )
BCD	HL219-( )-( )
~~BCE~~	~~NAS1398C( )AB( )~~
BCF	NAS1398D( )AB( )
~~BCG~~	~~NAS1399C( )AB( )~~
BCH	NAS1399D( )AB( )
BCJ	NAS1398CFA( )-( )
BCK	NAS1399CFA( )-( )
BCL	MS20604FL( )W( )
BCM	MS20605FL( )W( )
BCN	MS83459/1-( )-( )
BCP	MS83459/2-( )-( )
BCR	MS83459/3-( )-( )
BCS	NAS9309ML-( )-( )
BCT	NAS9309MN-( )-( )

Fasteners symbolisation - ISO 5845 - 2, IS 15023 part 2 and EN 2544 standards

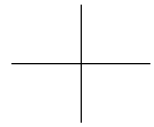
Objective: At the end of this lesson you shall be able to·

- **understand the symbol of the fastener and read the information.**

Symbolic representation for a set rivet

The symbolic representation for a set rivet consists of a cross indicating its position (see Fig 1). This representation shall be supplemented by relevant information regarding the rivet and the rivet assembly.

Fig 1



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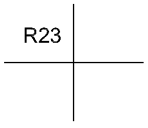
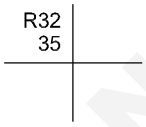
Information in the upper-left-hand quadrant

The upper-left-hand quadrant shows the item reference number assigned to the rivet in the item list of the drawing or in a table on the drawing giving the necessary information for the definition of therivet (reference number, head form, material, diameter, length, surface treatment, etc.).

This number shall be preceded by the capital letter R.

In the case of a composite rivet with a washer, for example, the item reference number assigned to the washer inthe item list shall be entered below that of the rivet.

Examples:

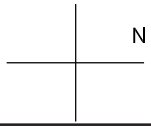
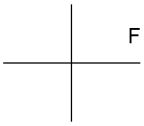
Symbolic representation	Interpretation
	**Solid rivet R23** Rivet, item reference 23 in a separate item list or in a table on the drawing.
	**Composite rivet R32** Rivet, item reference 32 in a separate item list or in a table on the drawing35 = Sleeve, item reference 35 in a separate item list or in a table on the drawing

Information in the upper-right-hand quadrant

This quadrant contains a capital letter giving the position of the preformed head:

- N for preformed head on the near side;
- F for preformed head on the far side.

Examples:

Symbolic representation	Interpretation
	Preformed head of the rivet on the near side.
	Preformed head of the rivet on the far side.

Information in the lower-left-hand quadrant

This quadrant contains information on the position of either a countersink or a dimpling or a combination of both.

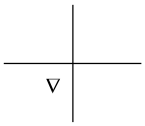
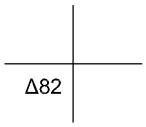
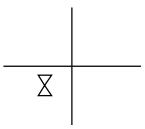
Countersink

A countersink to be made to the parts to be riveted shall be indicated by an equilateral triangle orientated as follows in the quadrant.

▽ for a countersink on the near side

△ for a countersink on the far side

If the countersink angle is 100°, the triangle alone is enough. If the countersink angle is other than 100°, the value of the angle in degrees shall be placed on the right of the triangle.

Symbolic representation	Interpretation
	100° countersink on the near side
	82° countersink on the far side
	100° countersink on both sides

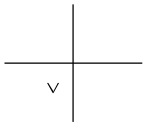
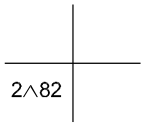
Dimpling

Dimpling of the sheets to be riveted shall be indicated by an open isosceles triangle orientated as follows in the quadrant:

- ∨ for a dimpling on the near side
- ∧ for a dimpling on the far side

If the dimpling angle is 100°, the open triangle alone is enough. If the dimpling angle is other than 100°, the value of the angle in degrees shall be placed on the right of the open triangle.

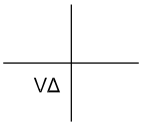
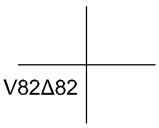
If several sheets are dimpled, the number of sheets shall precede the open triangle.

Symbolic representation	Interpretation
	100° dimpling on the near side
	Two sheets, dimpled 82° on the far side

Combined countersink and dimpling

The combination of a countersink on one part and a dimpling on the other shall be indicated by an open triangleand an equilateral triangle.

The combination of these triangles and the angle indication shall be in accordance with the information given above.

Symbolic representation	Interpretation
	First sheet dimpled 100° on the near sideSecond sheet countersunk 100" on the far side
	First sheet dimpled 82" on the near sideSecond sheet countersunk 82" on the far side

Lower-right-hand quadrant

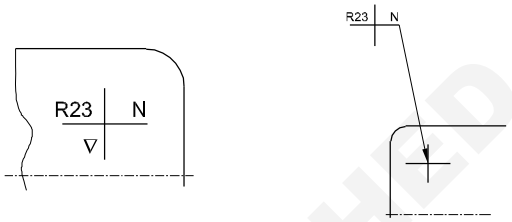
This quadrant shall not contain any information.

Symbolic representation of a line of rivets

The crosses shall be aligned along the axes of the drawing.

Additional indications are given either in the drawing, if space is available, or preferably outside it, with a leader line indicating the corresponding rivet assembly (see Fig 2).

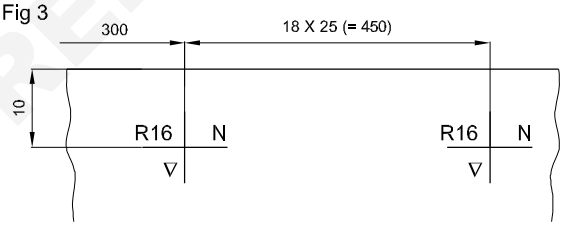
Fig 2



The position of the rivets, as well as the riveting pitch, shall be indicated by dimensioning.

When the rivets are aligned, identical and equidistant, the indications should be entered in the first and last crosses of the series, together with the total number of pitches multiplied by the pitch (see Fig 3).

Fig 3



Holes preparation procedure for riveting - Drilling

Objective: At the end of this lesson you shall be able to·
- **explain the different step to prepare hole for riveting.**

The hole preparation for riveting procedure consists of transferring and preparing the hole, drilling, and driving the rivets.

Before drilling the first component, mark or center punch all rivet locations.

If you choose to punch centre, the center punch mark should be large enough to prevent the drill from slipping out of position, yet it must not dent the surface surrounding the center punch mark. Place a bucking bar or other hard surface behind the metal during punching to help prevent denting.

To make a rivet hole the correct size, first drill a slightly undersized hole (pilot hole). Drill the pilot hole with a twist drill of the appropriate size to obtain the required dimension.

To drill, proceed as follows:

- Ensure the drill bit is the correct size and shape.
- Place the drill in the mark or in the centre-punched mark. When using a power drill, rotate the bit a few turns before starting the motor.
- While drilling, always hold the drill at a 90º angle to the work or the curvature of the material.
- Avoid excessive pressure, let the drill bit do the cutting, and never push the drill bit through stock.
- Remove all burrs with a metal countersink or a file.
- Clean away all drill chips.

When holes are drilled through sheet metal, small burrs are formed around the edge of the hole. This is especially true when using a hand drill because the drill speed is slow and there is a tendency to apply more pressure per drill revolution. Remove all burrs with a burr remover or countersink cutter.

- Place in position the elements and clamp them with C-clampsto hold sheets together.
- Hole Transfer. Accomplish transfer of holes from a drilled part to another part by placing the second part over first and using established holes as a guide.
- Clamp the holeswith temporary fasteners (cleco type).
- Deburr and/or countersink.

Hole Preparation

It is very important that the rivet hole be of the correct size and shape and free from burrs.

- **If the hole is too small**, the protective coating is scratched from the rivet when the rivet is driven through the hole.
- **If the hole is too large**, the rivet does not fill the hole completely. When it is bucked, the joint does not develop its full strength, and structural failure may occur at that spot.

Rivet holes in aircraft components may be drilled with a pneumatic hand drill. The standard shank twist drill is most commonly used.

Drill bit sizes for rivet holes should be the smallest size that permits easy insertion of the rivet, approximately 0.1 mm greater than the largest tolerance of the shank diameter.

The recommended clearance drill bits for the common rivet diameters are shown in Table 1.

Table 1

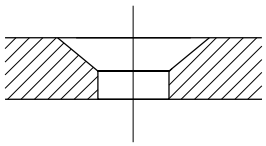
Rivet diameter		Recommended rill bit size	
Inch	mm	mm	Inch
3/32"	2.4 mm	2.5 mm	#40
1/8"	3.2 mm	3.3 mm	#30
5/32"	4.0 mm	4.1 mm	#21
3/16"	4.8 mm	4.9 mm	#11

Holes preparation procedure for riveting - Countersinking

Objectives: At the end of this lesson you shall be able to·
- **explain how to countersink hole for riveting**
- **explain the tools used to countersink.**

When using countersunk rivets, it is necessary to make a conical recess (Fig 1). in the skin for the head

Fig 1



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The type of countersink required depends upon the relation of the thickness of the sheets to the depth of the rivet head. Use the proper degree and diameter countersink and cut only deep enough for the rivet head and metal to form a flush surface.

Countersinking is an important factor in the design of fastener patterns, as the removal of material in the countersinking process necessitates an increase in the number of fasteners to assure the required load-transfer strength.

If countersinking is done on metal below a certain thickness, a knife edge with less than the minimum bearing surface or actual enlarging of the hole may result.

Keep the rivet high before driving to ensure the force of riveting is applied to the rivet and not to the skin.

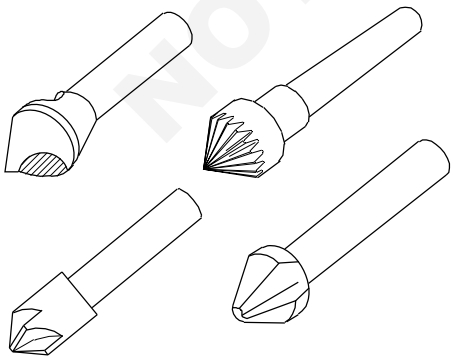
If the rivet is driven while it is flush or too deep, the surrounding skin is work hardened.

If the countersink is too deep that create a knife edge.

Countersinking Tools

While there are many types of countersink tools, the most commonly used has an included angle of 100°.

Fig 2



FREEHAND COUNTERSINK AND DEBURRING TOOLS

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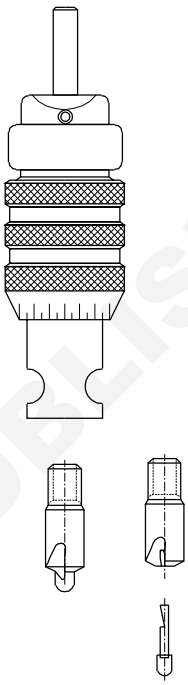
Sometimes types of 82° or 120° are used to form countersunk wells.

The **micro-stop countersink** is the preferred countersinking tool. (Fig. 3)

Fig 3



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It has an adjustable-sleeve cage that functions as a limit stop and holds the revolving countersink in a vertical position.

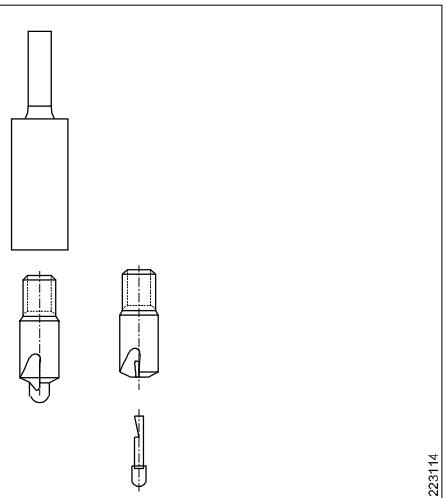
Its threaded and replaceable cutters may have either a removable or an integral pilot that keeps the cutter centred in the hole.

The pilot should be approximately 0.05 mm smaller than the hole size. It is recommended to test adjustments on a piece of scrap material before countersinking repair or replacement parts.

Freehand countersinking is needed where a micro-stop countersink cannot fit.

This method should be practiced on scrap material to develop the required skill. Holding the drill motor steady and perpendicular is as critical during this operation as when drilling.

Fig 4



Precautions

Chattering is the most common problem encountered when countersinking.

Some precautions that may eliminate or minimize chatter include:

- Use sharp tooling.
- Use a slow speed and steady firm pressure.
- Use a piloted countersink with a pilot approximately 0.05 mm smaller than the hole.
- Use back-up material to hold the pilot steady when countersinking thin sheet material.
- Prefer countersinking the parts of the assembly clamped together.
- Use a cutter with a different number of flutes.
- Pilot drill an undersized hole, countersink, and then enlarge the hole to final size.

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- Use a cutter with a different number of flutes.
- Pilot drill an undersized hole, countersink, and then enlarge the hole to final size.

Tools for riveting operation with squeezers.

Objectives: At the end of this lesson you shall be able to·
- **state the different types of squeezers and their use**
- **explain the accessories for squeezers.**

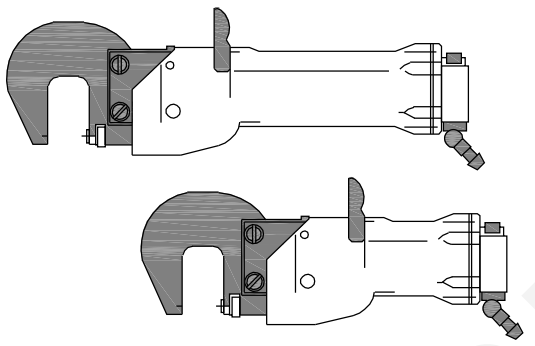
The two types of rivet squeezers, hand and pneumatic, operate on the same principles.

- In the hand rivet squeezer, compression is supplied by hand pressure.
- In the pneumatic rivet squeezer, by air pressure.

Pneumatic rivet squeezer

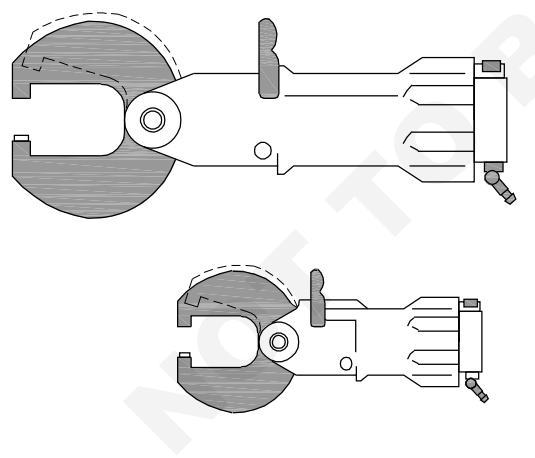
C-Yoke type (Fig. 1)

Fig 1



Alligator-Yoke type (Fig. 2)

Fig 2



Hand rivet squeezer (Fig. 3)

Bench and workshop rivet squeezer (Fig. 4)

Fig 3

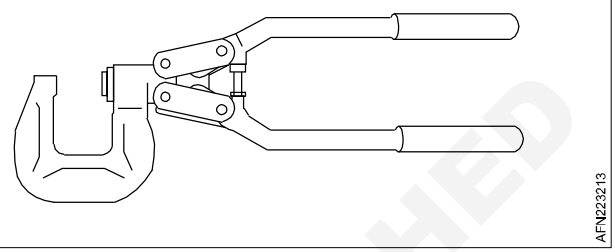
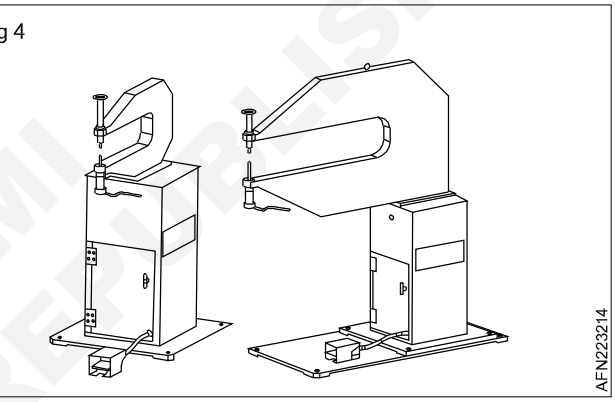


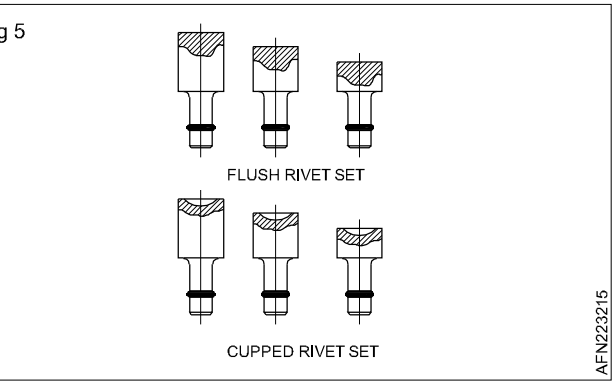
Fig 4



End sets for rivet squeezers (Fig. 5)

Rivet squeezer sets are available in flush and cupped style.

Fig 5



The choice of rivet set length is large and facilitates the setting.

Riveting operations with squeezer tools.

Objectives: At the end of this lesson you shall be able to·
- **explain about the rivet squeezers**
- **explain the use of rivet squeezers.**

Compression riveting (squeezing) is of limited value because this method of riveting can be used only over the edges of sheets or assemblies where conditions permit, and where the reach of the rivet squeezer is deep enough.

Riveting with a squeezer is a quick method and requires only one operator.

These riveters are equipped with either a C-yoke or an alligator yoke in various sizes to accommodate any size of rivet.

The working capacity of a yoke is measured by its gap and its reach. The gap is the distance between the movable jaw and the stationary jaw; the reach is the inside length of the throat measured from the centre of the end sets.

End sets for rivet squeezers serve the same purpose as rivet sets for pneumatic rivet guns and are available with the same type heads, which are interchangeable to suit any type of rivet head.

One part of each set is inserted in the stationary jaw, while the other part is placed in the movable jaws.

The manufactured head end set is placed on the stationary jaw whenever possible. During some operations, it may be necessary to reverse the end sets, placing the manufactured head end set on the movable jaw.

Setting the squeeze

To develop maximum power the riveter must squeeze the rivet near to the end of the riveting stroke. Therefore, the combined length of the two rivets sets must be correct.

You can adjust exactly the position of the rivet by adjusting the snap holder (stroke 5 mm). This allows to use the same rivet set for different thicknesses.

The squeezer can be set using the following calculation:

E - A - B = C + D

A: component thickness

B: height of finished rivet head (flush)

C: rivet set height (fixed)

D: rivet set height (mobile)

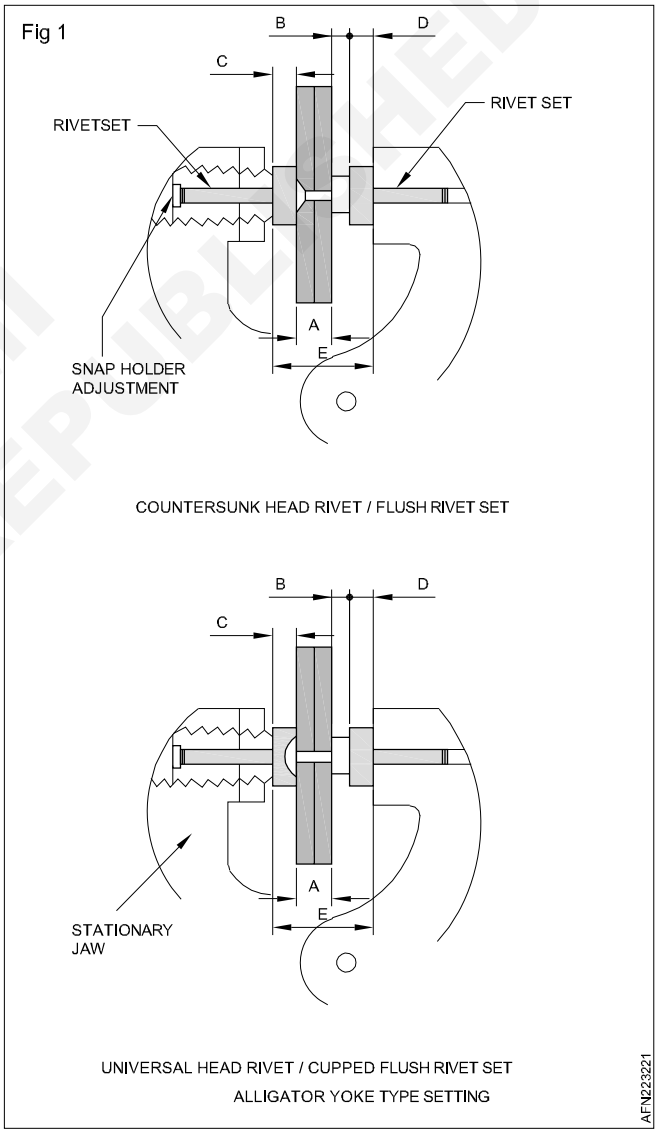
E: closed height dimension of the jaws (adjust by moving the snap holder)

Set the squeezer on scrap material of the same thickness

Once the adjustment is done in 2 or more squeezings, validate the setting by squeezing a new rivet at once. Indeed, the progressive hardening/squeezing of the rivet used for adjusting the squeezer can distort the first adjustment and the following rivet will be crushed.

If the up set head is not formed it may mean that the distance between the river sets is too small

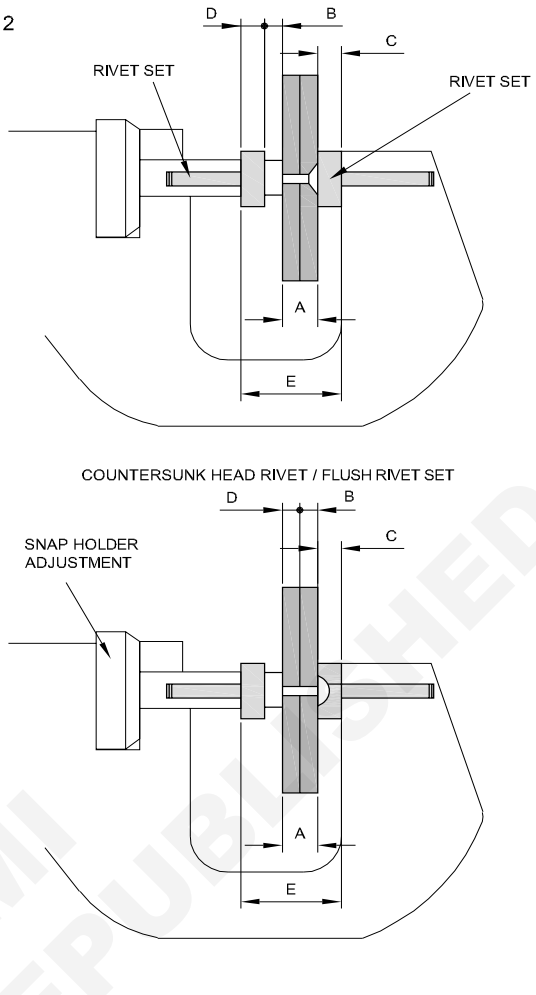
Fig 1



important points to remember when using pneumatic squeesers

- Keep the perpendicularity of the two arms with respect to the piece (aligned with the rivet).
- Ensure a stable support and hold head side strongly.
- Approach slowly (in alligator type, bring the mobile arm close to the hand)
- ·Avoid crashing the rivet set against the shank (risk of work hardening).
- If perpendicularity it lost during formation of upset head the squeezer will not be able to fix it.
- Choose the squeezer set that corresponds to the solid rivet.
- Never rework the pneumatic squeezer arms.

Fig 2



Evaluating the rivet

Objective: At the end of this lesson you shall be able to·
• state the riveting defects and theirs causes.

To obtain high structural efficiency in the manufacture of aircraft, an inspection must be made of all rivets before the part is put in service.

This inspection consists of examining both the shop and manufactured heads and the surrounding skin and structural parts for deformities.

A scale or rivet gauge can be used to check the condition of the upset rivet head to see that it conforms to the proper requirements.

Some common causes of unsatisfactory riveting are:

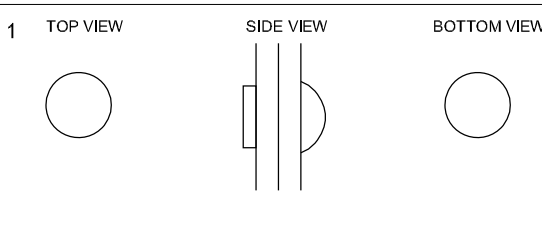
- Improper bucking,
- Rivet set slipping off or being held at the wrong angle,
- Rivet holes or rivets of the wrong size.

Additional causes for unsatisfactory riveting are countersunk rivets not flush with the well, work not properly fastened together during riveting, the presence of burrs, rivets too hard, too much or too little driving, and rivets out of line.

Rivets defects

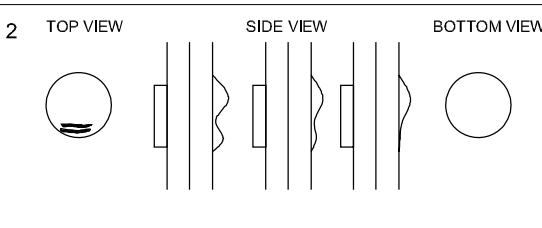
Driven correctly

Fig 1



Unsteady tool> Marked head

Fig 2



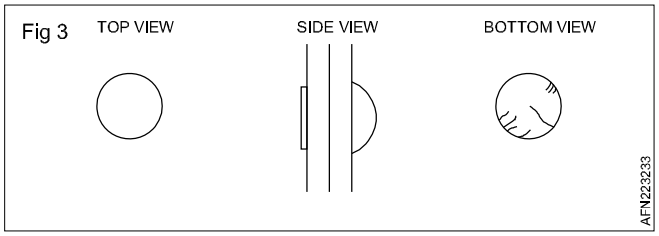
Imperfection : Cut or mark on the head.

Cause : Improperly held tools. Perpendicularity.

Remedy : Hold riveting tools perpendicular and firmly against the work.

Action : Replace rivet

Driven excessively



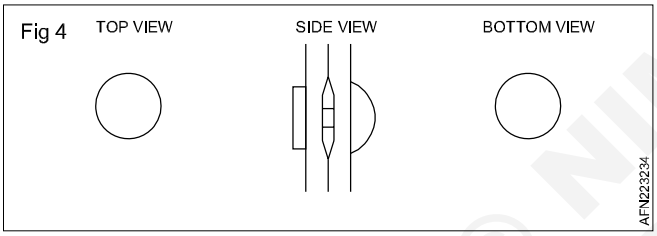
Imperfection : Excessively flat head. Resultant cracks.

Cause : Excessive driving. Too much pressure on the bucking bar.

Remedy : Improve riveting technique or setting squeezer.

Action : Replace rivet

Sheet separation



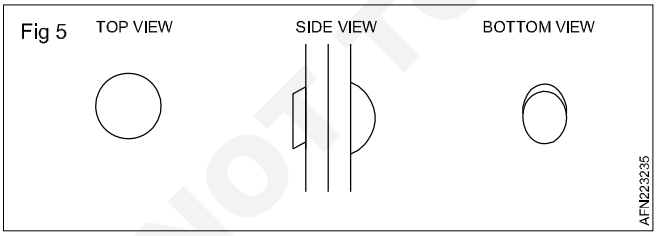
Imperfection : Sheet separation.

Cause : Work not held firmly, and rivet shank swelled.

Remedy : Fasten work firmly.

Action : replace rivet

Sloping upset head



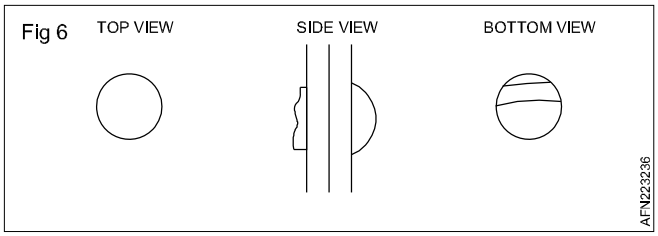
Imperfection : Sloping head.

Cause : Bucking bar not held correctly. Bucking bar sliding.

Remedy : Hold bucking bar firmly without too much pressure.

Action : Replace rivet

Marking upset head



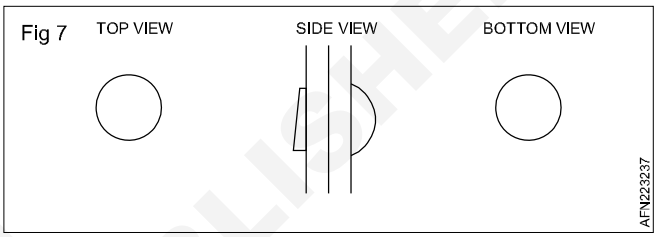
Imperfection : Bucking bar mark.

Cause : Bucking bar not held correctly. Bucking bar sliding.

Remedy : Hold bucking bar firmly without too much pressure.

Action : Replace rivet

Inclined upset head



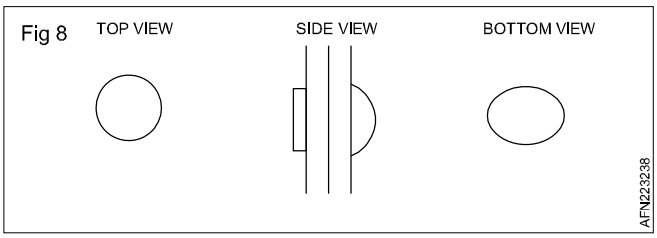
Imperfection : Inclined head.

Cause : Bucking bar not held perpendicular.

Remedy : Improve riveting technique.

Action : Check height and diameter. Replace rivet if out of limits.

Ovalized upset head



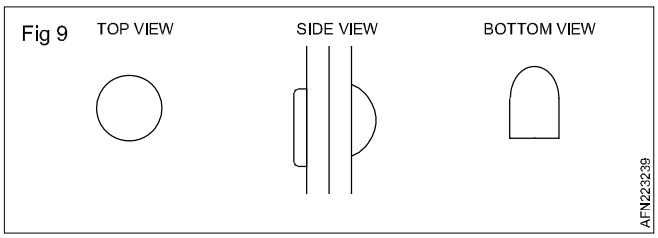
Imperfection : Ovalized head.

Cause : Bucking bar not held perpendicular.

Remedy : Improve riveting technique.

Action : Check both size diameter. Replace rivet if out of limits.

Buckled shank



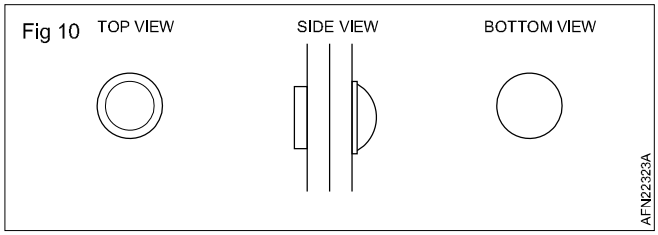
Imperfection : Buckled shank

Cause : Improper rivet length.

Remedy : Rivet proper length.

Action : Replace rivet.

Circular mark on the head



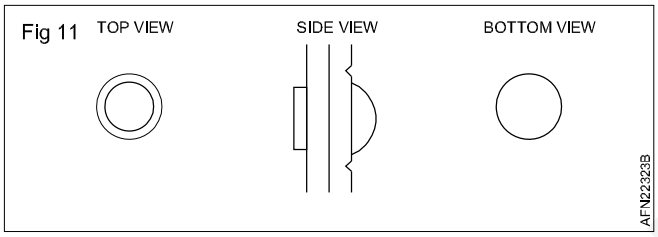
Imperfection : Circular mark.

Cause : Improper (too small) rivet set diameter.

Remedy : Rivet set proper diameter.

Action : Replace rivet.

Circular mark on the skin



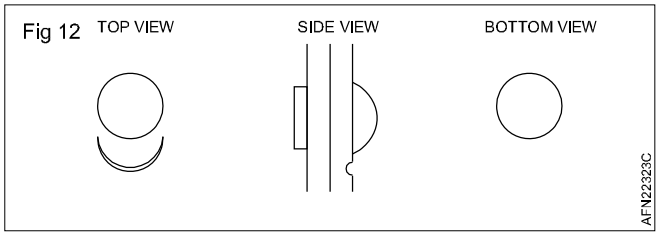
Imperfection : Circular mark.

Cause : Improper (too big) rivet set diameter.

Remedy : Rivet set proper diameter.

Action : Replace rivet.

Mark (eyebrow) on the skin



Imperfection : Mark on skin.

Cause : Rivet set not held perpendicular.

Remedy : Improve riveting technique.

Action : Check depth and angular size of the mark.

Tools for riveting operation with rivet gun

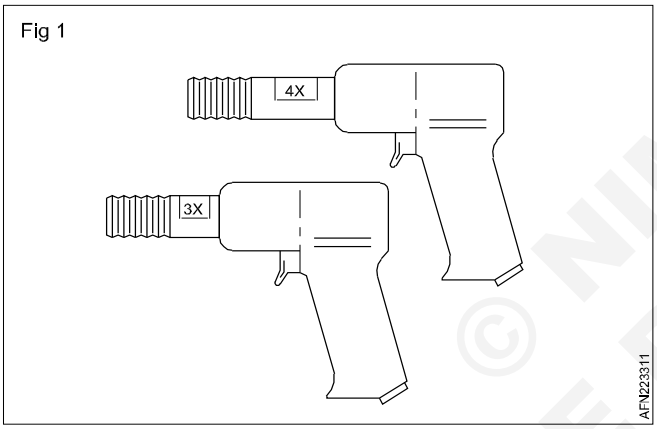
Objectives: At the end of this lesson you shall be able to·
- **explain the different tools for rivet gun riveting and their use**
- **explain the accessories for rivet gun riveters.**

Pneumatic Rivet Gun (Fig. 1)

The pneumatic rivet gun is the most common rivet upsetting tool used in airframe work. It is available in many sizes and types. The manufacturer's recommended capacity for each gun is usually stamped on the barrel. See table 1 for riveting capabilities.

Pneumatic guns operate on air pressure and are used in conjunction with interchangeable rivet sets. Each set is designed to fit the specific type of rivet and the location of the work.

Fig 1



Slow hitting rivet guns are the most common type.

These blows are slow enough to be easily controlled and heavy enough to do the job. These guns are sized by the largest rivet size continuously driven with size often based "X" series.

- 4X gun is used for normal work.
- 3X gun, the less powerful, is used for smaller rivets in thinner structure.
- 7X gun is used for large rivets in thicker structures.

A gun that is too powerful is hard to control and may damage the assembly. On the other hand, if the gun is too light, it may work harden the rivet before the head can be fully formed.

Table 1

Rivet diameter (mm)	Power of rivet gun
1.6 to 2.4	2X
3 to 4	3X
4 to 6	4X
6 to 8	7X

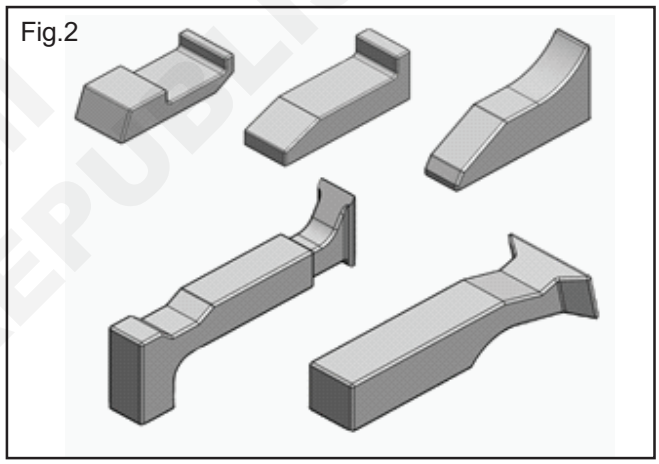
The rivet gun must be regularly lubricated by a drop of machine lubricant in the air flow entry point.

Bucking Bar

The bucking bar, sometimes called dolly bar, bucking iron, or bucking block, is a heavy chunk of steel (or tungsten alloy) whose counter-vibration during installation contributes to proper rivet installation.

They come in a variety of shapes and sizes (Fig.2), and their weights ranges depending upon the nature of the work.

Fig.2



Bucking bars are most often made from low-carbon steel that has been case hardened or alloy bar stock. Those made of better grades of steel last longer and require less reconditioning.

Bucking faces must be hard enough to resist indentation and remain smooth, but not hard enough to shatter.

The bucking bar usually has a light concave face to conform to the shape of the upset head (buck-tail) to be made.

Selection of the right bucking bar is one of the most important factors in bucking rivets.

When selecting a bucking bar, the first consideration is shape (Fig 1) then the weight (Table 2).

- If the bar does not have the correct shape, it deforms the rivet head.
- If the bar is too light, it does not give the necessary bucking weight, and the material may become bulged toward the upset head.
- If the bar is too heavy, its weight and the bucking force may cause the material to bulge away from the upset head.

Table 2 shows the bucking bar weights recommended for use with various sizes of rivets.

Table 2

Rivet diameter (mm)	Weight of bucking bar
1.6 to 2	100g
2.4 to 3.5	200g
4 to 5	300g
6 to 8	400g

This tool should be held against the shank end of a rivet while the upset head is being formed. Always hold the face of the bucking bar at right angles to the rivet shank. Failure to do so causes the rivet shank to bend with the first blows of the rivet gun and causes the material to become ovalized or buckled with the final blows.

The bucking bar do not touch the workpiece.

The bucker must hold the bucking bar in place until the rivet is completely driven.

If the bucking bar is removed while the gun is in operation, the rivet set may be driven through the material.

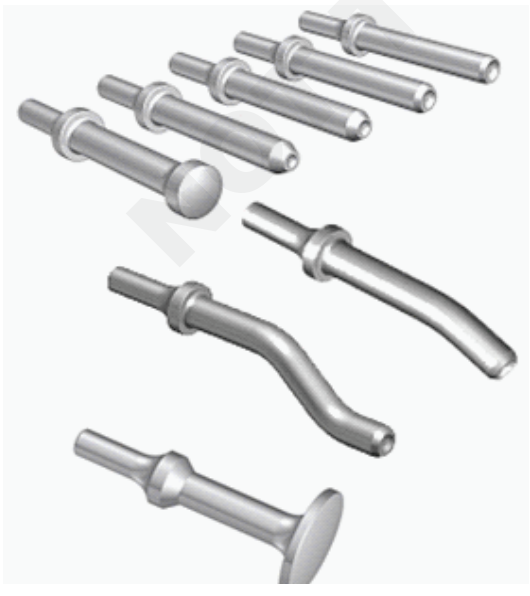
Defective rivet heads can be caused by lack of proper vibrating action, the use of a bucking bar that is too light or too heavy, and failure to hold the bucking bar at right angles to the rivet.

The bucking bars must be kept clean, smooth, and well-polished. Their edges should be slightly rounded to prevent marring the material surrounding the riveting operation.

Rivet Sets/Headers (Fig 3)

Pneumatic guns are used in conjunction with interchangeable rivet sets or headers. Each is designed to fit the type of rivet and location of the work. The shank of the rivet header is designed to fit into the rivet gun.

Fig 3



An appropriate header must be a correct match for the rivet being driven. The working face of a header should be properly designed and smoothly polished.

They are made of forged steel, heat treated to be tough but not too brittle.

Rivet headers are available in two shapes:

- Flush rivet head for countersunk rivets.
- Cupped rivet head for universal head rivets.

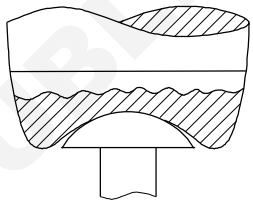
Flush headers come in various sizes:

- Smaller ones concentrate the driving force in a small area for maximum efficiency.
- Larger ones spread the driving force over a larger area and are used for the riveting of thin skins.

With cupped headers, care must be taken to match the size of the rivet. (Fig. 4)

- A header that is too small marks the rivet
- A header that is too large marks the workpiece.

Fig 4



Rivet headers are made in a variety of styles.

- The short, straight header is best when the gun can be brought close to the work.
- Offset headers may be used to reach rivets in obstructed places.
- Long headers are sometimes necessary when the gun cannot be brought close to the work due to structural interference.

Rivet headers should be kept clean.

Riveting operations with rivet gun

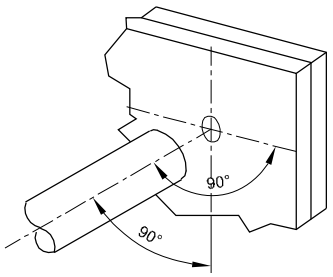
Objective: At the end of this lesson you shall be able to·
- **explain the function of rivet gun**

Pneumatic gun method

In pneumatic riveting, the pressure for bucking the rivet is applied with a rivet set and a pneumatic rivet gun.

When using a pneumatic rivet gun, the rivet gun and bucking bar should be held at right angles to the work piece and enough pressure should be applied to prevent the bucking bar from jumping off. (Fig. 1)

Fig 1

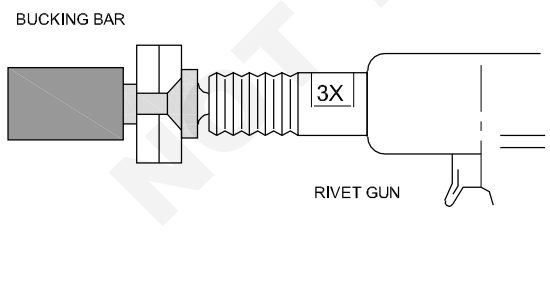


The shank of the set is designed to fit into the rivet gun. An air driven hammer inside the barrel of the gun supplies force to buck the rivet.

The bucker hands merely guide the bar and supply the necessary tension and rebound action. Coordinated bucking allows the bucking bar to vibrate in unison with the gun set. Do not push too hard.

A rivet gun with the correct rivet set must be held snugly against the rivet head and perpendicular to the surface while a bucking bar of the proper weight is held against the opposite end. The force of the gun must be absorbed by the bucking bar and not the structure being riveted. When the gun is triggered, the rivet is driven.

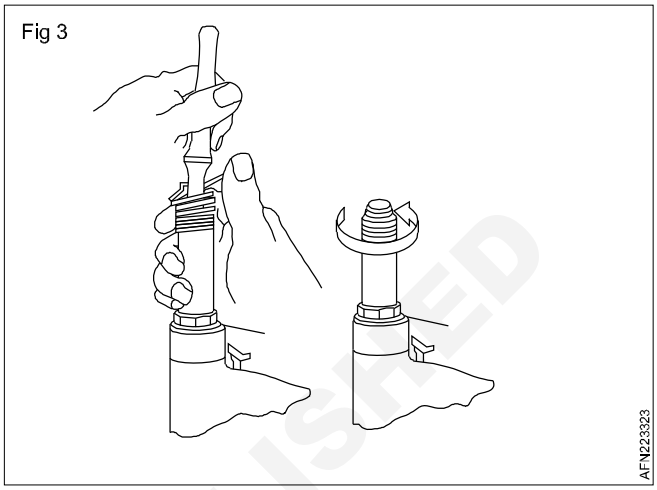
Fig 2



Always make sure the correct rivet header and the retaining spring are installed. (Fig. 3)

Test the rivet gun on a piece of wood and adjust the air valve to a setting that is comfortable for the operator. The driving force of the rivet gun is adjusted by a needle valve on the handle. Adjustments should never be tested against anything harder than a wooden block to avoid header damage.

Fig 3



The riveting action should start slowly and be one continued burst.

If the riveting starts too fast, the rivet header might slip off the rivet and damage the rivet (smiley) or damage the skin (eyebrow).

Try to drive the rivets within 3 seconds, because the rivet will work harden if the driving process takes too long. The dynamic of the driving process has the gun hitting, or vibrating, the rivet and material, which causes the bar to bounce, or counter-vibrate. These opposing blows (low frequency vibrations) squeeze the rivet, causing it to swell and then form the upset head (or buck-tail).

Some precautions to be observed when using a rivet gun are:

- Never point a rivet gun at anyone at any time. A rivet gun should be used for one purpose only: to drive or install rivets.
- Never depress the trigger mechanism unless the set is held tightly against a block of wood or a rivet.
- Always disconnect the air hose from the rivet gun when it is not in use for any appreciable length of time.

If a long row of rivets is to be driven, time can be saved by inserting several rivets in the holes and holding them in place with a strip of adhesive tape (Fig. 5) over their heads. The rivet gun may be placed on the rivets without removing the tape.

Thus, the tape serves a double purpose:

- It holds the rivets in place.
- It forms a cushion to prevent the rivet set from damaging the material.

Use of rivet adhesive tape (Fig 4)

In order to hold rivets in place before riveting, it is possible to use a special adhesive tape.

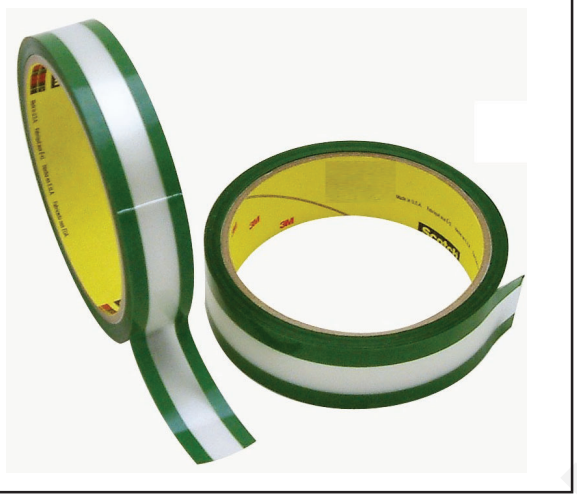
This tape is transparent in the centre and has two adhesive parts on the edges.

The transparent, tack-free center window also improves visibility and accuracy during the riveting process.

Always ensure a pinning as defined in the work card.

Use only authorized adhesive tape.

Fig 4



Never use paper adhesive tape to hold the rivet in place; adhesive can penetrate under the rivet head.

Never use paper adhesive tape on the tip of the rivet set (rivet header); the shape of the rivet head may be deformed.

Driving the rivet

Although riveting equipment can be either stationary or portable, portable riveting equipment is the most common type of riveting equipment used to drive solid shank rivets in airframe repair work.

Before driving any rivets into the sheet metal parts, be sure all holes line up perfectly, all shavings and burrs have been removed, and the parts to be riveted are securely fastened with temporary fasteners.

Depending on the job, the riveting process may require one or two people.

- In solo riveting, the riveter holds a bucking bar with one hand and operates a riveting gun with the other.
- If the job requires two aircraft fitters, a shooter or gunner, and a bucker work together as a team to install rivets.

A rivet gun should upset a rivet in 1 to 3 seconds. With practice, an aircraft fitter learns the length of time needed to hold down the trigger.

An important component of team riveting is an efficient signalling system that communicates the status of the riveting process.

This signalling system usually consists of tapping the bucking bar against the rivet buck-tail (not on the aircraft part) and is often called the “tap code”.

- One tap may mean not fully seated, hit it again.
- Two taps may mean good rivet.
- Three taps may mean bad rivet, remove and drive another.

Radio sets are also available for communication between the aircraft fitters.

A rivet installation is assumed satisfactory when the rivet head is seated snugly against the item to be retained (0.04 mm feeler gauge should not go under rivet head for more than one-half the circumference). See 2.1.41 chapter.

Be very careful when using a pneumatic rivet gun.If a rivet set is placed in a pneumatic rivet gun without a set retainer and the throttle of the gun is open, the rivet set could be projected out of the gun like a bullet and cause severe personnel injury, equipment damage, orboth.

Never point a rivet gun at anyone at any time.

Never depress the trigger mechanism un lessthe set is held tightly against a block of wood or a rivet.

Always disconnect the air hose from the rivet gun if it will not be used for some time.

Basic study of stress - strain curve for MS.

Objectives: At the end of this lesson you shall be able to·
- **explain the stress-strain curve**
- **name the points and zones on the stress-strain curve.**

Definitions

Stress (σ)

If an applied force causes a change in the dimension of the material, then the material is in the state of stress. If we divide the applied force (F) by the cross-sectional area (A), we get the stress.

The symbol of stress is σ (sigma). For tensile (+) and compressive (-) forces.

The standard international unit of stress is the pascal (Pa).

1 Pa = 1 N/m2.

The formula to derive the stress number is $\sigma = F/A$.

For tensile and compressive forces, the area taken is perpendicular to the applied force.

For sheer force, the area is taken parallel to the applied force. The symbol for shear stress is tau (σ).

σ : Tensile/compression stress

T : Shear stress

F : Applied force

A : Cross-sectional area

Strain (ε)

Strain is the change in the dimension ($L-L_0$) with respect to the original.

It is denoted by the symbol å(epsilon).

The formula is $\varepsilon = (L-L_0) / L_0$.

For a shear force, strain is expressed by ã (gamma)

ε : strain

Y : strain force

L : final length

L_0 : initial length

Proportional limit (Hooke's Law)

From the origin O to the point called proportional limit, the stress-strain curve is a straight line.

The stress is directly proportional to strain.

Yield Point (Y)

Yield point is the point at which the material will have an appreciable elongation or yielding without any increase in load.

Ultimate Strength (U)

The maximum ordinate in the stress-strain diagram is the ultimate strength or tensile strength.

Rupture Strength (R)

Rupture strength is the strength of the material at rupture. This is also known as the breaking strength.

Young's modulus or modulus of elasticity (E)

Within the proportional limit, stress = E × strain. E is a proportionality constant known as the modulus of elasticity or Young's modulus of elasticity. Young's modulus is a measure of the ability of a material to withstand changes in length when under lengthwise tension or compression. It is equal to the slope of the stress-strain diagram from the origin (O) to the proportional limit (P).

E has the same unit as the unit of stress because the strain is dimensionless.

The formula is **$E = \sigma / \varepsilon$ Pa.**

E : modulus of elasticity

σ : tensile/compression stress

ε : strain

The elastic limit is the limit beyond which the material will no longer go back to its original shape when the load is removed, or it is the maximum stress that may e developed such that there is no permanent or residual deformation when the load is entirely removed.

Elastic and Plastic Ranges

The region in stress-strain diagram from O to P is called the elastic range.

The region from P to R is called the plastic range.

Elasticity

Elasticity is the property of the material which enables the material to return to its original form after the external force is removed.

Plasticity

This is a property that allows the material to remain deformed without fracture even after the force is removed.

Modulus of resilience

The area under the curve which is marked by the grey area. It is the energy absorbed per volume unit up to the elastic limit.

Stress-strain curve

Suppose that a metal specimen be placed in tension-compression-testing machine. As the axial load is gradually increased in increments, the total elongation over the gauge length is measured at each increment of the load and this is continued until failure of the specimen takes place.

Knowing the original cross-sectional area and length of the specimen, the normal stress ó and the strain å can be obtained.

The graph of these quantities with the stress ó along the y-axis and the strain å along the x-axis is called the stress-strain diagram or curve. The stress-strain diagram differs in form for various materials.

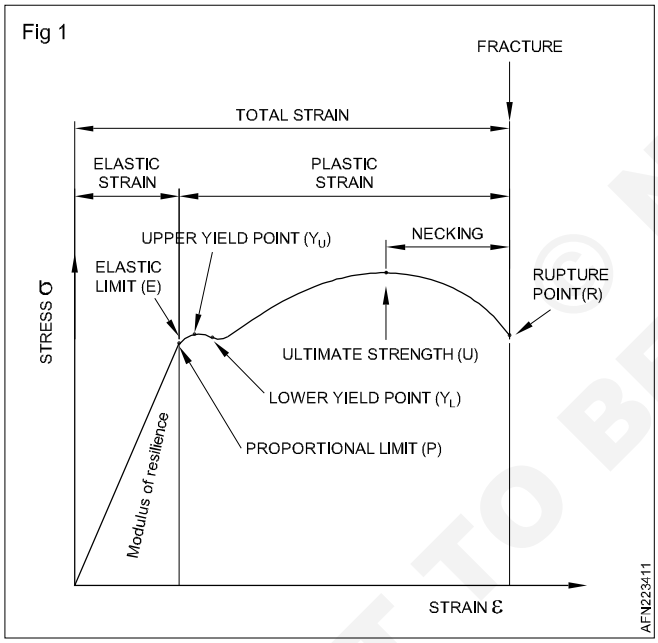
These curves reveal many of the properties of a material such as the Young's modulus, the yield strength and the ultimate tensile strength.

Basic study of stress-strain curve

The diagram shown below is that for a medium-carbon steel (Fig. 1).

See definitions for each zone and point.

Fig 1



If tensile force is applied to a steel bar, it will have some elongation. If the force is small enough, the ratio of the stress and strain will remain proportional.

This can be seen in the graph as a straight line between zero and point P (limit of proportionality).

If the force is greater, the material will experience elastic deformation, but the ratio of stress and strain will not be proportional. This is between points P and E, known as the elastic limit.

Beyond the elastic limit, the mild steel will experience plastic deformation. This starts the yield point –which is point Y_U (upper yield point).

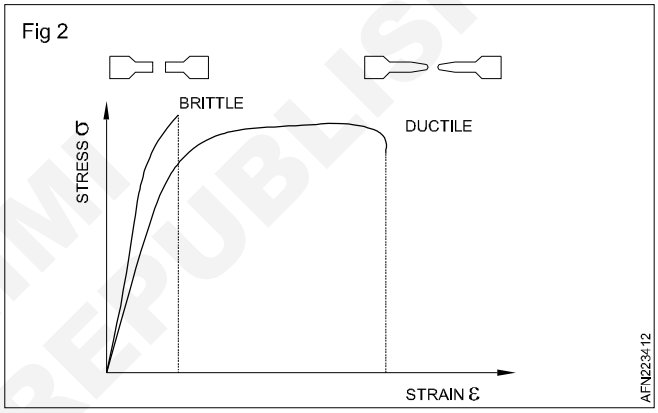
As seen in the graph, from this point on the correlation between the stress and strain is no longer on a straight trajectory. It curves from point Y_L (lower yield point), to U (maximum ultimate strength), ending at R (rupture point).

Classification of materials and theirs curves

Metallic engineering materials are classified as either ductile or brittle materials.

A ductile material is one having relatively large tensile strains up to the point of rupture like structural steel and aluminium, whereas brittle materials has a relatively small strain up to the point of rupture like cast iron. (Fig. 2)

Fig 2



Working Stress, Allowable Stress, and Factor of Safety

Working stress is defined as the actual stress of a material under a given loading.

The maximum safe stress that a material can carry is termed as the allowable stress.

The allowable stress should be limited to values not exceeding the proportional limit. However, since proportional limit is difficult to determine accurately, the allowable tress is taken as either the yield point or ultimate strength divided by a factor of safety.

The ratio of this strength (ultimate or yield strength) to allowable strength is called the factor of safety.

Physical and mechanical properties of metals

Objectives: At the end of this lesson you shall be able to·
- **state the physical properties of metals**
- **explain the mechanical properties of metals.**

Metal

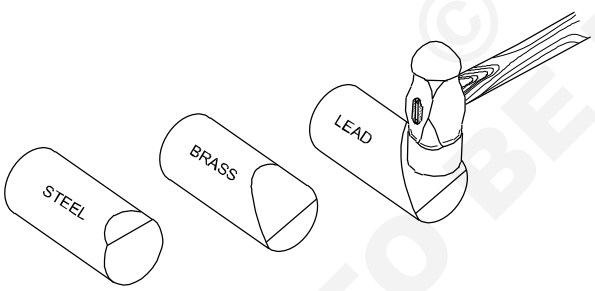
Metal is a mineral used in all types of engineering works such as machineries, bridges, aero planes etc., so we must have basic knowledge about the metals.

Understanding the physical and mechanical properties of metals has become increasingly important for a machinist since he has to make various components to meet the designed service requirements against factors, such as the raise of temperature, tensile, compressive and impact loads etc. A knowledge of different properties of materials will help him to do his job successfully. If proper material/ metal is not used it may cause fracture or other forms of failures and endanger the life of the component when it is put into function.

Fig 1 shows the way in which the metals get deformed when acted upon by the same load.

Note the difference in the amount of deformation.

Fig 1



Physical properties of metals

Colour

Weight/specific gravity

Structure

Conductivity

Magnetic property

Fusibility

Colour

Different metals have different colours.

For example, copper is distinctive red colour. Mild steel is blue/black sheen.

Weight

Metals may be distinguished, based on their weights for given volume. Metals like aluminium lighter weight (Specific gravity of aluminium: 2.7) and metals like lead have a higher weight. (Specific gravity 11.34)

Structure (Fig 2, 3)

Generally, metals can also be differentiated by their internal structures while seeing the cross-section of the bar through a microscope. Metals like wrought iron and aluminium have a fibrous structure and metals like cast Iron and bronze have a granular structure.

Fig 2

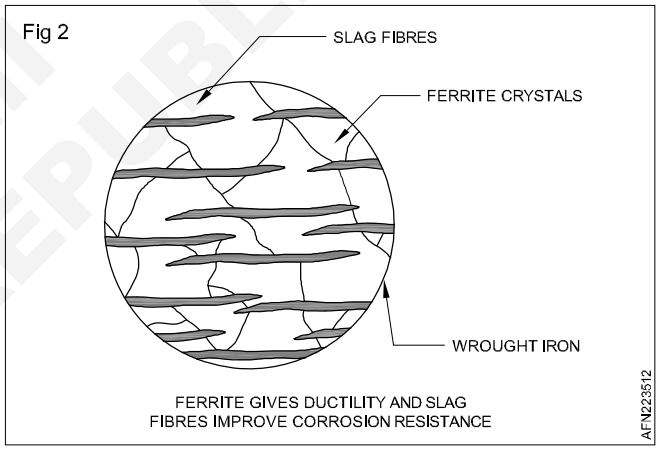
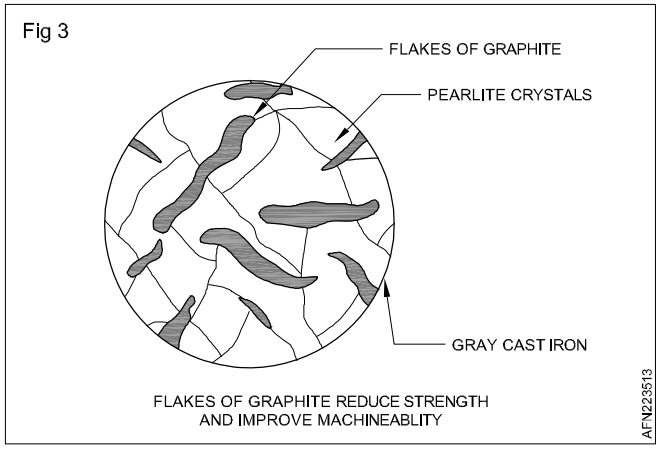


Fig 3



Conductivity (Fig 4, 5)

Thermal conductivity and electrical conductivity are the measures of ability of a material to conduct heat and electricity. Conductivity will vary from metal to metal.

Copper and aluminium are good conductors of heat and electricity

Fig 4

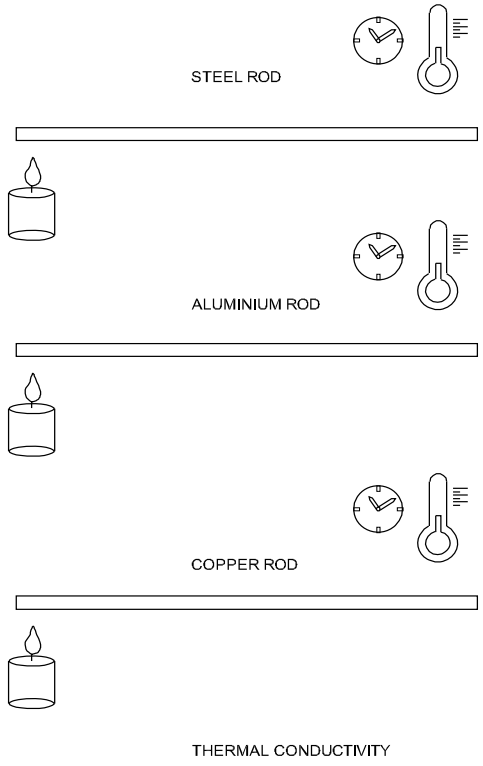


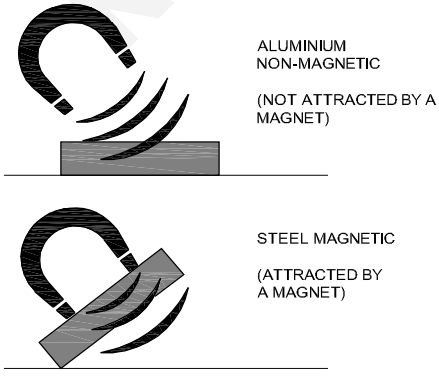
Fig 5

Magnetic property

A metal is said to possess a magnetic property if it is attracted by a magnet.

Almost all ferrous metals, except some types of stainless steel, can be attracted by a magnet, and all non-ferrous metals and their alloys are not attracted by a magnet.

Fig 6

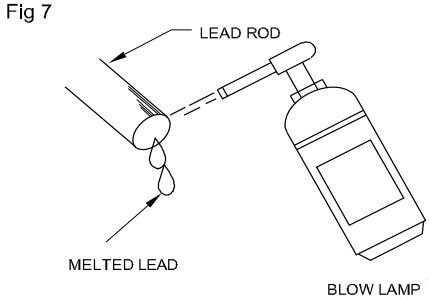


Fusibility (Fig 7)

It is the property possessed by a metal by virtue of which it melts when heat is applied. Many materials are subject to transformation in the shape from solid to liquid at different temperatures. Lead has a low melting temperature while steel melts at a high temperature.

- Tin melts at 232°C.
- Tungsten melts at 3370°C.

Fig 7



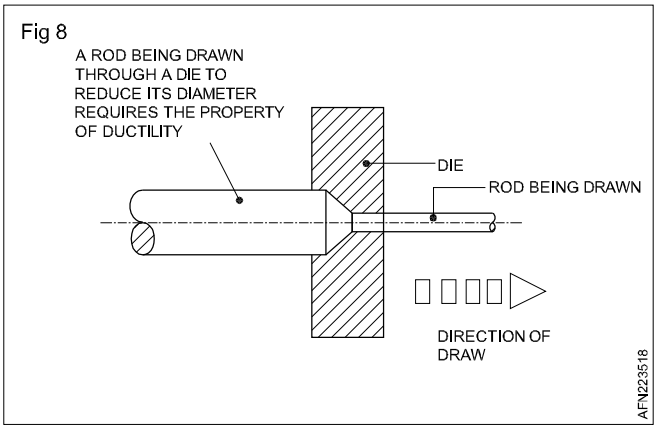
Mechanical properties

- Ductility
- Malleability
- Hardness
- Brittleness
- Toughness
- Tenacity
- Elasticity

Ductility (Fig 8)

A metal is said to be ductile when it can be drawn out into wires under tension without rupture. Wire drawing depends upon the ductility of a metal. A ductile metal must be both strong and plastic. Copper and aluminium are good examples of ductile metals.

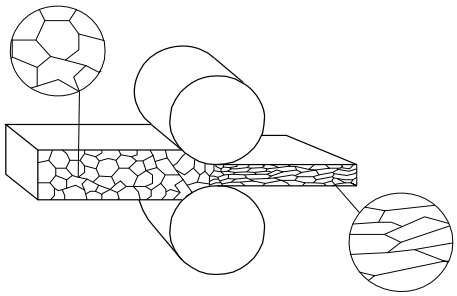
Fig 8



Malleability (Fig 9)

Malleability is the property of a metal by which it can be extended in any direction by hammering, rolling etc. without causing rupture. Lead is an example of a malleable metal.

Fig 9



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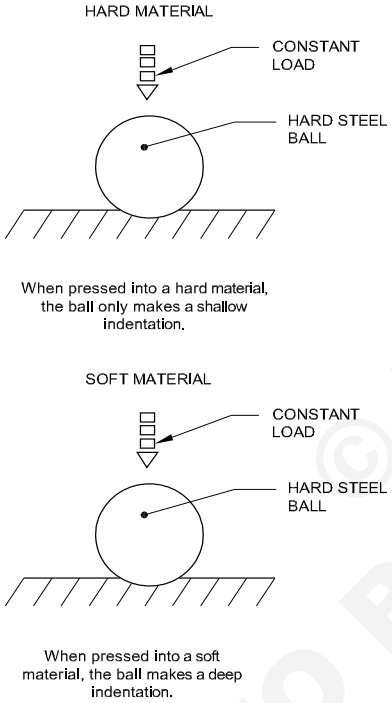
Hardness (Fig. 10)

Hardness is a measure of a metal's ability to withstand scratching, wear and abrasion, indentation by harder bodies. The hardness of a metal is tested by marking by a file etc.

Fig 10



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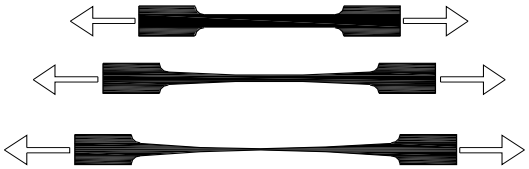
Tenacity (Fig 12)

The tenacity of a metal is its ability to resist the effect of tensile forces without rupturing. Mild steel wrought iron and copper are some examples of tenacious metals.

Fig 12



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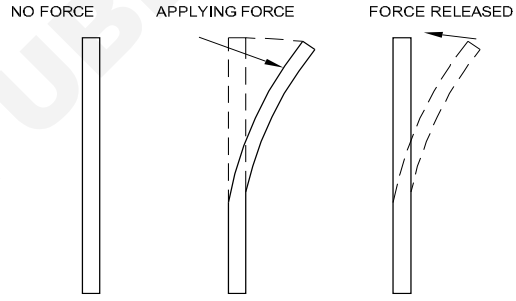
Elasticity

Elasticity of a metal is its power of returning to its original shape after the applied force is released. Properly heat-treated spring is a good example for elasticity.

Brittleness (Fig 11 a)

Brittleness is that property of a metal which permits no permanent distortion before breaking. Cast iron is an example of a brittle metal which will break rather than bend under shock or impact.

Fig 13



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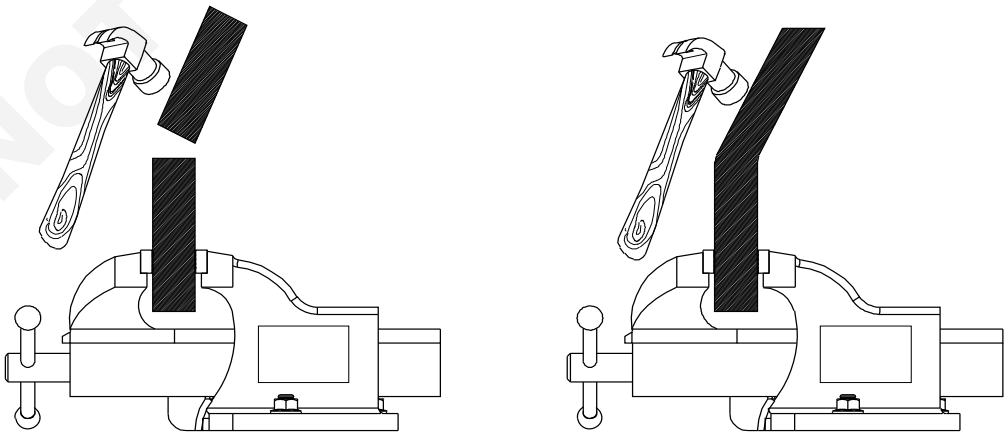
Toughness (Fig 11 b)

Toughness is the property of a metal to withstand shock or impact. Toughness is the property opposite to brittleness.

Wrought iron is an example of a tough metal.

Fig 11



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Mass, volume, density, weight and specific gravity

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

- **state the physical properties of metals**
- **explain the mechanical properties of metals**

Mass (Fig 1)

Mass of a body is the quantity of matter contained in a body. The unit of mass in F.P.S system is pound (lb), in C.G.S. system gram (gr) and in M.K.S and S.I systems kilogram (kg). 1ton which is 1000 kg is also used sometimes.

The conversion factor is 1000.

Three decimal places are shifted during conversion.

Examples:

- 1 ton = 1000 kg
- 1g = 1000mg

m - mass of a body

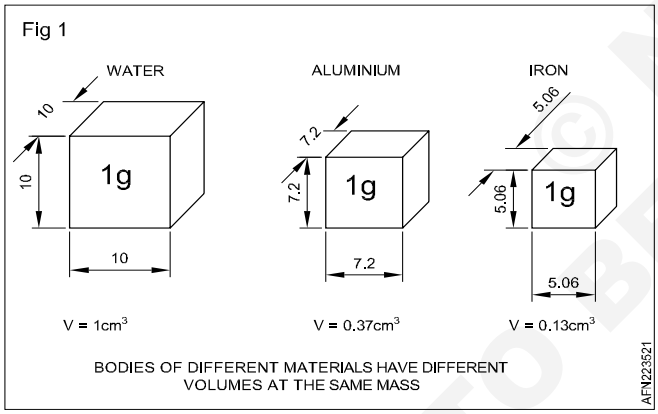
g - acceleration due to gravity in metre/sec^2

= 9.81 m/sec^2

V - volume of the body

r - density (pronounced as 'rho')

W or F_G - weight or weight force



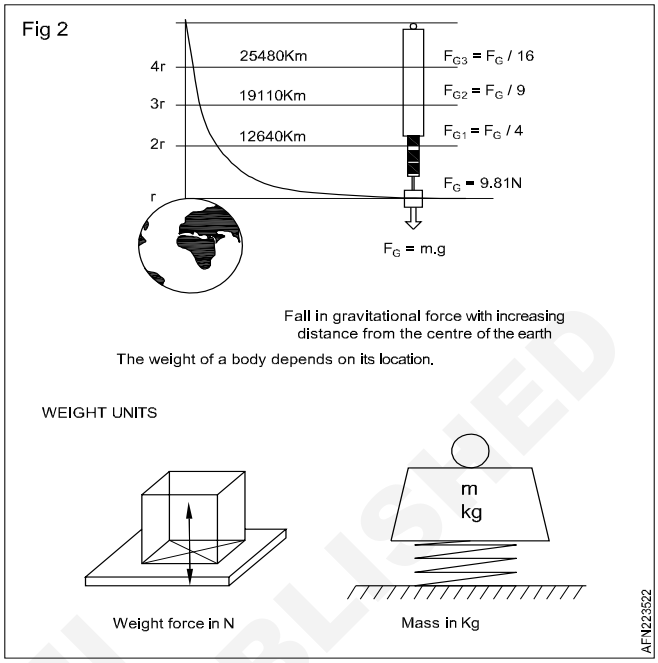
Density

Density is the mass of a body per unit volume. Hence its unit will be gr/cm3 or kg/dm3 or ton/m^3.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{m}{v} = p$$

Weight(Fig. 2)

Weight is the force with which a body is attracted by the earth towards its centre. It is the product of the mass of the body and the acceleration due to gravity. The weight of a body depends upon its location.



Weight

W or F_G = mass x gravitational force= m x g

System	Absolute unit	Derived unit	Conversion
F.P.S. system	1 poundal	1 Lbwt	32.2 poundals (1 lb x 1 ft/sec^2 = 1 pound)
C.G.S. system	1 dyne 1 gr x 1 cm/sec^2	1 Gr.wt	981 dynes
M.K.S.	Newton	1 kg.wt	1 Newton =
S.I.system	Newton	Newton	1 kg x 1 m/sec^2

1 kg.wt = 9.81 Newton (approximately 10N) **1 Newton = 10^5 dynes.**

Difference between mass and weight

S. No	Mass	Weight
1	Mass is the quantity of matter in a body (ie) measurement of matter in a body	Weight is measure of amount of force acting on mass due to acceleration due to gravity
2	It does not depend on the position or space	It depends on the position, location and space
3	Mass of an object will not be zero	Weight of an object will be zero if gravity is absent
4	It is measured using by physical balance	It is measured using by spring balance
5	It is a scalar quantity	It is a vector quantity
6	When immersed in water mass does not change	When immersed in water weight will change
7	The unit is in grams and kilogram	The unit is in kilogram weight, a unit of force

Mass and weight are different quantities.

Mass of a body is equal to volume x density.

Weight force is equal to mass x acceleration due to gravity.

Weight, Density and Specific gravity

It is now seen that the mass of a substance is measured byits weight only without any reference to volume. But if equal weights of lead & aluminium, are compared the volume of lead is much smaller than volume of aluminium.

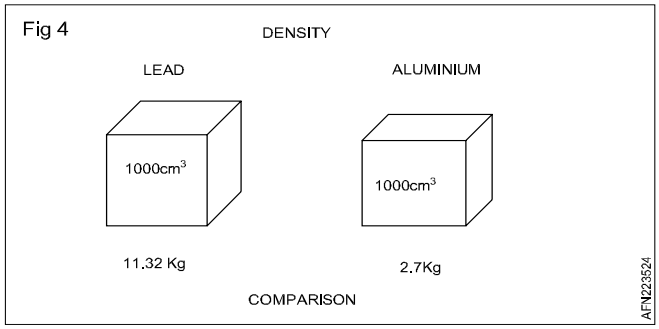
So, we can now say that lead is more dense than aluminium. In other words the density of lead is greater than aluminium.

Fig 3

The relation of mass and volume is called density.

The density expresses the mass of volume E.g. 1 dm^3 of water has the mass of 1kg - thus the density of 1kg/dm^3

Fig 4



Unit

The density is measured as below.

MKS/SI= Kg/m^3, CGS - 1 gm/cm3 FPS–lbs/c ft

Solids	gm/cc^3	Liquids	gm/cc^3
1 Aluminum	2.7	Water	1.00
2 Lead	11.34	Petrol	0.71
3 Cast iron	6.8 to 7.8	Oxygen	1.43
4 Steel	7.75 to 8.05	Diesel oil	0.83

The specific gravity of a substance is also called its relative density.

Formula

$$\text{Specificgravity} = \frac{\text{Density of the substance}}{\text{Desity of the water at } 4^\circ C}$$

(or) Relative density

$$= \frac{\text{Mass of an volume of a substance}}{\text{mass of an equal volume of water at } 4^\circ C}$$

Comparison Between Density and Specific Gravity (Relative Density)

Solids	gm/cc^3	Liquids	gm/cc^3
1 Aluminum	2.7	Water	1.00
2 Lead	11.34	Petrol	0.71
3 Cast iron	6.8 to 7.8	Oxygen	1.43
4 Steel	7.75 to 8.05	Diesel oil	0.83

Density	Relative density or Specfiic gravity
Mass per unit volume of a substance is called its density	The density of substance to density of water at 4°C is its relative density
Its unit is gm per cu cm; lbs per cu.ft and kg/cubic meter	It has no unit of measure-ment simply expressed in a number
$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$	Relative density $= \frac{\text{Density of the substance}}{\text{Density of water at 4°C}}$

	Solids	Sp.gy	Liquids	Sp.gy
1	Aluminium	2.72	Petrol	0.71
2	Lead	11.34	Battery acid	1.2 to 1.23
3	Cast iron	6.8 to 7.8	Water	1.00
4	Steel	7.82	Diesel Oil	0.83

From the above table, we can calculate the weight of any given volume of a substance (say Diesel oil) in any units provided we know the specific gravity of the substance.

Also, vice-versa for volume of density is known.

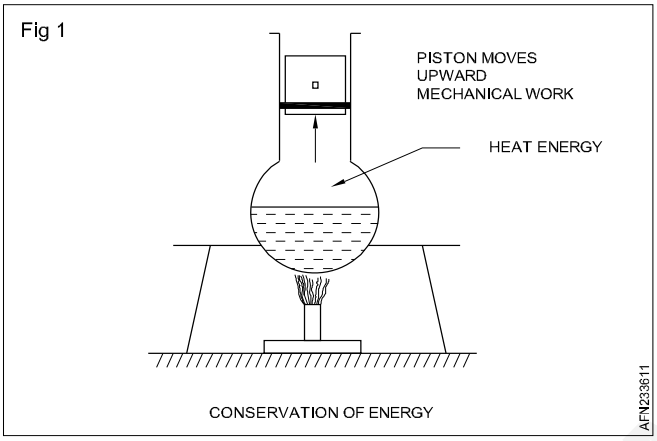
Concept of heat and temperature

Objective: At the end of this lesson you shall be able to·
- **understand the principal concepts of heat and temperature.**

Heat

It is a form of energy. Heat energy can be transformed in to other forms of energies. Heat flows from a hotter body to a colder body. (Fig 1)

Fig 1



Units of heat

Calorie: It is the quantity of heat required to raise the temperature of 1 gram of water through 1°C.

Joule: S.I. Unit (1 Calorie = 4.186 joules)

Effects of heat

- Change in temperature
- Change in size
- Change in state
- Change in structure
- Change in Physical properties

Specific heat

The quantity of heat required to raise the temperature of one gram of a substance through 1°C is called specific heat. It is denoted by the letter 's'.

- Specific heat of water = 1
- Aluminium = 0.22
- Copper = 0.1
- Iron = 0.12

Thermal capacity:

It is the amount of heat required to raise the temperature of a substance through 1°C is called the thermal capacity of the substance.

Thermal capacity = ms calories.

Calorific value

The amount of heat released by the complete combustion of unit quantity of the fuel (Mass or volume) is known as calorific value of fuels.

Temperature

It is the degree of hotness or coldness of a body. The temperature is measured by thermometers.

Boiling point

Any substance starts turning into a gas shows the temperature at which it boils this is known as the boiling point. The boiling point of water is 100°C.

Melting point

The temperature at which any solid melts into liquid or liquid freezing to solid is called the melting point of substance. The melting point of ice is 0°C.

List of melting point and boiling point of metals and Non - metals.

Metals and Non-metals	Melting Point °C	Boiling Point °C
Manganese	1246	2061
Mercury	-38.72	357
Molybdenum	2617	4636
Nickel	1453	2913
Nitrogen	-209 86	-195.79
Oxygen	-226.65	-182.95
Phosphorus (white)	44.1	280
Plutonium	640	3228
Potassium	63.35	759
Radium	700	1737
Silicon	1410	3265
Silver	961	2162
Sodium	98	883
Sulphur	115.38	444.6
Tin	232.06	2602
Titanium	1660	3287
Tungsten (wolfram)	3422	5555
Uranium	1132	4131
Zine	419.73	907

Metals and Non-metals	Melting Point °C	Boiling Point °C
Aluminium	660.25	2519
Argon	-189.19	-185.95
Arsenic	817	614
Barium	729	1897
Beryllium	1287	2469
Bromine	-7.1	58.8
Cadmium,	321.18	767
Calcium	839	1484
Carbon (diamond)	3550	4827
Carbon (graphite)	3675	4027
Chlorine	-100.84	-34.04
Cobalt	1495	2927
Copper	1084.6	2856
Gold	1084.58	2856
Helium	-	-268.93
Hydrogen	-259.98	-252.87
Iodine	113.5	184.3
Indium	2443	4428
Iron	1535	4428
Lead	327.6	1749
Lithium	180.7	1342
Magnesium	650	1090

Difference between heat and temperature

Heat	Temperature
It is a form of energy.	This tells the state of heat.
Its unit is calorie	Its unit is degree.
Heat is measured by calorimeter	Temperature is measured by the mometer.
By adding quantity of heat of two substances their total heat can be calculated.	by adding two temperature we cannot find the tmeperature of the mixture.
By heating a substance the quantity of heat is increased regardless of increase in temperture	Two substances read the same temperature though they might be having different amount of heat in them

Temperature measuring instruments and transmission of heat

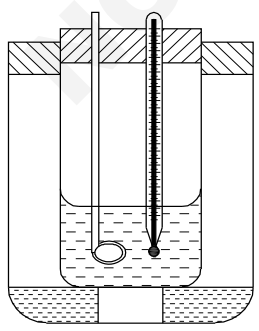
Objectives: At the end of this lesson you shall be able to·

- **State the types of thermometers.**
- **explain the transmission of heat.**

Measuring heat energy

Energy can be released in chemical reactions as light, sound or electrical energy. But it is most often released as heat energy. This allows us to easily measure the amount of heat energy transferred.

Fig 1



SIMPLE CALORIMETER

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The apparatus used to measure the amount of heat by mixer method is called calorimeter. It is nothing but cylindrical shaped vessel and a stirrer made out of mostly copper.

In a calorimeter when the hotter solid/liquid substance are mixed with the cooler solid/liquid substances, heat transfer takes place until both substances reach the same temperature.

By the same time calorimeter also reaches the same temperature. By mixing rule,

$$\begin{bmatrix}\text{lossofheat}\\ \text{bysolid/}\\ \text{liquid}\end{bmatrix} = \begin{bmatrix}\text{Heatabsorbedby}\\ \text{solid/liquid}\\ \text{substance}\end{bmatrix} + \begin{bmatrix}\text{Heatabsorbed}\\ \text{bycalorimeter}\end{bmatrix}$$

Measurement

Temperature is generally measured in degrees Celsius. In this system the freezing point of water is defined as 0°C and the boiling point of water is defined as 100°C. The Kelvin temperature scale begins from absolute 0. i.e.— 273°. The temperature intervals are the same.

273K = 0°C, 20°C = 273K + 20°C = 293K.

Instruments

The instruments used to measure and read temperature considers changes in the properties of materials, electrical phenomena incandescence, radiation and melting.

Thermometer

Types of thermometer

- Forehead strips
- Wearable thermometers
- Pacifier thermometers
- Ear thermometers (tympanic)
- Forehead thermometers (temporal)
- Digital thermometers

They are based on the principle that liquids and solids expand when they are subjected to heat. Mercury and alcohol expand uniformly. When heat is applied the volume of the liquid increases and the liquid rises in the capillary tube integral with the container. Mostly mercury is used in this type of thermometers because of its properties (Shiny and will not adhere to the glass tubes and we can measure up to 300°C).

The bimetal thermometer consists of metals with different coefficient of expansion. The bimetal is twisted into a spiral which curl when the temperature rises.

Pyrometer

Thermoelectric pyrometer is based on the principle that the soldering point between the wires of different metals, when heated a contact voltage is generated. The voltage depends upon the temperature difference between the hot measuring point and the cold end of the wire. Thermocouple elements are constructed of copper and Constant (up to 600°C) or of platinum and platinum-rhodium (up to 1600°C)

Radiation pyrometers are used to measure temperatures of red-hot metals up to 3000°C. These concentrate thermal rays through an optical lens and focus them on to a thermo element. The scale of the ammeter is calibrated in degrees Celsius or Kelvin.

Fig 2

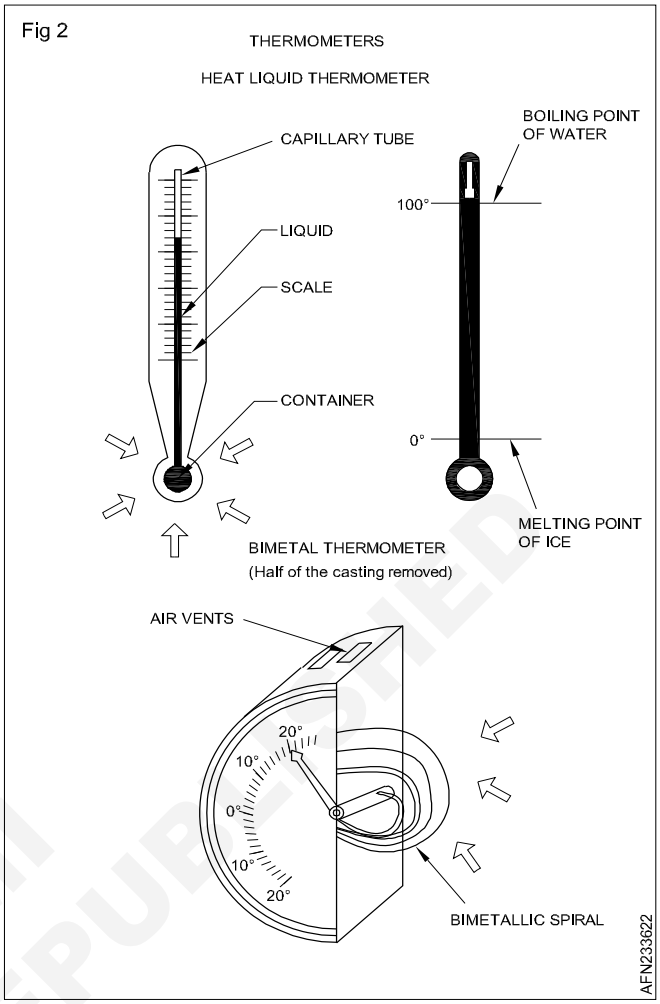
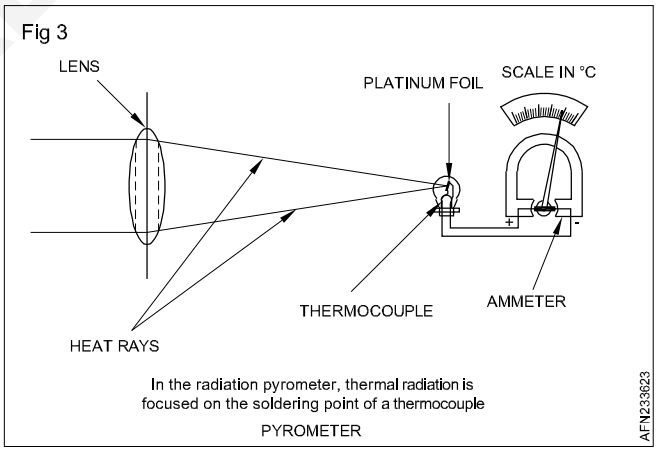


Fig 3



Transmission of Heat

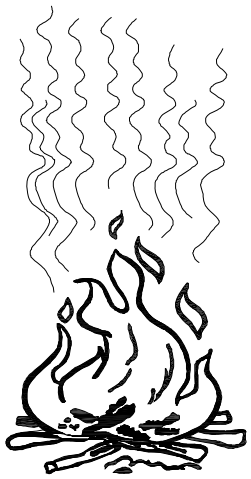
Heat is a form of energy and is capable of doing work. Heat flows from a hot body to a colder body or from a point of high temperature to a point of low temperature. The greater is the temperature difference the more rapidly will be the heat flow. Heat is transmitted in three ways.

- By Convection
- By Conduction
- By Radiation

Convection (Fig 4)

Convection is the name given to the transmission of heat energy by the up-ward flow. When heated, the fluid (liquid/ gas) becomes less dense and because of its mobility, is displaced upwards, by a similar but colder and more dense fluid. e.g., The domestic hot water system, The cooling system in motor cars.

Fig 4



CONVECTION

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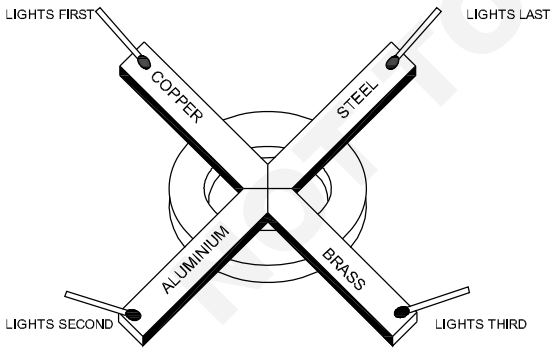
Conduction (Fig 5)

Conduction is the name given to the transmission of heat energy by contact. The heat source is in contact with the Conductor. (metal rod). The rod is in contact with a thermometer. Due to Conduction heat is transferred from the heated end to the free end. In general, good electrical conductors are also good heat conductors and good electrical insulators are also good heat insulators. A good heat insulator does not necessarily withstand high temperature.

Fig 5



CONSERVATION OF ENERGY

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Radiation

Heat is radiated or transmitted from one object to the other in space without being in contact, by means of electro-magnetic waves. These waves are similar to light waves and radio waves. They can be refracted by lenses and reflected by mirrors. This radiation is called infrared. It requires no medium to carry the radiation. (e.g) The heat of the sun travels through the space

Fig 6

RADIATION

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Expansion due to heat

When a solid, liquid or gaseous substance is heated, it expands, and volume is increased. Similarly, when it is cooled, it contracts (shrinks) and volume is decreased.

E.g : small gaps are left in between the lines of railway track to allow for expansion during summer. If this is not done, the rails would expand and bend thereby causing derailment of trains.

Except a few substances, all solids, liquids and gases expand. For the same amount of heat given, the expansion of liquids is greater than solid, and expansion of gas is more than liquid.

Volume of water is reducing while heating from 0°C to 4°C.

After that volume is increasing. The data at 4°C of water will be taken as reference point for any calculations relating with water.

Difference between speed and velocity, acceleration and retardation

Objective: At the end of this lesson you shall be able to·
- **state the different terms relating to motion.**

Rest

When a body does not change its position, with respect toots surroundings, it is said to be at rest.

Motion

When a body changes its position, with respect to its surroundings, it is said to be in motion. The motion maybe linear if the body moves in a straight line or it may be circular when it moves in a curved path.

Terms relating to motion

Displacement

When a body is in motion from one place to another, the displacement is the distance from the starting position to the final position.

Speed

It is the rate of change of displacement of a body in motion.

It has got no direction and it is a scalar quantity.

Speed = distance travelled per unit time

$$\frac{S}{L} = \frac{(\text{Distance})}{\text{Time}}$$

Unit = m/s, km/h, mile/h

For example:

- Vehicle speed in km/h
- Engine speed in rpm

Velocity

It is the rate of change of displacement of a body in motion in a given direction. It is a vector quantity and can berepresented both in magnitude and direction by a straight-line. Velocity may be linear or angular. The unit of linear velocity is metre/sec,

Velocity =

$$\frac{S}{t} = \frac{\text{Displacement}}{\text{Time}}$$

Unit = m/s, km/h, mile/h

For example, a motor vehicle, normally changes its speed and direction on road. Hence used in velocity calculation.

Difference between speed & velocity

Speed	Velocity
The rate of change of place of an object is it's speed	The speed in and definite direction is called velocity
in the speed direction is not indicated Only the magnitude is expressed.	Both the magnitude and direction are expressed
Speed = $\frac{\text{Distance covered}}{\text{Time}}$	Velocity = $\frac{\text{Distance in definite direction}}{\text{Time}}$

Acceleration

Rate of change of velocity is known as acceleration or it is the change of velocity in unit time. Its unit is metre/ sec2.

It is a vector quantity.

$$a = \frac{\text{Changeinvelocity}}{\text{Time}} \text{m/sec}^2$$

unit = m/s2 (metre per square second)

u = Initial velocity in metre per second(m/sec)

v = Final velocity in metre per second(m/sec)

s = Distance in metre (m)

t = Time in second (sec)

a = Acceleration m/sec2 (positive value)

R = Retardation m/sec2 (negative value of acceleration)

For example, when the speed of the vehicle is increased on road, it is said to be accelerated.

Equations of motion

Then v = u + at

$$S = ut + \frac{1}{2}at^2 \text{and} V^2 - U^2 = 2as$$

$$V^2 = U^2 + 2as$$

Retardation (or Deceleration)

When the body has its initial velocity lesser than its final velocity it is said to be in acceleration. When the final velocity is lesser than the initial velocity the body is said to be in retardation. Then the three equation of motion will be

$v = u – at$

$s = ut – at2$

$u2–v2 = 2as$

For example, during the application of brakes of a vehicle the speed of the vehicle is decreased. Then it is said to be decelerated or retarded.

NEWTON'S LAWS OF MOTION

Equations of motions under gravity

Upward	Downward
$V = U - gt$	$v = u + gt$
$S = Ut- 1/2\ gt^2$	$S = Ut + 1/2\ gt2$
$U^2 - V^2 = 2gs$	$V^2 - U^2 + 2gs$

Motion under gravity

A body falling from a height, from rest, has its velocity goes on increasing and it will be maximum when it hits the ground. Therefore, a body falling freely under gravity has a uniform acceleration. When the motion is upward, the body is subjected to a gravitational retardation. The acceleration due to gravity is denoted with 'g'.

Momentum

It is the quantity of motion possessed by a body and is equal to the product of its mass, and the velocity with which it is moving. Unit of momentum will be kg metre/ sec.

Momentum = mass x velocity

Newton's laws

First law

Every body continues to be in a state of rest or of uniform motion in a straight line unless it is compelled to change that state of rest or of uniform motion by some external force acting upon it.

Second law

The rate of change of momentum of a moving body is directly proportional to the external force acting upon it and takes place in the direction of the force.

Third law

To every action there is always an equal and opposite reaction.

In the rivet joint equal forces act on the strap and they opposite forces.

Law of conservation of momentum

When two moving bodies have an intentional or unintentional impact, then sum of the momentum of the bodies before impact = sum of the momentum after impact, or the change in momentum after the impact is zero.

m1 - mass of one body and

v1 - velocity with which it moves

m2 - mass of second body

v2 - velocity with which it moves

Momentum = m x v= mass of the body x its velocity

Rate of change of momentum = force acting on the body

$$m\left(\frac{(V-U)}{t}\right) = F$$

force = mass x acceleration

Sheet metal working techniques such as growing, shrinking.

Objective: At the end of this lesson you shall be able to·
- **state the methods to growing and shrinking sheet metal work pieces.**

Stretching, growing (Fig 1)

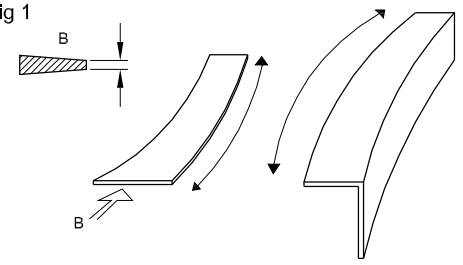
Hammering a flat piece of metal in one location will cause the material in that area to become thinner.

However, since the amount of material has not changed, it covers a greater area because the metal has been stretched.

Sheet metal can be stretch in 3 ways:

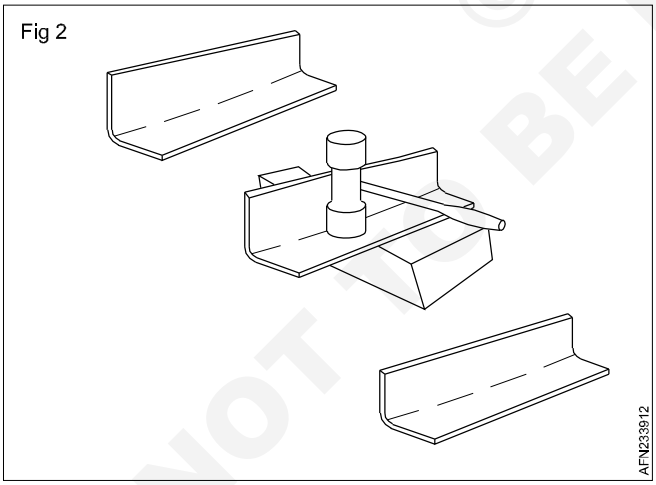
- Hammering on a hard block.
- Using a stretching jaws machine.
- Rolling metal under pressure with an English wheel.

Fig 1



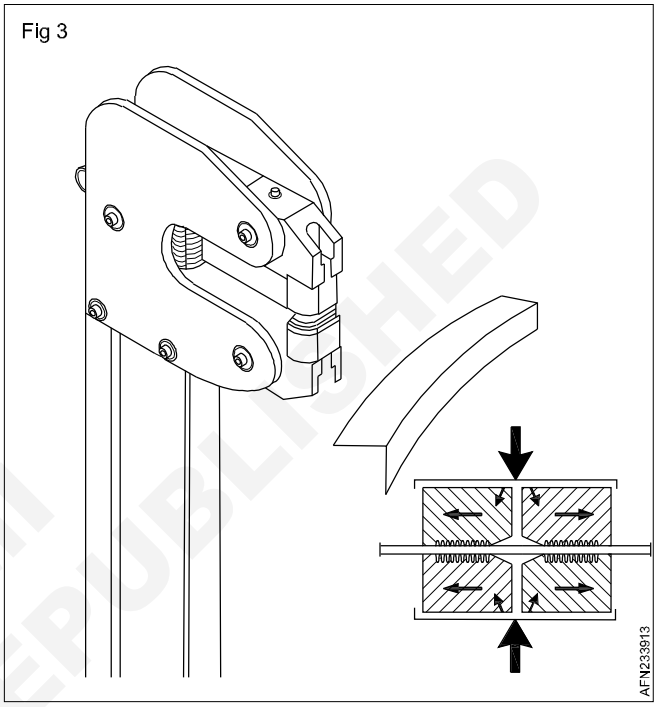
Growing using hammer

Fig 2



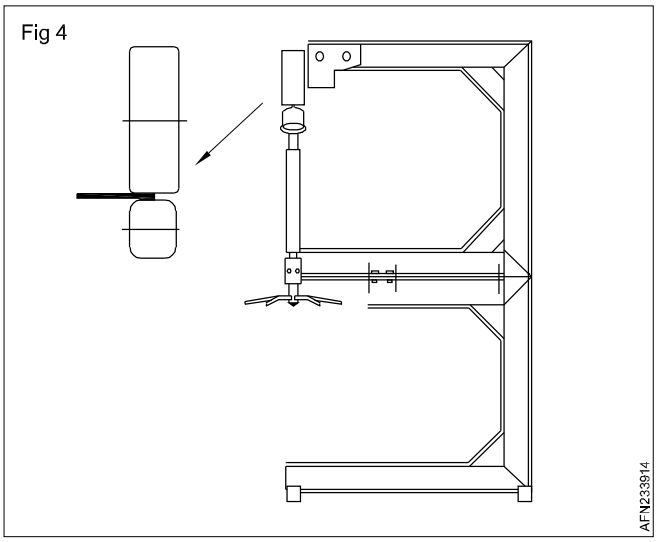
Growing using growing jaws machine

Fig 3



Growing using English wheel

Fig 4



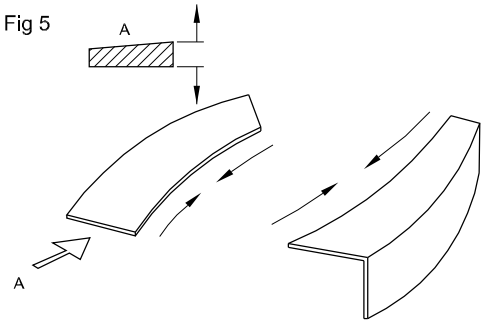
Shrinking (Fig 5)

During the shrinking process materialis forced or compressed into a smaller area. Thisprocess is used when the length of a piece of metal,especially on the inside of a bend, is to be reduced.

Sheet metal can be shrunk in 2 ways:

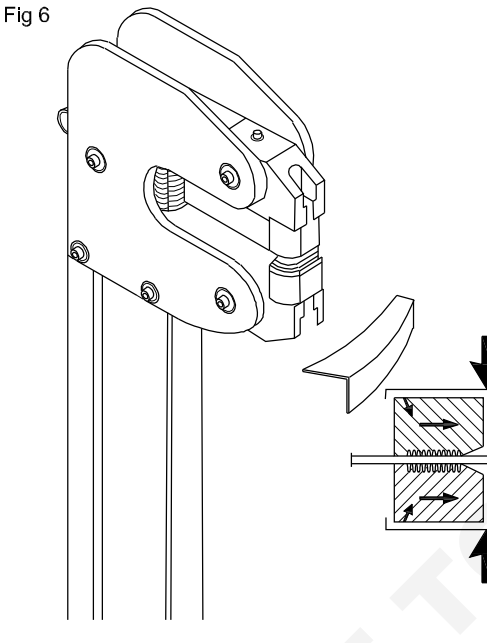
- Hammering on a V-block.
- Using a stretching jaws machine.

Fig 5



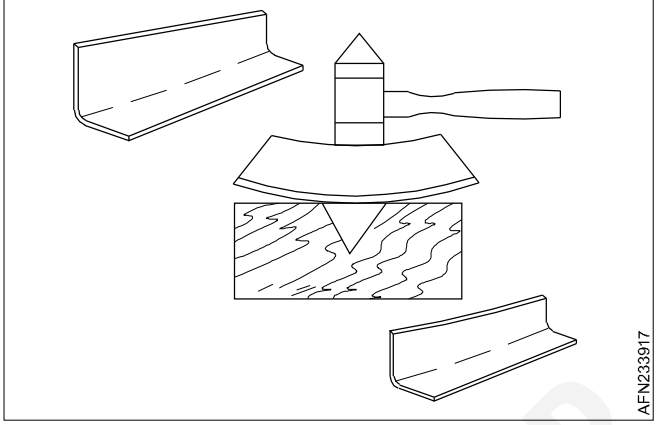
Stretching using stretching jaws machine

Fig 6



Stretchingangle using V-block and hammer

Fig 7



Work-hardening

Try to form thecurve with a minimum amount of hammering, forexcessive hammering will work-harden the metal.

Work-hardening can be recognized by a lack of bendingresponse or by springiness in the metal. It can be recognized very readily by an experienced worker insome cases, the part may have to be annealed duringthe curving operation. If so, be sure to heat treat thepart again before installing it on the aircraft.

Sealant types, uses, times, storage

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

- **state the uses of sealants.**
- **understand the different times for sealants.**
- **describe the influence of the temperature and humidity on application time.**

Sealant

A material of liquid or paste-like consistency. It is either applied as a single component or it is prepared by mixing two or more components together as a multiple component system.

Sealing

Sealing must prevent the ingress of moisture and liquids such as water from entering assembly joints, either in fuel tank or the aircraft structure in general.

To prevent such contaminations from penetrating into or being trapped in assembly joints sealing must ensure that all assembly joints and gaps between faying surfaces are completely filled with sealant. They shall be free from any holes, cavities, air inclusions or similar defects.

Sealing must also ensure the pressure tightness of the fuselage structure as a whole and guarantee the required level of aerodynamic smoothing of the aircraft exterior surface.

Sealing process shall prevent fuel leakages either within the aircraft structure or to the external environment.

Sealing must also protect against fretting fatigue between faying surfaces.

In some cases, specific requirements such as e.g. active corrosion protection, electrical conductivity or insulation may be subject to the sealant application.

Component

A component is a constituent part of a multiple component sealant, e.g. base or curing agent in the case of a two-component system.

Sealant Classification

Some sealants are classified according to the type of application. Where applicable, definitions are as follows:

Class A: Slightly fluid product applied by brush, syringe and extrusion gun or bell (generally used for over coating).

Class B: Thick product applied by spatula, extrusion gun, roller or syringe (generally used for beads, fillet and filling of cavities).

Class C: Slightly fluid product, applied either by brush, roller or spatula (generally used for interlay and wet installation of fasteners).

There are materials suitable for other types of application method such as spray (Class S).

Application Time

Application time is the maximum period that a mixed sealant remains at a consistency suitable for application. All sealants shall be applied before expiry of its application time. The maximum application time in hours for each sealant is indicated by a dash number, e.g. -1 indicates an hour application time at 23° C.

Assembly Time

Assembly time is the period after mixing that a sealed joint must be fastened to the required torque value using either permanent or temporary fasteners.

Work Life

Work life is the period after mixing within which the sealant can be worked after initial application, e.g. fairing of fillets with a spatula.

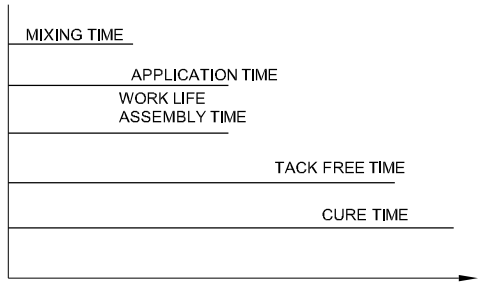
Tack Free Time

Tack free time is the period after mixing required to achieve a state of cure such that the sealant surface is touch dry.

Cure Time

Cure time is the period after mixing that is required for the sealant to achieve a hardness of 30 Durometer. The cure time of some sealants can be affected by temperature and humidity.

Fig 1



Application and cure temperature

The baseline temperature for curing of sealant is 23°C.

The application, tack-free and curing times will vary approximately as follows:

- They double for each drop-in temperature of 5°C below + 23°C,
- They are divided by two for each increase in temperature of 5°C above +23°C.

Example:

For a sealant with a curing time of 2 h at + 23°C, this time will be equal to 4 h at +18°C and 1 h at + 28°C.

It is permitted to raise the temperature of the assembly in order to reduce the curing time, but the increased temperature must not exceed 50°C.

For all temperatures above35ºC (not exceeding 50°C), a successful validation and qualification of the accelerated curing device is necessary to ensure that accelerated curing will not have any detrimental influence on sealant properties during the whole life of the aircraft. Thus, key sealant properties have to be checked by Engineering department at initial stage and after environmental exposure on accelerated cured sealant.

Application and cure relative humidity

The baseline relative humidity for curing of sealant is 50 ± 5%.

Increasing the relative humidity reduces application, tack-free and curing times; reducing the relative humidity increases these times.

The humidity of the heated air should be above 10%RH before heating parts to ensurethat the curing takes place at a higher speed.

Containers marking

Each container of material shall be durably and legibly marked by means of a securely attached label placed insuch a manner and location that the label remains in place until the material has been used. Marking shall include the following details:

- Reference of the manufacturers trade mark as well as designation of the material
- Indications concerning health and safety regulations
- Expiry date
- Delivery date if requested in the order
- Lot number
- Recommended storage conditions
- Mixing ratio (in the case of multiple component systems)

Example of a designation reading

PRXXXX A 2

Trade name
Note: PR(C) is the abbreviation for Product Research Corporation.

Sealant classification:
A, B, CSee chapter “Sealant classification” above.

Application time in hour at 23°
CSee chapter “Application time”and “ Application and cure temperature” above.

Sealant - application tools.

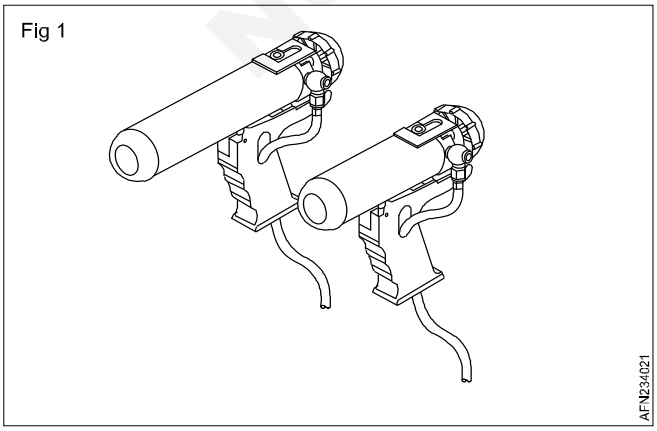
Objectives: At the end of this lesson you shall be able to·
• state the different tools used to sealant application.

Extrusion gun

Air extrusion guns currently used have capacities of 170 cm^3 and 70 cm^3. (Fig 1)

Models without the pistol grip are available to help sealing in areas where there is poor access.

Fig 1



Several gun models are available: mechanical portable gun, electrical, pneumatic, etc

Nozzles (Fig 2)

They are available in different lengths, diameters and shapes but may be cut to thelength and diameter that the user requires. Bent nozzles may be used to help to accessdifficult areas. (Fig 2)

Roller applicator (Fig 3)

This applies thin coats of low-viscosity interfay sealants and gives a good even spreadafter assembly.

Fig 2

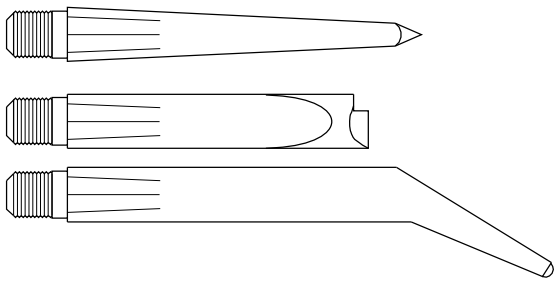


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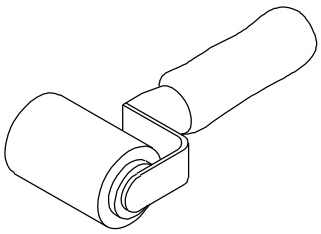
Fig 3



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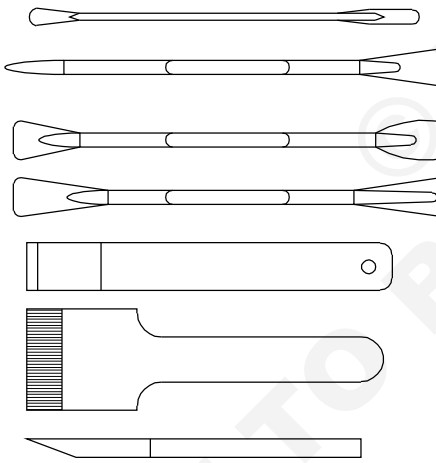
Sealant spatulas (Fig 4)

Spatulas could be used either for applying thin coats of interfay sealants or smoothingafter applying fillets.

Fig 4



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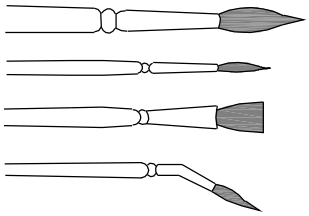
Sealant brush (Fig 5)

Different sizes and shapes are available. The choice will be made depending on applications.

Fig 5



AFN234025

Cartridge (Fig 6)

Different sizes are available. The choice will be made depending on applications.

Fig 6

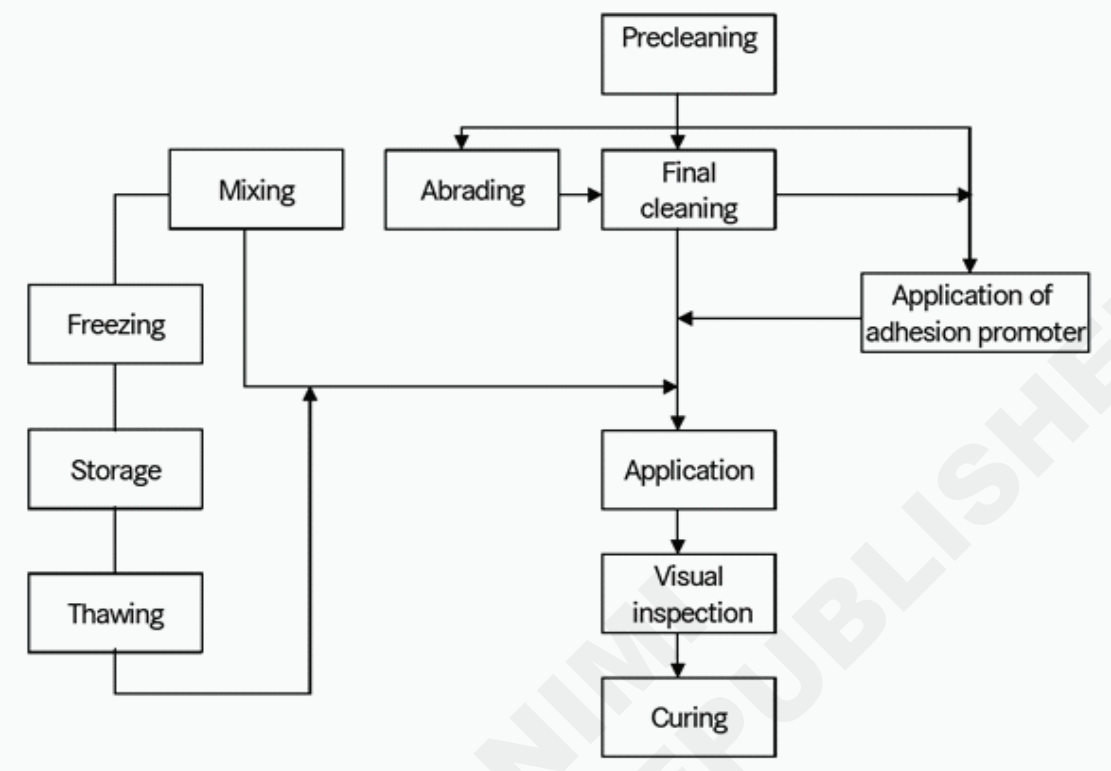
AFN234026

Sealing application methods

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

- **state the requirements to prepare surfaces**
- **explain the different sealant application methods.**

Overview of the process



General requirements

Prior to the sealing process all drilling and reaming of the components has to be completed, all holes have to be debarred, all sward has to be removed and all surfaces have to be cleaned (for elimination of oil, grease, marking inks, dust, etc.) to ensure proper adhesion of the sealant.

If needed, the surface has to be activated chemically (by adhesion promoter) or mechanically (by grinding).

Surface preparation

Initial cleaning

Previously to start any process of surface preparation process, the surface should be cleaned with a solvent in order to eliminate contamination (oil, grease, marking inks, dust, etc.) with the aim of not to affect subsequent processes of surface preparation neither applied sealant properties.

Abrading

Surfaces with primer or top coat aged more than 72 hours shall be activated either by light abrasion (using 320 grade silicon carbide paper or very fine non-woven nylon pad) to produce a uniform matt surface finish or by application of an appropriate adhesion promoter (see below).

Final cleaning

Final cleaning should be performed after abrading. Use the minimum quantity of cleaning agent. The cleaning agent shall not contaminate or have any detrimental affect on the surrounding areas (to avoid contamination or removal of the existing sealant by the approved cleaning agent).

Control for cleanliness

After drying the cleanliness of the cleaned surface may be checked by rubbing with a clean wiper. If there is any evidence for a residual contamination, repeat the cleaning operation.

The evaporation of cleaning solvents may result in dewing of the surface.

If required a check of surface dryness can be made outside the area to be sealed. A piece of any masking tape is pressed firmly onto the surface and then removed by pulling off rectangular to the surface. The tape adhering uniformly to the surface shows the dryness of the surface.

The sealant must be applied within one hourafter the cleaning.

Application of adhesion promoter

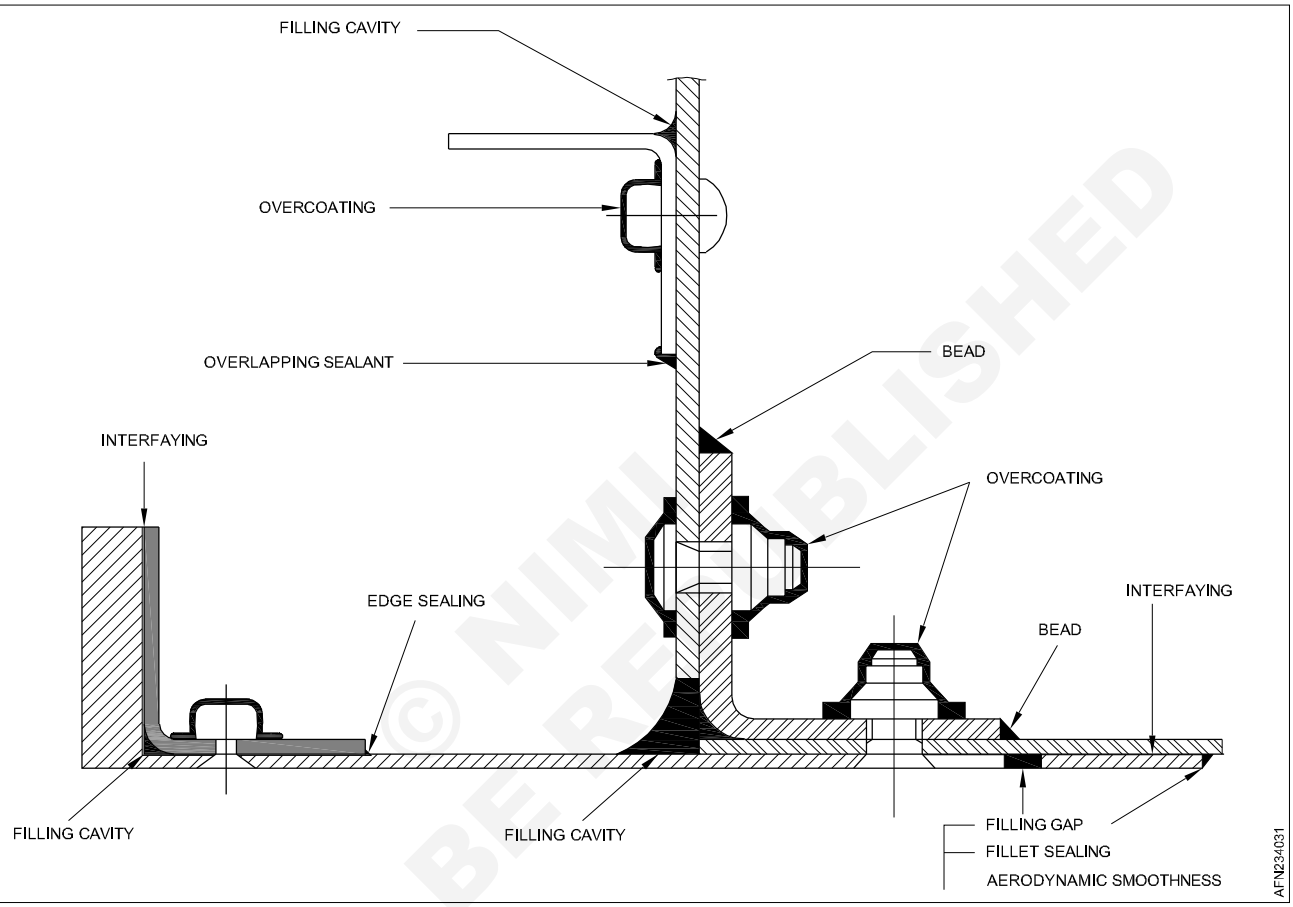
Adhesion promoter shall be applied prior to the sealant application in following cases:

- When relevant manufacturer data sheet of the sealant specify the use of an adhesion promoter.
- When required by corresponding drawing or design document.
- Sealing surfaces with difficult access.

Adhesion promoter may be used after or instead of final cleaning operation. The adhesion promoter is applied using a brush or a clean lint free wiper. Any excess is then wiped off while still wet using a clean, dry and lint free wiper.

Overview of sealant applications (Fig 1)

Fig 1



Application of sealant

Interlaying

If necessary, use masking tape to ensure that the sealed area is completely covered by sealant and the surrounding area is not contaminated.

Apply the sealant onto the surface of the smaller part to be joined by using an extrusion gun. A syringe may be used to apply sealant to small parts.

Spread the sealant over the complete surface for example by using either a roller or a spatula.

If using a highly viscous sealant (Class B) as an in berfay sealant, make sure that smallest possible layer thickness will be achieved.

This step must be done within the sealant assembly time, applying enough pressure, for example either temporary or final fasteners could be used to do the sealant squeezing and ensure thicknesses in compliance with (Fig 3)

Extra sealant must be seen by visual check around the joint.

The squeezed-out sealant should be either smoothed for thin sheets or removed by using cleaning agent and cloths. (Fig 2)

Fig 2

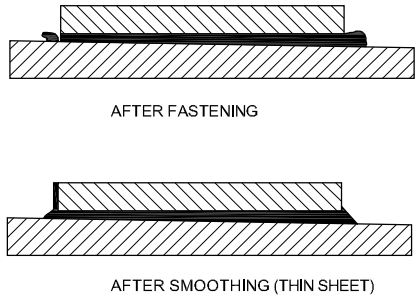
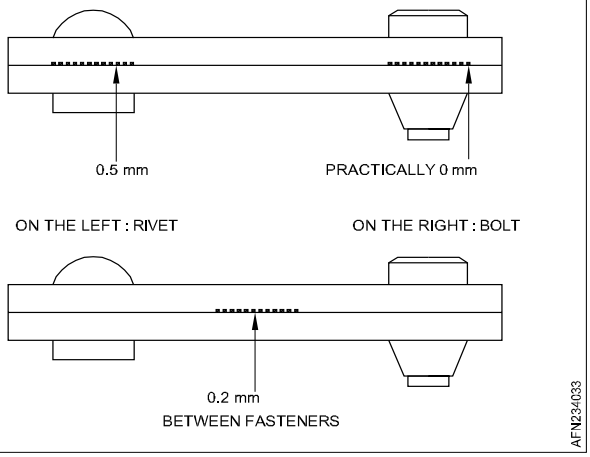


Fig 3



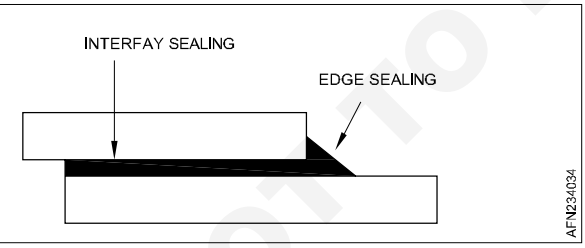
For information, the design of the fastening arrangement and the structure should ensure the in terfay thickness as shown below after curing.

Sealant beads

Edge sealing (Fig 4)

When edge sealing is required only the lower edge of the cover sheet shall be embedded in the sealant. Usually the sealant squeezed out of the interlay sealing will be sufficient.

Fig 4



Fillet sealing (Fig 5,6)

When fillet sealing is required upper and lower edge of the cover sheet shall be embedded in the sealant as per Fig 4 for fillet in flight direction and Fig 5 for fillet transverse to the flight direction (aerodynamic smoothing).

Fig 5

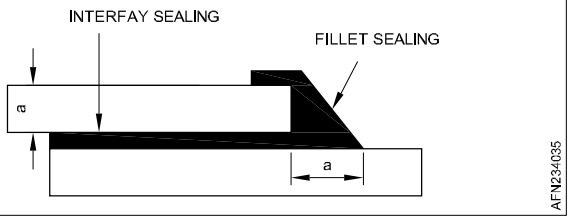
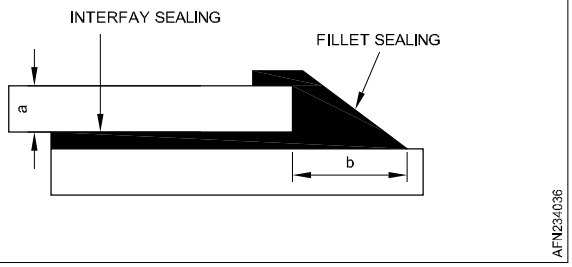


Fig 6



Sealant bead (Fig 7)

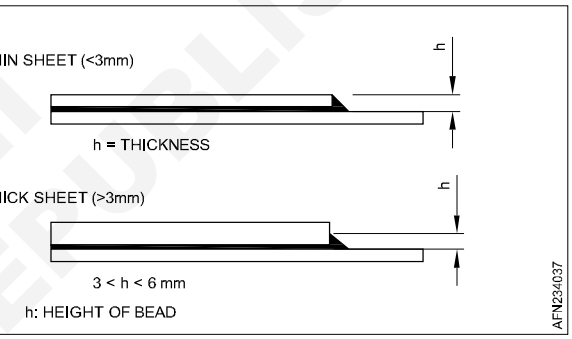
A Bead (Fillet) of sealant may be used to cover the edge of a structural assembly joint.

The fillet bead is applied after the fasteners have been installed.

The bead size depends on the thicknesses of the sheets to be assembled.

The sealant beads shall be free from any defects such as air inclusions, porosities, cracks or contaminants e.g. drilling chips. Dimension and shape have to match with the design documents.

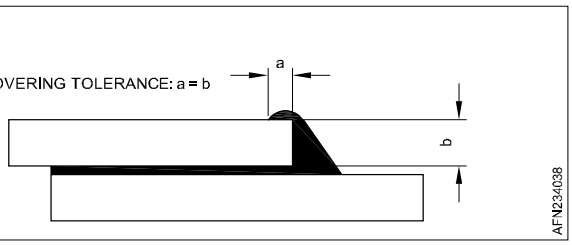
Fig 7



Overlapping sealant bead (Fig 8)

When overlapping sealing is required, the bead shall overlap the top section of the sheet. The width of the overlap (a) shall be no less than the sheet thickness (b).

Fig 8



Aerodynamic smoothing (Fig 10)

All cavities shall be completely filled with sealant. For external gaps sealants with low shrinkage should be preferred.

Mark out and mask the junction with adhesive masking tape.

The extrusion gun nozzle may be cut to the size required for the gap and may be pushed in to the bottom of the joint. (Fig 9)

Fig 9

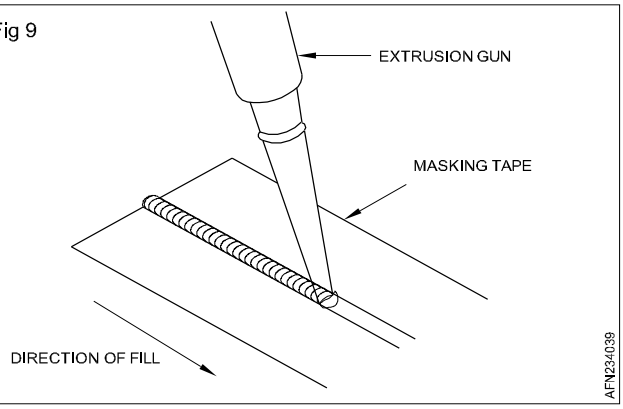
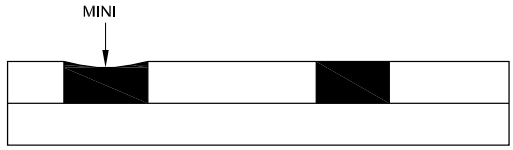


Fig 10



Smooth down the product with a non-metallic spatula held at a recommended angle of approximately 15-20° in relation to the surface

The filled gaps shall be free from any surface defects such as recessing bubbles, pores, cracks or contaminants. The aerodynamic sealing shall be homogeneous without discontinuities, gaps or excess/insufficient sealant as shown.

All variations in thickness or any waviness must be avoided.

Over coating/sealing of fastener heads

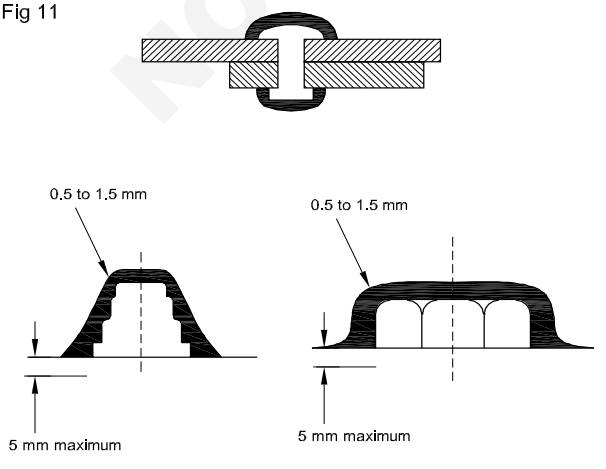
Where overcoat sealing of fastener heads is required, the over coating shall be performed as per Figure 11 ensuring full coverage of the over coated fastener.

It can be applied either by brush or with an extrusion gun, which may be equipped with a suitable tool.

Before applying the sealant, ensure that the surface of the panel and the fastener has been prepared.

It is very difficult to measure the thickness over the complete fastener for each individual fastener. In all cases, a continuous coat of sealant shall be ensured by detailed visual inspection.

Fig 11

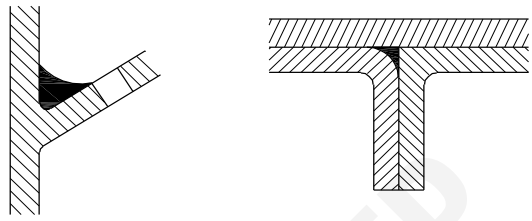


The over coating shall be free from any defects such as air inclusions, pores, cracks or contaminants e.g. drilling chips.

Filling cavities (Fig 12)

All internal and external cavities located in areas favouring condensation or infiltration of water initiating corrosion must be completely filled with sealant (Class B).

Fig 12



Fillet application using extrusion gun

To ensure a smooth bead and reduce the chance of trapped air bubbles, any squeezed-out sealant may first be removed using a plastic scraping tool.

Use of a metal scraper is not permitted since it may damage the protective coating of the parts.

Residues of sealant may be softened or removed using a cloth soaked in solvent.

Ensure that the surface has been prepared by cleaning.

Making a bead requires the use of a gun and a nozzle suitable for the work to be done.

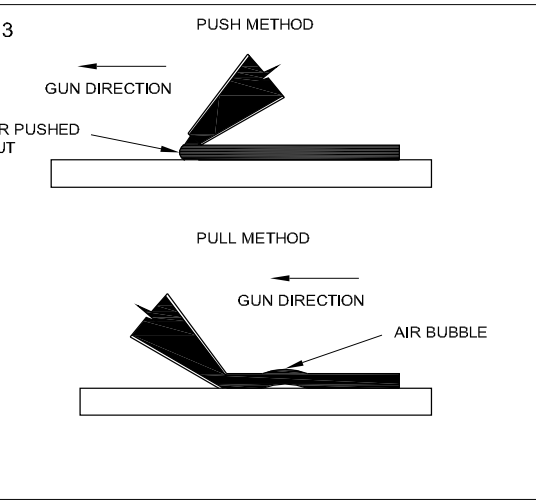
The end of the nozzle is cut to the size required.

The gun must be held at an angle of between 45° and 60° as shown in the figure below.

Additional precautions are required when the “pull” method is used (especially concerning speed of movement) in order to avoid air bubbles forming in the bead.

After the bead has been applied, smooth it down with the spatula to evenly spread out the product in the corner formed by the assembly.

Fig 13



Rivet removal

Objectives: At the end of this lesson you shall be able to·
- **explain about removable of universal head rivet**
- **explain about removable of countersunk head rivet.**

Rivets removal

When a rivet must be replaced, remove it carefully to retain the rivet hole's original size and shape.

If removed correctly, the rivet does not need to be replaced with one of the next larger size. Also, if the rivet is not removed properly, the strength of the joint may be weakened, and the replacement of rivets made more difficult.

When removing a rivet, work on the manufactured head. It is more symmetrical about the shank than the shop head, and there is less chance of damaging the rivet hole or the material around it.

To remove rivets, use hand tools and a power drill.

Universal rivet removal

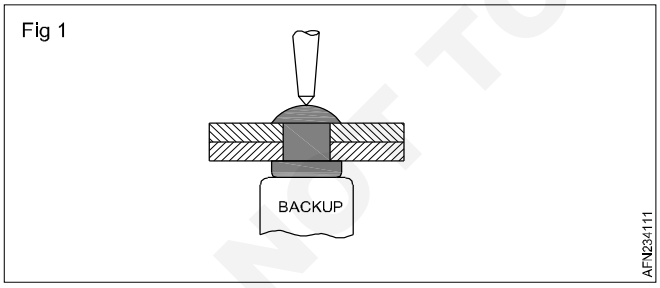
The procedure for universal or protruding head rivet removal is as follows:

Centre-punch the head for drilling. (Optionally to facilitate this operation, a flat area on the head of the rivet could be filed before centre-punching) (Fig 1)

On thin metal, back up the rivet on the upset head when centre-punching to avoid depressing the metal.

The dot dimpled in 2117 (DE or AD material code) rivets usually eliminates the necessity of centre-punching the rivet head.

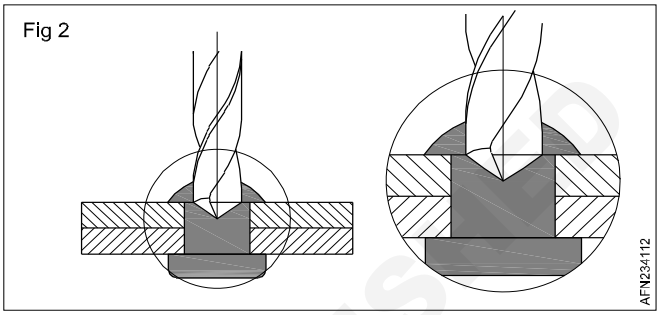
Fig 1



Use a drill bit about 0.2 mm smaller than the rivet shank to drill out the rivet head. NOTE: When using a power drill, set the drill on the rivet and rotate the chuck several revolutions by hand before turning on the power. This procedure helps the drill cut a good starting spot and eliminates the chance of the drill slipping off and tracking across the metal.

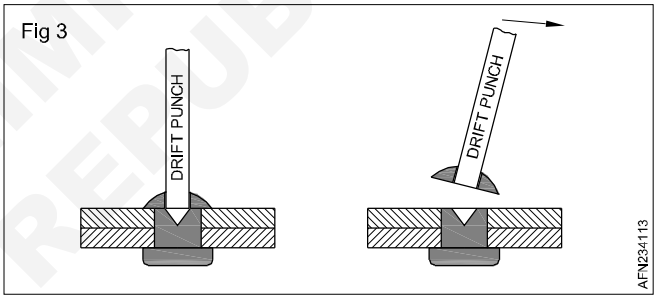
Drill the rivet to the depth of its head, while holding the drill at a 90° angle. Do not drill too deeply. (Fig 2)

Fig 2



Insert a drift punch into the hole and twist slightly to either side until the head comes off. (Fig 3)

Fig 3

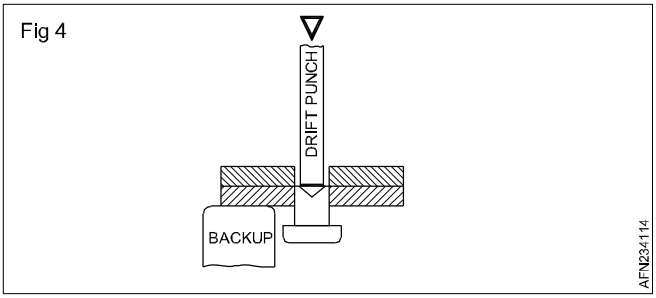


Drive the remaining rivet shank out with a drift punch slightly smaller than the shank diameter. (Fig 4)

On thin metal or unsupported structures, support the sheet with a suitable backup, preferably wood (or equivalent), or bucking bar while driving out the shank.

If the shank is unusually tight after the rivet head is removed, drill the rivet a little more and then drive the rest of it out with a drift punch.

Fig 4



Countersunk rivet removal

The procedure for countersunk head rivet removal is as follows:

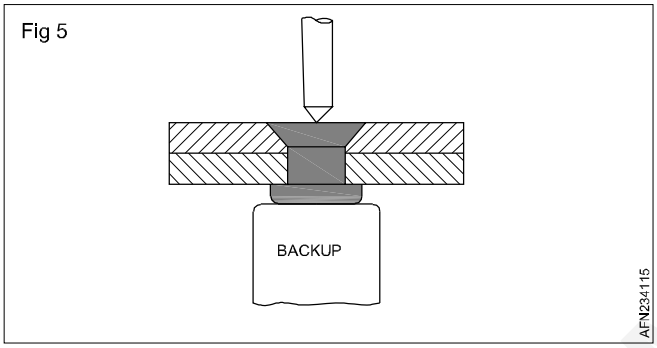
Centre-punch the head for drilling. (Fig 5)

On thin metal, back up the rivet on the upset head when centre-punching to avoid depressing the metal.

The dot dimpledin 2117 (DE or AD material code) rivets usually eliminates the necessity of centre-punching the rivet head.

An experienced operator is able to punch directly with the drill.

Fig 5



Select a drill about 0.2 mm smaller than the rivet shank diameter.

When using a power drill, set the drill on the rivet and rotate the chuck several revolutions by hand before turning on the power. This procedure helps the drill cut a good starting spot and eliminates the chance of the drill slipping off and tracking across the metal.

Drill into the exact centre of the rivet head to the approximate depth of the head. (Fig 6)

Remove the head by breaking it off. Use a punch as a lever. (Fig 7)

Fig 6

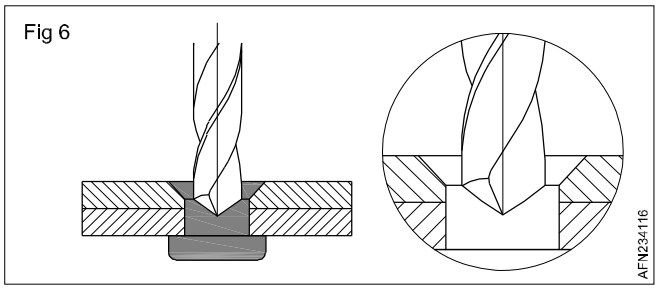
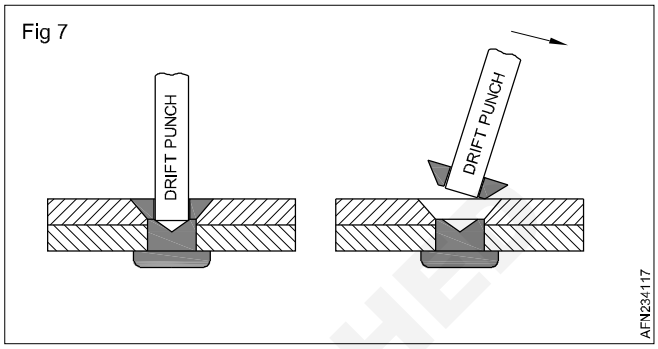


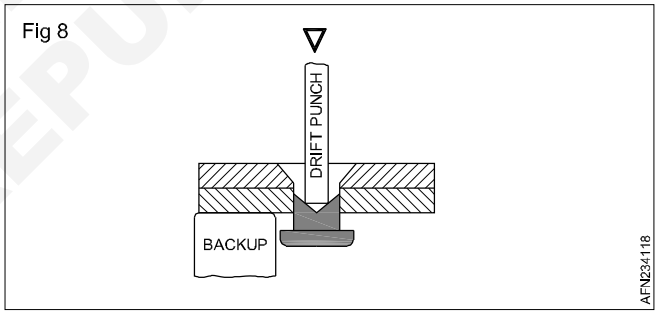
Fig 7



Punch out the shank. Use a suitable backup, preferably wood (or equivalent), or a dedicated backup block. (Fig 8)

If the shank does not come out easily, drill the rivet a little more and then drive the rest of it out with a drift punch.

Fig 8



Electrical bonding and grounding

Objectives: At the end of this lesson you shall be able to·
- **understand the importance of electrical bonding**
- **explain the rules to strip a metallic part for electrical bonding**
- **explain bonding brush and its use.**

Bonding is an electrical connection to the metal elements of the aircraft to guarantee current return and the dispersion of electromagnetic charges.

The correct application of the electrical bonding processes provides the electrical continuity between parts allowing:

- Returns of electric currents.
- Prevention of electric shocks for people.
- Fault detection (insulation defect).
- Flow of electrostatic charges.
- Flow of lightning currents.

Terms

Bonding

Electrical bonding refers to the establishment of a current path between electrical conductive parts in order to assure electrical continuity. This path may be between:

- Two structural parts.
- A system grounding point and structure (e.g. antenna).

Grounding

Electrical grounding refers to the establishment of low impedance current path in order to ensure the return of functional (power or signal) currents.

Varnish/Final protection

The varnish (or paint in any aircraft manufacturer) is used for two aims: to protect the bonding point (insulation of conductive layer of the material against corrosion) and to visually identify the bonding point.

Stripped or masked

Connected electrical bonding points must have stripped metallic contact surfaces to ensure electrical continuity between the parts.

The masking technique protects bonding points by application of masking tape or masking discs on the surface before applying the protective layer and painting.

Indication on drawings

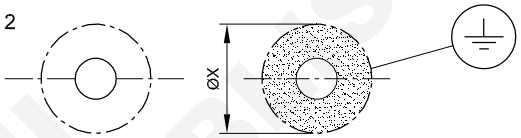
Electrical bonding points are conventionally identified on the drawings by the symbol. (Fig 1)

This symbol has a diameter of 10mm and is placed on the face where the electrical contact is to be made.

Fig 1

In certain cases, an annotation specifies the side to be stripped. The detail drawing detail give the number of planned electrical bonding points as well as their location and dimensions. (Fig 2)

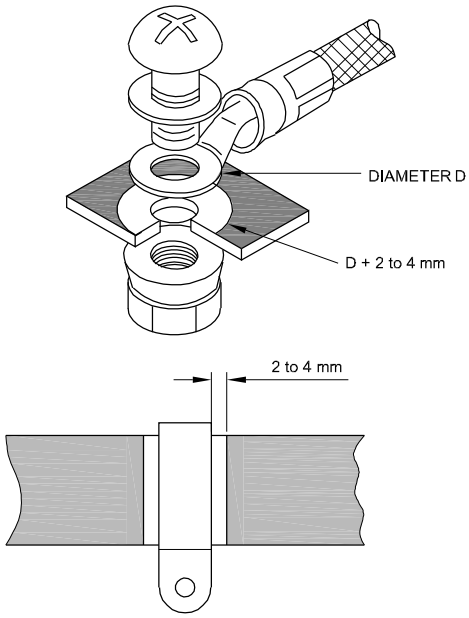
Fig 2



Dimension of stripped areas

If there is no specific characteristic on manufacturing drawings, stripped areas will extend 2 to 4 mm beyond the electrical contact surface. (Fig 3)

Fig 3



For example:

- Washer, convex rivet, etc.:

  Stripped area = (contact diameter) + (2 to 4 mm)

- Rectangular support, etc.:

  Stripped area = (contact length and width) + (2 to 4 mm)

- Clamp of pipe:

  Stripped area = (width of clamp) + (2 to 4 mm on both sides)

A countersunk hole in metallic structure left stripped is enough to ensure a proper electrical bonding. Therefore, there is no need to strip the surface around the countersunk.

Surface preparation with abrasive paper

Cleaning:

Remove all traces of grease, dust or particles from electrical bonding surfaces using a tissue dampened with solvent.

Stripping:

- Strip the surface with the abrasive paper. (grade 320 or finer)
- Clean surface blemishes with the Scotch Brita™ pad. (finest grade)
- Clean the stripped area with a dry, clean and lint free cloth.

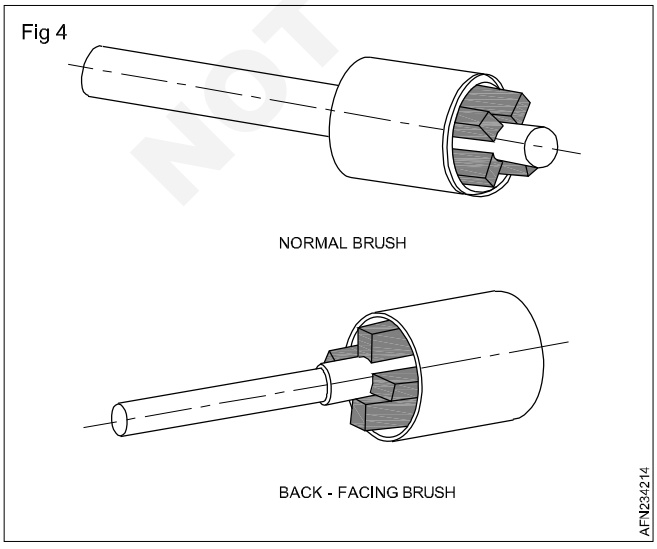
Check

- The stripped area shall be as smooth and as plan as possible
- The abrasive paper must not damage the bonding surface.
- Metal attack (Scratches), Lines on the surface, Damaged surface are not available.

Surface preparation with metallic brush

Rotary metallic brush (Fig 4)

Fig 4



The choice of brush is guided by the bonding to be done.

Three parameters guide the tool choice:

- The accessibility.
- The brushing diameter to do.
- The hole diameter.

The pilot of the brushes should be 0,3 to 0,5 mm smaller than the existing hole

Cleaning:

Remove all traces of grease, dust or particles from electrical bonding surfaces using a tissue dampened with solvent.

Stripping:

Adjust the rotation-speed of the support machine to a minimum.

Place the metallic brush perpendicular to the surface to be stripped with the pilot.

To avoid damaging surfaces, the metallic brush must to be free of debris. Clean tool if necessary.

Strip off the bonding point ensuring that the brush bears evenly over the surface

Use minimum force and adapt rotation speed when removing the surface treatment, so that no metal is attacked. (e.g.: excessive grinding, brushing, scratching)

Clean the stripped area with a dry, clean and lint free cloth

Check:

The stripped area shall be as smooth and as plan as possible

The metallic brush must not damage the bonding surface.

Metal attack (Scratches), lines on the surface, damaged surface are not available.

Be careful since a too fast rotation-speed may cause a rough surface.

Temporary protection in manufacturing period

Apply a thin layer of petroleum jelly and overlap at least 4 mm all around the stripped area.

The layer of petroleum jelly should be applied within 4 hours after stripping.

Temporary protection for long term storage and not used bonding point

Any surface which has been stripped, even by mistake, must be protected by varnish if it is not used for an assembly or covered with petroleum jelly.

- Cover all stripped areas carefully.
- Overlap the varnish 2 to 4 mm around the stripped area.

Final protection after assembly

Any bonding point must be protected by varnish.

Remove all traces of dust or particles from the surfaces to be protected, using a tissue dampened with solvent.

- Cover all bonding areas carefully.
- Overlap the varnish 5 mm around the stripped area.

In order to avoid paint raining, check its viscosity before application on not horizontal surface.

Types of bonding

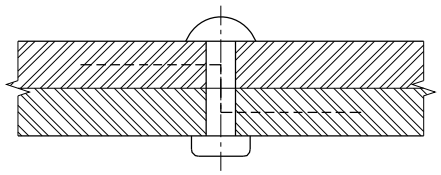
Contact through shank surfaces (Fig 5)

No stripping to be done.

Drilling to be done just before assembly.

No varnish protection to be done.

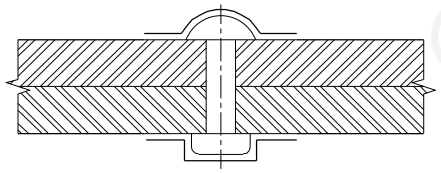
Fig 5



Contact through rivet head and shop head (Fig 6)

Process used: brush stripping + varnish on both sides.

Fig 6



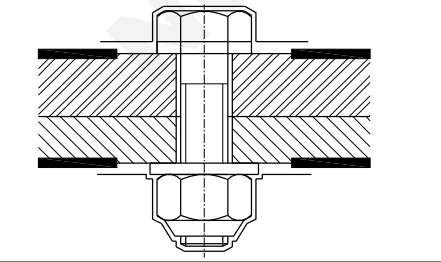
Bonding with screw / Bolt and nut (Fig 7)

Process used: brush stripping + varnish on both sides.

The torque values must absolutely be complied.

All possible paths for an interruption of varnish on the contact-surfaces during the final protection must be avoided.

Fig 7



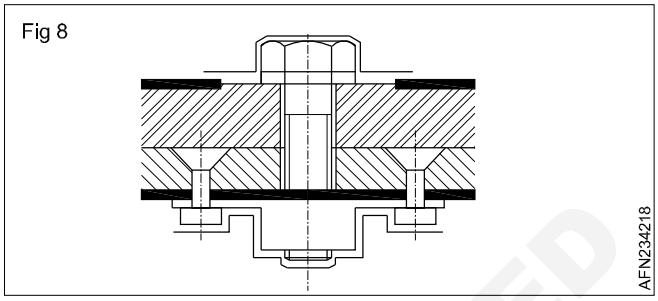
Bonding with screw / Bolt and anchor nut (Fig 8)

Process used: brush stripping on bolt side + varnish on both sides.

The torque values must absolutely be complied.

All possible paths for an interruption of varnish on the contact-surfaces during the final protection must be avoided.

Fig 8



Bonding using a bonding lead (Fig 9)

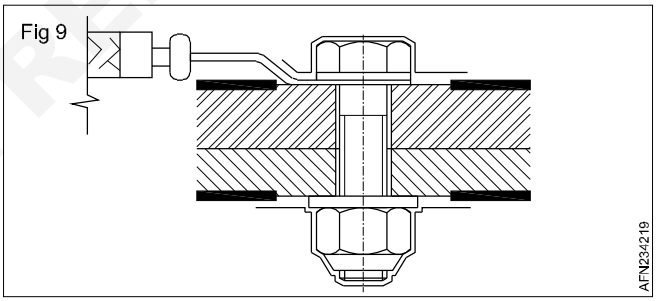
Process used: brush stripping on bonding lead side + varnish on both sides.

The torque values must absolutely be complied.

All possible paths for an interruption of varnish on the contact-surfaces during the final protection must be avoided.

The installed bonding lead must not interfere with any part of its environment. Therefore, the lug must be orientated without creating tension in the bonding lead.

Fig 9

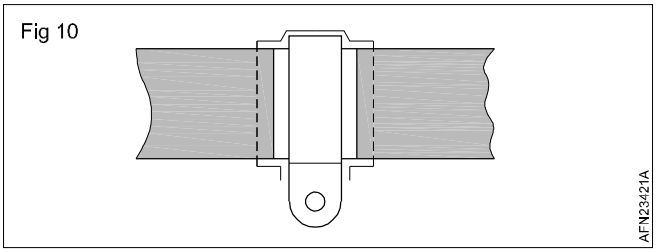


Bonding on pipes - Contact through the clamp (Fig 10)

Electrical resistance test

When the bonding process is completed a final inspection is done on the available stripped areas. When no stripped areas are available (final inspection after final protection), the use of probes without removing the paint scheme is acceptable except for pipes.

Fig 10



If any paint damage is visible after final verification, the paint scheme must be redone

If the measured value in the final inspection is out of tolerance, a rework must be done.

Poor preparation of the structure

Absence of petroleum jelly

⇓

Screws unsuitable

⇓

Screws not tighten

⇓

Poor preparation of varnish

⇓

Surplus of petroleum jelly

⇓

Absence of varnish

⇓

Corrosion

Partial or total damage of the bonding device

Poor electric protection of system

Bad flow of ESD

Electric pulling

Structure damaging

Overview of the bonding process