Sector : Capital Goods & Manufacturing
Duration : 2 - Years
Trade : Fitter 1st Year (Vol I of II) - Trade Theory - NSQF LEVEL - 5

Developed & Published by

National Instructional Media Institute
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FOREWORD

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

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for Fitter 1st Year (Vol I of II) Trade Theory NSQF Level - 5 in Capital Goods & Manufacturing Sector under Yearly Pattern. The NSQF Level - 5 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 - 5 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 5 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI’s effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

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

New Delhi - 110 001
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 Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

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

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

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

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

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

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

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

R. P. DHINGRA
EXECUTIVE DIRECTOR

Chennai - 600 032
ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material (Trade Theory) for the trade of Fitter under Capital Goods & Manufacturing Sector for ITIs.

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NIMI, Chennai - 32

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

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

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

TRADE THEORY

The manual of trade theory consists of theoretical information for the 1st year (Vol I of II) course of the Fitter Trade. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 5 syllabus on Trade Practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptual capabilities for performing the skills.

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

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

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

TRADE PRACTICAL

The trade practical manual is intended to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the 1st year (Vol I of II) course of 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 - 5 syllabus are covered.

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

<table>
<thead>
<tr>
<th>Module 1</th>
<th>Safety</th>
<th>25 Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 2</td>
<td>Basic Fitting</td>
<td>275 Hrs</td>
</tr>
<tr>
<td>Module 3</td>
<td>Sheet Metal</td>
<td>150 Hrs</td>
</tr>
<tr>
<td>Module 4</td>
<td>Welding</td>
<td>100 Hrs</td>
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<tr>
<td></td>
<td>Total</td>
<td>550 Hrs</td>
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</tbody>
</table>

The skill training in the shop floor is planned through a series of practical exercise centered around some practical object. However, there are few instances where the individual exercise does not from 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 traninee. 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.
<table>
<thead>
<tr>
<th>Lesson No.</th>
<th>Title of the Lesson</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module 1 : Safety</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.01</td>
<td>Safety</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Familiar with the working of Industrial Training Institute system including stores procedures</td>
<td>2</td>
</tr>
<tr>
<td>1.1.02</td>
<td>Importance of safety and general precautions observed in the industry/shop floor</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Approach on soft skills</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Personal Protective Equipment (PPE)</td>
<td>5</td>
</tr>
<tr>
<td>1.1.03</td>
<td>First-aid</td>
<td>9</td>
</tr>
<tr>
<td>1.1.04</td>
<td>Guidelines for good shop floor maintenance</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Importance of housekeeping</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Disposal of waste material</td>
<td>15</td>
</tr>
<tr>
<td>1.1.05</td>
<td>Occupational health and safety</td>
<td>17</td>
</tr>
<tr>
<td>1.1.06</td>
<td>Safety Sign</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Safety practice</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Response to emergencies - Power failure, System failure &amp; Fire</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Reporting emergency</td>
<td>23</td>
</tr>
<tr>
<td>1.1.07</td>
<td>Operation of electrical mains/ Circuit breakers and electrical safety</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Area of control of switches - operation on emergency</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Safety rules on electrical equipments</td>
<td>28</td>
</tr>
<tr>
<td>1.1.08</td>
<td>Safety practice - fire extinguishers</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Types of fire extinguishers</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Working on fire extinguishers</td>
<td>32</td>
</tr>
<tr>
<td>1.1.09</td>
<td>Safety, Health and Environment Guidelines</td>
<td>35</td>
</tr>
<tr>
<td>1.1.10</td>
<td>Basic understanding on Hot work, Confined space work and material handing equipment</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Lifting and handling loads</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Moving heavy equipment</td>
<td>39</td>
</tr>
<tr>
<td><strong>Module 2 : Basic Fitting</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.11</td>
<td>Linear measurement</td>
<td>43</td>
</tr>
<tr>
<td>1.2.12</td>
<td>Scribers</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Dividers</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Datum</td>
<td>46</td>
</tr>
<tr>
<td>1.2.13</td>
<td>Calipers</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Jenny calipers</td>
<td>47</td>
</tr>
<tr>
<td>Lesson No.</td>
<td>Title of the Lesson</td>
<td>Page No.</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1.2.14</td>
<td>Types of marking punches</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Hammers</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>‘V’ Blocks</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Marking off and marking off table</td>
<td>52</td>
</tr>
<tr>
<td>1.2.15</td>
<td>Bench vice</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Hacksaw frames and blades</td>
<td>54</td>
</tr>
<tr>
<td>1.2.16</td>
<td>Types of vices</td>
<td>56</td>
</tr>
<tr>
<td>1.2.17</td>
<td>Try square</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Elements of a file</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Cut of files</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>File specifications and grades</td>
<td>61</td>
</tr>
<tr>
<td>1.2.18</td>
<td>Types of files</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Needle files</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Special files</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Pinning of files</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Care and maintenance</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Convexity of files</td>
<td>66</td>
</tr>
<tr>
<td>1.2.19</td>
<td>Measurements of angles</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Angular measuring instruments (Semi - precision)</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Combination set</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Measuring standards (English &amp; metric)</td>
<td>69</td>
</tr>
<tr>
<td>1.2.20</td>
<td>Surface gauges</td>
<td>71</td>
</tr>
<tr>
<td>1.2.21</td>
<td>Cold Chisel</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Angles of chisels</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Ordinary depth gauge</td>
<td>75</td>
</tr>
<tr>
<td>1.2.22</td>
<td>Sharpening of Chisels</td>
<td>76</td>
</tr>
<tr>
<td>1.2.23</td>
<td>Marking media</td>
<td>78</td>
</tr>
<tr>
<td>1.2.24</td>
<td>Surface plates</td>
<td>79</td>
</tr>
<tr>
<td>1.2.25</td>
<td>Angle plates</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Parallel blocks</td>
<td>81</td>
</tr>
<tr>
<td>1.2.26-30</td>
<td>Physical and mechanical properties of metals</td>
<td>83</td>
</tr>
<tr>
<td>1.2.31</td>
<td>Power hacksaw</td>
<td>86</td>
</tr>
<tr>
<td>1.2.32</td>
<td>Metal-cutting saws</td>
<td>88</td>
</tr>
<tr>
<td>1.2.33</td>
<td>Outside micrometer</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Reading dimensions with outside micrometer</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Constructional features of outside micrometer</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>Inside micrometer</td>
<td>93</td>
</tr>
<tr>
<td>Lesson No.</td>
<td>Title of the Lesson</td>
<td>Page No.</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1.2.34</td>
<td>Depth micrometer</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>Digital micrometers</td>
<td>97</td>
</tr>
<tr>
<td>1.2.35</td>
<td>Vernier calipers</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td>Graduations and reading of vernier calipers</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>The british system of measurement</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Reading vernier caliper and micrometer with inch graduations</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Vernier height gauge</td>
<td>103</td>
</tr>
<tr>
<td>1.2.36</td>
<td>Vernier bevel protractor</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>Graduations on universal bevel protractor</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>Reading of universal bevel protractor</td>
<td>108</td>
</tr>
<tr>
<td>1.2.37</td>
<td>Dial Caliper</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>The digital caliper</td>
<td>110</td>
</tr>
<tr>
<td>1.2.38</td>
<td>Drilling processes - Drilling Machines, Types, Use and Care</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>Drill - Holding devices</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>Work-holding devices</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Cutting speed and RPM</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Feed in drilling</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>Radial drilling machines</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>Gang drilling machine and multiple spindle head drilling machine</td>
<td>117</td>
</tr>
<tr>
<td>1.2.39</td>
<td>Hand taps and wrenches</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>Tap drill size</td>
<td>119</td>
</tr>
<tr>
<td>1.2.40-41</td>
<td>Letter punch and number punch</td>
<td>122</td>
</tr>
</tbody>
</table>

**Module 3: Sheet Metal**

<table>
<thead>
<tr>
<th>Lesson No.</th>
<th>Title of the Lesson</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3.42</td>
<td>Safety precautions in sheet metal workshop</td>
<td>123</td>
</tr>
<tr>
<td>1.3.43</td>
<td>Metal sheets and their uses</td>
<td>129</td>
</tr>
<tr>
<td>1.3.44</td>
<td>Hand lever shears</td>
<td>134</td>
</tr>
<tr>
<td>1.3.45-1.3.47</td>
<td>Sheet Metal Tools</td>
<td>139</td>
</tr>
<tr>
<td>1.3.48</td>
<td>Stakes and their uses</td>
<td>166</td>
</tr>
<tr>
<td>1.3.49</td>
<td>Sheet metal seams</td>
<td>170</td>
</tr>
<tr>
<td>1.3.50-1.3.51</td>
<td>Solders</td>
<td>184</td>
</tr>
<tr>
<td>1.3.52-1.3.55</td>
<td>Rivets and riveting</td>
<td>195</td>
</tr>
</tbody>
</table>

**Module 4: Welding**

<table>
<thead>
<tr>
<th>Lesson No.</th>
<th>Title of the Lesson</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4.56</td>
<td>Safety</td>
<td>209</td>
</tr>
<tr>
<td>1.4.57-1.4.58</td>
<td>Welding hand tools</td>
<td>224</td>
</tr>
<tr>
<td>1.4.59</td>
<td>Setting up parameter for arc welding machine</td>
<td>255</td>
</tr>
<tr>
<td>1.4.60</td>
<td>Safety precautions in handling gas cutting plant</td>
<td>268</td>
</tr>
</tbody>
</table>
On completion of this book you shall be able to

- Recognise & Comply Safe working Practices, environment regulation and house keeping

- Plan and Organize the work to make job as per specification applying different types of basic fitting operation and check for dimensional accuracy. (Basic fitting operation - marking, hacksawing, chiseling, filing, drilling, taping and grinding etc., Accuracy ± 0.25mm)

- Manufacture Simple Sheet Metal items as per drawing and join them by soldering, brazing and riveting.

- Join Metal Components by arc welding observing standard procedure.

- Cut and Join Metal Component by gas (Oxy-acetylene)

- Cut and Join Metal Component by gas (Oxy-acetylene) & Join Metal components by riveting observing standard procedure.
### SYLLABUS

#### 1st Year (Volume I of II)

**Duration:** Six months

<table>
<thead>
<tr>
<th>Week No.</th>
<th>Ref. Learning Outcome</th>
<th>Professional Skills (Trade Practical) with Indicative hours</th>
<th>Professional Knowledge (Trade Theory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>• Recognize &amp; comply safe working practices, environment regulation and housekeeping</td>
<td>1 Importance of trade training, List of tools &amp; Machinery used in the trade. (1 hrs.)&lt;br&gt;2 Safety attitude development of the trainee by educating them to use Personal Protective Equipment (PPE). (5 hrs.)&lt;br&gt;3 First Aid Method and basic training. (2 hrs.)&lt;br&gt;4 Safe disposal of waste materials like cotton waste, metal chips/burrs etc. (2 hrs.)&lt;br&gt;5 Hazard identification and avoidance. (2 hrs.)&lt;br&gt;6 Safety signs for Danger, Warning, caution &amp; personal safety message. (1 hrs.)&lt;br&gt;7 Preventive measures for electrical accidents &amp; steps to be taken in such accidents. (2 hrs.)&lt;br&gt;8 Use of Fire extinguishers. (7 hrs.)&lt;br&gt;9 Practice and understand precautions to be followed while working in fitting jobs. (2 hrs.)&lt;br&gt;10 Safe use of tools and equipments used in the trade. (1 hr.)&lt;br&gt;11 Identification of tools &amp; equipments as per desired specifications for marking &amp; sawing. (5 hrs.)&lt;br&gt;12 Selection of material as per application. (1 hrs.)&lt;br&gt;13 Visual inspection of raw material for rusting, scaling, corrosion etc. (1 hrs.)&lt;br&gt;14 Marking out lines, gripping suitably in vice jaws, hacksawing to given dimensions. (10 hrs.)&lt;br&gt;15 Sawing different types of metals of different sections. (8 hrs.)</td>
<td>All necessary guidance to be provided to the new comers to become familiar with the working of Industrial Training Institute system including stores procedures.&lt;br&gt;Soft Skills: its importance and Job area after completion of training.&lt;br&gt;Importance of safety and general precautions observed in the industry/shop floor.&lt;br&gt;Introduction of First aid. Operation of electrical mains. Introduction of PPEs.&lt;br&gt;Response to emergencies e.g.; power failure, fire, and system failure.&lt;br&gt;<strong>Importance of housekeeping &amp; good shop floor practices.</strong>&lt;br&gt;Introduction to 5S concept &amp; its application.&lt;br&gt;<strong>Occupational Safety &amp; Health:</strong> Health, Safety and Environment guidelines, legislations &amp; regulations as applicable</td>
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<tr>
<td>2</td>
<td>• Plan and organize the work to make job as per specification applying different types of basic fitting operations &amp; check for dimensional accuracy. (Basic Fitting Operation – Marking, Hack sawing, filing drilling, taping etc.)</td>
<td></td>
<td>Linear measurements- its units, dividers, calipers, hermaphrodite, centre punch, dot punch, their description and uses of different types of hammers. Description, use and care of „V. Blocks, marking off table.</td>
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<tr>
<td>Week No.</td>
<td>Ref. Learning Outcome</td>
<td>Professional Skills (Trade Practical) with Indicative hours</td>
<td>Professional Knowledge (Trade Theory)</td>
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<tr>
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</tr>
<tr>
<td>3</td>
<td>-do-</td>
<td>16 Filing Channel, Parallel. (5 hrs.)</td>
<td>Bench vice construction, types, uses, care &amp; maintenance, vice clamps, hacksaw frames and blades, specification, description, types and their uses, method of using hacksaws.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 Filing: Flat and square (Rough finish), (10 hrs.)</td>
<td>Files—specifications, description, materials, grades, cuts, file elements, uses. Types of files, care and maintenance of files.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 Filing practice, surface filing, marking of straight and parallel lines with odd leg calipers and steel rule. (5 hrs.)</td>
<td>Measuring standards (English, Metric Units), angular measurements.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 Marking practice with dividers, odd leg calipers and steel rule (circles, ARCs, parallel lines). (5 hrs.)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-do-</td>
<td>20 Marking off straight lines and ARCs using scribing block and dividers. (5 hrs.)</td>
<td>Marking off and layout tools, dividers, scribing block, odd leg calipers, punches description, classification, material, care &amp; maintenance.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21 Chipping flat surfaces along a marked line. (10 hrs.)</td>
<td>Try square, ordinary depth gauge, protractor—description, uses and cares.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 Marking, filing, filing square and check using tri-square. (10 hrs.)</td>
<td>Calipers—types, material, constructional details, uses, care &amp; maintenance of cold chisels materials, types, cutting angles.</td>
</tr>
<tr>
<td>5 &amp; 6</td>
<td>-do-</td>
<td>23 Marking according to simple blue prints for locating, position of holes, scribing lines on chalked surfaces with marking tools. (20 hrs.)</td>
<td>Marking media, marking blue, Prussian blue, red lead, chalk and their special application, description.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 Finding center of round bar with the help of V. block and marking block. (5 hrs.)</td>
<td>Use, care and maintenance of scribing block.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 Joining straight line to an ARC. (25 hrs.)</td>
<td>Surface plate and auxiliary marking equipment, V. block, angle plates, parallel block, description, types, uses, accuracy, care and maintenance.</td>
</tr>
<tr>
<td>7 &amp; 8</td>
<td>-do-</td>
<td>26 Chipping, Chamfering, Chip slots &amp; oils grooves (Straight). (10 hrs.)</td>
<td>Physical properties of engineering metal: colour, weight, structure, and conductivity, magnetic, fusibility, specific gravity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 Filing flat, square, and parallel to an accuracy of 0.5mm. (10 hrs.)</td>
<td>Mechanical properties: ductility, malleability hardness, brittleness, toughness, tenacity, and elasticity.</td>
</tr>
<tr>
<td>Week No.</td>
<td>Ref. Learning Outcome</td>
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<td>Professional Knowledge (Trade Theory)</td>
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<tr>
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</tr>
<tr>
<td>9</td>
<td>-do-</td>
<td>28 Chip curve along a line-mark out, key ways at various angles &amp; cut key ways. (15 hrs.)</td>
<td>Power Saw, band saw, Circular saw machines used for metal cutting.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29 Sharpening of Chisel. (5 hrs.)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>30 File thin metal to an accuracy of 0.5 mm. (10 hrs.)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>-do-</td>
<td>31 Saw along a straight line, curved line, on different sections of metal. (15 hrs.)</td>
<td>Micrometer- outside and inside – principle, constructional features, parts graduation, leading, use and care.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32 Straight saw on thick section, M.S. angle and pipes. (10 hrs.)</td>
<td>Micrometer depth gauge, parts, graduation, leading, use and care. Digital micrometer.</td>
</tr>
<tr>
<td>11</td>
<td>-do-</td>
<td>33 File steps and finish with smooth file to accuracy of ± 0.25 mm. (10 hrs.)</td>
<td>Vernier calipers, principle, construction, graduations, reading, use and care. Vernier bevel protractor, construction, graduations, reading, use and care, dial Vernier Caliper, Digital vernier caliper.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34 File and saw on M.S. Square and pipe. (5 hrs.)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>-do-</td>
<td>35 File radius along a marked line (Convex &amp; concave) &amp; match. (15 hrs.)</td>
<td>Drilling processes: common type (bench type, pillar type, radial type), gang and multiple drilling machine. Determination of tap drill size.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36 Chip sheet metal (shearing). (5 hrs.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 Chip step and file. (5 hrs.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>38 Mark off and drill through holes. (5 hrs.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>39 Drill and tap on M.S. flat. (10 hrs.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 Punch letter and number (letter punch and number punch) (5 hrs.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>41 Practice use of different punches. (5 hrs.)</td>
<td></td>
</tr>
<tr>
<td>Week No.</td>
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</tr>
<tr>
<td>13</td>
<td>Manufacture simple sheet metal items as per drawing and join them by soldering, brazing and riveting.</td>
<td>42 Marking of straight lines, circles, profiles and various geometrical shapes and cutting the sheets with snips. (15 hrs.)</td>
<td>Marking and measuring tools, wing compass, Prick punch, tin man.s square tools, snips, types and uses. Tin man.s hammers and mallets type-sheet metal tools, Soldering iron, types, specifications, uses. Trammel description, parts, uses. Hand grooves specifications and uses.</td>
</tr>
<tr>
<td>14 &amp; 15</td>
<td>-do-</td>
<td>45 Make various joints: wiring, hemming, soldering and brazing, form locked, grooved and knocked up single hem straight and curved edges form double hemming..(15hrs.)</td>
<td>-do-</td>
</tr>
<tr>
<td>16</td>
<td>-do-</td>
<td>48 Bend sheet metal into various curvature form, wired edgessstraight and curves. Fold sheet metal at angle using stakes. (8 hrs.)</td>
<td>Stakes-bench types, parts, their uses. Various types of metal joints, their selection and application, tolerance for various joints, their selection &amp; application. Wired edges.</td>
</tr>
<tr>
<td>18</td>
<td>Join metal component by arc welding observing standard procedure.</td>
<td>52 Make riveted lap and butt joint.(9 hrs.)</td>
<td>Various rivets shape and form of heads, importance of correct head size.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>53 Make funnel as per development and solder joints. (10 hrs.)</td>
<td>Rivets-Tin man.s rivets types, sizes, and selection for various works.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>54 Drill for riveting. (1 hrs.)</td>
<td>-do-</td>
</tr>
<tr>
<td>Week No.</td>
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</tr>
<tr>
<td>19</td>
<td>Cut and join metal component by gas (oxy-acetylene) &amp; Join metal components by riveting observing standard procedure.</td>
<td>55 Riveting with as many types of rivet as available, use of counter sunk head rivets. (5 hrs.)</td>
<td>Riveting tools, dolly snaps description and uses. Method of riveting, The spacing of rivets. Flash riveting, use of correct tools, compare hot and cold riveting.</td>
</tr>
<tr>
<td>20</td>
<td>Cut and join metal component by gas (oxy-acetylene)</td>
<td>56 Welding - Striking and maintaining ARC, laying Straightline bead. (25 hrs.)</td>
<td>Safety-importance of safety and general precautions observed in a welding shop. Precautions in electric and gas welding. (Before, during, after) Introduction to safety equipment and their uses. Machines and accessories, welding transformer, welding generators.</td>
</tr>
<tr>
<td>22</td>
<td>Join metal components by riveting observing standard procedure.</td>
<td>58 Do setting up of flames, fusion runs with and without filler rod, and gas. (10 hrs.)</td>
<td>Setting up parameters for ARC welding machines-selection of Welding electrodes. Care to be taken in keeping electrode.</td>
</tr>
<tr>
<td>23 - 25</td>
<td>Revision</td>
<td>59 Make butt weld and corner, fillet in ARC welding (25 hrs.)</td>
<td>Oxygen acetylene cutting-machine description, parts, uses, method of handling, cutting torch-description, parts, function and uses.</td>
</tr>
<tr>
<td>26</td>
<td>Examination</td>
<td>60 Gas cutting of MS plates(25 hrs.)</td>
<td></td>
</tr>
</tbody>
</table>

(xv)
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 manpower 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 instructors etc.

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**

**ORGANISATIONAL CHART OF ITI**

```
PRINCIPAL/SUPERINTENDENT

TRAINING AND PLACEMENT OFFICER

VICE PRINCIPAL

GROUP INSTRUCTOR / TRAINING OFFICE

VOC. INSTRUCTOR / JUNIOR TRAINING OFFICER

INSTRUCTOR FOR ALLIED TRADE / JTO

DRAWING INSTRUCTOR

MILLWRIGHT INSTRUCTOR

MATHMATICS INSTRUCTOR

A.V. INSTRUCTOR

WORKSHOP ATTENDANT

OFFICE SUPDT.

ACOUNTANT

CLERICAL STAFF

CLASS IV STAFF FOR THE INSTITUTE

SUPPORTING STAFF

HOSTEL SUPDT. CUM PHYSICAL TRG. INSTRUCTOR

HOSTEL CLERK

CLASS IV STAFF FOR HOSTEL

STORE SUPDT.

STOREKEEPER

ASST. STOREKEEPER

STORE ATTENDANT

MEDICAL OFFICER

COMPOUNDER

DRESSER
```
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)

Safety in a workshop can be broadly classified into 3 categories.
- General safety
- Personal safety
- Machine safety

**General safety**
Keep the floor and gangways 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.

**Personal safety**
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 a one piece overall or boiler suit.
Keep the overall buttons fastened.
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.
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

Approach on soft skills

Objectives:

- At the end of this lesson you shall be 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.

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 is 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 (PPE)**

**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 bodysuits, 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 workplace 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 throughly 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 programme with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPE1</td>
<td>Helmet</td>
</tr>
<tr>
<td>PPE2</td>
<td>Safety footwear</td>
</tr>
<tr>
<td>PPE3</td>
<td>Respiratory protective equipment</td>
</tr>
<tr>
<td>PPE4</td>
<td>Arms and hands protection</td>
</tr>
<tr>
<td>PPE5</td>
<td>Eyes and face protection</td>
</tr>
<tr>
<td>PPE6</td>
<td>Protective clothing and coverall</td>
</tr>
<tr>
<td>PPE7</td>
<td>Ears protection</td>
</tr>
<tr>
<td>PPE8</td>
<td>Safety belt harness</td>
</tr>
</tbody>
</table>
Personal protective equipments and their uses and hazards are listed in Table 2

<table>
<thead>
<tr>
<th>Types of protection</th>
<th>Hazards</th>
<th>PPE to be used</th>
</tr>
</thead>
</table>
| Head protection (Fig 1)     | 1. Falling objects  
2. Striking against objects  
3. Spatter                  | Helmets              |
|                             | ![Helmet Image](image1.png)                  |                      |
| Foot protection (Fig 2)     | 1. Hot spatter  
2. Falling objects  
3. Working wet area         | Leather leg guards  
Safety shoes  
Gum boots             |
|                             | ![Foot Protection Image](image2.png)         |                      |
| Nose (Fig 3)                | 1. Dust particles  
2. Fumes/gases/vapours      | Nose mask            |
|                             | ![Nose Protection Image](image3.png)         |                      |
| Hand Protection (Fig 4)     | 1. Heat burn due to direct contact  
2. Blows spark moderate heat  
3. Electric shock           | Hand gloves          |
<p>|                             | <img src="image4.png" alt="Hand Protection Image" />         |                      |</p>
<table>
<thead>
<tr>
<th>Types of protection</th>
<th>Hazards</th>
<th>PPE to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye protection (Fig 5 &amp; Fig 6)</td>
<td>1. Flying dust particles</td>
<td>Goggles</td>
</tr>
<tr>
<td></td>
<td>2. UV rays, IR rays heat and high amount of visible</td>
<td>Face shield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hand shield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Head shield</td>
</tr>
<tr>
<td>Face protection (Fig 6 &amp; Fig 7)</td>
<td>1. Spark generated during welding, grinding</td>
<td>Face shield</td>
</tr>
<tr>
<td></td>
<td>2. Welding spatter striking</td>
<td>Head shield with or without ear muff</td>
</tr>
<tr>
<td></td>
<td>3. Face protection from helmets with welders</td>
<td>Helmets with welders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Screen for welders</td>
</tr>
<tr>
<td>Ear protection (Fig 7)</td>
<td>1. High noise level</td>
<td>Ear plug</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ear muff</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Types of protection</th>
<th>Hazards</th>
<th>PPE to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body protection (Fig 8, &amp; Fig 9)</td>
<td>1. Hot particles</td>
<td>Leather aprons</td>
</tr>
</tbody>
</table>

![Fig 8](image1.png)

![Fig 9](image2.png)
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 healthcare 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 leaned 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 steps. 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 lead 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 as possible through safe handling and transportation. The shorter that time, the more likely the best treatment applied.

Maintain the hygiene
Most importantly, first aider need 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 bystanders deliver breaths to victims compared to when they only do chest compressions. Second, it is very difficult to carry right maneuver 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 prevail 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 passerby 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 multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc., all to be done simultaneously. The mobile phones helps 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 is able to 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 rush into a situation, which may prove to be fatal.

Remember A-B-Cs

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)

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 them onto 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). 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 stimuli. 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 (Diarrohea & 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 heartbeat (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 have to 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 snakebite 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 (Fig 3)**

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 vital organs 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.
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 utilization 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.
Importance of housekeeping

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

• list the steps involves in house keeping
• 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 upkeep 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 work shop
• 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 (Fig 1)

• 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

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 thereby 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 (Fig.3). This reduced 90% volume of waste, some time the heat generated used to produce electric power.

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.

Colour code for bins for waste segregation given in Table-1

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Waste Material</th>
<th>Color code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Paper</td>
<td>Blue</td>
</tr>
<tr>
<td>2</td>
<td>Plastic</td>
<td>Yellow</td>
</tr>
<tr>
<td>3</td>
<td>Metal</td>
<td>Red</td>
</tr>
<tr>
<td>4</td>
<td>Glass</td>
<td>Green</td>
</tr>
<tr>
<td>5</td>
<td>Food</td>
<td>Black</td>
</tr>
<tr>
<td>6</td>
<td>Others</td>
<td>Sky blue</td>
</tr>
</tbody>
</table>
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) hygiene, 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 of the 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
  - absentism
  - disobedience
  - aggressive behaviour

6 Mechanical
- Unguarded machinery
- No fencing
- No safety device
- No control device etc.,

7 Electrical
- No earthing
- 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 Sign

Objectives: At the end of this lesson you shall be able to
• list three kinds of road sign
• describe the marking on the road
• describe the various police traffic hand signal and light signal
• list the collision causes.

In older days road locomotive carrying a red flag by day and red lantern by night. Safety is the prime motive of every traffic.

Kinds of road signs
Mandatory
Cautionary and
Informatory

Mandatory sign (Fig 1)
Violation of mandatory sign can lead to penalties. Ex. Stop, give way limits, prohibited, no parking and compulsory sign.

Cautionary signs (Fig 2)
Cautionary/ warning signs are especially safe. Do’s and don’ts for pedestrians, cyclists, bus passengers and motorists.

Information signs (Fig 3)
Information signs are especially benefit to the passengers and two wheelers.

Marking lines on road (Fig 4)
• Marking lines are directing or warn to the moving vehicles, cyclist and pedestrians to follow the law.
• Single and short broken lines with middle of the road allow the vehicle to cross the dotted lines safely overtake whenever required.
• When moving vehicle approaching pedestrian crossing, be ready to slow down or stop to let people cross.
• Do not overtake in the vicinity of pedestrian crossing.
**Police signals**

To stop a vehicle approaching from behind. Fig 5(1)
To stop a vehicle coming from front. Fig 5(2)
To stop vehicles approaching simultaneously from front and behind. Fig 5(3)
To stop traffic approaching from left and wanting to turn right. Fig 5(4)
To stop traffic approaching from the right to allow traffic from left turn right. Fig 5(5)
To allow traffic coming from the right and turning right by stopping traffic approaching from the left. Fig 5(6)
Warning signal closing all traffic. Fig 5(7)
Beckoning on vehicles approaching from left. Fig 5(8)

**Traffic light signals**

Red means stop. Wait behind the stop line on the carriage way. Fig 6(1)
Red and amber also means stop. Do not pass through or start until green shows. Fig 6(2)
Green means you may go on if the way is clear. Take special care if you mean to turn left or right and give way to pedestrians who are crossing. Fig 6(3)
Amber means stop at the stop line. You may only go on if the amber appears after you have crossed the stop line or so close to it that to pull up may not be possible. Fig 6(4)
Green arrow means that you may go in the direction shown by the arrow. You may do this whatever other lights may be showing. Fig 6(5)
Pedestrians - do not cross. Fig 6(6)
Pedestrians - cross now. Fig 6(7)
Flashing red means stop at the stop line and if the way is clear proceed with caution. Fig 6(8)
Flashing amber means proceed with caution. Fig 6(9)

**Collision causes**

Three factors are responsible for collision
- Roads
- Vehicles and
- Drivers.

The fig 7 shows approximately proportionate causes of collision. In wrong attitudes such that avoid foolish acts at the wheel. Driving time is not play time. (Fig 8)
Safety practice

Objectives: At the end of this lesson you shall be to
• state the responsibilities of employer and employees
• state the safety attitude and list the four 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 colour. 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)
**Prohibition signs**

<table>
<thead>
<tr>
<th>SHAPE</th>
<th>Circular.</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOUR</td>
<td>Red border and cross bar. Black symbol on white background</td>
</tr>
<tr>
<td>MEANING</td>
<td>Shows it must not be done.</td>
</tr>
<tr>
<td>Example</td>
<td>No smoking</td>
</tr>
</tbody>
</table>

**Mandatory signs**

<table>
<thead>
<tr>
<th>SHAPE</th>
<th>Circular.</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOUR</td>
<td>White symbol on blue background</td>
</tr>
<tr>
<td>MEANING</td>
<td>Shows what must be done</td>
</tr>
<tr>
<td>Example</td>
<td>Wear hand protection</td>
</tr>
</tbody>
</table>

**Warning signs**

<table>
<thead>
<tr>
<th>SHAPE</th>
<th>Triangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOUR</td>
<td>Yellow background with black border and symbol.</td>
</tr>
<tr>
<td>MEANING</td>
<td>Warns of hazard or danger.</td>
</tr>
<tr>
<td>Example</td>
<td>Caution, risk of electric shock.</td>
</tr>
</tbody>
</table>

**Information signs**

<table>
<thead>
<tr>
<th>SHAPE</th>
<th>Square of oblong.</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOUR</td>
<td>White symbols on green background.</td>
</tr>
<tr>
<td>MEANING</td>
<td>Indicates or gives information of safety provision.</td>
</tr>
<tr>
<td>Example</td>
<td>First aid point.</td>
</tr>
</tbody>
</table>
**Question about your safety**

Do you know the general safety rules that cover your place of work?

Are you familiar with the safety laws that govern your particular job?

Do you know how to do your work without causing danger to yourself, your workmates and the general public?

Are the plant, machinery and tools that you use really safe? Do you know how to use them safely and keep them in a safe condition?

Do you wear all the right protective clothing, and have you been provided with all the necessary safety equipment?

Have you been given all the necessary safety information about the materials used?

Have you been given training and instruction to enable you to do your job safely?

Do you know who is responsible for safety at your place of work?

Do you know who are the appointed "Safety Representatives"?

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**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 UPSs and 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 an 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 prevail 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 multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc, all to be done simultaneously. The mobile phones helps 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 there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.
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 withstand 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 influence 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 40 V) 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
- 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.
- 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 contact by pushing or pulling the person or the cable/equipment/point free
- 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 or at 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 heartbeat.
- 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.

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

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.

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 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 house hold 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.

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 submain 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. whereas in the ordinary switches, the switch off the circuit should be done by pushing the switch to upward position. (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 should always 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 practised 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 screwdrivers 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 gooo 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. Lossely 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 earthing 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 to prevent fire. When a fire outbreak 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)

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 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 temperature say 15°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 commonsense.

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 (Tinner, Adhesive solutions, Solvents, Kerosene, Spirit, LPG Gas etc.) should be stored in a separated place called the flammable material storage area.

Blowlamps 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.
<table>
<thead>
<tr>
<th>CLASS 'A' Fire</th>
<th>Wood, paper, cloth etc Solid materials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most effective i.e. cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS 'B' Fire</th>
<th>Flammable liquid. liquitiable solids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>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 used on burning liquids. Foam, dry powder or CO\textsuperscript{2} may be used on this type of fire.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS 'C' Fire</th>
<th>Gas and liquified gas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extreme caution is necessary in dealing with liquified 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 - shut off 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</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS 'D' Fire</th>
<th>Involving metals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>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 vapourising 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.</td>
</tr>
</tbody>
</table>
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 to extinguish 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)

Water-filled extinguishers

There are two methods of operation. (Fig 2)

- Gas cartridge type
- Stored pressure type

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

Dry powder extinguishers (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 (CO₂)

This type is easily distinguished by the distinctively shaped discharge horn. (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)**

Theses extinguishers may be filled with carbon tetrachloride and bromochlorodifluoro methene (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.

**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 windws, 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>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Wood, paper, cloth, solid material</td>
</tr>
<tr>
<td>B</td>
<td>Oil based fire (grease gasoline, oil) liquefiable gases</td>
</tr>
<tr>
<td>C</td>
<td>Gas and liquefiable gases</td>
</tr>
<tr>
<td>D</td>
<td>Metals and electrical equipment</td>
</tr>
</tbody>
</table>

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

• Select CO₂ (Carbon di oxide) fire extinguisher.
• Locate and pick up CO₂ fire extinguisher. Click for its expiry date.
• Break the seal (Fig 2)

• Pull the safety pin from the handle (Pin located at the top of the fire extinguisher) (Fig 3)
• Aim the extinguisher nozzle or hose at the base of the fire (this will remove the source of fuel fire) (Fig 4)

Keep your self low

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

• Sweep side to side approximately 15 cm over the fuel fire until the fire is put off (Fig 5)

Fire extinguishers are manufactured for use from the distance.

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

### Safety, Health and Environment guidelines

Rules & regulations followed in India are listed as follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Environment (Protection) Act, 1986</td>
</tr>
<tr>
<td>2</td>
<td>The Environment (Protection) Rules, 1986</td>
</tr>
<tr>
<td>3</td>
<td>Environmental Impact Assessment of Development Projects, 1994</td>
</tr>
<tr>
<td>4</td>
<td>The Prevention and Control of Pollution (uniform consent procedure) Rules, 1999</td>
</tr>
<tr>
<td>5</td>
<td>Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989</td>
</tr>
<tr>
<td>6</td>
<td>Manufacture, Storage and Import of Hazardous Chemicals (Amendment) Rules, 2000</td>
</tr>
<tr>
<td>7</td>
<td>Hazardous Wastes (Management and Handling) Rules, 1989</td>
</tr>
<tr>
<td>8</td>
<td>Bio-Medical Waste (Management and Handling) Rules, 1998</td>
</tr>
<tr>
<td>9</td>
<td>Batteries (Management &amp; Handling) Rules, 2000</td>
</tr>
<tr>
<td>10</td>
<td>Ozone Depleting Substances (Regulation) Rules, 2000</td>
</tr>
<tr>
<td>11</td>
<td>The Air (Prevention and Control of Pollution) Act, 1981 as amended by Amendment Act, 1987</td>
</tr>
<tr>
<td>12</td>
<td>The Air (Prevention and Control of Pollution) Act, 1982</td>
</tr>
<tr>
<td>13</td>
<td>The Air (Prevention and Control of Pollution) Rules, 1982</td>
</tr>
<tr>
<td>14</td>
<td>The Tamil Nadu Air (Prevention and Control of Pollution) Rules, 1983</td>
</tr>
<tr>
<td>15</td>
<td>Noise Pollution (Regulation and Control) Rules, 2000</td>
</tr>
<tr>
<td>17</td>
<td>The Tamil Nadu Water (Prevention and Control of Pollution) Rules, 1983</td>
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<td>19</td>
<td>The Water (Prevention and Control of Pollution) Cess Rules, 1978</td>
</tr>
<tr>
<td>20</td>
<td>Factories Act, 1948</td>
</tr>
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<td>21</td>
<td>Tamilnadu Factories Rules, 1950</td>
</tr>
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<td>22</td>
<td>The Gas Cylinders Rules, 1981</td>
</tr>
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<td>23</td>
<td>The Indian Electricity Act, 1910</td>
</tr>
<tr>
<td>24</td>
<td>The Indian Electricity Rules, 1956</td>
</tr>
<tr>
<td>25</td>
<td>The Petroleum Act, 1934</td>
</tr>
<tr>
<td>26</td>
<td>The Petroleum Rules, 1976</td>
</tr>
<tr>
<td>27</td>
<td>The Public Liability Insurance Act, 1991</td>
</tr>
<tr>
<td>28</td>
<td>The Public Liability Insurance Rules, 1991</td>
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<tr>
<td>29</td>
<td>Hazardous Wastes (Management and Handling) Rules, 2000</td>
</tr>
</tbody>
</table>

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
• Overcrowding
• Lighting
• Drinking water
• Latrines and urinals
• Spittoon
Capital Goods & Manufacturing
Fitter - Safety

Related Theory for Exercise 1.1.10

Basic understanding on hot work, confined space work and material handing 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 an object and falling or striking an object with a load.

Type of injury and how to prevent them?

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

By splinters and sharp or pointed projections. (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 used when raising and lowering heavy loads to ensure fingers and hands are...
Safety shoes with steel toe caps will protect feet (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.

**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. (Fig4)
4. 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.
5. 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)
6. 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...
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.

**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.

**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. 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.

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

**Safety consideration**

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

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)

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 swivelled around sideways. (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 sides with crowbars until the load is just over the ends of the rollers. (Fig 8)

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

Push the load forward on to these rollers. Twist the load further round and place the freed rollers in front 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 lowering it 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)

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.
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.

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.
Linear measurement

Objectives: At the end of this lesson you shall be able to
- name the base unit of linear measurement as per the International System of units of measurement (SI)
- state the multiples of a metre and their values
- state the purpose of steel rule
- name the types of steel rule
- state the precautions to be followed while using a steel rule.

When we measure an object, we are actually comparing it with a known standard of measurement.

The base unit of length as per SI is METRE.

Length - SI UNITS and MULTIPLES

Base unit

The base unit of length as per the Systems International is metre. The table given below lists some multiples of a metre.

- METRE (m) = 1000 mm
- CENTIMETRE (cm) = 10 mm
- MILLIMETRE (mm) = 1000 μ
- MICROMETRE (μm) = 0.001 mm

Measurement in engineering practice

Usually, in engineering practice, the preferred unit of length measurement is millimetre. (Fig 1)

Steel rules are made of spring steel or stainless steel. These rules are available in length 150mm, 300mm and 600mm. The reading accuracy of steel rule is 0.5 mm and 1/64 inch.

For accurate reading it is necessary to read vertically to avoid errors arising out of parallax. (Fig 4)

Steel rule in English measure, they can also be available with metric and English graduation in a complete range of sizes 150, 300, 500 and 1000 mm. (Fig 5)
### Other types of rule
- narrow steel rules
- short steel rules
- full flexible steel rule with tapered end.

### Narrow steel rule
Narrow steel rule is used to measure the depth of keyways and depth of smaller dia, blind holes of jobs, where the ordinary steel rule can not reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)

For maintaining the accuracy of a steel rule, it is important to see that its edges and surfaces are protected from damage and rust.

### Short steel rule (Fig 7)
This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent the use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. in machining operation on shapers, millers and tool and die work.

### Steel rule with tapered end
This rule is a favorite with all mechanics since its tapered end permits measuring of inside size of small holes, narrow slots, grooves, recesses etc. This rule has a taper from 1/2 inch width at the 2 inch graduation to 1/8 inch width at the end. (Fig 8)

Do not place a steel rule with other cutting tools. Apply a thin layer of oil when not in use.

### Angular measurement
Angular measurement of angles of an object is usually expressed in degrees, minutes and seconds. One degree is divided into 60 minutes and one minute is to 60 seconds.

### Measurements of fundamental, derived units

#### Measurement of length

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<thead>
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<th>Metric</th>
<th>British</th>
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<tr>
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<td>Millimetre (mm)</td>
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<td>1000μm</td>
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<tr>
<td>Decametre (dam)</td>
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<td>Thousandth of an inch</td>
<td>= 0.001&quot;</td>
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<tr>
<td>Inch</td>
<td>= 1&quot;</td>
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<tr>
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<tr>
<td>1 furlong</td>
<td>= 220 yds</td>
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<td>1 fur</td>
<td>= 8 fur</td>
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Scribers

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

Scribers

In lay out work it is necessary to scribe lines to indicate
the dimensions of the workpiece to be filed or machined. The scriber is a tool used for this purpose. It is made of
high carbon steel and is hardened. For drawing clear and
sharp lines, the point should be ground and honed
frequently for maintaining its sharpness.

Scribers are available in different shapes and sizes. The
most commonly used one is the plain scriber. (Fig 1)

While scribing lines, the scriber is used like a pencil so that
the lines drawn are close to the straight edge. (Fig 2)
Scriber points are very sharp; therefore, do not put the plain
scriber in your pocket.

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

Fig 1

Dividers

Objectives: At the end of this lesson you shall be able to
• name the parts of a divider
• state the uses of dividers
• state the specifications of dividers
• state the important hints on divider points.

Dividers are used for scribing circles, arcs and for
transferring and stepping off distances. (Fig 1, 2 and 3)

Dividers are available with firm joints and spring joints.
(Figs 1 & 4). The measurements are set on the dividers
with a steel rule. (Fig 2)

The sizes of dividers range between 50 mm to 200 mm.
The distance from the point to the centre of the fulcrum roller (pivot) is the size of the divider. (Fig 4)

For the correct location and seating of the divider point prick punch marks of 30° are used.

The two legs of the divider should always be of equal length. (Fig 5) Dividers are specified by the type of their joints and length.

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.

**Datum**

**Objectives:** At the end of this lesson you shall be able to
- state the need for datum while marking
- name the different datum references.

Say, the height of a person is measured from the floor on which he stands, the floor then becomes the datum or the common basis for measurement.

A datum is a reference surface, line or point, and its purpose is to provide a common position from which measurements may be taken. The datum may be an edge or centre line depending on the shape of the work. For positioning a point, two datum references are required. (Figs 1, 2 and 3)

Marking tables, surface plates, angle plates, ‘V’ blocks, and parallel blocks serve as a datum. (Figs 4 & 5)

The datum references are indicated in the drawing. The same datum references must be used for transferring dimensions to the work-piece.
Calipers

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

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

Calipers are classified according to their joints and their legs.

Joint
– Firm joint calipers (Fig 1a)
– Spring joint calipers (Fig 1b)

Legs
– Inside caliper for internal measurement. (Fig 2)
– Outside caliper for external measurement. (Fig 3)

Jenny calipers

Objectives: At the end of this lesson you shall be able to
• state the uses of a jenny caliper
• state the two types of legs of a jenny caliper.

Jenny calipers have one leg with an adjustable divider point, while the other is a bent leg. (Fig 1) These are available in sizes of 150 mm, 200 mm, 250 mm and 300 mm.

Jenny calipers are used
– for marking lines parallel to the inside and outside edges (Fig 2)
- for finding the centre of round bars. (Fig 3)

These calipers are available with the usual bent leg or with heel.
Calipers with bent leg (Fig 2B) are used for drawing lines parallel along an inside edge, and the heel type (Fig 2A) is used for drawing parallel lines along the outer edges.

The other names for this caliper are:
- hermaphrodite calipers
- leg and point calipers
- odd leg caliper
Types of 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 layout permanent. There are two types of punches. They are centre punch and 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 1a)

Prick Punch/Dot punch: The angle of the prick punch is 30° or 60°. (Fig 1b) The 30° point punch is used for making light punch marks needed to position dividers. The divider point will get a proper seating in the punch mark. The 60° punch is used for marking witness marks and called as dot punch. (Fig 2)

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 (1), pein (2), cheek (3) and the eyehole (4).

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.

Pein: The pein is the other end of the head. It is used for shaping and forming work like riveting and bending. The pein is of different shapes such as:
– ball pein (Fig 2a)
– cross-pein (Fig 2b)
– straight pein. (Fig 2c)
The face and the pein 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. The wedges fix the handle in the eyehole. (Figs 3 and 4)

**Application of hammer pein:** The ball pein is used for riveting. (Fig 5)

The cross-pein is used for spreading the metal in one direction. (Fig 6)

**Specification:** An engineer's hammers are specified by their weight and the shape of the pein. Their weight varies from 125 gms to 750 gms.

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

The ball pein hammers are used for general work in a machine/fitting shop.

**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.
'V' Blocks

Objectives: At the end of this lesson you shall be able to
• state the constructional features of 'V' blocks
• name the types of 'V' blocks and state their uses
• specify 'V' blocks as per B.I.S standard.

Constructional features

'V' Blocks are devices used for marking and setting up work on machines. The features of the common type of 'V' Blocks are as given in Figs 1 and 2.

![Fig 1](image1.png)

![Fig 2](image2.png)

The included angle of the VEE is 90° in all cases. 'V' Blocks are finished to a high accuracy in respect of dimension, flatness and squareness.

Types

Different types of 'V' blocks are available. As per BIS, there are four types, as listed below.

Single level single groove 'V' Block (Fig 1)

This type has only one 'V' groove, and has single groove (slots) on either side. These grooves are for accommodating the holding clamps.

Single level double groove 'V' Block (Fig 2)

This type will have one 'V' groove, and two grooves (slots) on either side for clamping in two positions.

Double level single groove 'V' Block (Fig 3)

In this case, the 'V' Block will have two 'V' grooves on the top and bottom, and a single groove for clamping on either side.

![Fig 3](image3.png)

Matched pair 'V' Block (Figs 4 and 5)

These blocks are available in pairs which 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 for supporting long shafts parallel on machine tables or marking off tables.

Grades and materials

'V' Blocks are available in Grade A and Grade B.

Grade A 'V' Blocks

These are more accurate, and are available only up to 100 mm length. They are made of high quality steel.

Grade B 'V' Blocks

These blocks are not as accurate as the ones in Grade A. These blocks are used for general machine shop work. These blocks are available up to 300 mm length. These 'V' Blocks are made of closely grained cast iron.

Clamping devices for 'V'-Blocks

'U' clamps are provided for holding cylindrical jobs firmly on 'V' Blocks. (Fig 6)

Designation

'V' Blocks are designated by the nominal size (length) and the minimum and maximum diameter of the workpiece capable of being clamped, and the grade and the number of the corresponding B.I.S. standard.
Example
A 50 mm long (nominal size) ‘V’ Block capable of clamping workpieces between 5 to 40 mm in diameter and of Grade A will be designated as
‘V’ Block 50/5-40 A - I.S. 2949.
In the case of a matched pair, it will be designated as
‘V’ Block M 50/5-40 A I.S.2949.
For ‘V’ Block supplied with clamps, the designation will be
‘V’ Block with clamp 50/5 40 A I.S. 2949.

Care and maintenance
- Clean before and after use.
- Choose the correct size of "V" block according to the job requirement.
- Apply oil after the use.

Marking off and marking off table

Objectives: At the end of this lesson you shall be able to
- state why marking off is necessary
- state the function of witness marks
- state the features of marking tables
- write the uses of marking tables
- state the maintenance aspects concerning marking tables.

Marking off
Marking off or layout is carried out to indicate the locations of operation to be done, and provide guidance during rough machining or filing.

Witness marks
The line marked on metal surfaces is likely to be erased due to handling. To avoid this, permanent marks are made by placing punch marks at convenient mark intervals along the marked line. Punch marks act as a witness against inaccuracies in machining and hence, they are known as witness marks.

Marking off table (Figs 1 and 2)

Marking tables are of rigid construction with accurately finished top surfaces. The edges are also finished at right angles to the top surface.

Marking tables are made of cast iron or granite, and are available in various sizes. These tables are also used for setting measuring instruments, and for checking sizes, parallelism and angles.

Care and maintenance

A marking table is very precise equipment, and should be protected from damage and rust.

After use, the marking table should be cleaned with a soft cloth.

The Surface of the marking table, made of cast iron, should be protected by applying a thin layer of oil.
Bench vice

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

Vices are used for holding the workpieces. They are available in different types. The vice used for bench work is the bench vice or called Engineer’s vice.

A bench vice is made of cast iron or cast steel and it is used to hold work for filing, sawing, threading and other hand operations. (Fig 1)

The size of the vice is stated by the width of the jaws. eg. 150mm parallel jaw bench vice

Parts of a bench vice (Fig 2)

The following are the parts of a vice.

Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of a vice.
The box-nut and the spring are the internal parts.

Vice clamps or soft jaws (Fig 3)

To hold a finished work use soft jaws (vice clamps) made of aluminium over the regular jaws. This will protect the work surface from damage.

Do not over-tighten the vice as, the spindle may be damaged.

Care and maintenance of vices

• Always keep all threaded and moving parts clean by wiping the vice with a cloth after each use.
• Make sure to oil and lubricate the joints and sliding parts.
• To oil the sliding section, open the jaws completely and apply a layer of grease to the screen.
• Remove the rust if appears on the vice using rust remover chemical.
• When the vice is not in use bring the jaws lightly gap together and place the handle in a vertical position.
• Avoid striking the handle of the vice by a hammer for tightening fully, otherwise the handle will become bend or damaged.
Hacksaw frames 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 type 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, and is specified by the type and maximum length of the blade that can be fixed.

Example
Adjustable hacksaw frame - tubular - 250 - 300mm or 8" - 12"

Types of hacksaw frames
Solid frame (Fig 1a): Only a blade of a particular standard length can be fitted to this frame. e.g. 300 mm or 250 mm.
Adjustable frame (flat type): Different standard lengths of blades can be fitted to this frame i.e. 250 mm and 300 mm.
Adjustable frame (tubular type) (Fig 1b): This is the most commonly used type. It gives a better grip and control, while sawing.

Parts of a hacksaw frame
1 Handle
2 Frame
3 Tubular frame with holes for length adjustment
4 Retaining pins
5 Fixed blade-holder
6 Adjustable blade-holder
7 Wing-nut

A hacksaw blade is made of either low alloy steel (LA) or high speed steel (HSS), and is available in standard lengths of 250 mm and 300 mm. (Fig 2)

Parts of a hacksaw blade (Fig 2)
1 Back edge
2 Side
3 Centre line
4 Pin holes

Type of hacksaw blades
All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.
Flexible blade: Only the teeth are hardened. Because of their flexibility these blades are useful for cutting along curved lines. Flexible blades should be thinner than all-hard blades.

Pitch of the blade (Fig 3): The distance between adjacent teeth is known as the ‘pitch’ of the blade.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>1.8 mm</td>
</tr>
<tr>
<td>Medium</td>
<td>1.4 mm &amp; 1.0 mm</td>
</tr>
<tr>
<td>Fine</td>
<td>0.8 mm</td>
</tr>
</tbody>
</table>

Specification: Hacksaw blades are specified by the length, pitch and type of material. (The width and thickness of blade is standardised)

Example
300 x 1.8 mm pitch LA all-hard blade.
To prevent the hacksaw blade binding when penetrating into the material, and to allow free movement of the blade, the cut is to be broader than the thickness of the hacksaw blade. This is achieved by the setting of the hacksaw teeth. There are two types of hacksaw teeth settings.

**Staggered set** (Fig 4): Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.

**Wave set** (Fig 5): In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

<table>
<thead>
<tr>
<th>Pitch</th>
<th>Type of set</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 mm</td>
<td>Wave-set</td>
</tr>
<tr>
<td>1.0 mm</td>
<td>Wave-set or staggered</td>
</tr>
<tr>
<td>Over 1.0 mm</td>
<td>Staggered</td>
</tr>
</tbody>
</table>

For the best results, the blade with the right pitch should be selected and fitted correctly.

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

**Pitch selection** (Fig 6): For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.

For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)

For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch. (Fig 8)

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

- **HSS** - Blades are used for tough resistant materials
- **High Carbon Steel** - General cutting

Select the correct number of teeth / inch the general rule is that at least 3 teeth should extend across the surface of the material to be cut.

The hand holds the hacksaw handle, and the index finger is support the handle and also points in the direction of cutting.

The other hand holds the frame, near the wing nut. Cutting/ sewing should be carried out close to the jaws of the vice. This ensures that the metal does not flex or bend under the force of the hacksaw and the sawing motion.
Types of vices

Objectives: At the end of this lesson you shall be able to
• state the different types of vices
• state the uses of quick releasing vice, pipe vice, hand vice, pin vice and leg vice.

There are different types of vices used for holding workpieces. They are quick releasing vice, pipe vice, hand vice, pin vice and toolmaker’s vice.

Quick releasing vice (Fig 1): A quick releasing vice is similar to an ordinary bench vice but the opening of the movable jaw is done by using a trigger (lever). If the trigger at the front of the movable jaw is pressed, the nut disengages the screw and the movable jaw can be set in any desired place quickly.

Pipe vice (Fig 2): A pipe vice is used for holding round sections of metal, tubes and pipes. In the vice, the screw is vertical and movable. The jaw works vertically.

The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Fig 2.

Hand vice (Fig 3): Hand vices are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44 mm. The jaws can be opened and closed using the wing nut on the screw that is fastened to one leg, and passes through the other.

Pin vice (Fig 4): The pin vice is used for holding small diameter jobs. It consists of a handle and a small collet chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.

Toolmaker’s vice (Fig 5): The toolmaker’s vice is used for holding small work which requires filing or drilling and for marking of small jobs on the surface plate. This vice is made of mild steel.

Toolmaker’s vice is accurately machined.

Leg vice

A leg vice is a holding device generally used in a forge shop for bending and forging work. It is made of mild steel to avoid breakage while hammering.
Main parts of a leg vice (Fig 6)
The following are the main parts of a leg vice.
1. Solid jaw
2. Movable jaw
3. Threaded jaw
4. Spindle
5. Spring
6. Pivot
7. Leg
8. Clamp

Since the hinged jaw moves in a radial path, the job held in this vice is not gripped properly because of the line contact. (Fig 7) Hence a work which can be carried out on a bench vice is not held on a leg vice. Jobs which require hammering only are held on a leg vice.
Try square

Objectives: At the end of this lesson you shall be able to
• name the parts of a try square
• state the uses of a try square.

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

![Fig 1](image1)

The accuracy of measurement by 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°.

Try squares are made of hardened steel.

Try squares are specified according to the length of the blade i.e. 100 mm, 150 mm, 200 mm.

Uses:
The try-square is used to:
– check the squareness (Fig 2)

![Fig 2](image2)

– check the flatness (Fig 3)

![Fig 3](image3)

– mark lines at 90° to the edges of workpieces (Fig 4)

![Fig 4](image4)

– set workpieces at right angles. (Fig 5)

![Fig 5](image5)
Elements of a file

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

Methods of material cutting

The three methods of metal cutting are abrasion (Fig.1),
fusion (Fig 2) and incision (Fig 3)

Filling is a method for removing excess material from a
workpiece by using a file which acts as a cutting tool.
Figure 4 shows how to hold a file. Files are available in
many shapes and sizes.

Parts of a file (Fig 5)
The parts of a file can be seen in figure 5, are

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.
Cut of files

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

The teeth of all file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

Types of cuts
Basically there are four types.
Single cut, Double cut, Rasp cut and Curved 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° to the centre line. 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 OVERCUT and they are cut at an angle of 70°. The other cut, made diagonal to this, is known as UPCUT, and is at an angle of 51°. This removes stock faster than the single cut file.

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 available only in half round shape.

Curved cut file (Fig 4)
These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper, and plastic.

The curved cut files are available only in a flat shape.

The selection of a file with a particular type of cut is based on the material to be filed. Single cut files are used for filing soft materials. But certain special files, for example, those used for sharpening saws, are also of single cut.
Files are manufactured in different types and grades to meet the various needs.

Files are specified according to their length, grade, cut and shape.

Length is the distance from the tip of a file to the heel.

File grades are determined by the spacing of the teeth.

A **rough file** is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.

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

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.

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

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).

Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

The number of cutting edge in rows in each of the above grades over a Length of 10mm as shown in Table (1).

It may also be observed that the number of cutting edges in rows of a file changes according to the Length of a file.

### Table (1)

<table>
<thead>
<tr>
<th>Length of file</th>
<th>Rough</th>
<th>Bastard</th>
<th>Second cut</th>
<th>Smooth</th>
<th>Deadsmooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>150mm</td>
<td>8</td>
<td>13</td>
<td>17</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>200mm</td>
<td>7</td>
<td>11</td>
<td>16</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>250mm</td>
<td>6</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>300mm</td>
<td>5</td>
<td>9</td>
<td>14</td>
<td>19</td>
<td>28</td>
</tr>
</tbody>
</table>
Capital Goods & Manufacturing
Fitter - Basic fitting

Related Theory for Exercise 1.2.18

Types 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, Hand files square, round, half round, triangular and knife-edge files
• state the correct shape of files for filing different profiles.

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

The shape of files is stated by its cross section.


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.

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.

Flat files are general purpose files. They are available in all grades. Hand files are particularly useful for filling at right angles to a finished surface.

Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 3)

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

Half round file: A half round file is in the shape of a segment of a circle. It is used for filing internal curved surfaces. (Fig 5)

Knife edge file: A knife edge file has the cross section of a sharp triangles. It is used for filing narrow grooves and angles above 10° (Fig 7)

The above files have one third of their lengths tapered. They are available both single and double cuts.
Triangular file: A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60°. (Fig.6)

Needle files

Objectives: At the end of this lesson you shall be able to
- name the different shapes of needle files
- designate needle files as per BIS.

Needle files are usually available in sets with assorted shapes. These types of files are used for delicate, light kinds of work. These files are available in bastard and smooth grade.

Shapes: The common shapes of needle files are shown in figure 1. The shapes are round edge, flat edge, flat taper, half round, triangular, square, round, knife, feather edge, crossing, barret and marking. (Fig 1)

Length: These files are available in a nominal length of 120mm to 180mm.

Grades: The grades of cut may be identified by the cut number as follows
- bastard - Cut 0.
- smooth - Cut 2.

Designation of needle files: The needle files are designated by their names
- grade of cut
- nominal length
- BIS number

Example
A flat edge needle file with grade of cut bastard, having a nominal length of 160mm shall be designated as flat edge needle file bastard, 160 IS 3152
Special files

Objectives: At the end of this lesson you shall be able to
• name the different types of special files
• state the uses of each type of special files.

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

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

Mill saw files (Fig 2): Mill saw files are usually flat and have square or rounded edges. These are used for sharpening teeth of wood-working saws, and are available in single cut.

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

Barrette file (Fig 4): This file has a flat, triangular face with teeth on the wide face only. It is used for finishing sharp corners.

Tinker’s file (Fig 5): This file has a rectangular shape with teeth only at the bottom face. A handle is provided on the top. This file is used for finishing automobile bodies after tinkering.

Rotary files (Fig 6): These files are available with a round shank. They are driven by a special machine with a portable motor and flexible shaft. These are used in diesinking and mould-making work.
Pinning of files

Objective: At the end of this lesson you shall be able to
• clean the files.

During filing, sometimes the metal chips (filings) will clog between the teeth of files. This is known as ‘pinning’ of files.

Files which are pinned will produce scratches on the surface being filed, and also will not bite well.

Pinning of the files is removed by using a file brush also called a file card, (Fig 1) with either forward or backward stroke.

Filings which do not come out easily by the file card should be taken out with a brass or copper strip. (Fig 2)

For new files, use only soft metal strips (brass or copper) for cleaning. The sharp cutting edges of the files will wear out quickly if a steel file card is used. When filing a workpiece to a smooth finish more ‘pinning’ will take place because the pitch and depth of the teeth are less.

Application of chalk on the face of the file will help reduce the penetration of the teeth and ‘pinning’.

Clean the file frequently in order to remove the filings embedded in the chalk powder.

Care and maintenance

Objective: At the end of this lesson you shall be able to
• write the care and maintenance of file.

• 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.

• Giving your files teeth a light brush with oil during long storage.

• 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.
Convexity of files

Objective: At the end of this lesson you shall be able to
• list the reasons for convexity on files.

Most files have the faces slightly bellied lengthwise. This is known as convexity of a file. This should not be confused with the taper of a file. A flat file has faces which are convex and it also tapers slightly in width and thickness.

Purpose: If the file is parallel in thickness, all the teeth on the surface of the work will cut. This would require more downward pressure to make the file ‘bite’ and also more forward pressure to make the file to cut.

It is more difficult to control a file of uniform thickness.

To produce a flat surface with a file of parallel thickness, every stroke should be straight. But it is not possible due to the see-saw action of the hand.

If the file is made with parallel faces, while giving heat treatment, one face may warp and become concave, and the file will be useless for flat filing.

Excessive chip removal at the front or rear workpiece edge is prevented and filing of the flat surface is made easier because of the convexity on the cutting faces. (Fig 1)
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. Each division is called a degree. (A half circle will have 180°) (Fig 1)

Fig 1

Subdivisions 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

<table>
<thead>
<tr>
<th>Sub divisions</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 complete circle</td>
<td>360°</td>
</tr>
<tr>
<td>1/2 circle</td>
<td>180°</td>
</tr>
<tr>
<td>1/4 of a circle</td>
<td>90° (right angle)</td>
</tr>
<tr>
<td>1 degree or 1°</td>
<td>60 mts or 60’</td>
</tr>
<tr>
<td>1 min or 1’</td>
<td>60 secs or 60”</td>
</tr>
</tbody>
</table>
Angular measuring instruments (Semi-precision)

Objectives: At the end of this lesson you shall be able to
- state the names of semi-precision angular measuring instruments
- differentiate between bevel and universal bevel gauges
- state the features of bevel protractors.

The most common instruments used to check angles are the:
bevel or bevel gauge (Fig 1)
universal bevel gauge (Fig 2)
bevel protractor. (Fig 3)

Universal bevel gauges: The universal bevel gauge has an additional blade. This helps in measuring angles which cannot be checked with an ordinary bevel gauge. (Fig 4)

Bevel gauges: The bevel gauges cannot measure angles directly. They are, therefore, indirect angular measuring instruments. The angles can be set and measured with bevel protractors.

Combination set

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** (1)
**Square Head** (2)
**Centre head, and a** (3)
**Rule** (4)

**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. (Fig 6)

**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.
Measuring standards (English & metric)

Objective: At the end of this lesson you shall be able to
• describe the measuring standards of english and metric units.

Necessity
All physical quantities are to be measured in terms of standard quantities.

Unit
A unit is defined as a standard or fixed quantity of one kind used to measure other quantities of the same kind.

Classification
Fundamental units and derived units are the two classifications.

Fundamental units
Units of basic quantities of length, mass and time.

Derived units
Units which are derived from basic units and bear a constant relationship with the fundamental units.

Ex : Area, Volume, Pressure, Force, etc.

System of units
F.P.S. system is the British system in which the basic units of length, mass and time are foot, pound and second respectively.

C.G.S. system is the metric system in which the basic units of length, mass and time are centimetre, gram and second respectively.

M.K.S system is another metric system in which the basic units of length, mass and time are metre, kilogram and second respectively.

S.I. units is referred to as Systems International units which is again of metric and the basic units, their names and symbols are Listed in table - 1
Fundamental units and derived units are the two classification of units.

Length, mass and time are the fundamental units in all the systems (ie) F.P.S, C.G.S, M.K.S and S.I systems.

<table>
<thead>
<tr>
<th>Basic Quantity</th>
<th>Metric Unit</th>
<th>British unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Symbol</td>
<td>Name</td>
</tr>
<tr>
<td>Length</td>
<td>Metre</td>
<td>Foot</td>
</tr>
<tr>
<td>Mass</td>
<td>Kilogram</td>
<td>Pound</td>
</tr>
<tr>
<td>Time</td>
<td>Second</td>
<td>Second</td>
</tr>
<tr>
<td>Current</td>
<td>Ampere</td>
<td>Ampere</td>
</tr>
<tr>
<td>Temperature</td>
<td>Kelvin</td>
<td>Farenheit</td>
</tr>
<tr>
<td>Light intensity</td>
<td>Candela</td>
<td>Candela</td>
</tr>
</tbody>
</table>

Table 1
Surface gauges

Objectives: At the end of this lesson you shall be able to
• state the uses of surface gauges
• name the types of surface gauges
• state the advantages of universal surface gauges.
• state care and maintenance of surface gauges

The surface gauge is one of the most common marking tools used for:

scribing lines parallel to a datum surface (Fig.1)

[Fig 1]

Setting jobs on machines parallel to a datum surface (Fig.2)

[Fig 2]

Checking the height and parallelism of jobs, setting jobs concentric to the machine spindle. (Fig 3)

[Fig 3]

Types of surface gauges

Surface gauges/scribing blocks are of two types, fixed and universal.

Surface gauge - fixed type (Fig 4)

The fixed Type of surface gauge consists of a heavy flat base and a spindle, fixed upright, to which a scriber is attached with a snug and a clamp nut.

[Fig 4]

Universal surface gauge (Fig 5)

This has the following additional features: The spindle can be set to any position. Fine adjustment can be made quickly. Can also be used on cylindrical surfaces.

[Fig 5]
Parallel lines can be scribed from any datum edge with the help of guide pins. (Fig 6)

**Fig 6**

Parts and functions of a Universal Surface Gauge

**Base**
The base is made of steel or cast iron with a 'V' groove at the bottom. The 'V' groove helps to seat on circular work. The guide-pins, fitted in the base, are helpful for scribing lines from any datum edge.

**Rocker arm**
The rocker arm is attached to the base along with a spring and a fine adjustment screw. This is used for fine adjustments.

**Spindle**
The spindle is attached to the rocker arm.

**Scriber**
The scriber can be clamped in any position on the spindle with the help of a snug and a clamping nut.

**Care and maintenance**
- Clean before and after the use
- Apply thin layer of oil to the bottom of the surface base before using for marking.
- Sharpen the Scriber if necessary.
- Do not exert more pressure while marking
Cold Chisel

Objectives: At the end of this lesson you shall be able to
• list the uses of a cold chisel
• name the parts of a cold chisel
• state the different types of chisels
• specify the chisel

The cold chisel is a hand cutting tool used by fitters for chipping and cutting off operations. (Fig 1)

Chipping is an operation of removing excess metal with the help of a chisel and hammer. Chipped surfaces being rough, they should be finished by filing.

Parts of a Chisel (Fig 2): A chisel has the following parts.

Head, body, point or cutting edge.

Chisels are made from high carbon steel or chrome vanadium steel. The cross-section of chisels is usually hexagonal or octagonal. The cutting edge is hardened and tempered.

Common types of chisels: There are five common types of chisels.
– Flat chisel
– Cross-cut chisel
– Half-round nose chisel
– Diamond point chisel
– Web chisel

Flat chisels (Fig.3a): They are used to remove metal from large flat surfaces and chip-off excess metal of welded joints and castings.

Cross-cut or cape chisels (Fig.3b): These are used for cutting key ways, grooves and slots.

Half-round nose chisels (Fig 4): They are used for cutting curved grooves (oil grooves).

Diamond point chisels (Fig 5): These are used for squaring materials at the corners, joints.
Web chisels/ punching chisels (Fig 6): These chisels are used for separating metals after chain drilling. Chisels are specified according to their
  - length

Angles of chisels

Objectives: At the end of this lesson you shall be able to
• select the point angles of chisels for different materials
• state the effect of rake and clearance angles
• brief the care and maintenance of chisels.

Point angles and materials: The correct point/cutting angle of the chisel depends on the material to be chipped. Sharp angles are given for soft materials, and wide angles for hard materials.

The correct point and angle of inclination generate the correct rake and clearance angles. (Fig 1)

Rake angle: Rake angle is the angle between the top face of the cutting point, and normal (90°) to the work surface at the cutting edge. (Fig 2)

Clearance angle: Clearance angle is the angle between the bottom face of the point and the tangent to the work surface originating at the cutting edge. (Fig 2)

If the clearance angle is too low or zero, the rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip. (Fig 3)

If the clearance angle is too great, the rake angle reduces. The cutting edge digs in and the cut will become deeper and deeper. (Fig 4) The correct point angle and angle of inclination for different materials for chipping is given in Table 1.
**Crowning:** A slight curvature is ground called “Crowning” to the cutting edge of the chisel, to prevent digging of corners, which leads to breakage of chisel point. “Crowning” allows the chisel to move freely along a straight line while chipping.

<table>
<thead>
<tr>
<th>Material to be cut</th>
<th>Point angle</th>
<th>Angle inclination</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Carbon Steel</td>
<td>65°</td>
<td>39.5°</td>
</tr>
<tr>
<td>Cast iron</td>
<td>60°</td>
<td>37°</td>
</tr>
<tr>
<td>Mild steel</td>
<td>55°</td>
<td>34.5°</td>
</tr>
<tr>
<td>Brass</td>
<td>50°</td>
<td>32°</td>
</tr>
<tr>
<td>Copper</td>
<td>45°</td>
<td>29.5°</td>
</tr>
<tr>
<td>Aluminium</td>
<td>30°</td>
<td>22°</td>
</tr>
</tbody>
</table>

**Table 1**

**Care & maintenance**
- Sharpen the chisel before use.
- Apply oil to avoid rust.
- Don't use the mushroom head chisel.
- Use safety goggles while chipping.
- While chipping.
- No greasy subject on the head of the chisel.

**Ordinary depth gauge**

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

**Ordinary depth gauge**

Ordinary depth gauge is semi precision instrument used for measuring of depth of recesses, slots and steps.

**Parts of ordinary depth gauge**
1. Graduated beam
2. Clamping screw
3. Scale
4. Base

Available in the ranges of 0-200 mm. Ordinary depth gauge is used to measure an accuracy of 0.5 mm.
Chisels will become blunt due to use. For efficiency in chipping, the chisels are to be re-sharpened regularly.
Chisels are sharpened on grinding machines. (Fig 1)

After re-grinding many times, the cutting edges become too thick. Such chisels are unsuitable for resharpening. They should be forged and brought to shape before grinding. (Fig 2)

Before commencing grinding, the following procedure should be observed.

- Ensure the wheel guards are in place, and are securely fastened.
- Inspect the condition of the grinding wheel for breakage and cracks.
- Wear safety goggles.
- When switching on the grinding machine, stand aside until the wheel reaches the operating speed.

Inspect the tool rest
If there is too much of gap between the tool-rest and the wheel, adjust it, and position it as close to the wheel as possible. (Fig. 3)

Ensure that there is sufficient coolant in the container.
While grinding, rest the body of the chisel on the tool-rest (A) and allow the point to touch the wheel. (Fig. 4)

Rock the point slightly on both sides in an arc (B) to provide a slight convexity at the cutting edge. This will help to avoid digging in the sides while chipping. (Fig 4)

Keep moving the chisel across the face (C) of to Prevent formation of curves and grooves at the cutting edge.
Dip the chisel frequently in the coolant to avoid overheating. Overheating will draw the temper of the chisel.
If the chisel-head is mushroomed, it should be cleaned by grinding. (Fig 5)

Use only the front of the grinding wheel. (Fig 4) Do not grind on the sides. (Fig 6)

Use goggles while using a grinder
Any damage to the grinding wheel, if noticed should be reported to the instructor.
Do not use cotton waste or other material for holding the chisel while grinding.
Objectives: At the end of this lesson you shall be able to
• state the purpose of marking media
• name the common types of marking media
• select the correct marking medium for different applications.

Purpose of marking media

In marking off/Layout, the surface of the job/workpiece is coated with a medium to show the marked lines clear and visible. To get clear and thin lines, the best layout medium is to be selected.

Different marking media

The different marking media are Whitewash, Marking blue, Prussian Blue, Copper Sulphate and Cellulose Lacquer.

Whitewash

Whitewash is prepared in many ways.
- Chalk powder mixed with water
- Chalk mixed with methylated spirit
- White lead powder mixed with turpentine

Whitewash is applied to rough forgings and castings with oxidised surface. (Fig 1)

Whitewash is not recommended for workpieces of high accuracy.

Marking blue

A Chemical dye, blue based colour mixed with methylated spirit used for marking on workpieces which are reasonably machined surface.

Prussian blue

This is used on filed or machine-finished surfaces. This will give very clear lines but takes more time for drying than the other marking media. (Fig 2)

Copper sulphated

The solution is prepared by mixing copper sulphate water and a few drops of nitric acid. The copper sulphate is used on filed or machine-finished surfaces. Copper sulphate sticks to the finished surfaces well.

Copper sulphate needs to be handled carefully as it is poisonous. Copper sulphate coating should be dried before commencing marking, as otherwise, the solution may stick on the instruments used for marking.

Cellulose lacquer: This is a commercially available marking medium. It is made in different colours and dries very quickly.

The selection of marking medium for a particular job depends on the surface finish and the accuracy of the workpiece.

In present days, marking media used are readily available in aerosol container, which can be applied by spraying on to any surface, which needs marking.

Readymade solutions of marking dye/ink which are quick drying and thin layer to mark precise dimensions and clear visible lines. Also permanent marker pens are available in different colours, which are quick drying and used for smaller workpieces of metal, wood and plastics.
Surface plates

Objectives: At the end of this lesson you shall be able to
• state the necessity of surface plate
• state the material of surface plate
• state the specification of surface plate.

Surface plates - their necessity

When accurate dimensional features are to be marked, it is essential to have a datum plane with a perfectly flat surface. Marking using datum surfaces which are not perfectly flat will result in dimensional inaccuracies. (Fig. 1) The most widely used datum surfaces in machine shop work are the surface plates and marking tables.

Materials and construction

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

The work-surface is machined and scraped. The underside is heavily ribbed to provide rigidity. (Fig 2)

Other materials used

Granite is also used for manufacturing surface plates. Granite is a dense and stable material. Surface plates made of granite retain their accuracy, even if the surface is scratched. Burrs are not formed on these surfaces.

Classification and uses

Surface plates used for machine shop work are available in three grades - Grades 1, 2 and 3. The grade 1 surface plate is more acceptable than the other two grades.

Specifications

Cast iron surface plates are designated by their length, breadth, grade and the Indian Standard number.

Example

Cast iron surface plate 2000 x 1000 Gr1. I.S. 2285.

Care & maintenance

• Clean before and after use.
• Do not keep job on the surface plate.
• Don't keep any cutting tool on the table.
Angle Plates

Objectives: At the end of the lesson you shall be able to
• state the constructional features of different types of angle plates
• name the types of angle plates
• state the uses of different types of angle plates
• state the grades of angle plates.
• specify angle plates.

Constructional features
Angle plates have two 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 unmachined part for good rigidity and to prevent distortion.

Types of Angle Plates

Plain solid angle plate (Fig 1)

Among the three types of angle plates normally used, the plain solid angle plate is the most common. It has the two plane surfaces perfectly machined at 90° to each other. Such angle plates are suitable for supporting work-pieces during layout work. They are comparatively smaller in size.

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

The slots are machined on the top plane surfaces for accommodating clamping bolts. This type of angle plate can be tilted 90° along with the work for marking or machining. (Figs 3 and 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 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 position.

**Box angle plate (Fig 6)**

They have applications similar to those of other angle plates. After setting, the work can be turned over with the box enabling further marking out or machining. This is a significant advantage. This has all the faces machined square to each other.

![Box Angle Plate](image)

**Grades**

Angle plates are available in two grades - Grade 1 and Grade 2. The Grade 1 angle plates are more accurate and are used for very accurate tool room type of work. The Grade 2 angle plates are used for general machine shop work. In addition to the above two grades of angle plates, precision angle plates are also available for inspection work.

### Sizes

Angle plates are available in different sizes. The sizes are indicated by numbers. Table 1 gives the number of the sizes and the corresponding size proportions of the angle plates.

**Specification of angle plates**

a) Size 6 Grade 1

Box plate will be designated as - box angle plate 6 Gr 1 IS 623.

b) Size 2 - Grade 2 angle plate will be designated as Angle plate 2 Gr 2 IS 623.

<table>
<thead>
<tr>
<th>Size No.</th>
<th>L</th>
<th>B</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>125</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>175</td>
<td>100</td>
<td>125</td>
</tr>
<tr>
<td>3</td>
<td>250</td>
<td>150</td>
<td>175</td>
</tr>
<tr>
<td>4</td>
<td>350</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>5</td>
<td>450</td>
<td>300</td>
<td>350</td>
</tr>
<tr>
<td>6</td>
<td>600</td>
<td>400</td>
<td>450</td>
</tr>
<tr>
<td>7</td>
<td>700</td>
<td>420</td>
<td>700</td>
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<td>8</td>
<td>600</td>
<td>600</td>
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<td>9</td>
<td>1500</td>
<td>900</td>
<td>1500</td>
</tr>
<tr>
<td>10</td>
<td>2800</td>
<td>900</td>
<td>2200</td>
</tr>
</tbody>
</table>

**Care & Maintenance**

- Clean before and after use.
- Apply oil after the use.

**Parallel blocks**

**Objectives:** At the end of this lesson you shall be able to
- name the types of parallels
- state the constructional features of parallel blocks
- specify parallel blocks as per BIS recommended
- state the uses of parallel blocks.

Parallel blocks of different types are used for setting workpieces for machining. The commonly used are of two types.

- Solid Parallels
- Adjustable Parallels

**Solid parallels (Solid parallel blocks) (Fig 1)**

This is the type of parallel which is very much used in machine shop work. They are made of steel pieces of rectangular cross section, and are available in different lengths and cross sectional sizes.
Uses
Solid and adjustable parallels are used for parallel setting of workpieces while machining. They are also useful for raising the workpieces held in vices or machine tables to provide better observation of the machining process. (Fig 3)

Grades
Parallels are made in two grades - Grade A and Grade B. Grade A is meant for fine toolroom type of work, and Grade B for general machine shop work.

Adjustable parallels (Fig 2)
These consist of two tapered blocks sliding one over the other in a tongue and groove assembly. These types of parallels can be adjusted and set to different heights.

Designation of parallels
Parallels are designated by the type, grade (for solid parallels only) size, and the number of the standard. Fig 4

Examples
Solid parallel A5 x 10 x 100 IS: 4241
Adjustable parallel 10 x 13 IS:4241

Table 1
Sizes of solid parallels

<table>
<thead>
<tr>
<th>Grade</th>
<th>Size T.W.L.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A &amp; B</td>
<td>5 x 10 x 100</td>
</tr>
<tr>
<td>A &amp; B</td>
<td>10 x 20 x 150</td>
</tr>
<tr>
<td>A &amp; B</td>
<td>15 x 25 x 150</td>
</tr>
<tr>
<td>A &amp; B</td>
<td>20 x 35 x 200</td>
</tr>
<tr>
<td>A &amp; B</td>
<td>25 x 45 x 250</td>
</tr>
<tr>
<td>A &amp; B</td>
<td>30 x 60 x 250</td>
</tr>
<tr>
<td>A &amp; B</td>
<td>35 x 70 x 300</td>
</tr>
<tr>
<td>B</td>
<td>40 x 80 x 350</td>
</tr>
<tr>
<td>B</td>
<td>50 x 100 x 400</td>
</tr>
</tbody>
</table>

Table 2
Range and size of Adjustable Parallels

<table>
<thead>
<tr>
<th>Height Range</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 13</td>
<td>40</td>
</tr>
<tr>
<td>13 - 16</td>
<td>50</td>
</tr>
<tr>
<td>16 - 20</td>
<td>60</td>
</tr>
<tr>
<td>20 - 25</td>
<td>65</td>
</tr>
<tr>
<td>25 - 30</td>
<td>70</td>
</tr>
<tr>
<td>30 - 40</td>
<td>85</td>
</tr>
<tr>
<td>40 - 50</td>
<td>100</td>
</tr>
</tbody>
</table>
Physical and mechanical properties of metals

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).

Structure (Figs 1 and 2)
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 (Fig 3)
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 (232°C) and tungsten melts at a high temperature (3370°C).

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

Mechanical properties
The mechanical properties of a metal are
• ductility
• malleability
• hardness
• brittleness
• toughness
• tenacity
• elasticity

Ductility (Fig 4)
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.
Malleability (Figs 5 and 6)

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.

Hardness (Fig 7)

Hardness is a measure of a metal's ability to withstand scratching, wear, abrasion and penetration.

Brittleness (Fig 8)

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.

Toughness (Fig 9)

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.

Tenacity (Fig 10)

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.
Elasticity (Fig 11)

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.

Specific gravity

It is the ratio between the weight of the metal and the weight of equal volume of water.
Power hacksaw

Objectives: At the end of the lesson you shall be able to
• state the features of a power hacksaw
• select the correct blade for different jobs
• state the features of a power hacksaw blade
• state the features of work-holding and supporting devices
• name the parts of a power hacksaw
• state the method of fixing power saw blades.

Cut off saws are used to cut metal stock roughly to the required length. The commonly used cut-off saw in small scale industries is a POWER SAW.

Features

The power saw works like a hand hacksaw, and has an arrangement for cutting during the movement in one direction and releasing pressure on the non-cutting stroke. The rotary motion of the motor is converted into linear motion by a crank mechanism. (Fig 1)

The required cutting pressure is obtained hydraulically or by an adjustable weight.

During the non-cutting motion the blade will be lifted away from the work.

A clamping device/vice holds the work firmly.

Power saw: This is most commonly used metal cutting saw. (Fig.2)

Power hacksaw blades

The saw blades are selected, depending on the machine and the type of work on hand. The blades are made of H.S Steel and are fully hardened.

For different materials, blades of different pitches are used (number of teeth per 25mm length). (Fig 3)

As a general rule, the softer the material, the lesser is the number of teeth, per length of 25 mm.

Teeth with a large pitch can accommodate large chips (Fig 4)

Blades are available with varying coarseness i.e between 4 to 14 teeth per inch length.

Coarse pitch blades are also used while cutting large sections of stock, as this will help in greater chip clearance and increased penetration.

For cutting hard material (example - tool steel), and thin material, a 14 T.P.I blade is recommended.

For general purpose sawing, a 10 TPI blade will be useful.

While selecting blades, make sure at least two teeth of the blade will be in contact with the work at all times.
What will happen if less than two teeth are in contact with the work?
The work can be caught in the tooth gullet, and cause breakage to the blade. (Fig 5)

Blade clearance (Fig 6)
In order to avoid jamming of the teeth and to provide for chip clearance, the teeth of the saw blades are offset or waved.

Fig 5

Specification of power hacksaw blades (Fig 7)
While specifying power hacksaw blades, it is necessary to state
- The length (the distance between centre of holes).
- The width
- The thickness and
- The teeth pitch.

Clamping arrangement (Fig 8)
Power saws are provided with clamping devices similar to those in machine vices, and the work can be gripped by using the crank handle.

Fig 8

When a number of pieces of the same size are to be cut an adjustable stop is used.

Long bars are supported, and the level maintained by the use of adjustable floor stands. (Fig 9)

Fixing blades (Fig 10)
The blades are mounted on frames using screws.
The teeth of the blade should point towards correct directions. (Depending on the type of machine the blade either cuts on the forward or on the return stroke).

It is necessary to follow the directions given by the manufacturer as indicated in the frame.

Tension the blade using the tensioning device.
Metal-cutting saws

Objectives: At the end of this lesson you shall be able to
• name the common types of metal-cutting saws
• state the advantages of a horizontal band-saw
• state the features of different types of cutting saws
• state the specific use of a contour-saw.
• state the precautions to be observed while machine sawing.

Metal-cutting saws of different types are used in industries. The most commonly used are the:
- power saw
- horizontal band-saw
- circular saw
- contour band-saw.

Power saw (Fig 1)
This is the most commonly used metal-cutting saw and discussed in related theory for Ex: 1.2.31.

Horizontal band-saw (Fig 2)
This has a saw frame on which a motor is fitted.
There are two pulley wheels on which an endless bandsaw passes.

Speed variation is obtained through the stepped pulleys on the motor.
The roller-guide brackets provide the rigidity for the blade in the cutting area and also prevent wandering of the blade while cutting.
The blade tension is maintained by using the adjusting handle provided for this purpose.
A vice is provided for holding the metal stocks. The vice is adjustable for angular cutting.
This machine has the advantage of continuous cutting ability, and is much faster than a power saw. It may be noted that a power saw cuts only in every alternate stroke.

Circular saw (Fig 3)
This type of cutting machine is used when cutting materials have a large cross-section. The circular saw has a continuous cutting action and is economical in production work where heavy section metals are used.

Contour saw (Fig 4)
In this, a metal band saw blade is used, and the contour saw has a continuous cutting motion. (Fig 5)
These machines are very much used for cutting metals to different profiles. (Fig 6)
Different speeds can be obtained while cutting, with the help of variable speed pulleys.
For repairing broken contour saw blades, these machines are fitted with a shear for trimming the blade ends, a butt-welding machine for joining the ends and the small grinder to finish the welded joint.
The table can be tilted to any angle for angular cutting.
The blade passes through a guide which prevents the blades from wandering and keeps it rigidly.
These machines are widely used for tool-room work, and not as a machine for cutting raw material stock.

**Precautions to be observed while machine sawing**

In order to work safely and efficiently, certain precautions are to be observed.

While taking measurements of the work for setting, always stop the machine.

Projecting ends of the work should be well guarded, so that safety may be provided to others.

Ensure that the work does not protrude into the gangways.

When sawing thin pieces, hold the material flat in the vice to prevent the saw teeth from breaking.

Ensure a cutting fluid is used always.

Avoid giving excessive cutting pressure, because this can cause breakage to the blade, and cut work out of square.

When several pieces of the same length are to be cut, use a stop gauge.

When holding short workpieces in a vice, be sure to place a short piece of the same thickness in the opposite end. This will prevent the vice from twisting when it is tightened.

Lubricate the machines on the indicated points using oil can, oil gun or grease gun as specified by the machine manufacturer.
Outside micrometer

Objectives: At the end of this lesson you shall be able to
• name the parts of an outside micrometer
• state the functions of the main parts of an outside micrometer.

A micrometer is a precision instrument used to measure a job, generally within an accuracy of 0.01 mm.

Micrometers used to take the outside measurements are known as outside micrometers. (Fig 1)

The parts of a micrometer are listed here.

Frame
The frame is made of drop-forged steel or malleable cast iron. All other parts of the micrometer are attached to this.

Barrel/Sleeve
The barrel or sleeve is fixed to the frame. The datum line and graduations are marked on this.

Thimble
On the bevelled surface of the thimble also, the graduation is marked. The spindle is attached to this.

Spindle
One end of the spindle is the measuring face. The other end is threaded and passes through a nut. The threaded mechanism allows for the forward and backward movement of the spindle.

Anvil
The anvil is one of the measuring faces which is fitted on the micrometer frame. It is made of alloy steel and finished to a perfectly flat surface.

Spindle lock nut
The spindle lock nut is used to lock the spindle at a desired position.

Ratchet stop
The ratchet stop ensures a uniform pressure between the measuring surfaces.

Graduations of metric outside micrometer

Objectives: At the end of this lesson you shall be able to
• state the principle of a micrometer
• determine the least count of an outside micrometer.

Working principle
The micrometer works on the principle of screw and nut. The longitudinal movement of the spindle during one rotation is equal to the pitch of the screw. The movement of the spindle to the distance of the pitch or its fractions can be accurately measured on the barrel and thimble.

Graduations (Fig 1)
In metric micrometers the pitch of the spindle thread is 0.5 mm.

Thereby, in one rotation of the thimble, the spindle advances by 0.5 mm.
On the barrel a 25 mm long datum line is marked. This line is further graduated to millimetres and half millimetres (i.e. 1 mm & 0.5 mm). The graduations are numbered as 0, 5, 10, 15, 20 & 25 mm.

The circumference of the bevel edge of the thimble is graduated into 50 divisions and marked 0-5-10-15 ........ 45-50 in a clockwise direction.

The distance moved by the spindle during one rotation of the thimble is 0.5 mm.

Movement of one division of the thimble = 0.5 x 1/50

= 0.01 mm

Accuracy or least count of a metric outside micrometer is 0.01 mm.

Objectives: At the end of this lesson you shall be able to
- select the required range of a micrometer
- read micrometer measurements.

Ranges of outside micrometer
Outside micrometers are available in ranges of 0 to 25 mm, 25 to 50 mm, 50 to 75 mm, 75 to 100 mm, 100 to 125 mm and 125 to 150 mm.

For all ranges of micrometers, the graduations marked on the barrel is only 0-25 mm. (Fig 1)

Reading micrometer measurements
How to read a measurement with an outside micrometer? (Fig 2)

First note the minimum range of the outside micrometer. While measuring with a 50 to 75 mm micrometer, note it as 50 mm.

Then read the barrel graduations. Read the value of the visible lines on the left of the thimble edge.

13.00 mm (Main division reading on barrel) + 00.50 mm (Sub division reading on barrel)
13.50 mm (Main division + sub - division value)

Next read the thimble graduations.
Read the thimble graduations in line with the barrel datum line, 13th div. (Fig 3)

Multiply this value with 0.01 mm (least count).
13 x 0.01 mm = 0.13 mm.

Add

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum range</td>
<td>50.00 mm</td>
</tr>
<tr>
<td>Barrel reading</td>
<td>13.50 mm</td>
</tr>
<tr>
<td>Thimble reading</td>
<td>00.13 mm</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>63.63 mm</strong></td>
</tr>
</tbody>
</table>

The micrometer reading is 63.63 mm.

**Constructional features of outside micrometer**

**Objectives:** At the end of this lesson you shall be able to
- name the internal parts of a micrometer
- state the functions of the various parts of a micrometer
- state the precautions to be observed while dismantling and assembling micrometers.

In order to dismantle and carry out cleaning or adjustment of a micrometer, it is essential to know the functions of its various parts. (Fig 1)

**Ratchet stop** (Fig 2)

This is a device fitted on micrometers to ensure uniform pressure between the measuring face of the micrometer while measuring.

The ratchet stop will slip beyond certain pressure, thus preventing further advancement of the spindle when excessive pressure is used.

This is mounted on the thimble of the micrometer, and it connects with the spindle when assembled.

A special spanner is provided along with the micrometer for fixing and removing the ratchet stop. (Fig 3)

**Thimble**

The thimble has a hollow taper (Fig 4) to match with the taper nose fitted on the spindle.
Spindle
One end of the spindle forms the measuring face. The other end of the spindle is threaded, the tapered nose is fitted on it. (Fig 5)

The taper nose is very accurately finished for axial alignment and it also permits positioning of the thimble in any required place during the adjustment of zero error.

The spindle passes through a split internal thread (Fig 6) which forms part of the barrel. The outer portion of this split internal thread has tapered external threads. A taper threaded nut is fitted on this.

Tightening and loosening of this nut enables the split internal thread to close or open. This permits the wear adjustment in the mating threads.

A special spanner is provided for this purpose. (Fig 7)

The locking device provided on the spindle is to arrest the movement of the spindle after taking the measurement.

Precautions while dismantling micrometers
Avoid touching the measuring faces with bare fingers as it might cause rusting.

Protect the the components of the micrometer free from dust while dismantling and assembling.

Use carbon tetrachloride for cleaning the parts after dismantling.

While assembling - apply a few drops of thin oil.

Do not use metallic surface for placing the parts after dismantling. An enamelled tray is preferable.

Apply a thin coating of oil when placing the micrometer back after the adjustment.

Avoid frequent dismantling and assembling.

Inside micrometer

Objectives: At the end of this lesson you shall be able to
- list the purposes of an inside micrometer
- identify the parts of an inside micrometer
- state the safety precautions to be followed while using an inside micrometer.

An inside micrometer is a precision measuring instrument which measures with an accuracy of 0.01mm.

Purpose
An inside micrometer is used to measure the diameter of holes. (Fig 1)

To measure the distance between internal parallel surfaces like slots (Fig 2)

Parts (Fig 3)
The following are the parts of an inside micrometer
**Micrometer head:** It consists of a sleeve, a thimble, an anvil, and a locking screw for extension rods.

**Extension rod:** This is fitted in the hole provided in the barrel of the micrometer head. It provides another measuring surface. It is available in different sizes.

**Locking Screw** It is used to lock the extension rods.

**Handle** It is fitted in the threaded hole provided in the micrometer head. It is used to hold the micrometer assembly while measuring deep bores.

**Spacing collar** It is added to the extension rod for additional length. It is available in different sizes.

**The range of inside micrometer**

Using the different sizes of extension rods and spacing collars, the following ranges of measurement can be taken:

- 25-50mm
- 50-200mm
- 50-300mm
- 200-500mm
- 200-1000mm

**Inside micrometer**

Ranges of extension rod for (50 - 200mm) Inside micrometer

Checking parallelism of surfaces of deep bores
An extended handle can be used while measuring deep bores. (Fig 4) for checking the parallelism of surfaces of the bore.

Precautions

Ensure that the extension rod/spacing collar are fitted correctly.

Check the ‘O’ setting of the inside micrometer with an outside micrometer.

Ensure that the measuring faces are perpendicular to the axis, and the handle parallel to the axis of the above.

When measuring bores the micrometer must be set for the largest value. While measuring between flat surfaces, the micrometer should be set for the smallest value. (Fig 5)

Ensure that the wall surfaces of the bore are free from burrs, oil etc. before using an inside micrometer. Set the inside micrometer in the bore to the correct FEEL. Do not drag or force the inside micrometer in the bore.

Find out the readings at 2 or 3 places i.e. one reading at the top, another reading at the middle and the third reading at the bottom of the bore. If all the three readings are the same, then the surfaces of the bore are parallel. Any variation in the readings shows an error in the bore.
Capital Goods & Manufacturing
Fitter - Basic Fitting
Related Theory for Exercise 1.2.34

Depth micrometer

Objectives: At the end of this lesson you shall be able to
• name the parts of a depth micrometer
• state the constructional features of a depth micrometer
• read depth micrometer measurements.

Constructional features

The depth micrometer consists of a stock on which a graduated sleeve is fitted.

The other end of the sleeve is threaded with a 0.5 mm pitch ‘V’ thread.

A thimble which is internally threaded to the same pitch and form, mates with the threaded sleeve and slides over it.

The other end of the thimble has an external step machined and threaded to accommodate a thimble cap. (Fig 1)

Graduation and least count

On the sleeve a datum line is marked for a length of 25 mm. This is divided into 25 equal parts and graduated, each line representing one millimetre. Each fifth line is drawn a little longer and numbered. Each line representing 1 mm is further subdivided into two equal parts. Hence each sub-division represents 0.5 mm. (Fig 3)

A set of extension rods is generally supplied. On each of them the range of sizes that can be measured with that rod, is engraved as 0-25, 25-50, 50-75, 75-100, 100-125 and 125-150.

These extension rods can be inserted inside the thimble and the sleeve.

The extension rods have a collar-head which helps the rod to be held firmly. (Fig 2)

The measuring faces of the stock and the rods are hardened, tempered and ground. The measuring face of the stock is perfectly machined flat.

The extension rods may be removed and replaced according to the size of depth to be measured.
The graduations are numbered in the reverse direction, to that marked on an outside micrometer.

The zero graduation of the sleeve is on the top and the 25 mm graduation near the stock.

The bevel edge of the thimble is also graduated. The circumference is equally divided into 50 equal parts and every 5th division line is drawn a little longer and numbered. The numbering is in the reverse direction and increases from 0, 5, 10, 15, 25, 30, 35, 40, 45 and 50 (0). (Fig 4)

This will be the smallest measurement that can be taken with this instrument, and so, this is the accuracy of this instrument.

**Reading of depth micrometer**

Barrel reading  =  8 x 1 mm  =  8.00 mm

Sub division  =  1 x 0.5 mm  =  0.50 mm

Thimble reading  =  3 x 0.01 mm  =  0.03 mm

(Thimble division x L.C) Total reading  =  8.53 mm

In barrel reading main division and sub division have been hidden covered by thimble

**Uses of depth micrometer**

- Depth micrometers are special micrometers used to measure
- the depth of holes.
- the depth of grooves and recesses
- the heights of shoulders or projections.

The advancement of the extension rod for one full turn of the thimble is one pitch which is 0.5 mm.

Therefore, the advancement of the extension rod for one division movement of the thimble will be equal to 0.5 / 50 = 0.01 mm.

**Digital micrometers**

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

- state the uses of digital micrometer
- list the parts of digital micrometer
- read the reading from LED display and thimble and barrel
- brief the maintenance, maintenance of digital micrometers.

Digital micrometers is one of the simplest and most widely used measuring equipment in any manufacturing industry. Its simplicity and the versatile nature make Digital Micrometers so popular. Different kinds of Digital Micrometers available in the market.

**Feature of digital micrometers** (Fig 1)

- LCD displays measuring data and makes direct read out with resolution of 0.001 mm.
- Origin setting mm/inch conversion, switch for absolute and incremental measurement.
- Carbide tipped measuring faces.
- Ratchet ensures invariable measurement and accurate repeatable reading

**Accuracy of digital micrometers**

Digital micrometers provide 10 times more precision and accuracy: 0.00005 inches or 0.001 mm resolution, with 0.0001 inches or 0.001 mm accuracy.
**Reading of the digital micrometer**

The digital micrometers are provided with high precision reading with LCD display. The reading is 14.054 mm as shown in Fig 2.

![Reading of the Digital Micrometers](image)

Reading also by reading the marks on the sleeve and the thimble. Usually, the reading from the large LCD display for the digital micrometer because the digital reading is more accurate. The reading on the sleeve and the thimble is just for reference. Read the markings on the sleeve and the thimble, firstly, read the point which the thimble stops at it on the right of the sleeve (It is 14mm here, because each line above the centre long line represents 1mm while each line below the centre long line represent 0.5mm) (Fig 3)

Secondly, read the markings on the thimble, It is between 5 and 6, So you need to estimate the reading. (It is 0.054mm for each line here represents 0.001mm). At last, add all the reading up : 14mm + 0.054 mm = 14.054mm. So the total reading is 14.054mm.

**Maintenance of a digital micrometers**

Never apply voltage (e.g. engraving with an electric pen) on any part of the Digital Micrometers for fear of damaging the circuit.

Press the ON/OFF button to shut the power when the Digital Micrometers stands idle; take out the battery if it stands idle for a long time.

As for the battery, abnormal display (digit flashing or even no display) shows a flat battery. Thus you should push the battery cover as the arrow directing and then replace with a new one. Please note that the positive side must face out If the battery bought from market doesn't work well (the power may wear down because of the long-term storage or the battery’s automatic discharge and etc.) Please do not hesitate to contact the supplier.

Flashing display shows dead battery. If this is the case please replace the battery at once. No displace shows poor contact of a battery or short circuit of both poles of the battery. Please check and adjust pole flakes and battery insulator cover. In case water enters the battery cover, open the cover immediately and blow the inside of the battery cover at a temperature of not more than 40°C till it gets dry.
Vernier calipers

Objectives: At the end of this lesson you shall be able to
• name the parts of a vernier caliper
• describe the parts of a vernier calipers
• state the uses of a vernier caliper.

A vernier caliper is a precision measuring instrument. It is used to measure up to an accuracy of 0.02 mm. (Fig 1)

Vernier slide (5): A vernier slide moves over the beam and can be set in any position by means of a spring-loaded thumb lever.

Beam (6): 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.

Depth bar (7) (Fig 4): The depth bar is attached to the vernier slide and is used for measurement of depth.

Thumb lever (8): The thumb lever is spring-loaded which helps to set the vernier slide in any position on the beam scale.

Vernier scale (9): The vernier scale is the graduation marked on the vernier slide. The divisions of this scale are called vernier divisions.

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

Sizes: Vernier calipers 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. Vernier calipers are precision instruments, and therefore, extreme care should be taken while handling them.

Never use a vernier caliper for any purpose other than measuring.

Vernier calipers 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.

Parts of a vernier caliper

(Numbers as per Fig 1)

Fixed jaws (1 and 2): Fixed jaws are part of the beam scale. One jaw is used for taking external measurements, and the other for taking internal measurements.

Movable jaws (3 and 4): 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)
Graduations and reading of vernier calipers

Objectives: At the end of this lesson you shall be able to
- determine the least count of a vernier caliper
- state how graduations are made on a vernier caliper with 0.02 mm least count
- read vernier caliper measurements.

Vernier calipers: Vernier calipers are available with different accuracies. The selection of the vernier caliper depends on the accuracy needed and the sizes of the job to be measured.

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 calipers: In the vernier caliper shown in Fig 1 the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

i.e. One main scale division (MSD) = 1 mm
One vernier scale division (VSD) = 9/10 mm
Least count = 1 MSD - 1 VSD
= 1 mm - 9/10 mm
= 0.1 mm

Fig 2 shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. 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.

![Fig 2](image1.png)

Least count = 1 mm - 49/50 mm
= 1/50 mm
= 0.02 mm.

Example for reading vernier caliper (Fig 3)

![Fig 3](image2.png)

Main scale reading = 60 mm

The vernier division coinciding with the main scale is the 28th division, value = 28 x 0.02 mm
= 0.56 mm

Reading = 60 + 0.56
Total Reading = 60.56 mm

Reading vernier measurements: Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper, the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide)
The British System of Measurement

Objectives: At the end of this lesson you shall be able to
• name the different units and multiples of linear measurements in the British System
• state the metric equivalent of the unit in the inch system

The metric system for measurement is most widely used for industrial measurements. But in certain industries, the British system of measurement is still being used.

In this system of measurement, the inch, its multiples and sub-divisions are used to represent length measurements.

36 inches or 3 feet make 1 yard. 5280 feet or 1760 yards make 1 mile.

<table>
<thead>
<tr>
<th>Conversions from inch to metric and vice versa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONVERSION FACTORS</strong></td>
</tr>
<tr>
<td>1” = 25.4 mm or 2.54 cm</td>
</tr>
<tr>
<td>1 yard = 36” or 0.9144 m</td>
</tr>
<tr>
<td>1 mm = 0.03937”</td>
</tr>
<tr>
<td>1 metre = 1000 mm or 39.37”</td>
</tr>
</tbody>
</table>

Fractions/Decimals Equivalent

- 1/64” = 0.015625”
- 1/32” = 0.03125”
- 1/16” = 0.0625”
- 1/8” = 0.125”
- 1/4” = 0.25”
- 1/2” = 0.5”

1.00 unit inch
0.1 one tenth
0.01 one hundredth
0.001 one thousandth
0.0001 one ten thousandth

Reading Vernier Caliper and Micrometer with Inch Graduations

Objectives: At the end of this lesson you shall be able to
• state the graduations of vernier calipers in the inch system
• state the graduations of micrometers in the inch system
• read the measurement of vernier calipers and micrometers with inch graduations.

Reading Vernier Caliper and Micrometer

The universal vernier calipers generally used in machine shop will have graduations in both metric units and inches.

The vernier caliper with inch graduation will have a least count of 0.001”.

The vernier scales for these calipers have graduation with 25 division or 50 divisions.

Vernier Caliper with 25 Divisions in Vernier Scale (Fig. 1)

One inch of the mainscale is divided into 10 major divisions, and each of these is further divided into 4 equal parts. The value of each sub-division is 0.025 inch. Such 49 divisions of the main scale are equal to 25 divisions of the vernier scale.

0.00001 one hundred thousands
0.00001 one millionth (one micro inch)

Example of conversion (Metric to inch)

1) 0.05 mm = 0.00196 inch (.05 x 0.03937 = 0.0019685 inch)
2) 1.25 m = 49.215 inch (1.25 x 39.37 = 49.215 inches)

Example of conversion (Inch to Metric)

1) 3/4” = 0.75” = 19.05 mm (.75 x 25.4 = 19.05 mm)
2) 1/1000” = 0.001 = 0.0254 mm (.001 x 25.4 = 0.0254 mm)

(A one thousandth of an inch = 25 micrometre approx)

Assignment

Convert the following.

1) 38.1 mm = _______ inches
2) 300 mm = _______ inches
3) 8” = _______ mm
4) 40” = _______ mm.

5) Express the tolerance ± .05” in metric terms to the nearest mm. _______________________________

6) Express the tolerance ± .02 mm in terms of inches to the nearest 1/10,000”. _____________________
Example of reading (Fig 2)

In Figure 2 the vernier '0' line is after 1" on the scale

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full inch</td>
<td>1.000&quot;</td>
</tr>
<tr>
<td>2 main scale divisions</td>
<td>0.200&quot;</td>
</tr>
<tr>
<td>Value of 1 subdivision</td>
<td>0.025&quot;</td>
</tr>
<tr>
<td>coinciding</td>
<td>0.013&quot;</td>
</tr>
<tr>
<td><strong>Reading</strong></td>
<td><strong>1.238&quot;</strong></td>
</tr>
</tbody>
</table>

Example of reading (Fig 4)

Vernier '0' line is after 1" on the main scale

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full inch</td>
<td>1.000&quot;</td>
</tr>
<tr>
<td>The value of 4 major divisions</td>
<td>(4 x 0.1&quot;)</td>
</tr>
<tr>
<td>The value of 1 subdivision</td>
<td>(1 x 0.05&quot;)</td>
</tr>
<tr>
<td>The value of 9th vernier division coinciding</td>
<td>(9 x 0.001&quot;)</td>
</tr>
<tr>
<td><strong>Reading</strong></td>
<td><strong>1.459&quot;</strong></td>
</tr>
</tbody>
</table>

Micrometer with graduations in inches

On micrometers with graduations in the inch system, the datum line on the barrel of the micrometer is graduated to a distance of 1 inch. This one inch is divided into 10 equal parts, and each of this is further subdivided into 4 equal parts. (Fig 5)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>The value of each subdivision</td>
<td>1/40&quot;</td>
</tr>
<tr>
<td>The thimble had 25 equal divisions marked on the circumference. The least count is</td>
<td>1/40&quot; x 1/25 = 1/1000&quot; = 0.001&quot;</td>
</tr>
</tbody>
</table>

Example of reading (Fig 6)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main divisions</td>
<td>3 x 0.1&quot;</td>
</tr>
<tr>
<td>Subdivisions</td>
<td>2 x 0.025&quot;</td>
</tr>
<tr>
<td>Thimble divisions</td>
<td>9 x 0.001&quot;</td>
</tr>
<tr>
<td><strong>Reading</strong></td>
<td><strong>0.359&quot;</strong></td>
</tr>
</tbody>
</table>

The barrel is graduated into 10 equal divisions each of which is further subdivided into 4 smaller divisions. The length of the sleeve graduations is 1". It is the distance the thimble travels in 40 complete revolutions.
Barrel subdivision 1/40 or 0.025 of an inch is equal to the
distance the thimble moves in one complete revolution. The
spindle screw has 40 TPI.

**Assignment**

1. Read the vernier caliper measurement as shown in
   Figures 7 and 8.

   **Answer** ....................inch.

   ![Fig 7](image)

   Answer ....................inch.

   ![Fig 8](image)

2. Read and record the measurements of an outside
   micrometer shown in the Figures 9 and 10.

   **Answer** ....................inch.

   ![Fig 9](image)

   **Answer** ....................inch.

   ![Fig 10](image)

**Vernier height gauge**

**Objectives:** At the end of this lesson you will 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)**

<table>
<thead>
<tr>
<th>A</th>
<th>Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Base</td>
</tr>
<tr>
<td>C</td>
<td>Main slide</td>
</tr>
<tr>
<td>D</td>
<td>Jaw</td>
</tr>
<tr>
<td>E</td>
<td>Jaw clamp</td>
</tr>
<tr>
<td>F</td>
<td>Vernier scale</td>
</tr>
<tr>
<td>G</td>
<td>Main scale</td>
</tr>
<tr>
<td>H</td>
<td>Finer adjusting slide</td>
</tr>
<tr>
<td>I</td>
<td>Finer adjusting nut</td>
</tr>
<tr>
<td>J&amp;K</td>
<td>Locking screws</td>
</tr>
<tr>
<td>L</td>
<td>Scribe blade</td>
</tr>
</tbody>
</table>

**Constructional features of a vernier height gauge:**

The construction of a vernier height gauge is similar to
that of the vernier caliper that it is vertical with a rigid base.
It is graduated on the same vernier principle which is
applied to the vernier caliper.

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.

The thickness of the jaw is marked on the instrument. As like in a vernier caliper, 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) 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.

Obtaining the exact markable dimension, the main slide is also to be locked in position.

Modern vernier height gauges are designed on the screw rod principle. In these height gauges, the screw rod may be operated with the help of the thumb screw at the base. In order to have a quick setting of the main slide, it is designed with a quick releasing manual mechanism. With the help of this, it is possible to bring the slide to a desired approximate height without wastage of time. For all other purposes, these height gauges work as ordinary height gauges. In order to set the 'zero' graduation of the main scale for the initial reading.

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.

Another kind of modern vernier height gauge has a rack and pinion set up for operating the sliding unit. This is shown in Fig 3.

**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 have to 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.

**Various applications of a vernier height gauge:** The vernier height gauge is mainly used for layout work. (Fig 4)

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

The vernier height gauge is used with the dial indicator to check hole location, pitch dimensions, concentricity and eccentricity.

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.
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)

**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, properly heat-treated 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 than 90° (Fig.2) obtuse angles more than 90° (Fig.3).

For setting work-holding devices to angles on machine tools, work tables etc., (Fig 4 & Fig 5)
Graduations on universal bevel protractor

Objectives: At the end of this lesson you will be able to
• state the main scale graduations on the disc
• state the vernier scale graduations on the dial
• determine the least count of the vernier bevel protractor.

The main scale graduations (Fig 1 & 2): 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. (Fig 1)

One vernier scale division VSD (Fig 2)

The least count of the vernier bevel protractor: When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2nd main scale division. (Fig 2)

Hence the least count is
2 MSD - 1 VSD
i.e the least count = 2°

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. (Fig 3)
Reading of universal bevel protractor

Objectives: At the end of this lesson you will be able to
• read a vernier bevel protractor for acute angle setting
• read a vernier bevel protractor for obtuse angle setting.

For reading acute angle set up (Fig 1): First read the number of whole degrees between zero of the main scale and zero of the vernier scale.

For obtuse angle set up (Fig 3)

Fig 3

The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 4). The reading value is subtracted from 180° to get the obtuse angle value.

Example 180°- 22°30’ = 157°30’

Care and maintenance of vernier bevel protractor

1. Clean the vernier bevel protractor before use.
2. Loosen the locking screw of dial to move the blade according to the angle measurement.
3. While taking a measurement apply light pressure on vernier bevel protractor.
4. Heavy pressure will force the two scales out of parallel and show the false reading.
5. After using vernier bevel protractor wipe it clean and apply a thin coating of oil and keep it in safe place.

For reading acute angle set up (Fig 1):

First read the number of whole degrees between zero of the main scale and zero of the vernier scale. 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 2)

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.

Note: The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 4). The reading value is subtracted from 180° to get the obtuse angle value.

Reading 22°30’
Measurement 180°- 22°30’ = 157°30’
Dial Caliper

Objectives: At the end of this lesson you shall be able to
• state the advantages of a dial caliper over a vernier caliper
• state the constructional features of a dial caliper
• read the dial caliper.

A dial caliper is a direct reading instrument which resembles the vernier caliper. It is faster and easier to read a dial caliper than to read the traditional vernier caliper. (Fig 1)

The resemblance of a dial caliper is similar to normal Vernier caliper, but with additional construction of a rack mounted over the beam scale which is engaged to a pinion of the dial. The dial pointer is actuated by the movable action of vernier slide unit fixed with dial gauge.

The caliper dial on the movable jaw is graduated into 100 equal divisions. The hand of the dial makes one complete revolution for each 5 mm. Therefore, each dial graduation represents 1/100th of 5mm or 0.05 mm.

The dial hand is operated by a pinion that engages a rack on the beam.

Dial calipers are available in various sizes like vernier calipers. A dial caliper with 0.02 mm accuracy is also available.

For reading a measurement (Fig 2)
Read the beam scale reading (25 mm) and add the reading shown by the hand of the dial. 24 x 0.05 = 1.2mm
Reading = 25+1.2 mm = 26.2 mm.

Care and maintenance of dial caliper
1. Clean the dial caliper with a soft cloth before use.
2. Apply a small drop of oil to the beam, rack and pinion of the dial caliper to slide freely.
3. Check calibration of dial caliper, make sure that it is working correctly.
4. After using dial caliper, wipe it with a clean dry cloth, apply a thin coating of oil on sliding parts and keep it in safe place.
The digital caliper

Objectives: At the end of this lesson you shall be able to
• state the uses of digital caliper
• name the parts of a digital caliper
• brief the zero setting of a digital caliper

The digital Caliper (sometime incorrectly called the digital vernier caliper) is a precision instrument that can be used to measure internal and external distance accurately to 0.01 mm. The digital vernier caliper is shown in Fig 1. The distance or the measurements are read from LCD/LED display. The parts of digital calipers are similar to the ordinary vernier caliper except the digital display and few other parts.

Part of Digital Caliper (Fig 1)
1. Internal jaws
2. External jaws
3. Power On/Off button
4. Zero Setting button
5. Depth measuring blade
6. Beam scale
7. LED/LCD Display
8. Locking screw
9. Metric/Inch button.

The digital caliper requires a small battery whereas the manual version does not need any power source. The digital calipers are easier to use as the measurement is clearly displayed and also, by pressing inch/mm button the distance can be read as metric or inch.

Zero setting of Digital Caliper
The display is turned on with the ON/OFF button. Before measuring, the zero setting to be done, by bringing the external jaws together until they touch each other and then press the zero button. Now the digital caliper is ready to use.

Caution
Always set zero position when turning on the display for the first time.
Drilling processes - Drilling Machines, Types, Use and Care

Objectives: At the end of this lesson you shall be able to
• name the various types of drilling machines
• name the parts of the bench and pillar type drilling machines
• compare the features of the bench and pillar type drilling machines.

The principle types of drilling machines are
– the sensitive bench drilling machine
– the pillar drilling machine
– the column drilling machine
– the radial arm drilling machine (radial drilling machine).

(You are not likely to use the column and radial type of drilling machines now. Therefore, only the sensitive and pillar type machines are explained here)

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.

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

For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted. (Tilting arrangement is shown in Fig.1)

Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (Fig 2)

The pillar drilling machine (Fig 3): 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.
Drill - 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 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 1)

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 bigger 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. (Fig 2) 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)

Work-holding devices

Objectives: At the end of this lesson you shall be able to
- state the purpose of work-holding devices
- name the devices used for holding work
- state the precautions to be observed while using work-holding devices.

Workpieces to be drilled should be properly held or clamped to prevent from rotating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage to the drill. Various are used to ensure proper holding.

The machine vice

Most of the drilling work can be held in a machine vice. Ensure that the drill does not drill through the vice after it has passed through the work. For this purpose, the work can be lifted up and secured on paralle blocks providing a gap between the work and the bottom of the vice. (Fig 1)

Clamps and bolts

Drilling machine tables are provided with T-slots for fitting bolt heads. Using clamps and bolts, the workpieces can be held very rigidly. (Fig 3) While using this method, the
packing should be, as far as possible, of the same height as the work, and the bolt nearer to the work. (Fig 4)

There are many types of clamps and it is necessary to determine the clamping method according to the work. (Fig 5 & 6)

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 Cutting

<table>
<thead>
<tr>
<th>Materials being drilled for HSS</th>
<th>Cutting speed (m/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>70 - 100</td>
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<tr>
<td>Brass</td>
<td>35 - 50</td>
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<tr>
<td>Bronze (phosphor)</td>
<td>20 - 35</td>
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<tr>
<td>Cast iron (grey)</td>
<td>25 - 40</td>
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<tr>
<td>Copper</td>
<td>35 - 45</td>
</tr>
<tr>
<td>Steel (medium carbon/mild steel)</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Steel (alloy, high tensile)</td>
<td>5 - 8</td>
</tr>
<tr>
<td>Thermosetting plastic</td>
<td>20 - 30</td>
</tr>
</tbody>
</table>

\[ n = \frac{\pi d v x}{1000} \]

\[ n = \text{RPM} \]
\[ v = \text{cutting speed in m/min.} \]
\[ d = \text{diameter of the drill in mm} \]
\[ \pi = 3.14 \]

**Example:** Calculate the RPM for a high speed steel drill Ø 24 to cut mild steel.

The cutting speed for MS is taken as 30 m/min. from the table.

\[ n = \frac{1000 \times 30}{3.14 \times 24} = 398 \text{ RPM} \]

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 millimeter.

Example - 0.040mm

The rate of feed is dependent upon a number of 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)
TABLE 1

<table>
<thead>
<tr>
<th>Drill diameter (mm) HSS</th>
<th>Rate of feed (mm/rev)</th>
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</thead>
<tbody>
<tr>
<td>1.0 - 2.5</td>
<td>0.040 - 0.060</td>
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<td>2.6 - 4.5</td>
<td>0.050 - 0.100</td>
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<tr>
<td>4.6 - 6.0</td>
<td>0.075 - 0.150</td>
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<td>6.1 - 9.0</td>
<td>0.100 - 0.200</td>
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<td>9.1 - 12.0</td>
<td>0.150 - 0.250</td>
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<td>0.230 - 0.330</td>
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<td>18.1 - 21.0</td>
<td>0.260 - 0.360</td>
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<tr>
<td>21.1 - 25.0</td>
<td>0.280 - 0.380</td>
</tr>
</tbody>
</table>

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.

Radial drilling machines

Objectives: At the end of this lesson you shall be able to
• state the uses of a radial drilling machine
• state the features of radial drilling machine.

Radial drilling machines are used to drill
- large diameter holes
- multiple holes in one setting of the work
- heavy and large workpieces.

Features (Fig 1)

The arm is supported by a pillar (column). It can be rotated about with the pillar as centre. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered.

The motor mounted on the spindle head rotates the spindle.

The variable-speed gear box provides a large range of R.P.M.

The spindle can be rotated in both clockwise and anticlockwise directions.

Angular holes can be drilled on machines having tilting tables.

A coolant tank is mounted on the base.

Precautions

Ensure that the spindle-head and the arms are locked properly to avoid vibration.

The workpiece and the drill should be rigidly held.

Bring back the spindle head nearer to the pillar after use.

Switch off power when not in use.

Use the drill drift for removing the drills, chucks or sockets.

Use a minimum number of sockets and sleeves to make for the spindle bore size.

Clean and oil the machine after use.

Stop the machine to remove the swarf.

Use a brush to clean the chips and swarf.
Gang drilling machine and multiple spindle head drilling machine

Objectives: At the end of this lesson you shall be able to
• state the uses of a gang drilling machine
• state the construction of a gang drilling machine
• state the uses and construction of a multiple spindle head drilling machine.

Gang drilling machine (Fig 1)

It consists of a large base supporting a long table. The top of the table is designed in such a way that several units may be mounted on it. Each spindle is driven by its individual directly connected motor.

The table has a groove around the outside for the return of the cutting lubricant, and may have 'T'-slots on its surface for ease in clamping the work to the table.

This type of machine is generally preferred when the work is to be moved from spindle to spindle for successive operations.

Multiple spindle head drilling machine (Fig 2)

The multiple spindle head drilling machine is specially designed for mass production operations such as drilling, reaming or tapping many holes at one time in a specific unit of work such as an automobile engine block.

There may be two or more drill heads on one machine, each with many spindles. This is necessary when holes are drilled from more than one direction - for example, on the top side, and the end of a piece of work. Production units of this type are seldom used in a tool room that usually does highly skilled work.
Hand taps and wrenches

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
• name the different types of tap wrenches
• state the uses of different types of wrenches.

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 and the type of the thread are usually marked on the shank.
In certain cases, the pitch of the thread will also be marked.
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 particular thread are available as a set consisting of three pieces. (Fig 2)

These are
first tap or taper tap
second tap or intermediate tap
plug or bottoming tap.
These taps are identical in all features except in the taper 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)

Tap 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 3)
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.

**T-Handle tap wrench** (Fig 4)

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.

**Solid type tap wrench** (Fig 5)

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.

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**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 ISO 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 sufficient material in the hole for the tap to cut the thread.

**Tap drill sizes for different threads**

**ISO 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 dia (D1)=10 mm – 1.839 mm

=8.161 mm or 8.2 mm

This tap drill will produce 100% thread because this is equal to the minor diameter of the thread. For most fastening 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.**

ISO 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.

What will be the tapping size for the following threads?

(a) M 20
(b) UNC 3/8

<table>
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<th>NC National Coarse</th>
<th>NF National Fine</th>
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<tbody>
<tr>
<td>Tap size</td>
<td>Threading per inch</td>
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NPT National pipe thread

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</table>
Letter punch and number punch

Objective: At the end of this lesson you shall be able to
• state the uses of letter Punch and Number Punch

Metal stamps are used to mark or identify work pieces. They are available for stamping letters (Letter Punch) and numbers (Number punch). They can not be used on hardened metal surfaces (Fig.1).

Fig 1

The letter punch set consists of A, B, C, D, E, F, G, H, N, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, and ‘&’ (Symbol) of 27 Letter punches in a set. The Number punch set consists of 0, 1, 2, 3, 4, 5, 6, 7, 8, the number punch 6 will be used for punching number both 6 and 9.

The letters and numbers are formed in the reverse order. So that while punching letters and numbers will be in correct position. A base line should be scribed on the metal surface, before stamping the letter or number using these punches. Also to locate the position of middle letter (Fig.2) or number (Fig.3) or space (Fig.4) a centre line should be scribed on the base line (Fig.2). Letters or numbers before stamping should be placed on either side of the line from center line, so that middle letter is stamped over the centreline large size letter number punches are used for better impression by applying more than one stroke. While Punching on cast iron or hot rolled steel, the hard outer layer of the metal should be removed by grinding or filing or machining for better impression are visibility.

Fig 2

Fig 3

Fig 4
Safety precautions in sheet metal workshop

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

- state various hazardous while working in a SMW shop
- state different precautions to be taken for safe working in a SMW shop.

Whenever a work is done in a shop the following aspects may create an injury to the workman/trainee or to others working nearby.

1. Way of handling the materials, tools and machine.
2. Cleaning of the work area/shop floor.
4. Carelessness and negligence of the workman/trainee.
5. Ignorance of general safety rules.

To avoid the accident/injuries taking place, while working it is very important to follow certain safety precautions. They are:

- Do not bend your whole body while lifting heavy loads. Instead use your thigh muscles for lifting.
- Use gloves while handling thin sheets.
- Use chipping screen during chiseling operation.
- Avoid using a mushroom head chisel.
- Arrange the tools properly over the work table so that the tools are not allowed to fall from the table on your foot.
- Wear proper size safety shoes.
- Remove burrs by filing from a plate or sheet after cutting them by chisel or hacksaw.
- Do not use a hammer with a broken or damaged handle.
- Fix the hammer head with the handle securely using a wedge.
- Do not wear loose garments/dress.
- Wear plain goggles/face shield while grinding.
- Do not grind materials which are 3mm or less in thickness and non-ferrous metals.
- Adjust the gap between the work rest and the grinding wheel to 1-2mm.
- Select and use the right kind of tool for the right job.
- Keep the floor on the work area neat and clean without any cut pieces of material, oil, etc.
- Keep a separate bin/basket for throwing cotton waste, metal chips etc.
- Always keep fire fighting equipment and the First Aid Box ready for use in case of any emergency.
- After completion of work keep the tools in the tool box.
- Wear helmet if anybody is working above your work place, either to repair at the roof or on a overhead crane.
- Use tongs while handling hot objects.
- Do not try to check the sharpness of any tool with bare fingers.
- Switch off the mains of a machine while leaving the machine after completion of work.
- Do not try to rectify any electrical fault by yourself. Call an electrician for doing any electrical repair work.
- Wherever and whenever possible avoid polluting the environment.
- If any other person is affected by electric shock, immediately switch off the mains or separate the person from the electrical contact using a wooden rod or any other insulating material.
- Always fix the job at a convenient height on the vice.
- Use sufficient leverage while tightening or loosening a nut or bolt.

General Workshop Rules

- Safety glasses must be worn.
- Safety footwear must be worn when working in the workshop.
- Ask workshop instructor before using equipment.
- Visitors must remain within marked walkways.
- Long hair must be tied back.
- Clean, equipments & machines after use.
- Take care when using compressed air.
- Hearing protection should be worn when using machinery.
- Working alone after hours is not permitted.
General safety precautions

Objectives: At the end of this lesson you shall be able to
- state what an accident is
- state the causes for accidents in general terms
- state what is safe attitude
- name the four basic categories of safety signs.

What is an accident?

Nobody deliberately makes an accident; accidents occur due to the causes which are not foreseen. Sometimes nothing can be done to prevent them from happening. For example, a part of a machine fails when nobody has any reason to think there is anything wrong with it, or the driver of a vehicle collapses at the wheel. Most accidents however occur as the result of a human error, of ignorance or neglect, forgetfulness or recklessness. These accidents can be prevented. If people had acted differently at some point, the event which we call an ‘accident’ would not have occurred. (Fig 1)

Fig 1

Lots of accidents still happen every year killing a lot of people. Although most people are alarmed and horrified by this state of affairs, accidents continue to happen, costing the industry millions of rupees every year. Older workers who have come to terms with the dangers, young workers who may be reckless, employers who turn a blind eye to the possibility of things going wrong - because they want to get the job done, all these factors contribute to this senseless waste. Fortunately there are many who do not take this view. They have a different attitude to wards safety - and ‘attitude’ is an all-important factor in the chain of events which leads to someone causing, being involved in, or becoming the victim of an ‘accident’.

Safe attitudes: People’s attitudes govern what they do or fail to do. In most cases where someone is working with unsafe equipment or in an unsafe situation, somebody has allowed that state of affairs to come about by something they have done or failed to do. (Fig 4)

Fig 4

Causes for accidents:

Causes for accidents are many. Some of the important causes are listed below. (Fig 3)

- Unawareness of danger
- Disregard for safety
- Negligence
- Lack of understanding of proper safety procedures
- Untidy condition of workplace
- Inadequate light and ventilation
- Improper use of tools
- Unsafe conditions
Most accidents don’t just happen; they are caused by people who (for example) damage equipment or see it is faulty but don’t report it, or leave tools and equipment lying about for other people to trip over. Anybody who sees a hazard and does nothing about it is also contributing to the possibility of an accident. A worker doesn’t necessarily need to do anything to bring about an accident; just going mindlessly about his work may be enough to ensure a work-mate being crippled for life. He didn’t do it - but by proper and timely thinking and acting, he could have prevented it.

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 the employer and his employees have the 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 is responsible for the equipment provided, the working conditions, what 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 the employers and other people to make your working life safer; but always remember you are responsible for your own actions and its effect on others. You must not take that responsibility lightly.

Rules and procedures 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; 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; other signs 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 colour. Sometimes they may be just symbols 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 safety signs are as follows.

- prohibition signs
- mandatory signs
- warning signs
- information signs

Prohibition signs Fig5

<table>
<thead>
<tr>
<th>Shape</th>
<th>Circular.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Red border and cross bar.</td>
</tr>
<tr>
<td>Meaning</td>
<td>Black symbol on white background.</td>
</tr>
<tr>
<td>Example</td>
<td>Shows it must not be done.</td>
</tr>
</tbody>
</table>

Mandatory signs Fig6

<table>
<thead>
<tr>
<th>Shape</th>
<th>Circular.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>White symbol on blue background.</td>
</tr>
<tr>
<td>Meaning</td>
<td>Shows what must be done.</td>
</tr>
<tr>
<td>Example</td>
<td>Wear hand protection.</td>
</tr>
</tbody>
</table>

Warning signs Fig7

<table>
<thead>
<tr>
<th>Shape</th>
<th>Triangular.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Yellow background with black border and symbol.</td>
</tr>
<tr>
<td>Meaning</td>
<td>Warns of hazard or danger.</td>
</tr>
<tr>
<td>Example</td>
<td>Caution, risk of electric shock.</td>
</tr>
</tbody>
</table>

Information signs Fig8

<table>
<thead>
<tr>
<th>Shape</th>
<th>Square or oblong.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>White symbols on green background.</td>
</tr>
<tr>
<td>Meaning</td>
<td>Indicates or gives information of safety provision.</td>
</tr>
<tr>
<td>Example</td>
<td>First aid point.</td>
</tr>
</tbody>
</table>

Prohibition signs (Fig 9)

<table>
<thead>
<tr>
<th>Fig 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMOKING AND NAKED FLAMES PROHIBITED</td>
</tr>
<tr>
<td>DO NOT EXTINGUISH WITH WATER</td>
</tr>
<tr>
<td>PEDESTRIANS PROHIBITED</td>
</tr>
</tbody>
</table>

CG&M : Fitter (NSQF Level -5) - Related Theory for Exercise 1.3.42
Questions about your safety

Do you know the general safety rules that cover your place of work?

Are you familiar with the safety laws that cover your particular job?

Do you know how to do your work without causing danger to yourself, your workmates and the general public?

Are the plant, machinery and tools that you use really safe? Do you know how to use them safely and keep them in a safe condition?

Do you wear all the right protective clothing, and have you been issued with all the necessary safety equipment?

Have you been given all the necessary safety information about the materials used?

Have you been given training and instruction to enable you to do your job safely?

Do you know who is responsible for safety at your place of work?

Do you know who are the appointed ‘Safety Representatives’?

### Importance of sheet metal work in industries

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

- state the scope and the importance of the trade.

**Introduction**

Many engineering products are made out of sheet metal. The person who works on metal sheets is called sheet metal worker. The skilled sheet metal worker make and install various kind of sheet metal products. (Fig 1)

- roofings
- ductings
- vehicles body buildings like 3 wheelers, 4 wheelers, ships, air crafts etc.
To carry out these works, the sheet metal worker has to plan, layout and determine the size and the type of the sheet metal to be used. The sheet metal worker carries out the operations such as cutting, folding, forming, fastening and assembling manually and by means of power machines.

The above requirements needs proper training and to know the basic principles of operation and process. All the advance technologies are developed from basic principles only. The advance technologies facilitates for mass production, consistance in accuracy of product and the volume of needs.

Technical terms in sheet metal work

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

- state the meaning of various terms used in sheet metal work.

1. **Beading**: The process of raising a strip of metal around the end of a round pipe.

2. **Bench machines**: Machines clamped to a bench and operated by turning a crank. Used by the sheet metal worker to turn edges on circles and round pipes.

3. **Bench stakes**: Steel anvils of various specialized shapes that the sheet metal worker uses to form and seam sheet metal objects.

4. **Black iron**: Iron and steel sheets covered with an oxidized coating only.

5. **Braising**: The process of stretching a piece of metal by hitting it with a round head hammer, as in forming a bowl.

6. **Brake**: A machine that the sheet metal worker uses for bending and folding edges on metal.

7. **Burring**: The process of turning an edge on a circular piece of metal.

8. **Clips**: Special strips of sheet metal bent in a manner to connect two pieces of sheet metal duct.

9. **Crimping**: The process of corrugating the end of a round pipe to make it smaller so it will fit into the end of another pipe.

10. **Cut acid**: Zinc chloride, made by putting strips of zinc in hydrochloric acid.

11. **Edges**: Bends on the edges of sheet metal to eliminate sharp edges and provide stiffening.

12. **Embossing**: A stamping process that produces a shallow relief design on sheet metal.

13. **Flux**: Chemical used to clean metal and remove the oxides from the metal surface prior to soldering.

14. **Forming**: The process of rolling sheet metal into pipe or making bends to form objects.

15. **Gauge**: The system of classifying the thickness in which sheet metal is produced. Also a tool used for measuring and determining the thickness of a metal sheet.

16. **Hem**: A folded edge on a sheet metal object.

17. **Layout work**: The process of developing the pattern for a sheet metal object.

18. **Longitudinal seam**: A seam running the long length of a pipe.

19. **Miter**: The joining of two pieces at an evenly divided angle.

20. **Nibble**: Nibble to piece metal along or on its edge.

21. **Oxides of metal**: A chemical formed by a combination of the oxygen in the air with the metal. Iron rust is iron oxide.

22. **Parallel line development**: A method of pattern drafting employing parallel lines.

23. **Pattern**: The shape of an object to be made out of sheet metal as it appears when marked out on the flat sheet. Also, the exact size and shape that a piece of sheet metal must be in order to be formed into the object desired.

24. **Pickle**: To clean dirt and oxide from metal by immersing it in an acid bath.

25. **Pictorial drawings**: A drawing of an object in three dimensions as it actually appears after being formed into shape.

26. **Pierce**: To cut out interior waste stock from a metal part with a die.
27 **Planish**: To make a metal surface smooth by hammering it over a stake or block.

28 **Press brake**: A power machine used by the sheet metal worker to form sheet metal.

29 **Press forming**: Creating sheet metal products using dies to cut and shape the metal and presses to power the dies. Also called stamping.

30 **Primer**: A first coat of finish on a metal, it binds and adheres to the metal giving good base for later coats.

31 **Punching**: The process of making holes in sheet metal by the use of dies.

32 **PVC (polyviny/chloride)**: A plastic often used for hoods and tanks that require high corrosion resistance.

33 **Radial line development**: A method of pattern drafting using lines radiating from a center and using arcs.

34 **Raw acid**: Hydrochloric acid (HCl)

35 **Rivets**: Fasteners used to join two pieces of sheet metal together. The rivet is inserted in a hole and a head is formed by pounding the rivet with a hammer.

36 **Seams**: Various types of bent and hooked edges used to join two pieces of sheet metal. For lighter sheet metal, mechanical joints are used. In medium and heavy gauge metal, a riveted or welded seam is used.

37 **Seam welding**: A kind of resistance welding in which rollers are used instead of electrodes.

38 **Sheet metal**: Any type of metal sheets that are 1/8” thick or less.

39 **Sheet metal screws**: Special screws used for joining sheet metal. Also called self-tapping because the screws tap their own threads in the drilled hole.

40 **Overlapping parts**: Resistance to electricity generates heat producing the weld.

41 **Square-to-round**: The name of a common sheet metal fitting that is square or rectangular on one end and round on the other end.

42 **Stainless steel**: A special steel containing other types of metals such as chromium, nickel and molybdenum. There are many types of stainless steel sheets. All of them vary in corrosion resistance.

43 **Swage**: A special forging tool used for smoothening and finishing.

44 **Sweat soldering**: The process of soldering two pieces of metal together by making the solder “sweat” completely through the seam.

45 **Tinning**: Covering an area of metal with molten solder.

46 **Transition piece**: A sheet metal fitting that changes size or shape from one end to the other.

47 **Triangulation**: A method of pattern drafting employing the use of triangles.

48 **Wired edge**: A sheet metal edge folded around a piece of wire for added strength.
Metal sheets and their uses

Objectives: At the end of this lesson you shall be able to
• state the types of metals used in sheet metal work
• state the uses of the different types of metals.

In sheet metal work, different types of metal sheets are used. The sheets are specified by their standard gauge numbers.

It is very essential to know the different uses and applications of these metal sheets.

**Black iron sheets:** The cheapest sheet metal is the black iron, which is rolled to the desired thickness. The sheets are rolled in two conditions. When it is rolled in cold state, it is called cold rolled and when it is rolled in hot state, it is called hot rolled. Hot rolled sheets have a bluish black appearance, and are often referred to as uncoated sheets, since they are uncoated. They corrode rapidly.

Cold rolled sheets have plain silver whitish appearance and are uncoated. To decrease the work hardness, the cold ruled sheets are annealed in a closed atmosphere. These sheets are known as C.R.C.A (Cold rolled close annealed) sheets.

The use of this metal is limited to making articles that are to be painted or enamelled such as tanks, pans, stoves, pipes etc.

**Galvanised iron sheets:** Zinc coated iron is known as ‘galvanised iron’. This soft iron sheet is popularly known as G.I.sheet. The zinc coating resist corrosion and improves the appearance of the metal and permit it to be soldered with greater ease. Because it is coated with zinc, galvanised iron sheet withstands contact with water and exposure to weather.

Articles such as pans, buckets, furnaces, heating ducts, cabinets, gutters etc. are made mainly from G.I. sheets.

**Stainless sheets:** This is an alloy of steel with nickel, chromium and other metals. It has good corrosive resistance and can be welded easily. Stainless steel used in a sheet metal shop can be worked similar to galvanised iron sheets, but is tougher than G.I. sheets. The cost of stainless steel is very high.

Stainless steel is used in dairies, food processing, chemical plants, kitchenware etc.

**Copper sheets:** Copper sheets are available either as cold rolled or hot rolled. They have a very good resistance to corrosion and can be worked easily. They are commonly used in sheet metal shops. Copper sheet has better appearance than other metals.

Gutters, expansion joints, roof flashings, hoods, utensils and boiler plates are some of the common examples where copper sheets are used.

**Aluminium sheets:** Aluminium cannot be used in its pure form, but is mixed with very small amount of copper, silicon, manganese and iron. Aluminium sheets are whitish in colour and light in weight. They are highly resistant to corrosion and abrasion.

Aluminium is now widely used in the manufacture of articles such as household appliances, refrigerator trays, lighting fixtures, windows and also in the construction of airplanes and in many electrical and transport industries.

**Tinned plate:** Tinned plate is sheet iron coated with tin, to protect it against rust. This is used for nearly all solder work, as it is the easiest metal to join by soldering.

This metal has a very bright silvery appearance and is used in making roofs, food containers, dairy equipment, furnace fittings, cans and pans etc.

**Lead sheets:** Lead is very soft and heavy in weight.

Lead sheets are used for making the highly corrosive acid tanks.

When lead is coated on black iron sheets, they are called Terne sheets. They are highly anti-corrosive and commonly used in preservation of chemicals.
Indian Standard sheet sizes & strip sizes

Objectives: At the end of this lesson you shall be able to
• specify the Indian Standard sheet sizes
• specify the Indian Standard strip sizes
• calculate the weight of the steel sheet, and the measure of the strip.

Table 2 gives the weight of steel sheets of different standard sizes.

Exercise
Calculate the weight of the steel sheet given below.
ISSH 1800x1200 x 1.40mm

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Indian Standard sheet sizes & strip sizes
As per Indian Standard are designated as ISSH received by figures denoting length (mm) x width (mm) x thickness (mm) of the sheet as per IS 1730 : 1989.

Example
ISSH 3200 x 600 x 1.00

Where
3200 is the length of the sheet (mm)
600 is the width of the sheet (mm)
1.00 is the thickness of the sheet (mm)
Based on the density of steel =7.85 g/cm²

For determining the mass of sheet above 2mm thickness refer to IS1730:1989

<table>
<thead>
<tr>
<th>Size mm x mm</th>
<th>Standard Nominal Surface Area in m²</th>
<th>Standard Nominal Thickness in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.40</td>
<td>0.50</td>
</tr>
<tr>
<td>1800 x 600</td>
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<tr>
<td>750</td>
<td>1.08</td>
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<td>2000 x 600</td>
<td>1.35</td>
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</tr>
<tr>
<td>1500</td>
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</tr>
</tbody>
</table>

Based on the density of steel =7.85 g/cm²

For determining the mass of sheet above 2mm thickness refer to IS1730:1989

CG&M : Fitter (NSQF Level -5) - Related Theory for Exercise 1.3.43 131
Indian Standard strip sizes

Indian Standard strips are designated as ISST followed by width (mm) x thickness (mm) of the strip as per IS 1730 - 1989. (Fig.1)

Example

ISST 1050 x 3.15: Where 1050 mm is the width of the strip and 3.15mm is the thickness.
<table>
<thead>
<tr>
<th>Width in mm</th>
<th>1.60</th>
<th>1.80</th>
<th>2.00</th>
<th>2.24</th>
<th>2.50</th>
<th>2.80</th>
<th>3.15</th>
<th>3.55</th>
<th>4.00</th>
<th>4.50</th>
<th>5.00</th>
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<tr>
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<td>1.25</td>
<td>1.41</td>
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<td>1.76</td>
<td>1.96</td>
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<td>2.47</td>
<td>2.79</td>
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<td>3.53</td>
<td>3.92</td>
<td>4.71</td>
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<td>1.77</td>
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Table 2 gives the weight in kg of a particular strip per metre length.

**Exercise**

Calculate the weight of a ISST 500 x 4 of 2 metres

**Answer**

________________________________________________________________________
Hand lever shears

Objectives: At the end of this lesson you shall be able to
• identify the hand lever shear
• state the principle of working
• state the constructional feature parts and their functions.

Hand lever shear is a hand operated machine used to cut sheet metal up to a thickness of 3 mm (10 SWG). When the machine is mounted on the bench, it is called a hand lever bench shear. It may also be mounted on the floor, over a small platform. It is used for cutting along straight lines and convex cutting of sheet metal. (Fig.1)

The lower blade of the hand lever shear is fixed (bottom blade) and the upper blade is pivoted at an angle.

The sheet being cut is prevented from tilting by a clamping device, which can be adjusted to the thickness of the sheet.

The knife cutting edge of the upper blade is curved so that the opening angle at the point of cut remains constant.

As the upper blade moves down on the sheet metal, the metal is subjected to shearing force, which causes deformation of the metal. (Fig 2 & 3) Increase in force causes plastic deformation of metal.

After a certain amount of plastic deformation, the cutting member begin to penetrate. The uncut metal work, harden at the edge (Fig 4).

Blade clearance is very important and should not exceed 10 percent of the thickness to be cut and should suit the particular material.

Results of incorrect and correct setting of shear blade are as follows.

1. Excessive clearance causes a burr to form on the underside of the sheet as shown in the (Fig 6).
2. With no clearance, over strain is caused, the edge of the sheet becomes flattened on the under sides as shown in (Fig 7).
**Objectives:** At the end of this lesson you shall be able to
- state the function of the squaring shear
- describe the adjustments on the machine to control the length of the cut
- state the capacity of the machine
- explain the safety precautions to be observed when working on squaring shears.

**Squaring shear**

Cutting sheet metals is called shearing.

Squaring shears are used to cut large sheets into pieces to handle sheets easily.

Sheet metal can be cut by many simple machines.

Squaring shears, (Fig 1) operated by foot, are used to cut and trim large pieces of sheet metal. The size of the machine is specified by the length of the bed and maximum thickness of sheet it cuts. Front gauge and back gauge is provided to adjust the length of cut. A back gauge controls the length of the cut, when sheet is inserted from the front.

A front gauge cut the sheet which is inserted from the back.

Sheet holder is provided to hold the sheet firmly while it is being cut. It is operated by sheet holder lever.

The square gauge is adjustable and is kept at right angles to the cutting blade. 18 gauge sheets or lighter can usually be cut by squaring shear parts are as shown in Fig 1.

The clearance between the blades (Fig2) can be adjusted by two adjusters. One adjuster shifts the table forward and other shifts the table backward. (Fig 3)

Too much clearance causes a burr to form on the underside of the sheet (Fig 2a) with no clearance overstrain is caused, the edges of the sheet becomes flattened on the underside (Fig 2b). With the correct clearance optimum shearing results are obtained (Fig 2c).
Guillotine shears

Objectives: At the end of this lesson you shall be able to
• state the constructional features of guillotine shears
• explain working of guillotine shears
• explain setting procedures of squaring guide, front gauge and back gauge
• state the safety precautions to be followed while working on guillotine shears.

Guillotine shears: On a treadle, guillotine, the bottom cutting blade is fixed to the machine bed and the top blade is operated by the treadle. The material to be cut is kept on the bed and held in position by hand. The hold down clamp comes into operation when the treadle is depressed. Figs 1&2 shows the treadle guillotine.

Safety

Keep your fingers away from the cutting blade at all times. Never attempt to cut bar iron, wire or any heavy metal on the squaring shears. This may nick the blade, which will then make a notch in every edge you cut. For better shearing results blade clearances and setting of blades are shown in Fig 2 & 3.
On some power operated guillotines, provision is given for a single or continuous cutting action. If there is any doubt in operating cutting control, check as follows.

- Switch on guillotine
- Depress pedal
- If the control is set for single cutting the cutting beam is descent once for each depression of the pedal.
- If the controls are set for continuous cutting the beam will continue to raise and descend when pedal is depressed.

Power shear mechanism is shown in Fig 3.

Use of the squaring guide: Guillotines are commonly fitted with a guide at one end of the bed, to enable sheets to be cut without marking on the sheet.

Where the guide is fitted with a scale, a stop is fitted to enable strips of a predetermined length to be cut accurately as shown in Fig 4.

Position sheets against guide for squaring the other end over lap stops slightly as shown in Fig 5.

Safety:
1. All guillotines are very dangerous.
2. Place the guard in position before operating.
3. Never work from the back of a guillotine.
4. Understand its safe operation fully, and the operation of emergency switches should be known perfectly.
5. Gauges, if not being used, should be clear of the material being cut.

Cutting procedure: When cutting, already marked line as shown in Fig 3.
- Switch on power guillotine
- Place the sheet on bed of machine and slide between blades
- Place the sheet on the bed of machine and slide between blades
- Align cutting mark to the edge of the bottom blade
- Depress pedal, ensuring that the other foot is away from pedal bar.

Parallel setting of front gauge: The front gauge is used when there is less overhang.
Before setting, check that the guillotine is switched off and separated. (Power machine only)

Keep wooden block under pedal as an added safe guard.
Fit gauge bar by tee bolts of bar into slots in brackets.

**Procedure for tape measure (Fig 7)**

- Slide the tape end between blades
- Edge of the tape is hooked against bottom blade
- Position gauge bar, keeping the bar parallel to the blade
- Tighten securing nuts slightly
- Adjust the gauge to required position by tapping lightly by palm
- Adjust the gauge bar parallel to the blade and fully tighten the nuts.

**When using a rule**

- Place the rule between blades. Position required dimension on the edge of bottom blade.
- Place the gauge bar against end of the rule.
- Position the bar parallel. Slightly tighten the nut and adjust as shown in Fig 8.

**Using scale on gauge brackets:** Where a machine is fitted with a graduated scale on the brackets, position gauge bar to the required dimension and fully tighten the nuts.

Keep place supported against gauge bar as shown in Fig 9.

Mark off plate to the size and shape. Set guide stop to give correct length.

Cut the sheet metal to the size and shape as per marking.
Sheet Metal Tools

Objectives: At the end of this lesson you shall be able to
• List out the measuring tools, marking tools and production tools used in the sheet metal work

Tools used in the sheet metal work are:

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<tr>
<th>Measuring tools</th>
<th>Production tools</th>
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<td>1 Snips</td>
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<td>2 Outside micrometer</td>
<td>11 Timper</td>
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<td>3 Vernier caliper</td>
<td>12 Trammel</td>
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<td>4 Combination set</td>
<td>13 Marking table</td>
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<td>5 Standard wire gauge</td>
<td>14 Surface plate</td>
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<table>
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<td>2 Tin man's hammers</td>
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<td>3 Mallet</td>
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<td>4 Bend scriber</td>
<td>4 Ball pane hammer</td>
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<tr>
<td>5 Punches</td>
<td>5 Straight edge</td>
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<td>6 Try square</td>
<td>6 Templates</td>
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<td>7 Soldering iron</td>
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<td>8 Trammel</td>
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<td>9 Jenny caliper</td>
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<td></td>
<td>11 Surface plate</td>
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<td>12 Riveting tools, dolly, staps etc.</td>
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Measuring Tools

Fig 1

STEEL RULE

Fig 2

RATCHET STOP
THIMBLE
BARREL/SLEEVE
SPINDLE LOCK
FRAME
OUTSIDE MICROMETER

Fig 3

VERNIER CALIPER

Fig 4

CENTRE HEAD
PROTRACTOR HEAD
SQUARE HEAD
SCRIBER
SPIRIT LEVEL
CLAMP NUT
COMBINATION SET

Fig 5

STANDARD WIRE GAUGE
SLOT
STANDARD WIRE GAUGE
RELEEVING HOLE

Fig 6

RADIUS GAUGE
INTERNAL RADIUS
EXTERNAL RADIUS
12.5
R7.5 - 15mm
12.5

Marking Tools Sheet Metal Worker

Fig 1

BODY OR BLADE

HEEL
TIANANMEN 'L' SQUARE

CG&M : Fitter (NSQF Level -5) - Related Theory for Exercise 1.3.45 -1.3.47
Production Tools

Fig 1

**STRAIGHT SNIPS**

Fig 2

**BEND SNIPS**

Fig 3

**FACE**

**BODY**

**HANDLE**

**ORDINARY WOODEN MALLETS**

**BLOWING MALLETS**

**END - PACKED MALLETS**

**RAWHIDE MALLETS**

**SHEEEL METAL MALLETS**

Fig 4

**PEEN**

**WEDGE**

**EYE HOLE**

**CHEEK**

**FACE**

**BALL PEEN HAMMER**

Fig 5

**BALL PEEN**

**CROSS PEEN**

**STRAIGHT PEEN**

Fig 6

**SETTING HAMMER**

Fig 7

**BEVEL STRAIGHT EDGE**

**SQUARE STRAIGHT EDGE**

**STRAIGHT EDGE**

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CG&M : Fitter (NSQF Level -5) - Related Theory for Exercise 1.3.45 -1.3.47
Machines and appliances tools

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Fig 59

Fig 60

Fig 61

Fig 62

Fig 63

Fig 64

Fig 65
Standard wire gauge

Objectives: At the end of this lesson you shall be able to
• state the use of the standard wire gauge
• state some important hints in using standard wire gauge
• state the metal thickness in mm for the given gauge numbers.

The job drawing indicate only gauge or thickness of the sheet to be used. Before starting the work identify the correct thickness of the sheet. The thickness of the sheet is measured with the help of the standard wire gauge.

The gauge consist of a disc shape smoothened steel metal piece with numerous slots around the outside edge. These slots are of various width and correspond to certain gauge number. (Fig 1)

Gauge number is stamped on one side of each slot and on the other side, the decimal part of an inch is stamped to show the thickness of the sheet and the diameter of the wire.

Thickness of the sheet is checked by inserting the edge of the sheet in the appropriate slot of the standard wire gauge.

Wire diameter is checked by inserting the wire only in the slot, and not in the circle. (Fig 2)

Steel 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.

Engineer’s steel rules (Fig 1) are used to measure the linear dimensions of workpieces. Steel rules are made of spring steel or stainless steel. These rules are available in lengths of 150 mm, 300 mm and 600 mm and 1000 mm. The reading accuracy of the steel rule is 0.5 mm.

For accurate reading it is necessary to read vertically to avoid errors arising out of parallax. (Fig 2)

For maintaining the accuracy of the steel rule, it is important to see to it that its edges and surfaces are protected from damage and rust.

Do not place a steel rule with other cutting tools.

Apply a thin film of oil when not in use.
Try square

Objectives: At the end of this lesson you shall be able to
• name the parts of a try-square
• state the uses of a try-square.

The try-square (Fig 1) is a precision instrument which is used to check the squareness of a surface and the flatness of surfaces.

![Fig 1](image1.png)

The accuracy of measurement by a try-square is about 0.002 mm per 10 mm length, which is accurate enough for most workshop purpose. The try-square has a blade with parallel surfaces. This blade is fixed to the stock at 90°. Burr slot is provided on the stock at meeting point of blade to accommodate the burr, if present on the component, to avoid inaccuracy in measuring squareness.

Uses: The try square is used to check the squareness of a sheet. (Fig 2)

![Fig 2](image2.png)

To mark lines at 90° to the edges of a workpiece. (Fig 3)

![Fig 3](image3.png)

Try squares are specified according to the length of the blade i.e. 100 mm, 150, 200 mm.

Clean the surface of the surface plate. Place the marking media on the face of the surface plate. Keep the try square blade on the surface and stock to the side of the surface plate as shown in Fig 4. Scribe straight line.

![Fig 4](image4.png)

Place the try square as shown in Fig 5 at the edge point of marking and scribe straight line.

![Fig 5](image5.png)

If the two marked lines are in one line as shown in Fig 6. Trysquare blade is 90° to the stock and it is correct.

![Fig 6](image6.png)

If the two marked lines do not stand on the same line as shown in Fig 7 means the blade is not 90° to the stock.

![Fig 7](image7.png)

To check the trueness of a trysquare.
**Tinman’s “L” square**

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

- state the use of the Tinman’s “L” square.

A Tinman’s “L” square is an "L" shaped piece of hardened steel with graduation marks on the edges of the Tongue and Body or blade (Fig.1). It is used for marking in the perpendicular direction to any base line and to check the perpendicularity.

The short arm of the “L” square is called the tongue and the long arm is called the body or blade and the corner is called the heel. The angle between the tongue and the body of the “L” square is 90°.

The size of the “L” square is specified by the length of the body and the tongue.

It is also called as Tinman’s square.

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**Straight edge**

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

- state the uses of straight edge
- list the types of straight edge.

**Straight edge**: Straight edge is a flat bar of steel. It is used to mark straight lines on a sheet metal surface.

**Types** (Fig 1)

Straight edges are available in two types.

1. Square straight edges
2. Bevel straight edge.

Straight edges are available in 600 mm, 1 to 3 mtrs in length. While marking with the help of a straight edge, place the straight edge on the sheet and hold it by your left hand.
**Scriber/Scratch awl**

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

In layout work, it is necessary to scribe lines to indicate the dimensions of the workpiece to be cut or folded.

It is made out of high carbon steel about 3 to 5 mm dia. for drawing clear lines on sheet metal, working point is ground at one end angle of 10° to 20°. Scriber working point is hardened and tempered.

Scribers are available in different types and sizes.

**Types of scribers** (Fig 1)
- Straight scriber
- Bend scriber
- Scratch AWL

Scriber points are very sharp and they are to be handled very carefully. Do not put the scriber in your pocket. Place a cork on the point, when not in use to prevent accidents.

---

**Types of marking punches**

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

Punches are used in order to make certain dimensional features of the layout permanent. There are three types of punches. They are
- Centre punch
- Prick punch
- Dot punch.

**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 holes. The wide punch mark gives a good seating for starting the drill.

(Fig 1)

**Prick punch:** The angle of the prick punch is 30°. This punch is used for making light punch marks needed to position dividers and trammels. The divider leg will get a proper seating in the punch mark.

(Fig 2)
Ball pane hammer

Objectives: At the end of this lesson you shall be able to
• state the construction of the ball pane hammer
• identify the parts of the ball pane hammer
• state the use of the ball pane hammer.

A hammer consist of a head and a wooden handle.
Hammer is used for light tapping and hard striking purposes while punching, bending, straightening, chipping, forging, riveting and planishing.

Major parts of the hammer are shown in Fig 1.

The handle is fixed in the eye hole of the hammer at right angle to the head.

Face: The face is the striking portion. Slight convex is given to avoid the digging of the edges.

Peen: The peen is the other end of the head. It is used for shaping, forming, riveting and bending. The peen is of different shapes like, ball peen, cross peen and straight peen as shown in (Fig 2). The face and peen are hardened.

Cheek: The cheek is the middle portion of the head. The weight of the hammer is stamped here. This portion of the hammer head is left soft.

Eye hole: An eye hole is meant for fixing the handle. It is shaped to fit the handle rigidly. The wedge is used to fix the handle tight in the eye hole as shown in Fig 3 & 4.

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.

Dividers are used for scribing arcs and circles, and stepping of distances. (Figs 1,2&3)

Dividers are available with firm joints and spring joints. (Fig 1 & 4) The measurements are set on the dividers with a steel rule.

Constructional features: Spring 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.
Wing compass

Objectives: At the end of this lesson you shall be able to
• Name the parts of a wing compass
• state the uses of the wing compass
• state the specification of the wing compass
• state some important hints on the wing compass
• state the uses of a trammel beam.

Wing compass is used for scribing circles, arcs and for transforming and stepping off distances. (Fig 1, 2 and 3)

Compasses are available with (A) Firm joints (B) Wing (C) Spring joints and (D) Beam Compass or Trammel. (Fig 4)

The measurements are set on the wing compass with a steel rule.

The sizes of a wing compass range between 50 mm to 200 mm. The distance from the point to the centre of the rivet is the size of the wing compass. (Fig 5)

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. (Fig 4)

For the correct location and seating of the divider legs, prick punch marks of 30° are used.

The two legs of the divider should always be of equal length. (Fig 5)

Dividers are specified by the type of their joints and length.

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.
For the correct location and seating of the wing compass legs, 60° dot punch mark is indented. (Fig 6)

The beam compass (or) Trammel is used to scribe a circle or an arc with a large diameter which cannot be scribed by a wing compass. (Fig 7)

Parts of the wing compass are shown in Fig 8.

The two legs of the compass should always be equal in length. (Fig 9)

Compass are specified by the type of the joints and length. When using spring type wing compass the measurement once taken will not vary while marking.

The compass point should be kept sharp, in order to produce fine lines. Frequent sharpening with an oilstone is better than sharpening by grinding. (Fig 10) Sharpening by grinding will make the points soft.
Straight snips

Objectives: At the end of this lesson you shall be able to
• state the uses of straight snips
• state the parts of straight snips
• state care and maintenance.

A snip is also called a hand shear. It is used like a pair of scissors to cut thin soft metal sheets. Snips are used to cut sheet metal up to 20 S.W.G.

Uses of straight snips: The straight snips are used to cut sheet metal along straight lines and outer sides of curves.

Parts of straight snips are shown in Fig 1.

While cutting a sheet metal, blades are pressed against the sheet, which causes shearing tension from both sides as shown in Fig 2 and the cutting action takes place.

Cutting edge of the blade and clearance: Clearance between the blades should be free but without gap. For straight snips, cutting angle is 87°.

If the clearance is too large it cause unclean cut, chamfered and jamming of workpiece as shown in Fig 3.

Types: There are two types of snips
1. Straight snip
2. Bent snip

Specification: Snips are specified by its overall length and the shape of the blade. (snips are available in 150 mm, 200mm, 300 and 400 mm overall length) Ex. 200 mm, straight snips.

Safety: Avoid cutting wires and nails, if so the cutting edge of the blade becomes damaged (Fig 4).

Avoid cutting hard sheet metal, if so the blade becomes blunt.

Due to wear and tear, the cutting edge of the blades becomes blunt. To resharpen the blade, the cutting angle alone should be ground to an angle of 87° (Fig 5) and should not grind the face of the cutting side of the blade. (Fig 6)
Bend snips

Objectives: At the end of this lesson you shall be able to
• state the use of the bend snips
• state the parts of the bend snips
• state the specification of the bend snips
• state types of shears and their application.

The bend snips are used to cut the inside curved lines and for trimming curved edges as shown in (Fig 1).

Parts of the bend snips are shown in fig 2. The blades of the bend snips are curved. (Fig 2)

Specification: Bend snips are specified by their overall length. Bend snips are available in 150, 200, 300 and 400 mm length.

Type of shears
1 Tinman’s shears is sometimes called straight shears.
2 Universal combination shears or Gilbow shears.
3 Pipe shears
4 Scotch shears
5 Block shears
6 Rohdes shears

Uses

Tinmans shears (Fig.3): It is used for making straight cuts and large external curves up to the thickness of 18 SWG. Cutting angle of a shears is 87°. The cross sectional view of the cutting blades is shown in Fig 3. Never grind the face of the blade.

Universal combination shears or Gilbow shears (Fig 4)

Its blades are designed for universal cutting, straight line or internal and external cutting of curves may be right hand or left hand, easily identifiable as the top blade is either on the right or the left. (Fig 5)
Pipe shears (Fig.6): It is applied as bend shears in all cases. Particularly it is used to time the edges of the pipes.

Scotch shears (Fig.7): It is a shape as shown in the fig.9 its handles are formed as eye holes to give extra grip to the hands. It is also used as Tinman’s shears.

Block shears (Fig.8): One of the handle of the shear is bent downwards as shown in the figure. The bending portion should be fixed on the iron plates hole and the upper handle will be held by the worker. It is used in mass production purposes.

Rohdes shears: Its one handle is shorter in length as compared with the other handle as shown in Fig.9.

The short handle is to be pressed by the right leg of the worker and the other handle should be held by the right hand. It is used to cut lengthy sheets.

Shearing force: To produce the maximum cutting force, the hand must be kept far from the rivet and the metal being cut must be kept close to the rivet.

Hawk billed shears (Fig.10): It is used for the inside cutting of an intricate work. The snips have narrow curved blades that allow you to make sharp turns without bending the metal.

Aviation shears (Fig.11): It can be used for all kinds of cutting. These are made with left, right or universal cutting blades.

Bench shears (Fig.12): These are designed to have one handle held in a vice or bench plate, while the other handle is moved up and down.

They can cut 16 gauge to 18 gauge thickness sheet metal.

Double cutting shears (Fig.13): These shears have three blades used to cut around cylindrical objects, such as cans and pipes. A single blade is pushed through the metal to sheet to cut.

Electric portable shear (Fig.14): Electric shears are used to cut corrugated metal sheets or a sheet metal of 18 gauge thickness or lighter sheet metals.

The shear point can be inserted with a light hammer blow. Successive blows will drive the shear on a scribed line for almost any shape like inner circles, zig zag, curvature line easily. A strip of metal about 3”/32 (2.5 mm) wide is removed in this shearing operations.
Sheet metal mallets & hammers

Objectives: At the end of this lesson you shall be able to
• state the different types of mallets
• state the uses of mallets
• state the care and maintenance.

Mallet is a shaping tool used for general purpose work like flattening, bending and forming to required shape of sheet metal.

These are made of hard wood

When using any metal hammer for flattening the sheet metal, the face of the hammer may damage or leave impression on the sheet more than what is required for the job. To avoid such damage and a impression, mallets are used.

Types (Fig 1)
– Ordinary mallet
– Bossing mallet
– End-faked mallet
– Raw hide mallet.

Ordinary mallet: Both the faces of the mallets are provided the little convexity. If the face is not in convex shape the edges of the mallet face will get frozen while beating the job.

Mallets are specified by the dia and the shape of the face. Mallets are available in 50 mm, 75 mm and 100 mm dia.

Avoid using the mallet as hammer for doing chipping and to drive nails and work on the sharp corners.

If so the face will get damaged and the mallet is liable to break.
Sheet metal hammers

Objectives: At the end of this lesson you shall be able to
- state the names of sheet metal hammers
- state the constructional features of sheet metal hammers
- state the uses of sheet metal hammers
- specify the sheet metal hammers
- state safety precautions while using the hammers.

In the previous lessons, you learned about the Engineering hammers such as Ball pane hammer, cross pane hammer and straight pane hammer. Apart from these, there are some special type of hammers used in sheet metal trade, which are called sheet metal hammers.

They are
1. Setting hammer
2. Riveting hammer
3. Creasing hammer
4. Stretching hammer
5. Hollowing hammer
6. Bullet hammer
7. Planishing hammer
8. Peening hammer

Setting hammer: Its face is either round or square in shape. Its pane is tapered from the eye hole and the other side is straight to the handle. The tip of the pane is rectangular in shape, and slightly convexed. It is used to set up the seams, flaring the edge of the cylindrical jobs and to set up the long channel also. Its face is used for general purposes. (Fig 1)

Riveting hammer: Riveting hammer's face is round in shape and the face is slightly convex. Its pane is long tapered and straight to the handle vertically. The tip of the pane is blended.

Riveting hammer is used to jump the rivet shanks and finish the rivet heads. (Fig 2)

Creasing hammer: Its both ends are sharpened and cross to the handle. It is used to finish the wired edges, false wiring edge and make corners of the sheet with the help of a creasing stake. (Fig 3)

Fig 3

CREASING HAMMER

Stretching hammer: Its shape is like a creasing hammer but its pane ends are blended. It is used to stretch the sheets to increase the length of the sheet. It is mostly used in raising operation. (Fig 4)

Fig 4

STRETCHING HAMMER

Hollowing hammer: Its both ends are shaped like ball and well polished.

It is used to make hollowing operation on the metal sheet and to remove the dents from the hollowed articles. This hammer is mostly used for panel beating work. (Fig 5)

Fig 5

HOLLOWING HAMMER

Bullet hammer: Its panes look like the hollowing hammer but the body is longer than the hollowing hammer and slightly bent. The pane ends are well polished and suitable to work on deep portion.
Safety precautions (Fig 9)

- Always handle and face of the hammers should be free from oil and grease.
- Face of the hammers should be free from scratches, dents, splits, burrs, chips etc.
- The handle should be securely fitted to the head. The wedge should be tight. (Fig 10)

- Hammers fitted with broken, cracked, splinted handles should not be used. Replace the handles immediately. (Fig 11)

- Heads flying from poorly fitted or broken handle can cause serious injuries.
- Always use a piece of soft metal between the hammer and the hard steel.
- Never hit two hammer faces together because the faces would split and the chips would fly dangerously.
- Select the right hammer for that particular job.

Planishing hammer: It’s one face is square and other is round in shape and well polished. Its pane is slightly convex. This hammer is heavy in weight.

It is used to give smooth surface finish to the jobs which are hollowed and raised, and to planish the surface of the plain sheets. (Fig 7)

Peening hammer: It’s face is round and slightly convex and a pane is just like stretching hammer. This hammer is used to peen polished impressions on the spinned aluminium job and hollowed copper, brass house hold vessels. (Fig 8)

Specification: The sheet metal hammers are specified by the Type of pane and the weight of the hammer.

Example
1 lb Planishing hammer

It is used to draw deep hollowing where the hollowing hammer cannot be used and also it is used to remove the dents from the deep hollow portion. (Fig 6)
Soldering iron (soldering bit)

Objectives: At the end of this lesson you shall be able to
• state the purpose of soldering iron
• describe constructional features of soldering iron
• state different types of copper bits and their uses.

Soldering iron: The soldering iron is used to melt the solder and heat metal that are joined together.

Soldering irons are normally made of copper or copper alloys. So they are also called as copper bits.

Copper is the preferred material for soldering bit because
- it is a very good conductor of heat
- it has affinity for tin lead alloy
- it is easy to maintain in serviceable condition
- it can be easily forged to the required shape.

A soldering iron has the following parts. (Fig 1)

- Head (copper bit)
- Shank
- Wooden handle
- Edge

SOLDERING COPPER BIT

Types of soldering copper bits: There are 7 types of soldering copper bits in general use,

They are
- The pointed soldering copper bit.
- The electric soldering copper bit.
- The gas heated soldering copper bit.
- Straight soldering copper bit.
- Hatchet soldering copper bit.
- Adjustable copper bit.
- Handy soldering copper bit.

The bits of soldering irons are made in various shapes and sizes to suit the particular job. They should be large enough to carry adequate heat to avoid too frequent reheating and not too heavy to be awkward to manipulate.

Soldering bits are specified by the weight of the copper head. For general soldering process, the shape of the head is a square pyramid but for repetition, or awkward placed joints, other shapes are designated.

Point soldering copper bit: This is also called a square pointed soldering iron. The edge is shaped to an angle on four sides to form a pyramid. This is used for tacking and soldering. (Fig 2)

Electric soldering copper bit: The bit of the electric soldering iron is heated by an element. This type is preferred, if current is available because it maintains uniform heat. Electric soldering irons are available for different voltages and are usually supplied with a number of interchangeable tips. They can be made quite small and are generally used on electrical or radio assembly work. (Fig 3)

Gas heated soldering copper bit: A gas heated soldering copper bit is heated by a gas flame which impinges on the back of the head. High pressure gas is used and the bits is large enough to have a good heat storage capacity. Liquified petroleum gas (LPG) flame is used extensively for this purpose. Soldering kit normally includes many sizes and shapes of bits which can be used to make most kinds of soldering connections. (Fig 4)
**Straight soldering copper bit:** This type of soldering iron is suitable for soldering the inside bottom of a round job. (Fig 5)

**Fig 5**

**Hatchet soldering copper bit:** This type of soldering iron is very much suitable for soldering on flat position lap or grooved joint outside round or square bottom. (Fig 6)

**Fig 6**

**Adjustable soldering copper bit:** This type of soldering iron is used for soldering where straight or hatchet bit cannot be used for soldering. Adjustable soldering bit can be adjusted in any position for soldering. (Fig 7)

**Handy soldering copper bit:** It is like a hatchet type but bigger in size than the hatchet. It is used for soldering heavy gauge of metal. It should not be used for soldering on light gauges of metal because additional heat will cause the metal to buckle. (Fig 8)

**Fig 7**

**Fig 8**

**Trammels**

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

**Beam Trammels and taper measures:** Trammel set is used for striking lines at 90° to each other, and also for measuring the distances accurately. It is a usual practice for the craftsman to use a pair of trammel heads or ‘trams’ and any convenient beam such as a length of wooden batten. The arrangement of the trammel for fine adjustment for accurate marking out is shown in Fig 1.

**Fig 1**

The 90° angle lines i.e lines square with each other, may be set out, with the aid of the beam trammel set or steel tape as shown in Fig 2.

The normal accuracy obtainable when marking out with the dividers, and the trammels is within 0.15 mm of the true dimension. Fig 3 show how the properties of a right angled triangle can be used to set out a perpendicular line by using trammel set.
Objectives: At the end of this exercise you shall be able to
- state what is groover
- state the size of the groovers
- state the uses and applications of groovers.

Any seam in sheetmetal should be locked or closed properly for effective functioning. Otherwise the joint will be a failure.

What is a groover?
A groover is hand tool used for closing and locking of seams in sheetmetal work. (Fig 1)

The end of the tool is recessed to fit over the lock making the grooved seams. (Fig 2)

Sizes
Groovers are available in various sizes viz. 3mm, 4mm, 5mm etc.
Generally a groover 1.5mm wider than the width of the fold is used.
For thicker materials, a groover 3mm larger than the width of the fold is used.

The width of the groove is stamped on the tool body.

Closing and locking
First the joint is held in position and then it is closed with a mallet. (Fig 3)

Then the groover is placed over the closed end of the joint. The groover is positioned at a very slight angle. The edge of the joint acts as a guide to position the groover.

The grooving operations are repeated for the other end of the joint. (Fig 4 and 5).

The joint is locked working along the joint in stages.
The seam is tightened using a mallet or a light planishing hammer.
Failure to lock the joints in stages with the end of the groover will result in bite marks along the joint.
Using too small a groover will mark the metal and prevent locking.
Stakes are the sheet metal workers anvils used for bending, seaming or forming. They actually work as supporting tools as well as forming tools.

Stakes are made in different shapes and sizes to suit the types of operations for which machines are not readily available or readily adaptable.

Some stakes are made of forged mild steel, faced with cast steel. The better class stakes are made either of forged steel or of cast steel.

A stake used in sheet metal working consists of a head (or) a horn. (shank or body and heel) The shanks are designed to fit into a tapered bench socket. (Fig 1)

**Round bottom stake** (Fig 1): It has a round and a concave face head. It is used for hollowing the sheet.

**Hatchet stake** (Fig 2): The hatchet stake has a sharp, straight edge, bevelled along one side. It is very useful for making sharp bends, folding the edges of sheet metal, forming boxes and pans by hand.

**Half moon stake** (Fig 3): This stake has a sharp head in the form of an arc of a circle, bevelled along one side. It is used for turning up flanges on metal discs.

**Funnel stake** (Fig 4): This stake is used when shaping and seaming funnels and tapered articles.

**Beak or Bick Iron stake** (Fig 5): This stake has two horns, one of which is tapered the other is a rectangular shaped anvil. The thick tapered horn or beak is used when making spouts and sharp tapered articles. The anvil may be used for squaring corners, seaming and light riveting.

**Creasing Iron** (Fig 6): This stake has two rectangular shaped horns, one of which is plain. The other horn contains a series of grooving slots of various sizes. The grooves are used when ‘Sinking’ a bead on a straight edge of a flat sheet. This is also used when making small diameter tubes with thin gauge metal.

**Pipe stake or Square edge stake** (Fig 7): This stake has the horn and the shank. The horn is available in two types. one is with flat face as shown in (Fig 7A). Other one is with curved face as shown in (Fig 7B) Flat face horn stake is used to fold the edges, and to turn up straight edges. The
curved face horn stake is used to turn circular disc or curved edges and to make knocked up joints.

**Tinman’s Anvil** (Fig 8): It is used for planishing all types of flat shaped works. It is highly polished on its working surface.

**Tinman’s Horse** (Fig 9): This stake has two arms at its both ends, one of which is usually cranked downwards for clearance purpose. There is a square hole for the reception of a wide variety of heads. (Fig 10)

The surface of the stake is important for the workmanship of the finished article. Therefore, care must be taken to avoid any damage to the surface of the stake when centre punching or cutting with a cold chisel.

Apart from these stakes, special types of stakes are also available to suit different types of jobs.
Copper smith stake

Objectives: At the end of this lesson you shall be able to
• identify a copper smith stake
• state the constructional features of a copper smith stake
• state the uses of a copper smith stake
• state safety, care and maintenance while using a copper smith stake.

It is not economical to have too many stakes for simple operations in a sheet metal shop.

Hence, an economical way of tooling is adopted and designed by combining two edges of different cross sections on a common head as in Fig 1. This stake is called a copper smith stake or tinman’s anvil. It is a very useful stake used in sheet metal work, due to its constructional features.

This stake is used for flattening the surfaces of the sheet metal, bending, flanging, finishing wired edges on both straight and curved edges.

These stakes are made of medium carbon steel and case hardened.

Safety care and maintenance
1 Fix the stake firmly in the bench plate or stake holder to avoid slipping and causing accidents.
2 Do not use it for heavy work.
3 Do not spoil the surface of the stake by chiseling and punching.
4 Do not spoil the edges by cutting wire or nails on the edges of the stake.
5 Remove and keep it in its place after use.

Bottom round stake

Objectives: At the end of this lesson you shall be able to
• identify the Round Bottom Stake
• state the constructional features of this stake
• state the uses of this stake.

Bottom round stake: This is a very common stake used in a sheet metal shop. This stake is round in shape with a flat face, slightly chamfered to avoid the cracking or tearing of sheets while using it.

It is used for turning edge on circular discs, seaming and fixing bottom to cylindrical parts, making a paneled down joint at the bottom of the cylindrical parts. The tail is designed to fit in the square slot made in the work bench or stake holder.

Do not cut wires or nails on the edge of the stake. This will spoil the edge and the same impression will be formed on the sheet or the part formed on it.
Stake holders

Objectives: At the end of this lesson you shall be able to
• name the different types of stake holders
• state the constructional features of stake holders
• state the uses of stake holders
• state safety, care and maintenance when using stake holders.

There are three types of stake holders

1  Bench plate
2  Revolving bench plate
3  Universal stake holder

Bench plate: Stakes are held in position while using them by means of a plate which is fastened to the work bench with bolts and nuts. These plates are called bench plates or stake holders.

These bench plates are made of cast iron and are rectangular in shape as in Fig 1. The tapered holes are conveniently arranged so that the shanks of the stakes may be fixed and used in any convenient position. The smaller holes are used to support the bench shears.

Revolving bench plate: Revolving bench plate consists of a revolving plate with tapered holes to support the shanks of the stakes while using them.

This revolving bench plate can be held in any convenient position by clamping it on to the work bench, with the clamping provision provided on it as in Fig 2.

Universal stake holder: Universal stake holder can be clamped to any desired position on the work bench. So it is preferred by most of the mechanics.

This stake holder is designed with a set of stakes which can be easily fixed on to the stake holder and hence it is termed as universal stake holder set as shown in Fig 3. One stake may be replaced by another very quickly by simply turning the swivel handle and replacing the stake.

When placing an order to purchase this type of stake holder set, we should specify clearly the type of stakes to be supplied along with the stake holder.

Safety, care and maintenance:

– Fix the stake holder firmly on to the work bench.
– Do not use it for very heavy work.
– Do not overtighten the locking arrangements which may spoil the threads on the device.
– Do not place the unnecessary accessories on the work table. Place only the required ones.
– Avoid chiseling or punching on this stake holder.
– Remove and keep it in its place after use.
The straight tabs are bent over the part to be joined and the bent tabs act as stops. This seam may be made water tight by soldering around the joint.

Introduction

In Sheet metal construction, mechanical seams are employed when joining light and medium gauge metal sheets. While fabricating sheet metal articles, the sheet metal worker should be able to select the type of seam that is best suited for the specific job.

Types of seams

1 Grooved seam: Grooved seam is most commonly used for joining sheet metal. This seam consists of two folded edges called locks as shown in Fig 1. The edges are hooked together and locked with a hand groover or a grooving machine.

2 Pittsburgh seam: This seam is also called hammer lock or hoberlock. This seam is used as a longitudinal corner seam for various types of pipes such as duct work. The single lock is placed in a pocket lock and then the flange is hammered over, step by step as shown in Fig 2.

3 Dovetail seam: This seam is an easy and convenient method of joining flanges to collars. There are three types of dovetail seams - plain dovetail, beaded dovetail and the flange dovetail as shown in Fig 4.

The straight tabs are bent over the part to be joined and the bent tabs act as stops. This seam may be made water tight by soldering around the joint.
(B) Flange dovetail seam

This seam is used where neat appearance and strength are important. The seam shown in Fig 6 is the assembly of a flange type dovetail seam for a cylindrical pipe. It is commonly used where pipes intersect with a metal plate such as furnace flues, ceilings etc. Steps in forming a flange dovetail seam are shown in Fig 6. First, a flange is turned on the collar, next, slits are cut at regular intervals at the end of the sleeve and matching rivet holes are drilled in the sleeve and the collar. The rivet holes are aligned and the rivets are installed and finally the tabs are hammered over to complete the seam.

(C) Beaded dovetail seam

This is similar to the plain dovetail seam, except a bead is formed around one end of the cylinder by a beading machine. This bead acts as the stop for the flange to rest upon and the tabs are bent over to hold the flange in the desired place.

4 Double seam

There are two types of double seams. One type is used for making irregular fittings such as square elbows, boxes, offsets, etc. This seam is used on corners and can also be used as a longitudinal seam on small square and rectangular ducts. A double edge is formed and placed over the single edge and the seam is completed step by step as shown in Fig 7.

If the seam is not turned up, as in D, the seam is called paneled down seam.

5 Butt seam

This seam has two pieces butt together and soldered as shown in Fig 9. Figure shows two types of butt seams. One is flanged butt seam and the other one is butt seam.

6 Lap seam

The lap seam is made by lapping the edge of one piece over the other piece and soldered as shown in Fig 10. Figure shows plain lap, sunk lap, inside lap and outside lap seams.

7 Slip joint seam

This seam is used for a longitudinal corner seam as shown in Fig 11.

The assembly of the seam consists of a single lock A and a double lock B. The single lock is slipped into the double lock C to complete the seam.
For making pipes with a slip joint seam, proper care should be taken to see that the corners of the metal are squared and the edges are trimmed. The proper slip joint is shown as A and improper as B in Fig 12. If the edges are not trimmed, it will twist the pipe out of shape and may cause the edges of the pipe to be uneven.
Locked grooved joint

Objectives: At the end of this lesson you shall be able to
• state the purpose of a joint
• state the use of the groover
• determine the allowance for the locked grooved joint
• know the type of shears
• know the uses of shears
• know about the shearing force
• know the blade clearance for optimum cutting.

Locked grooved joint: Many methods are employed to join and strengthen the pieces of a sheet metal. One of the common joint is called locked grooved joint. This is usually done on straight lines. The workpieces to be joined are made in the form of a hook, inserted and locked using a groover.

When they are interlocked and tightened only then it is called a “grooved joint” (Fig 1).

When the grooved joint is clinched down, making one side plane using a groover is called a “Locked grooved joint”. (Fig 2)

External and internal locked grooved joints: This joint is used to join the two ends of a sheet metal to form a circular shape in longitudinal direction. When the seam is formed outside as shown in Fig 3 then it is called ‘external locked grooved joint’.

If the seam is formed using grooved mandrel then it is called ‘Internal locked grooved joint’ (Fig 3)

Hand Groover: The hand groover is made up of cast steel and is used to make external locked grooved joint. A groove is made at the bottom of this tool to the required width and depth. This has a handle in square or hexagonal shape like chisel to hold. This whole part is hardened and tempered. (Fig 4)

The hand groover is specified according to the size of the groove of the groover.

Locked grooved joint allowance: To arrive the size (width) of the fold to suit a particular groover, subtract the thickness by 3 times from the width of the groove. (Fig 5)

For example, the width of the groover is 6 mm and the sheet thickness is 0.5 mm,
Then the width of the fold
= 6 - (3 x 0.5)
= 4.5 mm (See Fig 6).
Stake joint

Objectives: At the end of this exercise you shall be able to
• State the applications of stake joint
• State the types of stake joints.

Stake joint

It is one of the folded joint and is used in light articles such as toys. It is also called as joint.

In this type of joint, clips are cut on one pieces to be jointed. Clips are inserted in slots and folded flat either in one direction or alternate clips are folded in opposite direction. (Fig 1)

Straight stake joint

In this joint, clips and slots are in a line an the clips are inserted directly, into the slots, folded and smashed in opposite direction. (Fig 1)

Zigzag stake joint

In this joint, clips are inserted in the slots and alternate clips are folded in opposite direction. (Fig 2)

Types of stake joint

i. Straight stake joint
ii. Zigzag stake joint

Dovetail seam

Objectives: At the end of this exercise you shall be able to
• State a dovetail seam
• State the uses of a dovetail seam
• Differentiate between a dovetail seam and a cramped joint.

Dovetail seam is a very useful joint in sheetmetal fabrication work. The shape of the tabs cut like the tail of a dove. Hence it is called a dovetail seam. It is mostly used to join the bottom to the body of sheet metal articles.

This seam is very useful when joining a collar to a flange without using solder or screws or rivets. This is done by slitting the end of the collar at regular intervals and bending every other tabs as in Fig 1. The bent tabs act as stoppers and the remaining tabs are bent over the plate to be joined as in Fig 1. This joint may be made water tight by soldering if required.

Flange dovetail seam (Fig 2): Fig 2 shows the assembly of a flange dovetail seam for cylindrical pipe. It is commonly used where pipes intersect within a flat metal plate such as furnace constructional works. This is done where extra strength and good appearance is required. First a flange is turned on the collar Fig 2A. Next slits are cut at regular intervals at the end of the sleeve and matching rivet holes are drilled in the collar and sleeves Fig 2B. The plate rests on the collar flange and sleeve is inserted into the collar Fig 2C. The rivet holes are aligned and the assembly is riveted. Finally the tabs are bent over to complete the seam. Fig 2D.
Pittsburgh lock

Objectives: At the end of this exercise you shall be able to
• define the pittsburgh seam
• state the different types of pittsburgh seams
• state the uses of pittsburgh seams.

Pittsburgh lock is used in Duct work and is formed using folding machine.
It consists of a single lock or flanged section and a pocket lock or pocket section. (Fig 1)

Single lock can be turned on the curve and pocket lock to be formed on a flat sheet and then rolled to fit the curve.
Example: \( W + W + 6.35 \text{mm} \)
The width of the flanged edge is normally made slightly less than the depth of the pocket.
Usually, the allowances for the pocket is between 25 and 30 and for the flange is between 6 to 8.
Fig2 shows the applications of pittsburgh lock the seam.

Snap lock seam: Snap lock seam is as role formed seam and is machine similar to pittsburgh lock seam. (Fig 3)
The allowance for this joint depends on the machine setting and is usually 25 to 30mm on the female lock section and 10mm allowance for the male section.
The male section has small wedge shaped projections, punched at regular intervals on the flange as shown in Fig 4. When this flange is pressed into female section, the projections lock under a fold edge. This joint is a longitudinal seam in used in duct work. It is better than Pittsbugh seam because it is heat in a apperances and requires less time in fabrication.

Pittsburgh lock seam applied to curved work Fig 3

When curved ducts like elbows are to be which incorporate the pittsburgh lock, the female section of the seam is formed prior to curving.
To make correct lock shape, a sheet metal strip spacer is placed in between the first and second layers of the lock.
The side is then curved t the shape in curving rolls. The spacing strip is removed before assembling the component.
The standing seam (Fig 5): This standing seam is used primarily to join panel section together, by allowing large castings and wall cladding to be made with standard sized sheets.

Strength and rigidity of the panel and the joint design is simple and cost effective as shown in Fig.

The standing seam has a standing flange section which may be from 25mm to 40mm depending on the length of the seam and thickness of the material. Movement of the seam is arrested by button punching, riveting or bolting the flange upstand 50mm from the end of the seam at 150mm intervals. The standing seam can be prepared in a bar folder or by manual folding.

Cleat joints

Description and Allowances: Folded joints are the integral parts of an article and they all considered to be permanent fixtures.

Cleats vary in application and design and commonly made in a barfolding machine. Cleats which are of simple design can be manually folded.

It is a good practice to make a sample of the component to be connected. Determine the size of the cleat.

The drive slip: the drive slip is a simple design consisting of a metal strip formed into a ‘C’ shaped section as shown in Fig 6. The joint is made by driving the cleat over the folds positioned at each end of the work to be joined. The drive slip is mainly used to join lengths of duct work. the joint is simply made by driving the cleat over the folds on the ends of the jobs as shown in Fig 7.

However, cleat joints consist of a folded cleat section which inter locks with folds on articles to be joined and can be dismantled, if necessary.

It is a good practice to insert a tongue into the end folds of the abutting cleat. An alternate is to bend the tongue and secure with blind the tongue and secure with blind rivets as shown in Fig 8. A similar corner finish may be done.

Variation of duct end design will provide additional strength as shown in Fig 9. In one example drive slip can be used to connect channel folded ducts ends, which is giving the appearance of a standing.

Another example is the modification to a drive slip to include on upstand section.

The Hemmed “S” slip: Used on ducts up to 600 mm in width.

Insert the ends of the duct sections into the open folds of the “S” and secure with rivets at 100 mm intervals as shown in Fig 10.
Standing "S" Slip: Used on ducts upto 1200 mm width in made with a 35 mm upstand and 1500 mm wide with stand of 50 mm as shown in Fig 11.

Pocket lock
For using a transverse joint on vertical duct, the cleat slips over the upper edge of the bottom duct and the channel part of the cleat takes the flanged end of the upper duct as shown in fig 12

The upstanding fold of the channel is dressed down by hand, commonly at the time of installation.

Mechanical fasteners

Introduction
A mechanical fastened joint is one in which two or more sheet metal pieces are held together by a manufactured device.
There are many variety of mechanical fasteners available. The riveted joints in aircraft wing and the joints bolted in air conditioning duct work provide two examples as shown in Fig 13.

![Fig 13](image)

**Use of angle stiffeners**

Welded angle frames are used as the means of stiffening and supporting rectangular ducts which are used for high velocity systems. They also serve the purpose of joining media when assembling sections together by bolting as shown in (Fig 14)

![Fig 14](image)

The large size of square or rectangular ducting tend to drum when the air pressure passing through them varies. To overcome this drum, it is necessary to keep adequate stiffening to the walls of ducts, it is necessary to keep adequate stiffening to the walls of ducts. This can be achieved by the use of swaging but often a diamond break is used as shown in (Fig 15)

![Fig 15](image)

Simple angle frames of welded construction may be used for supporting and stiffening the open ends of tanks or bins made from sheet metal. Two methods of attaching the angle frames are shown in (Fig 16)

![Fig 16](image)
Folding and joining allowances

Objectives: At the end of this lesson you shall be able to
• state the necessity for providing allowances in sheet metal operations
• calculate the allowances for grooved joints
• calculate the allowances for dovetail joints
• calculate the allowances for paneled down and knocked up joints.

When making self secured joints or seams, it is necessary to provide material for the preparation of the edges and seams, the extra material is called an allowance.

The allowance is necessary for maintaining the correct size of the finished product and for improving the strength at the joints of all edges.

Allowance is also necessary for avoiding cracking or warping, and for obtaining the required finish.

This allowance depends upon the width of the folded edge and the thickness of the metal.

You may neglect the thickness of the metal for thinner sheet of 0.4 mm or less.

Allowance for grooved joints/ seams (Fig 1): If we fold over the edges to width W and form the joint, the final completed width of the joint G will be greater than W. It can seen that the final width of the groove will have a minimum value of W+ 3T, where T represents the metal thickness.

The allowance for a grooved seam is the width of the seam + three times the thickness of the sheet

Allowance for double grooved seam/joint: It will be seen from Fig.2 that the width of the capping strip is equivalent of two times the width of the folded edge plus four times the thickness of the metal size.

Allowance for paneled down and knocked-up-joints.

The complete allowance for the Double Grooved Seam/ Joint will be four times the width of the folded edge plus four times the thickness of the metal.

Allowance for paneled down and knocked-up-joints.

The size of paneled down and knocked-up joints is determined by the width of the single folded edge. ‘P’ represents the size of the paneled down joint (Fig 3) and ‘K’ represents the size of the knocked-up joint. (Fig 4)

Edge stiffening by wiring

Objectives: At the end of this lesson you shall be able to
• state what is edge stiffening
• state what is the purpose of edge stiffening
• state methods of edge stiffening by wiring.

Edge stiffening: Edge stiffening is the process by which edges of the sheets are made stronger and rigid.

Edge stiffening is done by

1 Wiring
2 Hemming
3 Flanging
4 Curling
5 Beading
6 Gutting
7 Ribbing

Purpose of edge stiffening

1 To give extra strength and rigidity to edges, to prevent it from bending/buckling, damage during handling etc.
2 To avoid sharp edges for safe handling.
Methods of edge stiffening by wiring

1. Solid wiring
2. False wiring

In solid wiring, sheet metal edges are wrapped around the wire and wires are kept permanent in place. This is generally called simple “Wiring”.

In false wiring, sheet metal edges are wrapped around the wire, after forming final shape, the wire is removed from the edge to retain it hollow.

If the edge of the sheet metal is straight, the edge formed is called “straight wired edge”.

If the edge of the sheet metal is curved, the edge formed is called “curved wired edge”.

False wiring cannot be done on curved edges

Wiring allowance

Objectives: At the end of this lesson you shall be able to
- state what is wiring allowance
- determine the wiring allowance.

Wiring allowance is nothing but the amount of additional length provided on sheet metal to wrap around the wire to make a wired edge.

Wiring allowance is determined by the following formula.

Wiring allowance = 2.5 x d + t

where

d = dia of wire

(t = thickness of sheet metal

If wiring allowance provided is more, then the correct shape of the wire is not formed. If wiring allowance provided is less, the gap is found at the inner side of the edge and the wire can be seen.

Generally, the length of the wire provided is slightly more than the length of the edge. This is required to hold the wire at ends, while forming the edge of the sheet metal around the wire.

Surplus wire is cut after the wired edge is finished.

Making wired edge along a curved surface by hand process

Objectives: This shall help you to
- mark the wiring allowance at the curved edge
- make a wired edge along a curved surface by hand process

Mark the wiring allowance at the curved edge to be wired using a gauge with sheet metal as shown in Fig 1.

Flange the edge to be wired using a hatchet stake and a setting hammer, step by step up to 90°. (Fig 2) Then upset the flange to its half the width and make curve on the flange for wiring. (Fig 3)

Make a round ring from the given G.I. wire to the required dia. (Fig 3)

The joint of the wire should be opposite to the locked grooved joint.

Place the G.I. Wire ring on the flange. (Fig 4)
Complete the wiring using a creasing hammer. (Fig 5)
Dress the wiring by using a half moon stake and a mallet.
Redress the trueness of the cylindrical shape by a round mandrel and a mallet.

False wiring

Objectives: At the end of this lesson you shall be able to
• state what is false wiring
• state advantages of false wiring

False wiring is one of the methods of edge stiffening in which wired edge is formed and finally wire is removed from the edge, to make the edge hollow.
Advantages of false wiring: In addition to advantages by wiring, false wiring gives following advantages.
1 Cost of the article is reduced.
2 Weight of the article is also reduced.
In sheet metal articles like trunks, boxes etc., wiring is done only at the corners of the adjacent sides and the remaining portion of the wired edge is kept hollow.
This helps to maintain the sides in position.

Hemming

Objectives: At the end of this lesson you shall be able to
• state the importance of hemming
• determine the hemming allowance.

The sheet metal edges being thin are very unsafe while we handle. They are like knife edge and can cause injuries. Therefore the edges should be made blunt by way of making the edge folded to 180°. Also since the sheet metal is very thin the edges will deflect due to low strength without stiffness.

For the above reasons the edges are hemmed (Fig 1) which will ensure safety, retaining of shape, owing to the stiffness and also enhance good appearance.

The folded edge will be more strong if it is not completely flattened and a hollow channel is made.

Usually the hemming allowance will be 3 to 4 times the thickness of the sheet to be hemmed, subject to a minimum of 4 M M.

If the hemming width is more, wrinkles are formed at the hemmed edges.

A hemmed box is shown in Fig 2 gives good appearance, safe and strong edge.
Double hemming by Hand Process

Objectives: At the end of this lesson you shall be able to
• state the purpose of double hemming
• give the hemming allowance for the first and second folds.

Double hemming is done by folding twice. This give more strength, when compared to single hemming. This is done on various sheet metal articles which in square, rectangular objects like trays. (Fig 1 & Fig 2)

While doing double hemming, care must be taken making second fold. Angle of folding should be grade increased throughout the length of the fold.

Edge Stiffening

Objectives: At the end of this lesson you shall be able to
• make a single hemming on a curved edge using anvil stake and setting hammer.

Mark the hemming allowance on the formed body using a marking template.

Fix the anvil stake on to the vice or bench plate.

Hold the workpiece such that the marked line coincides with the edge of the stake approximately inclined an angle of 10° as shown in Fig 1.

Strike and rotate the workpiece gradually along the marked line to form a small flange using a setting hammer. (Fig 2)

Gradually increase the angle of inclination while forming range as shown in Fig 3.

Finish the hemmed edge on a round mandrel stake by a let (Fig 4)

Press the disturbed body of the cylinder to a round shape using round mandrel stake and a mallet

Check the cylindrical body for roundness and the marking allowance for flanging.

Fix the copper smith stake in the benchvice or bench plate firmly.
Mark the flanging allowance as guideline on the stake as in Fig 5

Hold the cylinder such that the marked line on the cylinder for flanging, coincides with the straight edge of the stake. (Fig 6)

Position the cylinder as in Figure 1 and strike the metal using the flat face of the finishing hammer.

Rotate the body of the cylinder by one hand.

Strike with finishing hammer to increase the angle of bending gradually as in (Fig 7) till the flange is bent to 90°
Solder is a bonding filler metal used in soldering process. Pure metals or alloys are used as solders. Solders are applied in the form of wires, sticks ingots, rods, threads, tapes, formed sections, powder, pastes etc.

Types of solders

There are two types of solders.
- Soft solder
- Hard solder

Soft solders: Soft solders are alloys of tin and lead in varying proportions. They are called soft solders because of their comparatively low melting point. One distinguishes between soft solder whose melting points are 450ºC and hard solders whose melting points lie above 450ºC. These are alloys of the materials tin, lead, antimony, copper, cadmium and zinc and are used for soldering heavy (thick) and light metals. Table shows different compositions of solder and their application.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Types of solder</th>
<th>Tin</th>
<th>Lead</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Common solder</td>
<td>50</td>
<td>50</td>
<td>General sheet metal applications</td>
</tr>
<tr>
<td>2</td>
<td>Fine solder</td>
<td>60</td>
<td>40</td>
<td>Because of quick setting properties and higher strength, they are used for copper water tanks, heaters and general electrical work.</td>
</tr>
<tr>
<td>3</td>
<td>Fine solder</td>
<td>70</td>
<td>30</td>
<td>Used on galvanised iron sheets</td>
</tr>
<tr>
<td>4</td>
<td>Coarse solder</td>
<td>40</td>
<td>60</td>
<td>Soldering brass, copper and jewellery</td>
</tr>
<tr>
<td>5</td>
<td>Extra fine solder</td>
<td>66</td>
<td>34</td>
<td>Similar to fine solder</td>
</tr>
<tr>
<td>6</td>
<td>Eutectic alloy</td>
<td>63</td>
<td>37</td>
<td></td>
</tr>
</tbody>
</table>

Hard solders: These are alloys of copper, tin, silver, zinc, cadmium and phosphorus and are used for soldering heavy metals.

WARNING
For cooking utensils, do not use solder containing lead. This could cause poisoning. Use pure tin only.

Soldering flux

Objectives: At the end of this lesson you shall be able to
- state the functions of soldering fluxes
- state the criteria for the selection of fluxes
- distinguish between corrosive and non-corrosive fluxes
- state different types of fluxes and their applications.

All metal rust to some extent, when exposed to the atmosphere because of oxidation. The layer of the rust must be removed before soldering. For this, a chemical compound applied to the joint is called flux.

Functions of the fluxes
1. Fluxes removes oxides from the soldering surface it prevents corrosion
2. It forms a liquid cover over the workpiece and prevents further oxidation.
3. It helps molten solder to flow easily in the required place by lowering the surface tension of the molten solder.

**Selection of flux:** The following criteria are important for selecting a flux.
- Working temperature of the solder
- Soldering process
- Material to be joined

**Different types of fluxes:** Flux can be classified as (1) Inorganic or Corrosive (Active) & (2) Organic or non-corrosive (Passive).

Inorganic fluxes are acidic and chemically active and remove oxides by chemically dissolving them. They are applied by brush directly onto the surface to be soldered and should be washed immediately after the soldering operation is completed.

Organic fluxes are chemically inactive. These fluxes coat the surface of the metals to be joined and exclude the air from the surface, to avoid further oxidation. They are applied only to the metal surfaces which have been previously cleaned, by mechanical abrasion. They are in the form of lump, powder, paste or liquid.

**Different types of fluxes**

**(A) Inorganic fluxes**

1. **Hydrochloric acid:** Concentrated hydrochloric acid is a liquid which fumes when it comes into contact with air. After mixing with water 2 or 3 times the quantity of the acid, it is used as dilute hydrochloric acid. Hydrochloric acid combines with zinc forming zinc chloride and acts as a flux. So it cannot be used as a flux for sheet metals other than zinc iron or galvanised sheets. This is also known as muriatic acid.

2. **Zinc chloride:** Zinc chloride is produced by adding small pieces of clean zinc to hydrochloric acid. It gives off hydrogen gas and heat after a vigorous bubbling action, thus producing zinc chloride. The zinc chloride is prepared in heat resisting glass beakers in small quantities. (Fig 1)

Zinc chlorides are known as killed spirits. It is mainly used for soldering copper, brass and tin sheets.

3. **Ammonium chloride or Sal-Ammoniac:** It is a solid white crystalline substance used when soldering copper, brass, iron and steel. It is used in the form of powder or mixed with water. It is also used as a cleaning agent in dipping solution.

4. **Phosphoric acid:** It is mainly used as flux for stainless steel. It is extremely reactive. It is stored in plastic containers because it attacks glass.

**(B) Organic fluxes**

1. **Resin:** It is an amber coloured substance extracted from pine tree sap. It is available in paste or powder form.

Resin is used for soldering copper, brass, bronze, tin plate, cadmium, nickel, silver and some alloys of these metals. This is used extensively for electrical soldering work.

2. **Tallow:** It is a form of animal fat. It is used when soldering lead, brass and pewter.
Soft soldering

**Objectives:** At the end of this lesson you shall be able to
- explain soft soldering process
- state the melting characteristics of soft solders
- state the essential features of the soldering technique
- explain the importance of the attitude of the bit
- state the importance of movement of the bit in soldering
- state the characteristics of the soldered seams to be observed while inspection.

### Table 1

The following Table shows the nature and type of flux used in soldering.

<table>
<thead>
<tr>
<th>Metal to be soldered</th>
<th>Inorganic flux</th>
<th>Organic flux</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminium-bronze</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brass</td>
<td>Killed spirits</td>
<td>Resin</td>
<td>Commercial flux available</td>
</tr>
<tr>
<td></td>
<td>Sal-ammoniac</td>
<td>Tallow</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>Killed spirits</td>
<td>Resin</td>
<td>Commercial flux available</td>
</tr>
<tr>
<td>Copper</td>
<td>Killed spirits</td>
<td>Resin</td>
<td>Commercial flux available</td>
</tr>
<tr>
<td></td>
<td>Sal-ammoniac</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td></td>
<td>Resin</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>Killed spirits</td>
<td>Tallow</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resin</td>
<td></td>
</tr>
<tr>
<td>Monel</td>
<td></td>
<td></td>
<td>Commercial flux required</td>
</tr>
<tr>
<td>Nickel</td>
<td>Killed spirits</td>
<td>Resin</td>
<td>Commercial flux available</td>
</tr>
<tr>
<td>Silver</td>
<td></td>
<td>Resin</td>
<td></td>
</tr>
<tr>
<td>Stainless steel</td>
<td>Phosphoric acid</td>
<td>Resin</td>
<td>Commercial flux available</td>
</tr>
<tr>
<td>Steel</td>
<td>Killed spirits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tin</td>
<td>Killed spirits</td>
<td>Resin</td>
<td>Commercial flux available</td>
</tr>
<tr>
<td>Tin-bronze</td>
<td>Killed spirits</td>
<td>Resin</td>
<td></td>
</tr>
<tr>
<td>Tin-lead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tin-zinc</td>
<td>Killed spirits</td>
<td>Resin</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>Muriatic acid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Soft soldering

**Melting characteristics of soft solders:** The eutectic alloy of tin lead solder is a mixture of 63% tin and 37% lead. 63/37 solder melts at 183°C and is the lowest melting point of all combinations in the alloy series as shown in Fig 2.

**Soldering Techniques:** The following features are essential to do soldering:
- Correct joint design
- Preparation of the joint
- Selection of the solder

Soft soldering involves the process
- preparing the workpiece.
- select the correct soft solder.
- preparing the soldering iron.
- select and apply suitable flux.
- heat the soldering iron bit and the workpiece to the correct temperature.
- manipulating the soldering iron on the workpiece skillfully as shown in Fig 1.
- complete the job to a satisfactory standard.

186 CG&M : Fitter (NSQF Level -5) - Related Theory for Exercise 1.3.50 -1.3.51
– Selection and preparation of the soldering iron.
– Copper bit heating
– Soldering bit manipulation
– Cleaning after soldering
– Inspection of the seam.

**Attitude of the bit:** The soldering iron bit should be placed in a position that enables sufficient heat and solder to flow into the joint.

The angle between a working face of the bit and the joint surface should be filled with a pocket of solder. (Fig 3)

Any variation of this angle will control the amount of heat and solder which is transferred onto the lapped surfaces.

Contact between the molten solder and the joint opening is essential for the penetration of the solder into the joint as shown in figure.

Flux residues and stains should be removed from the seam, to keep clean dry surfaces for paint finishes.

**Inspection of the seam:** A soldered seam should have the following characteristics.

– The solder has penetrated the lapped surfaces.
– The joint gap is sealed with a neat smooth fillet of the solder.
– The upper surfaces of the seam must be smooth, thin coating of solder, with tidy solder margins with uniform width.

Visual inspection is good to rectify the faults of the solder. However, physical testing for air or water tight seams is specified often. Leaks, detected by the tests are corrected by re-cleaning, re-fluxing and re-soldering of the faulty area in the soldered seam.
Process of soft soldering and hard soldering

Objectives: At the end of this exercise you shall be able to
- define ‘soldering’
- state the different types of soldering processes
- state the different types of solder and their applications
- state the different types of soldering bits and their uses.

Soldering method: There are different methods of joining metallic sheets. Soldering is one of them.

Soldering is the process by which metallic materials are joined with the help of another liquified metal (solder). The melting point of the solder is lower than that of the materials being joined.

The solder wets the base material without melting it.

Soldering should not be done on joints subjected to heat and vibrations and where more strength is required.

Soldering can be classed as soft soldering and hard soldering.

The process of joining metals using tin lead solders which melt below 420°C is known as soft soldering.

The process of joining metals using hard solders consisting of copper, zinc, cadmium and silver which melt above 600°C is known as hard soldering.

Brazing is a hard soldering process used to join copper brass and most ferrous metals.

The bonding filler metal usually consists of copper and zinc alloys. Silver brazing or silver soldering is a process used to join steel, copper, bronze and brass and precious metals like gold and silver.

The bonding filler metal consists of silver, copper and zinc tin alloys.

Factors considered while soldering

Objectives: At the end of this exercise you shall be able to
- follow the conditions for proper define ‘soldering’
- state the different types of soldering processes.

Soldering is joining two metal parts with a solder, i.e. a third metal that has a lower melting point.

Before soldering the following conditions must be met.
1. The metal must be clean
2. The correct soldering device must be used and it must be in good condition
3. The correct solder and flux or soldering agent must be chosen.
4. Proper amount of heat must be applied. If you folds these conditions, you could get a good solder joint.

Cleanliness: Solder will never stick to a dirty, oil or oxide coated surface. Beginners often ignore this simple point the metal is dirty. Clean it with a liquid cleaner. If it is a annealed sheet remove the oxide with an abrasive and clean it until the surface is bright.

A bright metal, such as copper, can be coated with even though you cannot see it. This oxide can be removed with any fine avrasive.

Successful soldering

Objective : At the end of this lesson you shall be able to
- follow the hints for successful soldering.

Hints for successful soldering

You should always wear safety glasses to avoid possible injury to the eyes.

Sheet metal must be cleaned with a file, wire brush, steel wool strip, or emery cloth.

Be sure that the pieces to be soldered fit closely together, for a strong joint.

Soldering flux must be applied by a swab or brush only to the surfaces on which molten solder is to be applied.

Hold the pieces to be soldered firmly to prevent their movement.

Hold the soldering iron in one hand, placing its widest tinned face flat against the surface to be soldered.

When soldering iron is held incorrectly, the point of the soldering iron touches only a portion of the area to be soldered, this is referred to as “skimming” the joint and results in a weak joint.

Apply the wire solder beneath the edge of the iron and nearest to the work. Move the soldering iron slowly along the work making sure that the solder melts, spreads and penetrates properly.

Solder as much surfaces as possible without re-heating the soldering iron or changing to another iron.
A temperature capable of merely melting the solder is not sufficient enough, heat must be transmitted by the soldering iron to the workpiece to quickly raise the temperature of the metals to the solder melting temperature. It is this step in soldering that beginners often fail to understand and remember.

A soldering iron that is too small, often causes difficulty. Do not breathe any smoke from the sal ammoniac block as it is a toxic gas and is dangerous.

### Sweating of sweat soldering

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

- explain the process of sweating.

Sweating or Sweat soldering is a process, in which two or more surfaces are soldered one on the top of the other without allowing the solder to be seen after assembly.

In sweating, metal surfaces to be joined are tinned first, then placed on above the other and heated together. While heating, the solder melts and flows to join the overlapped surfaces.

Sweating process is applied in body repairing works in which the damaged surface is sweat soldered with a piece of metal called patch. This process is also applied in rectifying leakages of water tanks and fuel tanks.
Soldered Joint

Objectives: At the end of this lesson you shall be able to
• state the types of the soldered joints
• state the points to be considered for correct joint design.

Types of soldered joints: Sheet metal components are joined together by soldered joints. In many cases, the edges are joined by sheet metal mechanical joints and then soldered to make the joint stronger and leak proof.

Fig 1 shows soldered lap joints.

Sheet metal joints both lapped and folded, are suitable for silver soldering application as shown in Fig. 4

Fig 2 shows soldered seams.

Silver solder effects the union of lapped joints and seals the beam openings of the interlocking folded joints.

Correct joint design: Sheet metal joints with overlapping surfaces are ideal for joining or sealing with solder. Close fitting of lapped surfaces are essential for the flow of molten solder into the joint by capillary action.

Joint design suitable for silver brazing or soldering mainly depends on the type of assembly and its intended use.

Maximum strength can be achieved by observing the following conditions.

– A suitable filler alloy must be used.
  Component metal is of major consideration.
– Joint clearances should be minimum.
  Close fitting surfaces helps capillary flow and gaps between 0.05 and 0.13 mm should be used.
– The solder must contact lapped surface sufficiently.
  Lap width is commonly made 2 to 10 times the component metal thickness. In case of unequal thickness, the lap size is based on the thinner materials.
– Workpieces must be firmly supported.
  It is essential to prevent the movement for the control of the solder application, alignment and accuracy of the component assembly.

Fig 3 shows soldered joint on round shaped parts.
Dipping solution

Objectives: At the end of this lesson you shall be able to
- state the use of the dipping solution
- state the constituents of the dipping solution.

It is used to dissolve oxides from solder coated faces of the copper bit before applying it to the workpiece.

It is made of
1. Dissolving sal-ammoniac powder in water.
2. Dilute zinc-chloride with water.
3. Adding commercial flux with zinc chloride or ammonium chloride as active ingredients to water.

A mixture of approximately one part of active component and four parts of water is satisfactory as the acidity of the solution should not be strong.

Safety precautions in soldering

Objective: At the end of this lesson you shall be able to
- follow safety precautions in soldering to avoid injuries/accidents.

Safety precautions followed while soldering
1. Wear safety glasses to protect your eyes from solder splattering and flux.
2. Be careful while storing hot soldering irons after use to avoid burns.
3. Wash your hands thoroughly after using soft solder because it is poisonous.
4. Tin the soldering iron in a well ventilated area to exhaust fumes coming out while soldering.
5. Wear safety goggles when using acids for cleaning.
6. When making acid solution, always pour acid into water slowly.
7. Never pour water into the acid.
8. All inorganic fluxes are poisonous.
9. Wear goggles and gloves while handling corrosive flux.

Fluxes types and description

Objectives: At the end of this lesson you shall be able to
- explain flux and its function
- describe the types of fluxes and their storage.

Flux is a fusible (easily melted) chemical compound to be applied before and during welding to prevent unwanted chemical action during welding and thus making the welding operation easier.

The functions of fluxes: To dissolve oxides and to prevent impurities and other inclusions that could affect the weld quality.

Fluxes help the flow of filler metal into very small gap between the metals being joined.

Fluxes act as cleaning agents to dissolve and remove and clean the metal for welding from dirt and other impurities.

Fluxes are available in the form of paste, powder and liquid.

The method of application of flux is shown in Fig. 1.

Storing of fluxes: where the flux is in the form of a coating on the filler rod, protect carefully at all times against damage and dampness. Fig 2.

Seal flux tin lids when storing especially for long periods (Fig 2)
Though the inner reducing envelope of an oxy-acetylene flame offers protection to the weld metal, it is necessary to use a flux in most cases. Fluxes used during welding not protect the weldment from oxidation but also from a slag which floats up and allows clean weld metal, to be deposited. After the completion of welding, flux residues should be cleaned.

**Removal of flux residues**: After welding or brazing is over, it is essential to remove the flux residues. Fluxes in general are chemically active. Therefore, flux residues, if not properly removed, may lead to corrosion of parent metal and weld deposit.

Some hints for removal of flux residues are given below:

- **Aluminium and aluminium alloys**: As soon as possible after welding, wash the joints in warm water and brush vigorously. When conditions allow, follow up by a rapid dip in a 5 percent solution of nitric acid; wash again, using hot water to assist drying.

- **Molten wax in this recess seals contents**

- **Replace the lid immediately after use**

- **Method of storing flux**

- **Flux**

- **Use a clean receptacle into which the rod may be dipped**

- **Dipping the hot rod in the tin of flux may ruin the whole contents**

- **When containers, such as fuel tanks, have been welded and parts are inaccessible for the hot water scrubbing method, use a solution of nitric and hydrofluoric acids. To each 5.0 litres of water add 400 ml of nitric acid (specific gravity 1.42) followed by 33 ml of hydrofluoric acid (40 percent strength). The solution used at room temperature will generally completely remove the flux residue in 10 minutes, producing a clean uniformly etched surface, free from stains. Following this treatment the parts should be rinsed with cold water and finished with a hot water rinse. The time of immersion in hot water should not exceed three minutes, otherwise staining may result; after this washing with hot water the parts should be dried. It is essential when using this treatment that rubber gloves be worn by the operator and the acid solution should preferably be contained in an aluminium vessel.**

- **Magnesium alloys**: Wash in water followed quickly by standard chromating. Acid chromate bath is recommended.

- **Copper and brass**: Wash in boiling water followed by brushing. Where possible, a 2 percent solution of nitric or sulphuric acid is preferred to help in removing the glassy slag, followed by a hot water wash.

- **Stainless steel**: Treat in boiling 5 percent caustic soda solution, followed by washing in hot water. Alternatively, use a de-scaling solution of equal volume of hydrochloric acid and water to which is added 5 percent of the total volume of nitric acid with 0.2 percent of total volume of a suitable restrainer.

- **Cast iron**: Residues may be removed easily by a chipping hammer or wire brush.

- **Silver brazing**: The flux residue can be easily removed by soaking brazed components in hot water, followed by wire brushing. In difficult cases the work piece should be immersed in 5 to 10 percent sulphuric acid solution for a period of 2 to 5 minutes, followed by hot water rinsing and wire brushing.

**Types of spelters and fluxes used in brazing**

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

- state the types of spelter and flux used in brazing
- state the composition of spelter and its melting point.

Brazing is essentially similar to soldering but it gives a much stronger joint than soldering. The principal differences is the use of a harder filler material, commercially known as spelter which fuses at some temperature above red heat, but below the melting temperature of the parts to be joined. Filler materials used in this process may be divided into two classes. Copper base alloys and silver base alloys. There are a number of different alloys in each class, but brass (Copper and Zinc) sometimes with upto 20% tin are mostly used mainly for brazing the ferrous metals. Silver alloys (Silver and Copper or Silver and Copper and Zinc) having a melting point range of 600 to 850°C are suitable for brazing any metals capable of being brazed. They are giving a clean finish and a strong ductile joint. Spelters are commonly made according to the thickness of sheets.

After brazing, the joint must be hammered to check the leakages and to remove flux. Mostly and commonly used flux is “Borax” for ferrous and non-ferrous metals. It removes rust and prevents atmospheric effect, when brazing operation is going on.
### COMPOSITION OF SPELTER AND MELTING POINTS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Types of spelters</th>
<th>Common metals</th>
<th>Copper %</th>
<th>Zinc %</th>
<th>Silver %</th>
<th>Melting temperatures</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Copper + Zinc Base spelter</td>
<td>Common</td>
<td>60</td>
<td>40</td>
<td>NIL</td>
<td>850°C</td>
<td>Hard brazing on copper sheets and non-ferrous</td>
</tr>
<tr>
<td>2</td>
<td>-do- Ferrous metals</td>
<td>Ferrous</td>
<td>80</td>
<td>20</td>
<td>NIL</td>
<td>600°C</td>
<td>Brass sheet thick</td>
</tr>
<tr>
<td>3</td>
<td>-do- brass</td>
<td>brass</td>
<td>30</td>
<td>70</td>
<td>NIL</td>
<td>400°C</td>
<td>Brass sheet thin</td>
</tr>
<tr>
<td>4</td>
<td>Silver solder</td>
<td>Gold</td>
<td>10</td>
<td>10</td>
<td>80%</td>
<td>350°C</td>
<td>It is used for gold ornaments brazing</td>
</tr>
</tbody>
</table>

### Silver brazing of copper pipes by gas

**Objectives:** At the end of this lesson you shall be able to
- explain the term silver brazing
- state the various applications of silver brazing.

### Silver brazing (Fig 1)

A low temperature brazing method.
Also called by other names such as:- Silver soldering, Hard soldering.
Its temperature range is 600°C to 850°C.
Silver-brazing filler rods are composed of copper and silver with a small percentage of Zinc, Cadmium and Nickel.
Silver content may vary from 40 to 60%.

### Applications

- Joining of thin sheets and close fitted joints in steel, copper, brass, bronze, nickel alloys and nickel-silver alloys.
- Brazing tungsten carbide tips to ROCK DRILLS, MILLING CUTTERS, CUTTING and SHAPING TOOLS. (Fig 3)

### Silver brazing of copper pipes by gas

- Food handling and processing equipment. (Stainless steel).
- Economy in brazing operation requiring a low temperature, thin layer, quick and complete penetration.

*CG&M : Fitter (NSQF Level -5) - Related Theory for Exercise 1.3.50 -1.3.51*
Joining dissimilar metals and jewellery making works.

There is economy in the brazing operation as it requires only low temperature and a thin layer of deposition. There is quick and complete penetration in this method of joining.

**Blow lamp**

**Objectives:** At the end of this lesson you shall be able to
- state the constructional feature of blow lamp
- identify the parts of blow lamp
- describe the operation of blow lamp.

In blow lamp (Fig 1) the kerosene is pressurized to pass through pre-heated tubes, thus becoming vaporised. The kerosene vapour continues through a jet to mix with air and when ignited directed through a nozzle, producing a forceful flame.

The flame within the housing provides the heat to maintain vaporisation of the kerosene. The free flame at the nozzle outlet is used to heat the soldering bit.

Blow lamp is a portable heating appliance used as a direct source of heat for soldering irons or other parts to be soldered. Fig 1 shows parts of blow lamp.

It has an tank made of brass, filler cap is fitted at its top to fill kerosene. A pressure relief valve is connected to the mouth to switch ON/OFF and control the flame.

Priming trough is provided for filling methylated spirit for lighting the blow lamp. Set of nozzle is provided to direct the kerosene vapour to produce forceful flame. Burner housing is mounted on support brackets on which soldering iron is placed for heating as shown in figure.

Pump is provided to pressurise the kerosene in the tank.

**Portable hand forge with blower**

**Objectives:** At the end of this lesson you shall be able to
- state the purpose of hand forge
- describe the constructional feature of hand forge
- state the fuel used in hand forge.

**Hand forge:** It is used for heating the soldering bit.

It is made of mild steel plates and angles. It is generally round in shape. The hand blower is attached to it for air supply.

A perforated plate is fixed at the bottom to remove burnt residuals.

The fuel zone is built up with fire bricks and coated with the mixture of clay and sand, providing space at the centre for fuel. (Fig 1)

The fuel used for firing is mainly charcoal. The charcoal is prepared from hard wood.
Rivets and riveting

Objectives: At the end of this lesson you shall be able to
• define rivets
• specify rivets
• name the materials from which rivets are made
• name the different types of rivets and state their uses.
Rivets are used to join together two or more sheets of metal permanently. In sheet metal work riveting is done where:
- brazing is not suitable,
- the structure changes owing to welding heat,
- the distortion due to welding cannot be easily removed etc.

Specification of rivets
Rivets are specified by their length, material, size and shape of head.

Rivets
There are various kinds of rivets as shown in Fig 1. Snap head rivets, countersink rivets and thin bevelhead rivets are widely used in sheet metal work.

Material:
Rivets are made of ductile materials like low carbon sheet (mild steel), brass, copper, yellow brass, aluminium are their alloys.

The length of the rivets ‘L’ is indicated by the shank length. (Fig 1)
Rivets are cylindrical rods having heads of various shapes. They are used for assembling the parts of a workpiece together.

Parts of the rivet (Fig 1)

Shape of head
The shape of the rivet head is to be selected according to the intended use of the workpiece to be riveted.

Diameter
The diameter is to be selected depending on the required strength.

Length
Length is to be selected depending upon the thickness of the components to be riveted.
Types and uses

Snap head (Fig 2)
It is the most commonly used form, and it gives a very strong joint.

Pan head (Fig 3)
It is used in heavy structural work where the strength of rivet is very important.

Conical head (Fig 4)
It is generally used in light assembly where riveting is done by hand hammering.

Countersunk head (Fig 5)
It is used where projection of the rivet head is to be avoided.

Bifurcated rivet (Fig 6)
The shape of the head is shown in the figure and the bifurcated portion is used for fastening light parts- tin plates, leather, plastics, etc.

Riveted Joint

Objectives: At the end of this exercise you shall be able to
• define ‘riveting’
• state the use of riveting
• name the materials from which rivets are made

• name the different types of rivets used in sheet metal work
• follow rules and formulas for riveting process
• Name the orienting process

Riveting: Riveting is one of the methods of making permanent joints of two or more pieces (Metal strips). It is customary to use rivets of the same metal as that of the parts that are being joined together.

Uses: Rivets are used for joining metal sheets and plates in fabrication work, such as bridges, ship building, games, structural steel work.

Types of rivets:
• Tinman’s rivet
• Flat head rivet
• Round head rivet
• Countersunk head rivet

Each rivet consists of a head and cylindrical body.

Sizes of rivets: Sizes of rivets are determined by the diameter and length of the shank.

Selection of rivet size: The diameter of the rivet is calculated by using the formula $D = (21/2$ to 3) x $T$ where $T$ is total thickness

Lapping allowance: Normally in sheet metal trade, we will use the following formula that is Three times of the dia of rivet +2 times the sheet thickness on thin sheets

Pitch allowance: Three or four times the diameter of rivet +Sheet thickness 1 time

The shank length is given by

Length :- $L = T + D$ where $T$ is the Sheet thickness and $D$ is the diameter of the rivet.
Normally Tinman’s rivets are designated by numbers.

<table>
<thead>
<tr>
<th>Thickness of sheet</th>
<th>Dia of rivet</th>
</tr>
</thead>
<tbody>
<tr>
<td>14, 16, 18, 20, 22, 25</td>
<td>22, 24, 26, 27, 28, 30</td>
</tr>
</tbody>
</table>

**Sketch**

**Draw a straight line of 1.25” and add sheet thickness, for total distance find out centre, and draw a semi circle with spring divider, Draw a perpendicular line projecting the line upto semi circle the distance is taken as a dia of rivet.**

**Rivet hole size and clearance:** A rivet hole should be formed a little bigger than the nominal diameter of the rivet. The hole diameter will be bigger than the rivet shank nominal diameter by 0.2 to 0.3 mm for cold riveting and by 0.5 to 1.5 mm for high temperature (Red) for hot riveting process.

**Working condition**

**Cold Riveting**

**Hot Riveting Process**

<table>
<thead>
<tr>
<th>Rivet Nominal</th>
<th>Diameter (MM)</th>
<th>Tolerance (DA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 3 4 5 -6</td>
<td>8 10 12 15 15 to 40</td>
<td>0.2+ 0.2 +0.5-0.2+0.5-0.2</td>
</tr>
</tbody>
</table>

**Annealing of rivet:** Riveting is usually performed in the normal temperature when the rivet diameter is less than 6 mm. To prevent the breakage and failure of rivets and to facilitates the operation, rivets are used in the normal temperature. Rivets are annealed in the temperature of 650°C to 700°C and allow them to cool slowly. Generally M.S Rivets are heated in furnaces uniformly. Aluminium rivets are used without annealing. High strength aluminium alloyed Rivets in the Duralumin group are heated to 480°C adn 500°C and, coded in water. Generally Electric furnaces are used for heating the rivets.

**Method of riveting:** Riveting may be done by hand or to machine. While riveting by hand it can be done with a ball pane hammer and a rivet set.

**Rivet set:** The shallow, cup shape hole is used to draw the sheet and the rivet together. The output on the side allows the slug to drop out.

**Spacing of rivets:** The space of distance from the edge of the metal to the centre of any rivet should be at least the twice diameter of the rivet to avoid tearing. The maximum distance should never exceed 24 times thickness of the sheet. Otherwise, buckling will take place.

**Rivets proportions**

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

- determine the hole sizes for different diameters of rivets
- choose the rivet diameters according to the thickness of the plates/sheets
- calculate the length and rivet interference for different diameter rivets and plate sizes.

**Riveting:** In order to produce efficient and good quality riveted joints the following aspects are important.

The size of the hole drilled for inserting the rivets.

The diameter of the rivet in proportion to the thickness of the plates/sheets to be joined.

The length of the rivet according to the type of the rivet and the thickness of the plates/sheets.

**The size of the rivet and hole:** The size of the hole to be drilled is according to the diameter of the rivet used.

A formula generally used for determining the diameter a solid rivet is

\[ D_{\text{Min}} = T \]

\[ D_{\text{Max}} = 2T \]

The actual value used will depend upon the actual joint features and service conditions.

The size of the hole has to be slightly larger than the nominal diameter of the rivet. (Table 1)

For hot working, rivets will have holes with more clearance than for cold working.

CG&M : Fitter (NSQF Level -5) - Related Theory for Exercise 1.3.52-55
TABLE 1
Hole diameter for rivets

<table>
<thead>
<tr>
<th>Rivet nominal dia</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>15</th>
<th>15-40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hole dia</td>
<td>2.2</td>
<td>3.2</td>
<td>4.2</td>
<td>5.3</td>
<td>6.3</td>
<td>8.5</td>
<td>11</td>
<td>18</td>
<td>16.5</td>
<td>Holes larger than the nominal dia by 1.5 to 2.0 mm</td>
</tr>
</tbody>
</table>

Length of rivets: The length of a rivet is the shank length. This will vary according to the thickness of the plates to be riveted and the type of the rivet head. (Fig 1 & 2)

![Fig 1](image1.png)

Rivet interference: The length required to form the head in riveting is called rivet interference.

When forming a round head (Fig 3) the interference \( x \) is given as

\[
x = d \times (1.3, -1.6)
\]

where \( x \) = rivet interference (mm)

\( d \) = rivet diameter (mm)

![Fig 3](image2.png)

Therefore, the length of the rivet (\( L \) mm) to form a round head when the total thickness of the piled plates is \( T \) mm will be, as given below.

\[
L = T + d \times (1.3 \sim 1.6)
\]

When forming a flat head (Fig 4) the length of the rivet (\( L' \) mm) will be as given below.

\[
L' = T + d \times (0.8 \sim 1.2)
\]

![Fig 4](image3.png)

When the appropriate values of the rivet diameter and the length for the plate thickness are found out, choose the rivets with the standard size close to the calculated values.

Types of riveted joints

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

- state the different types of riveted joints
- state the features of different types of riveted joints
- distinguish between chain riveting and zigzag riveting.

In construction and fabrication work different types of riveted joints are made.

The commonly used joints are:

- single riveted lap joint
- double riveted lap joint
- single strap butt joint
- double strap butt joint
Single riveted lap joint: This is the simplest and most commonly used type of joint. This joint is useful for joining both thick and thin plates. In this, the plates to be joined are overlapped at the ends and single row of rivets is placed in the middle of the lap. (Fig 1)

Double riveted lap joint: This type of joint will have two rows of rivets. The overlap is large enough to accommodate two rows of rivets. (Fig 2)

Double riveted (Zigzag) lap joint: This provides a stronger joint than a single lap joint. The rivets are placed either in a square formation or in a triangular formation. The square formation of rivet placement is called CHAIN riveting. The triangular formation of rivet placement is called zigzag riveting. (Fig 3)

Single strap butt joint: This method is used in situations where the edges of the components are to be joined by riveting. (Fig 4)

A separate piece of metal called STRAP is used to hold the edges of the components together. This joint is also used for joining the edges of components together. This is stronger than the single strap butt joint. This joint has two cover plates placed on either side of the components to be assembled. (Fig 5)

When single or double straps are used for riveted butt joints, the arrangement of rivets may be:
- Single riveted i.e one row on either side of the butt.
- double or triple riveted with chain or zigzag formation. (Fig 6)
Layout the spacing of rivet holes in chain riveting

Objectives: At the end of this exercise you shall be able to
• lay out the spacing of rivet holes to make chain riveting

Fig 1 shows the layout of the spacing of rivet holes in chain riveting

In chain riveting, square formation of rivets is formed in placement of rivets.

Zig Zag Riveting

Objectives: At the end of this exercise you shall be able to
• State what is zigzag riveting
• draw the layout for the spacing of rivets in zigzag riveting

Zig zag riveting is one type of layout of rivet spacing in jointed joint

Zig zag riveting, triangular formation of rivets is formed in placement of rivets.

Layout of spacing for zigzag riveting is shown in Fig 1.

Spacing of rivets in joints

Objectives: At the end of this lesson you shall be able to
• determine the distance between the rivet and the edge of the joint
• state the effect on the joints when the rivets are too close or too far from the edge
• determine the pitch of rivets in joints
• state the effect of too close and too far a pitch of rivets in joints.

The spacing of the rivet holes depends upon the job. Given below is a general approach in determining this.

Distance from the edge to the centre of the rivet. (Fig 1)

The space or distance from the edge of the metal to the centre of any rivet should be at least twice the diameter of the rivet.

The purpose of this is to prevent the splitting of the edges. The maximum distance from the edge should not be more than ten times the thickness of the plate. (Fig 2)
Too much distance from the edge will lead to GAPING. (Fig 3)

Pitch of rivet: The minimum distance between rivets should be three times the diameter of the rivet. (3D) (Fig 4)

The distance will help to drive the rivets without interference. (Fig 5)

Too closely spaced rivets will tear the metal along the centre line of the rivets.

The maximum distance between the rivets should exceed twenty four times the thickness of the metal. (Fig 6)

Too far a pitch will allow the sheet/plate to buckle between the rivets.

**Tubular bifurcated and metal piercing rivets**

Objectives: At the end of this lesson you shall be able to
- state different types of tubular and bifurcated rivets
- state the constructional features of them
- state the application of them.

**Tubular and bifurcated rivets:** These rivets are used in low tension joints or for joining softer materials to sheet metals, as given hereunder.

**Semi-Tubular rivets:** This rivet has straight hole or tapered hole at the end of the shank. The depth of the hole must not exceed 1.12 time shank diameter as shown in Fig 1. The rivet shank should extend upto the full thickness of the joint, with the hollow portion set to give correct upsetting.

**Insulated rivets:** This rivet is semi-tubular and under the rivet head, it is covered with thick nylon as shown in Fig 2.

The main application of these rivets are in electrical assemblies, where the rivet needs to be insulated from the workpiece, and also for air tight or water tight joints.

**Full Tubular rivets:** This rivet has a hole greater than 1.12D and is designed for use, where the rivets is desired to punch the rivet through soft materials as shown in Fig 3.
**Blind rivet or pop rivet**

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

- state the types of blind rivets, their parts and application
- state the blind riveting equipment
- state the steps in riveting the blind rivets.

Blind rivets are designed to allow them to be installed in joints which are accessible from one side only. However, for many reasons including simplicity and good appearance, they are used for joints from both sides are accessible. Prepared holes are required for blind riveting.

The parts of the rivet is shown in the Fig 1. The mandrel portion is used for assembly purposes only and after use, it is either totally or partially discarded. (Fig 2)

**Blind riveting equipment:** The equipment used for blind rivets are blind rivet pliers, lazy tongs, lever hand tools,

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**Bifurcated or Split rivet:** The bifurcated or split rivet is machined to produce two prongs at the shank end to pierce soft materials as shown in Fig 4.

**Metal piercing rivets** (Fig 5): These rivets pierce their own holes into the sheet metal joints.

These are similar to solid rivets and have good tension and shear characteristics. These are economical as they produce their own holes and are used in mass production applications.

**Semi-tubular metal piercing rivets:** These rivets are designed to use as punches to penetrate fully or partially on both pieces of the metal.

If the rivet fully penetrates the metal, it then completes the joint as shown in Fig . When the rivet partially penetrates the metal, the tail of the rivet forms a sealed joint.

Total sheet metal base thickness upto 2.5 mm can be used for semi-tubular metal piercing rivets.

**Metal-piercing solid rivets:** In this countersunk solid rivets can be driven into the sheet steel upto 3.2 mm total thickness with out the need of a hole. Penetration by the rivet, counter sinking and clinching the rivet against an upsetting tool, are completed in a single stroke. The counter sunk head produces a flashed hole which improves joint shear strength.

Expansion of the rivet end on the other side of the workpiece, prevents pull out.
pneumatic and hydraulic magazine feed and semi-automatic fasteners as shown in Fig 3.

Types of Blind or Pop rivets: In setting a blind rivet, the body of the rivet is inserted into a hole and the mandrel is pulled deforming the tail which pulls and fixes the joint together. Blind rivets are available in many types and systems. Some of these are given here-under.

Plugged break stem: After the rivet tail has been deformed by the action of the mandrel, the mandrel stem breaks, leaving the head behind forming a plug as shown in Fig 4.

Open break stem: It is similar to the break stem, but the head breaks off and falls out after deforming the tail, leaving the hollow body open. (Fig 5)

Sealed: The sealed type rivet is hollow cored with a closed blind end and is used where a water or pressure tight rivet is essential. (Fig 6)

Externally threaded blind rivets: This rivet is a conventional pull mandrel blind rivet. When the rivet is set, the head section protrudes providing a metric thread stud into which a nut can be fastened. (Fig 7)

Collapsible shank: The tail or shank of this rivet is designed to deform into three segments. (Fig 8) It spreads the clamp up load over a wide area, making it suitable for assemblies having bigger size hole and also to prevent pull out in soft materials.

Flush break high strength: This blind rivet in 3 to 6 mm diameters has a mandrel with specially designed head that breaks off flush with the top of the rivet. (Fig 9)
Repetition blind riveting systems: Rivet is loaded onto a mandrel which is placed into a pneumatic setting tool with a rivet in the ready position. This rivet is inserted into a preformed hole, the tool trigger is actuated, drawing the mandrel through the rivet, expanding the rivet tail. Sequence of rivet setting is shown in Fig 10.

Drive pin rivets: Drive pin rivets consist of a hollow body and a pin. In the manufactured condition itself, the pin projects from the rivet head. A hammer blow forces the rivet into the prepared hole, the pin expands the rivet and spreads pre-slotted shank prongs. (Fig 11)

Riveting blind rivet

Riveting steps
1. Select a rivet for the correct size of dia and length.
2. Drill a hole to the recommended diameter.
3. Open the riveting tool and insert the rivet stem into the tool nozzle.
4. Place the rivet body into the preformed hole.
5. Squeeze the rivet tool handles together to set the rivet, at the correct point of tension, the rivet stem will break.
6. When the rivet stem has broken, remove the tool from the job. Allow the tool to open fully to eject the spent rivet stem. (Fig 12)
Lazy tong

Objectives: At the end of this lesson you shall be able to
• state what is a lazy tong
• state parts and mechanism of a lazy tong
• state the operating instructions.

Lazy tong is a hand operated tool, used for setting 1/8", 5/32" and 3/16" diameter standard open type blind rivets. It is important to use the correct nosepiece for the diameter of the rivet to be placed, to ensure the best performance of the tool. The parts list is shown in the figure and all parts are fully interchangeable.

Description of mechanism: The mandrel gripping mechanism consists of a set of jaws (6) fitted into the jaw case (5) and screwed on to the power coupling assembly. The jaws are kept in the forward position by the jaw pusher (12) AND JAW PUSHER SPRING (11).

The lazy tong mechanism is connected to the power coupling in such a way that the operation of the handle (8) which draws the jaws, is gripping the rivet mandrel, thus setting the rivet.

Operating instructions: Check that the suitable nosepiece is fitted to the tool and firmly screwed into the threads.

When the mandrel breaks, the rivet is set.

Hand-riveting tools

Objectives: At the end of this exercise you shall be able to
• name the different hand-riveting tools
• state the uses of different hand-riveting tools

Rivet set
It is used for bringing the sheet metal closely together after inserting the rivet in the hole
This is required while riveting thin plates or sheet with small rivets (Fig 1)

Dolly
It is used to support the head of the rivet which is already formed and also to prevent damage to the shape of the rivet head (Fig 1)

Rivet snap
It is used to form the final shape of the rivet during riveting. Rivet snaps are available to match the different shapes of rivet heads (Fig 2)

Combined rivet set: This is a tool which can be used for setting and forming the head (Fig 3)

Hand riveter: This has a lever mechanism which exerts pressure between the jaws when the handle is pressed.
This is useful for riveting copper or aluminium rivets. Inter-changeable anvils can be provided. (Fig 4)

Pop riveter: This is used for riveting pop rivets by hand. The trigger mechanism squeezes the rivet and separates the mandrel of the rivet. In this method as the mandrel is being separated from the rivet, the head is formed on the other end (Fig 5)
**Drift**

It is used to align the holes to be riveted. (Fig 6)

**Caulking tool**

It is used for closing down the edges of the plates and heads of the rivets to form a metal-to-metal joint (Fig 7)

**Fullering tool**

It is used for pressing the surface of the edge of the plate (Fig 8) Fullering helps to make fluid-tight joints.

**Reasons for faulty rivetting**

The holes on the plate are not in line (Fig 9)

The shank or body of the rivet is not perpendicular to the plate before riveting (Fig 10)
Too much or too little allowance has been given. (Fig 11 and 12)

Improper joining of plates. (Fig 14) plates are not brought closely together using rivet set.

Rivet head is not centered with the shank or body of the rivet (Fig 13)

Burrs between plates and in drilled holes. (Fig 15 and 16)

**Caulking and fullering**

**Objectives:** At the end of this lesson you shall be able to
- state the purpose of caulking and fullering
- distinguish between caulking and fullering processes.

**Caulking:** Caulking is an operation of closing down the edges of the plates and heads of the rivets to form a metal-to-metal joint. (Fig 1)

The edge of the rivet head is tightly pressed and expanded on the plate by a caulking tool which looks like a fattened cold chisel.

**Fullering:** Fullering is an operation of pressing the whole surface of the edge of the plate. It is done by a fullering tool. (Fig 2)

When the caulking tool is about as thick as the plate, it is called a fullering tool.

The whole surface of the edge of the first plate is tightly pressed on the second plate.

A better fluid-tight joint is achieved by fullering.

Caulking is done on the edges of the plates as well as on the edges of the rivet heads. But fullering is done on the edges of the plate only. To facilitate caulking and fullering on the plates, the edges of the plates are bevelled about 80° to 85°.

**The strength of riveted joints:** A riveted joint is only as strong as its weakest part and it must be borne in mind that it may fail in one of the following four ways.
- Shearing of the rivet
- Crushing of the metal
- Spliting of the metal
- Rupture or tearing of the plate

These four undesirable effects are illustrated in the table below.

<table>
<thead>
<tr>
<th>Riveted joints</th>
<th>Effects</th>
<th>Causes</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shearing of the rivet</td>
<td>Diameter of the rivet too small compared with the thickness of the plate. The diameter of the rivet must be greater than the thickness of the plate, in which it is to be riveted. Strength of rivet material is less when compared to the materials of the plates.</td>
<td>Select the correct diameter rivet to suit thickness of the plate. Select a suitable material visit.</td>
</tr>
<tr>
<td></td>
<td>Crussing of the rivet</td>
<td>Diameter of the rivet too large compared with the thickness of the plate. The rivets when driven tend to bulge and crush the metal in front of them.</td>
<td>Select the correct diameter rivet for the thickness of the metal plate.</td>
</tr>
<tr>
<td></td>
<td>Splitting of the metal</td>
<td>Rivet holes punched or drilled too near the edge of the plate. Metal is likely to fail by splitting in front of the rivets.</td>
<td>Drill or punch the rivet at the correct distance from the edge and use the correct lap allowance for the diameter of the rivet.</td>
</tr>
<tr>
<td></td>
<td>Tearing of the plate</td>
<td>Plates weakened by rivet holes being too close together. Plates tend to rupture along the centre line of the rivets</td>
<td>Punch or drill rivet holes at the correct spacing or pitch. In addition remove all burrs from the holes before final assembly.</td>
</tr>
</tbody>
</table>
Safety

Welding can be dangerous and unhealthy if the proper precautions are not taken. However, using new technology and proper protection greatly reduces risks of injury and death associated with welding. Since many common welding procedures involve an open electric arc or flame, the risk of burns and fire is significant, that is why it is classified as a hot work process.

To prevent injury, welders wear personal protective equipment in the form of heavy leather gloves and protective long-sleeve jackets to avoid exposure to extreme heat and flames. Additionally, the brightness of the weld area leads to a condition called arc eye or flash burns in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes. Goggles and welding helmets with dark UV-filtering face plates are worn to prevent this exposure.

Since the 2000s, some helmets have included a face plate which instantly darkens upon exposure to the intense UV light. To protect bystanders, the welding area is often surrounded with translucent welding curtains. These curtains, made of a polyvinyl chloride plastic film, shield people outside the welding area from the UV light of the electric arc, but can not replace the filter glass used in helmets.

Welders are often exposed to dangerous gases and particulate matter. Processes like flux-cored arc welding and shielded metal arc welding produce smoke containing particles of various types of oxides. The size of the particles in question tends to influence the toxicity of the fumes, with smaller particles presenting a greater danger. This is because smaller particles have the ability to cross the blood brain barrier. Fumes and gases, such as carbon-dioxide, ozone, and fumes containing heavy metals, can be dangerous to welders lacking proper ventilation and training. Exposure to manganese welding fumes, for example, even at low levels (<0.2 mg/m³) may lead to neurological problems or to damage to the lungs, liver, kidneys, or central nervous system. Nano particles can become trapped in the alveolar macrophages of the lungs and induce pulmonary fibrosis. The use of compressed gases and flames in many welding processes possess an explosion and fire risk. Some common precautions include limiting the amount of oxygen in the air, and keeping combustible materials away from the workplace.

General safety

- To prevent injury to personnel, extreme caution should be exercised when using any types of welding equipment. Injury can result from fire, explosions, electric shock, or harmful agents. Both the general and specific safety precautions listed below must be strictly observed by workers who weld or cut metals.
- Do not permit unauthorized persons to use welding or cutting equipment.
- Do not weld in a building with wooden floors, unless the floors are protected from hot metal by means of fire resistant fabric, sand, or other fireproof material. Be sure that hot sparks or hot metal will not fall on the operator or on any welding equipment components.
- Remove all flammable material, such as cotton, oil, gasoline, etc., from the vicinity of welding.
- Before welding or cutting, warm those in close proximity who are not protected to wear proper clothing or goggles.
- Remove any assembled parts from the component being welded that may become warped or otherwise damaged by the welding process.
- Do not leave hot rejected electrode stubs, steel scrap, or tools on the floor or around the welding equipment. Accidents and/or fires may occur.
- Keep a suitable fire extinguisher nearby at all times. Ensure the fire extinguisher is in operable condition.
- Mark all hot metal after welding operations are completed. Soapstone is commonly used for this purpose.
Safety precautions in handling gas welding plant

Objectives: At the end of this lesson you shall be able to
• state the general safety precautions in oxy-acetylene plants.
• state the safety rules for handling gas cylinders
• state the safety practices for handling gas regulators and hose-pipes.
• state the safety precautions related to blowpipe operations.

To be accident-free, one must know the safety rules first and then practise them as well. As we know can ‘accident starts when safety ends’.

Ignorance of rules is no excuse!

In gas welding, the welder must follow the safety precautions in handling gas welding plants and flame-setting to keep himself and others safe.

Safety precautions are always based on good common sense.

The following precautions are to be observed, to keep a gas welder accident-free.

General safety

Do not use lubricants (oil or grease) in any part or assembly of a gas welding plant. It may cause explosion.

Keep all flammable material away from the welding area.

Always wear goggles with filter lens during gas welding. (Fig 1)

Always wear fire resistant clothes, asbestos gloves and apron.

Never wear nylon, greasy and torn clothes while welding.

Whenever a leakage is noticed rectify it immediately to avoid fire hazards. (Fig 2)

Always wear fire resistant clothes, asbestos gloves and apron.

Even a small leakage can cause serious accidents.

Always keep fire-fighting equipment handy and in working order to put out fires. (Fig 3)

Keep the work area free from any form of fire.

Safety precautions before gas welding

Safety for cylinders.

Do not roll gas cylinders or use them as rollers.

Use a trolley to carry the cylinders.

Close the cylinder valves when not in use or empty.

Keep full and empty cylinders separately.

Always open the cylinder valves slowly, not more than one and a half turn.

Use the correct cylinder keys to open the cylinders.

Do not remove the cylinder keys from the cylinders while welding. It will help to close the cylinders QUICKLY in the case of a back-fire or flash-back.

Always crack the cylinder valves to clean the valve sockets before attaching regulators. (Fig 4)
Safety precautions before, during, after arc welding

Objective: At the end of this lesson you shall be able to
• state the precautions necessary in arc-welding.

Safety precautions
- Never stand on a damp or wet place while arc-welding.
- Always wear all the safety apparels (gloves, apron, sleeves, shoes). (Fig 1)
- Use welding and a chipping screen during welding and chipping respectively, for the protection of the eyes and the face.
- Switch off the machine when not in use.
- Keep the clothes free from oil and grease.
- Use tongs while handling hot metals.
- Do not carry matches or petrol lighters in your pocket during arc-welding.
- Protect the outsiders from radiation and reflection of rays, by using portable screens or welding booths. (Fig 2)
- Keep the welding area free from moisture and flammable material.
- Do not try to rectify electrical faults yourself; call an electrician.
- Do not throw the electrode stubs on the floor. Put them in a container. (Fig 3)
- Use exhaust fans to remove the arc-welding smoke and fumes. (Fig 4)
- Safety precautions after gas and electric welding after working gas welding and gas cutting bleed the lines to take pressure off regulators, neatly coil the hoses and replace equipment.
- Store hoses, torches, blow pipes regulators safety in proper place.
- Store away the gas cylinders from in flammable and combustible materials.
- After electric welding operations are completed the welder will mark the hot metal or provide some other means of warning other workers.
- Welding machines will be disconnected from the power source.
- Disconnect the welding cables from welding equipment.
- Neatly coil the cable and kept in place safety.
- Place and store electrode holder and other hand tools safely.
Safety equipments and their uses in welding

Objectives: At the end of this lesson you shall be able to
• Name the safety apparels and accessories used in arc welding
• Select the safety apparels and accessories to protect from burns and injuries
• learn how to protect yourself and others from the effect of harmful arc rays and toxic fumes
• select the shielding glass for eye and face protection.

Non-fusion welding

This is a method of welding in which similar or dissimilar metals are joined together without melting the edges of the base metal by using a low melting point filler rod but without the application of pressure.

Example: Soldering, Brazing and Bronze welding.

During arc welding the welder is exposed to hazards such as injury due to harmful rays (ultra violet and infra red rays) of the arc, burns due to excessive heat from the arc and contact with hot jobs, electric shock, toxic fumes, flying hot spatters and slag particles and objects falling on the feet.

The following safety apparels and accessories are used to protect the welder and other persons working near the welding area from the above mentioned hazards.

1 Safety apparels
   a Leather apron
   b Leather gloves
   c Leather cape with sleeves
   d Industrial safety shoes
2 a Hand screen
   b Adjustable helmet
   C Portable fire proof canvas screens
3 Chipping/grinding goggles
4 Respirator and exhaust ducting

The leather apron, gloves, cape with sleeves and leg guard Fig 3, 4, 5 and 6 are used to protect the body, hands, arms, neck and chest of the welder from the heat radiation and hot spatters from the arc and also from the hot slag particles flying from the weld joint during chipping off the solidified slag.
All the above safety apparels should not be loose while wearing them and suitable size has to be selected by the welder.

The industrial safety boot (Fig 7) is used to avoid slipping injury to the toes and ankle of the foot. It also protects the welder from the electric shock as the sole of the shoe is specially made of shock resistant material.

Welding hand screens and helmet: These are used to protect the eyes and face of a welder from arc radiation and sparks during arc welding.

A hand screen is designed to hold in hand (Fig.8)

Clear glasses are fitted on each side of the coloured glass to protect it from weld spatters. (Fig.10)

The helmet screen provides better protection and allows the welder to use his both hands freely.

Coloured (filter) glasses are made in various shades depending on the welding current ranges used. (Table 1)

<table>
<thead>
<tr>
<th>Shade No of coloured glass</th>
<th>Range of welding current in amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-9</td>
<td>Up to 100</td>
</tr>
<tr>
<td>10-11</td>
<td>100 to 300</td>
</tr>
<tr>
<td>12-14</td>
<td>Above 300</td>
</tr>
</tbody>
</table>

Table 1

Recommendations of filter glasses for manual metal arc welding

Portable fire proof canvas screens. Fig.11 are used to protect the persons who work near the welding area from arc flashes.

Plain goggles are used to protect the eyes while chipping the slag or grinding the job. Fig12
It is designed for comfortable fit, proper ventilation and full protection from all sides.

Sometimes toxic fumes and heavy smoke may be liberated (given out) from the weld while welding non-ferrous alloys like brass etc. Use a respirator and use exhaust ducts and fans near the weld area to avoid inhaling the toxic fumes and smoke. Fig13.

Inhaling toxic fumes will make the welder to become unconscious and fall on the hot welded job/ on the floor. This causes burns or injury.

It is made of Bakelite frame fitted with clear glasses and an elastic band to hold it securely on the operator's head.
Gas welding equipment and accessories

Objectives: At the end of this lesson you shall be able to
• brief the process of gas welding
• list the equipment used in gas welding
• state the functions of each equipment used in gas welding.

Oxy-acetylene welding, popularly known as gas welding is simple, cheap and easy to operate. The heat input can be closely controlled to weld even thin, tiny components. In oxy-acetylene welding process, the metal is heated by an intense flame (3300°C) produced by burning proper quantity of oxygen and acetylene at the tip of welding torch. The flame is directed towards the weld location to melt the metal to be joined and are fused together thus producing weld.

Gas welding equipment

The principle function of the oxy-acetylene welding equipment is to supply the oxy-acetylene gas mixture in the correct ratio to the welding tip at the correct rate of flow and velocity. (Fig 1)

The basic equipments used to carry out gas welding are
• Oxygen gas cylinder
• Acetylene gas cylinder
• Oxygen pressure regular
• Oxygen gas hose (black/green)
• Acetylene gas hose (Maroon)
• Welding torch or blow pipe with a set of nozzles and gas lighter.
• Tralleys for transportation of oxygen and acetylene cylinder.
• A set of keys and spanners
• Filler rod and fluxes
• Protective clothing for welder (Leather apron, gloves, goggles, etc)

Oxygen gas cylinders: The oxygen gas required for gas welding is stored in bottle-shaped cylinders. These cylinders are painted in black colour. (Fig 2) Oxygen gas cylinder valves are right hand threaded.

Dissolved acetylene cylinders: The acetylene gas used in gas welding is stored in steel bottles (cylinders) painted in maroon colour. The normal storing capacity of storing acetylene in dissolved state is 6m³ with the pressure ranging between 15-16 kg/cm².
Oxygen pressure regulator: This is used to reduce the oxygen cylinder gas pressure according to the required working pressure and to control the flow of oxygen at a constant rate to the blowpipe. The threaded connections are right hand threaded. (Fig 3)

Acetylene regulator: As with the case of oxygen regulator this also is used to reduce the cylinder gas pressure to the required working pressure and to control the flow of acetylene gas at a constant rate to the blowpipe. The threaded connections are left handed. For quickly identifying the acetylene regulator, a groove is cut at the corners of the nut. (Fig 4)

Rubber hose-pipes and connections: These are used to carry gas from the regulator to the blowpipe. These are made of strong canvas rubber having good flexibility. Hose-pipes which carry oxygen are black in colour and the acetylene hoses are of maroon colour. (Fig 5)

Rubber hoses are connected to regulators with the help of unions. These unions are right hand threaded for oxygen and left hand threaded for acetylene. Acetylene hose unions have a groove cut on the corners. (Fig 6)

At the blowpipe end of the rubber hoses hose-protectors are fitted. The hose protectors are in the shape of a connecting union and have a non-return disc fitted inside to protect from flashback and backfire during welding. (Fig 7)

Blowpipe and nozzle: Blowpipes are used to control and mix the oxygen and acetylene gases to the required proportion. (Fig 8)
Arc welding machines and accessories

Objectives: At the end of this lesson you shall be able to
• state the function of arc-welding machines
• name the different types of arc-welding machines.

In the arc-welding process, the source of heat is electricity (high ampere low voltage). This heat is supplied by the arc-welding machine which is the power source.

Function (Fig 1)
The equipment is used to
– provide A.C. or D.C. supply for arc welding
– change the high voltage of main supply (A.C.) to low voltage, heavy current (A.C. or D.C.) suitable for arc welding
– control and adjust the required supply of current during arc welding

Types (Fig 2)
Basically the power sources are
– alternating current (A.C.) welding machine
– direct current (D.C.) welding machine.

The size of the nozzle varies according to the thickness of the plates to be welded. (Table 1)

<table>
<thead>
<tr>
<th>Plate thickness (mm)</th>
<th>Nozzle size (Number)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>1</td>
</tr>
<tr>
<td>1.2</td>
<td>2</td>
</tr>
<tr>
<td>1.6</td>
<td>3</td>
</tr>
<tr>
<td>2.4</td>
<td>5</td>
</tr>
<tr>
<td>3.0</td>
<td>7</td>
</tr>
<tr>
<td>4.0</td>
<td>10</td>
</tr>
<tr>
<td>5.0</td>
<td>13</td>
</tr>
<tr>
<td>6.0</td>
<td>18</td>
</tr>
<tr>
<td>8.0</td>
<td>25</td>
</tr>
<tr>
<td>10.0</td>
<td>35</td>
</tr>
<tr>
<td>12.0</td>
<td>45</td>
</tr>
<tr>
<td>19.0</td>
<td>55</td>
</tr>
<tr>
<td>25.0</td>
<td>70</td>
</tr>
<tr>
<td>Over 25.0</td>
<td>90</td>
</tr>
</tbody>
</table>
These may be further classified as

- D.C. Machines
  - motor generator set
  - engine generator set
  - rectifier sets.

A.C. Machines

- Transformer sets

A.C. means Alternating Current. It changes or reverses its direction of flow 50-60 cycles per second. (Fig 3)

D.C. means Direct Current. It flows steadily and constantly in one direction. (Fig 4)

A.C. welding transformer and welding generator

Objectives: At the end of this lesson you shall be able to
- state the features of A.C. welding transformers
- state the advantages and disadvantages of A.C. welding machines.

A.C. welding transformer

An A.C. welding transformer is a type of A.C. welding machine which converts the A.C. main supply into an A.C. welding supply. (Figs 1 and 2)

The A.C. main supply has high voltage - low ampere.

The A.C. welding supply has high ampere - low voltage.

It is a STEP-DOWN transformer which reduces the main supply voltage (220 or 440 volts) to the welding supply open circuit voltage (O.C.V.), between 40 and 100 volts.

It increases the main supply low current to the required output welding current in a hundred or thousand amperes.

The A.C. welding machine cannot be operated without the A.C. main supply.
Advantages
- Less initial cost
- Less maintenance cost
- Freedom from arc blow.

Magnetic effect which disturbs the arc is called the arc blow.

Disadvantages
- Not suitable for the welding of non-ferrous metals, light coated and special electrodes.
- The A.C. cannot be used without special safety precautions.

D.C. Arc-welding machines

Objectives: At the end of this lesson you shall be able to
• state the features of a D.C. welding machine
• state its advantages and disadvantages.

Motor generator set (Fig 1)
It is used to generate D.C. for arc-welding.
The generator is driven by an A.C. or D.C. motor.
Main supply is a must to run the machine.

Engine generator set (Fig 2)

Equipment is similar to the motor generator set except that the generator is driven by a petrol or diesel engine.
Its running and maintenance charges are higher.
It can be used anywhere in field work, away from electric lines.

Rectifier set (Fig 3)
It is used to convert A.C. into D.C. welding supply.
Basically it is an A.C. welding transformer. The output of the transformer is connected with a rectifier to change the A.C. into D.C.

It may be designed to supply both A.C. and D.C. currents for welding (called A.C.-D.C. rectifier set).

**Advantages**

Suitable for welding all ferrous and non-ferrous metals using all types of electrodes
- Better heat distribution in the electrode and job due to polarity in the welding current supplies constant main load and accurate current setting.

It ensures safe working.

**Disadvantages**

- Initial cost is higher
- Maintenance cost is more
- Arc-blow trouble faced at certain times.

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**Polarity in arc welding**

**Objectives:** At the end of this lesson you shall be able to
- state what is polarity in arc welding
- state the types of polarity.

**Polarity in D.C. power source**

The polarity of a machine refers to the direction of the current flow.

The polarity can be obtained only in D.C.

Polarity may be straight or reverse.

**Reverse polarity** (Fig 1)

When the electrode cable is connected to the positive terminal, it is called positive polarity or reverse polarity.

**Straight polarity** (Fig 2)

When the electrode cable is connected to the negative terminal as it is called negative polarity or straight polarity.

**Remember**

**A.C. has no polarity**

The total heat produced in D.C. arc consists of 2/3 heat from the POSITIVE Terminal (66%) and 1/3 heat from the NEGATIVE Terminal (33%).
Arc length and its effects

Objectives: At the end of this lesson you shall be able to
• state what is arc length
• differentiate normal arc, length arc and short arc
• explain the effects of different arc lengths.

Arc length (Fig 1)
It is the straight distance between the electrode tip and
the job surface when an arc is formed.

There are three types of arc length.
- Normal
- Long
- Short

Normal arc length (Fig 2)
The correct arc length or normal arc length is approximately
equal to the diameter of the core wire of the electrode.

Long arc length (Fig 3)
If the distance between the tip of the electrode and the
base metal is more than the diameter of the core wire, it is
called 'long arc'.

Short arc length (Fig 4)
If the distance between the tip of the electrode and the
base metal is less than the dia. of the core wire, it is
called a 'short arc'.

Effects of arc length
- A long arc makes a humming sound
- The arc is unstable
- Causes oxidation of the weld metal.
- Fusion and penetration are poor.
- Poor control of the molten metal.
- Creates more spatters resulting in wastage of the
electrode metal.

Short arc
- It makes a popping sound.
- The electrode to melt slowly and try to freeze the job.
- Higher metal deposition with narrow width bead.
- Less spatters.
- Fusion and penetration is less.
Normal arc
- A stable arc produces a steady sharp crackling sound
- Electrode burns evenly.
- Less spatters.

Faults in arc welding

Objective: At the end of this lesson you shall be able to
- name the visible and invisible defects of weldments.

Weld defects
An imperfection in the weld, by which resulting in loss of strength, is known as weld fault or defect. (Fig 1)

Visible faults
These are visible to the naked eye on the weld surface. (Fig 2)

Invisible
These faults are inside the weld metal and cannot be seen by the naked eye. (Fig 3)

Types
Weld faults are classified as:
- Visible faults, and
- Invisible faults.

Defective welds can result in grave damage to Men and materials.
The following are the details of different hand tools used by a welder.

**Double ended spanner:** A double ended spanner is shown in Fig.1 and 1a. It is made of forged chrome vanadium steel. It is used to loosen or tighten nuts, bolts with hexagonal or square heads. The size of the spanner is marked on it as shown in Fig.1. In welding practice the spanners are used to fix the regulator onto the gas cylinder valves, hose connector and protector to the regulator and blow pipe, fix the cable lugs to the arc welding machine output terminals, etc.

Do not use the spanner as a hammer; use the correct size spanner to avoid damage to the nut/bolt head.

**Cylinder key:** A cylinder key is shown in Fig.2. It is used to open or close the gas cylinder valve socket to permit or stop the gas flow from the cylinder to the gas regulator.

Always use correct size key to avoid damage to the square rod used to operate the valve. The key must always be left on the valve socket itself so that the gas flow can be stopped immediately in case of flash back/back fire.

**Nozzle or tip cleaner**

**Cleaning the tip:** All welding torch tips are made of copper. They can be damaged by the slightest rough handling-dropping, tapping or chopping with the tip on the work may damage the tip beyond repair.

**Tip cleaner:** A special tip cleaner is supplied with the torch container. For each tip there is a kind of drill and a smooth file Fig.3.

Before cleaning the tip, select the correct drill and move it, without turning, up and down through the hole in the tip Fig.4.
The smooth file is then used to clean the surface of the tip Fig.5. While cleaning, leave the oxygen valve partly open to blow out the dust.

**Spark lighter:** The spark lighter, as illustrated in Fig.6 & 7 is used for igniting the torch. While welding, form the habit of always employing a spark lighter to light a torch. Never use matches. The use of matches for this purpose is very dangerous because the puff of the flame produced by the ignition of the acetylene flowing from the tip is likely to burn your hand.

**Chipping hammer:** The chipping hammer (Fig.8) is used to remove the slag which covers the deposited weld bead. It is made of medium carbon steel with a mild steel handle. It is provided with a chisel edge on one end and a point on the other end for chipping off slag in any position.

**Carbon steel wire brush:** A carbon steel wire brush is shown in Fig.9. It is used for

- Cleaning the work surface from rust, oxide and other dirt etc. prior to welding.
- Cleaning the interbead weld deposits after chipping off the slag.
- General cleaning of the weldment.

A stainless steel wire brush is used for cleaning a non-ferrous and stainless steel welded joint.

It is made of bunch of steel wires fitted in three to five rows on a wooden piece with handle. The wires are hardened and tempered for long life and to ensure good cleaning action.

**Tongs:** Fig.10 and Fig.11 shows a pair of tongs used to hold hot work pieces and to hold the job in position.

**Welding hand screen** (Fig 12)

A welding hand screen is used to shield and protect the face and the eyes from the arc radiation.

It is fitted with a filter lens, and plain glass to protect the lens.

Care should be taken to maintain the sharp chisel edge and the point for effective chipping of slag.
**Welding helmet screen** (Fig 13)

It is used as a hand screen but it can be worn on the head of the welder to enable him to use both his hands.

**Chipping goggles** (Fig 14)

Chipping goggles are used to protect the eyes while chipping the slag.

They are fitted with a plain glass to see the area to be cleaned.

**Tong** (Fig 15)

Tongs are used to handle the hot metal-welding job while cleaning.

They are also used to hold the metal for hammering.

**Electrode holder with cable** (Fig 16)

An electrode holder is used to hold and manipulate the electrode.

The cable is insulated with a good quality flexible rubber, and copper core wires, to carry the high current from the welding machines.

**Earth clamp with cable** (Fig 17)

An earth clamp is used to connect the return lead firmly to the job or to the welding table.

**Welding table**

The welding table is used to keep the jobs and assemble the pieces during welding. The top of the table is made of metal.

**Apron** (Fig 18)

An apron is used to protect the body.

It should be made of leather and worn.

It must be worn for protection from the radiation of the heat rays and hot spatters.

**Hand gloves** (Fig 19)

Hand gloves are used to protect the hands from electrical shock, arc radiation, heat, and hot spatters.

The gloves are also made of leather.
Arc welding accessories

Objectives: At the end of this lesson you shall be able to
• name the arc welding accessories
• explain the function of each accessory.

Arc welding accessories: Some very important items, used by a welder with an arc welding machine during the welding operation, are called arc welding accessories.

Electrode-holder (Fig 1): It is a clamping device used to grip and manipulate the electrode during arc welding. It is made of copper/copper alloy for better electrical conductivity.

Partially or fully insulated holders are made in various sizes i.e. 200-300-500 amps.

The electrode-holder is connected to the welding machine by a welding cable.

Earth clamp (Fig 2): It is used to connect the earth cable firmly to the job or welding table. It is also made of copper/copper alloys.

Screw or spring-loaded earth clamps are made in various sizes i.e. 200-300-500 amps. (Fig 3)

Welding cables/leads: These are used to carry the welding current from the welding machine to the work and back.

The lead from the welding machine to the electrode-holder is called electrode cable.

The lead from the work or job through the earth clamp to the welding machine is called earth (ground) cable.

Cables are made of super flexible rubber insulation, having fine copper wires and woven fabric reinforcing layers. (Fig 4)

Welding cables are made in various sizes (cross-sections) i.e. 300, 400, 600 amps etc.

The same size welding cables must be used for the electrode and the job.

The cable connection must be made with suitable cable attachments (lugs) (Fig 5).
Loose joints or bad contacts cause overheating of the cables.

The length of the cable has considerable effect on the size to be used. (See Table 1).

Voltage drop app. 4 volts with all connections clean and tight.

<table>
<thead>
<tr>
<th>Cable dia. (mm)</th>
<th>0 - 15</th>
<th>15 - 30</th>
<th>30 - 75</th>
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<tr>
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<td>600</td>
<td>600</td>
<td>400</td>
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</tr>
<tr>
<td>13.5</td>
<td>125</td>
<td>100</td>
<td>75</td>
</tr>
</tbody>
</table>

Hammer

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

- state the uses of an engineer's hammer
- name the parts of an engineer's hammer and state their functions
- name the types of engineer's hammers
- specify the engineer's hammer.

An engineer's hammer is a hand tool used for striking purposes while:

- Punching (Fig. 1)
- Bending
- Straightening
- Chipping
- Peening (Fig. 2)
- Forging
- Riveting

![Fig 1: Extracting a Broken Stud Using a Hammer and Punch](image1)

![Fig 2: Peen the Weld Bead While It is Cooling](image2)
Major parts of a hammer: The major parts of a hammer are a head and a handle.

The head 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, pein, cheek, eye hole (Fig 3)

Face: The face is the striking portion. Slight convexity is given to it to avoid digging of the edge into the job.

Peen or Pein: The pein is the other end of the head. It is used for shaping and forming work like riveting, peening and bending. The pein is of different shapes (Fig. 4) like the

- Ball pein
- Cross pein
- Straight pein

The face and the pein are hardened.

A welder uses the ball pein hammer for punching, chiseling, peening, removing bends and for straightening of sheets.

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.

Eye hole: An eye hole is meant for fixing the handle. It is shaped to fit the handle rigidly. The wedges fix the handle in the eye hole. (See Figs 5 and 6)

Specification: An engineer’s hammer is specified by their weight and the shape of the pein. Their weight varies from 125g to 1500 g.

The weight of an engineer’s hammer, used by a welder is 1000 g and for making purposes, is 500 g.

The ball pein hammers are used for general work in a workshop.

Before using a hammer
- Make sure the handle is properly fitted.
- Select a hammer with the correct weight suitable for the job.
- Check the head and handle for any cracks.
- Ensure the face of the hammer is free from oil or grease.
- Always the handle is to be held at its extreme end while hammering.
Types and uses of welding processes

Objectives: At the end of this lesson you shall be able to
• state the classify the electric welding processes
• state the classify the gas welding processes
• name and classify the other welding processes
• state the applications of various welding processes.

According to the sources of heat, welding processes can be broadly classified as:
- Electric welding processes (heat source is electricity)
- Gas welding processes (heat source is gas flame)
- Other welding processes (heat source is neither electricity nor gas flame)

Electric welding processes can be classified as:-
- Electric arc welding
- Electric resistance welding
- Laser welding
- Electron beam welding
- Induction welding

Electric arc welding can be further classified as:
- Shielded Metal Arc Welding/Manual Metal Arc Welding
- Carbon arc welding
- Atomic hydrogen arc welding
- Gas Tungsten Arc Welding / TIG Welding
- Gas Metal Arc Welding / MIG/MAG Welding
- Flux cored arc welding
- Submerged arc welding
- Electro-slag welding
- Plasma arc welding.

Electric resistance welding can be further classified as:
- Spot welding
- Seam welding
- Butt welding
- Blash butt welding

Projection welding

Gas welding processes can be classified as:
- Oxy-acetylene gas welding
- Oxy-hydrogen gas welding

The other welding processes are:
- Thermit welding
- Forge welding
- Friction welding

<table>
<thead>
<tr>
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<th>Welding process</th>
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<tr>
<td>AAW</td>
<td>Air Acetylene</td>
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<tr>
<td>AHW</td>
<td>Atomic Hydrogen</td>
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<tr>
<td>BMAM</td>
<td>Bare Metal Arc</td>
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<tr>
<td>CAW</td>
<td>Carbon Arc</td>
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<td>EBW</td>
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<td>FCAW</td>
<td>Flux cored Arc</td>
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<td>Flash</td>
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<td>Induction</td>
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<tr>
<td>LBW</td>
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<td>Oxy-Acetylene</td>
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<td>Oxy-Hydrogen</td>
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<tr>
<td>PAW</td>
<td>Plasma Arc</td>
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<tr>
<td>PGW</td>
<td>Pressure Gas</td>
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<tr>
<td>RPW</td>
<td>Resistance Projection</td>
</tr>
<tr>
<td>RSEW</td>
<td>Resistance Seam</td>
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<tr>
<td>SAW</td>
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<td>Stud Arc</td>
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<td>TW</td>
<td>Thermit</td>
</tr>
<tr>
<td>UW</td>
<td>Ultrasonic</td>
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</table>
Applications of various welding processes

**Forge welding**: It is used in olden days for joining metals as a lap and butt joint.

**Shielded Metal arc welding** is used for welding all ferrous and non-ferrous metals using consumable stick electrodes.

**Carbon arc welding** is used for welding all ferrous and non-ferrous metals using carbon electrodes and separate filler metal. But this is a slow welding process and so not used now-a-days.

**Submerged arc welding** is used for welding ferrous metals, thicker plates and for more production.

**Co welding (Gas Metal Arc Welding)** is used for welding ferrous metals using continuously fed filler wire and shielding the weld metal and the arc by carbon-di-oxide gas.

**TIG welding (Gas Tungsten Arc Welding)** is used for welding ferrous metals, stainless steel, aluminium and thin sheet metal welding.

**Atomic hydrogen welding** is used for welding all ferrous and non-ferrous metals and the arc has a higher temperature than other arc welding processes.

**Electroslag welding** is used for welding very thick steel plates in one pass using the resistance property of the flux material.

**Plasma arc welding**: The arc has a very deep penetrating ability into the metals welded and also the fusion is taking place in a very narrow zone of the joint.

**Spot welding** is used for welding thin sheet metal as a lap joint in small spots by using the resistance property of the metals being welded.

**Seam welding** is used for welding thin sheets similar to spot welding. But the adjacent weld spots will be overlapping each other to get a continuous weld seam.

**Projection welding** is used to weld two plates one over the other on their surfaces instead of the edges by making projection on one plate and pressing it over the other flat surface. Each projection acts as a spot weld during welding.

**Butt welding** is used to join the ends of two heavy section rods/blocks together to lengthen it using the resistance property of the rods under contact.

**Flash butt welding** is used to join heavy sections of rods/blocks similar to butt welding except that arc flashes are produced at the joining ends to melt them before applying heavy pressure to join them.

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**Principle and method of operating of arc welding**

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

- state the methods of operating the ARC welding.

When high current passes through an air gap from one conductor to another, it produces very intense and concentrated heat in the form of a spark. The temperature of this spark (or arc) is app. 3600°C, which can melt and fuse the metal very quickly to produce a homogeneous weld (Fig 1)

**Shielded Metal Arc welding** (Fig 2): This is an arc welding process in which the welding heat is obtained from an arc, formed between a metallic (consumable) electrode and welding job.

The metal electrode itself melts and acts as a filler metal.

**Carbon arc welding** (Fig 3): Here the arc is formed between a carbon electrode (non-consumable) and the welding job.

A separate filler rod is used since the carbon electrode is a non-metal and will not melt.
Atomic hydrogen arc welding: In this process, the arc is formed between two tungsten electrodes in an atmosphere of hydrogen gas. The welding job remains out of the welding circuit. A separate filler rod is used to add the filler metal.

Tungsten inert gas arc welding (TIG): In this case, the arc is formed between the tungsten electrodes (non-consumable) and the welding job in an atmosphere of an inert gas (argon or helium). A separate filler rod is used to add the filler metal. This process is also called gas tungsten arc welding (GTAW) process.

Gas metal arc welding (GMAW) or Metal inert gas arc welding (MIG): In this process, the arc is formed between a continuous, automatically fed, metallic consumable electrode and welding job in an atmosphere of inert gas, and hence this is called metal inert gas arc welding (MIG) process. When the inert gas is replaced by carbon dioxide then it is called CO2 arc welding or metal active gas (MAG) arc welding. The common name for this process is gas metal arc welding (GMAW).

Submerged arc welding: Here the arc is formed between a continuous, automatically fed, metallic consumable electrode and the welding job under a heap of powdered/granulated flux. The arc is totally submerged in the flux (invisible).
Electro-slag welding (Fig 8): The arc is formed between a continuous, automatically fed, metallic consumable electrode and the welding job under a thick pool of molten flux (slag).

This automatic process requires special equipment and is used only in vertical position for the welding of heavy thick plates.

Plasma arc welding (Fig 9): In this process the arc is formed between a tungsten electrode and the welding job in an atmosphere of plasma-forming gas-nitrogen, hydrogen and argon.

A separate filler rod is used to add the filler metal in the joint, if necessary. But normally no filler rod is used.

The process is similar to TIG welding.

Plasma cutting is used to cut non-ferrous metals and alloys successfully and quickly.
Material preparation method

Objectives: At the end of this lesson you shall be able to
- State the necessity of preparing the materials to be welded
- State different methods used to cut mild steel sheets and plates to the required size before welding
- Name different tools and equipments used to prepare the mild steel sheets and plates.

Necessity of materials preparation for welding: While fabricating (producing or making) different components or parts by welding, different sizes of plates, sheets, pipes, angles, channels with different dimensions are joined together to get the final objects. For example, a railway compartment, an aeroplane, an oil or water pipe line, a gate, a window grill, a stainless steel milk tank, etc. So these objects can be made to the required dimensions only by cutting them from the larger size sheets, plates, pipes etc. which are available in standard sizes, thickness, diameters and lengths in the market. Hence cutting and preparing the base metal to the required dimensions from the original material available in many stores is necessary before welding them.

Also the base metals before cutting them to size will have impurities like dirt, oil, paint, water and surface oxides, due to long storage. These impurities will affect the welding and will create some defects in the welded joint. These defects will make the joint weak and it is possible that the welded joint will break, if the weld defects are present in the welded joints. So in order to get a strong welded joint, it is necessary to clean the surfaces to be joined and remove the dirt, oil paint, water, surface oxide etc. from the joining surfaces before welding.

Different methods used to cut metals
1. By chiselling the sheets
2. By hacksawing
3. By shearing using hand lever shear
4. By using guillotine shear
5. By gas cutting

For thin sheets the first 4 methods are used. For thick materials method 2, 4 and 5 are used.

Tools and equipments used to cut metals
1. Cold chisel
2. Hacksaw blade with frame
3. Hand lever shear
4. Guillotine shear
5. Oxy-acetylene cutting torch

The cut edges of the sheet or plate are to be filed to remove burrs and to make the edges to be square (at 90° angle) with each other. For ferrous metal plates, which are more than 3mm thick, the edges can be prepared by grinding them on a bench/pedestal grinding machine.

Welding description (fusion, non-fusion and pressure)

Objectives: At the end of this lesson you shall be able to
- distinguish between fusion and non-fusion welding
- state the method of pressure welding.

Welding is a method of joining metals permanently. The method used in ancient days was forge welding.

Types of welding

Fusion welding (Fig 1)

![Fusion welding diagram](image)

A method of welding in which similar metals are joined together by melting and fusing their joining edges with or without the addition of filler metal but without the application of any kind of pressure is known as fusion welding. The joint made is permanent. The common heating sources are arc welding and gas welding.

Non fusion welding

A method of welding in which similar or dissimilar metals are joined together without melting the edges is known as non-fusion welding. A low melting point filler rod is fused between the joints without the application of pressure. (Fig 2) The joint made is temporary.

The heat source may be arc or gas welding as in fusion welding.
Welding processes

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

- list the different welding process
- describe the welding process of SMAW, GMAW & GTAW
- select the welding process depending up on the requirements.

Welding Processes

- The number of different welding processes has grown in recent years. These processes differ greatly in the manner in which heat and pressure (when used) are applied, and in the type of equipment used. There are currently over 50 different types of welding processes; we’ll focus on 3 examples of electric arc welding, which is the most common form of welding.

- The most popular processes are shielded metal arc welding (SMAW), gas metal arc welding (GMAW) and gas tungsten arc welding (GTAW).

- All of these methods employ an electric power supply to create an arc which melts the base metal(s) to form a molten pool. The filler wire is then either added automatically (GMAW) or manually (SMAW & GTAW) and the molten pool is allowed to cool.

- Finally, all of these methods use some type of flux or gas to create an inert environment in which the molten pool can solidify without oxidizing.

Shielded Metal Arc Welding (SMAW) (Fig 1)

SMAW is a welding process that uses a flux covered metal electrode to carry an electrical current. The current forms an arc that jumps a gap from the end of the electrode to the work. The electric arc creates enough heat to melt both the electrode and the base materials. Molten metal
from the electrode travels across the arc to the molten pool of base metal where they mix together. As the arc moves away, the mixture of molten metals solidifies and becomes one piece. The molten pool of metal is surrounded and protected by a fume cloud and a covering of slag produced as the coating of the electrode burns or vaporizes (Fig 2). Due to the appearance of the electrodes, SMAW is commonly known as ‘stick’ welding.

Some of the biggest drawbacks to SMAW are (1) that it produces a lot of smoke & sparks, (2) there is a lot of post-weld cleanup needed if the welded areas are to look presentable, (3) it is a fairly slow welding process and (4) it requires a lot of operator skill to produce consistent quality welds.

Gas Metal Arc Welding (GMAW) (Fig.3)

In the GMAW process, an arc is established between a continuous wire electrode (which is always being consumed) and the base metal. Under the correct conditions, the wire is fed at a constant rate to the arc, matching the rate at which the arc melts it. The filler metal is the thin wire that’s fed automatically into the pool where it melts. Since molten metal is sensitive to oxygen in the air, good shielding with oxygen-free gases is required. This shielding gas provides a stable, inert environment to protect the weld pool as it solidifies. Consequently, GMAW is commonly known as MIG (metal inert gas) welding. Since fluxes are not used (like SMAW), the welds produced are sound, free of contaminants, and as corrosion-resistant as the parent metal. (Fig.4)

GMAW is extremely fast and economical. This process is easily used for welding on thin-gauge metal as well as on heavy plate. It is most commonly performed on steel (and its alloys), aluminum and magnesium, but can be used with other metals as well. It also requires a lower level of operator skill than the other two methods of electric arc welding discussed in these notes. The high welding rate and reduced post-weld cleanup are making GMAW the fastest growing welding process.
In the GTAW process, an arc is established between a tungsten electrode and the base metal. Under the correct conditions, the electrode does not melt, although the work does at the point where the arc contacts and produces a weld pool. The filler metal is thin wire that’s fed manually into the pool where it melts. Since tungsten is sensitive to oxygen in the air, good shielding with oxygen-free gas is required. The same inert gas provides a stable, inert environment to protect the weld pool as it solidifies. Consequently, GTAW is commonly known as TIG (tungsten inert gas) welding. Because fluxes are not used (like SMAW), the welds produced are sound, free of contaminants and slags, and as corrosion-resistant as the parent metal.

Tungsten’s extremely high melting temperature and good electrical conductivity make it the best choice for a non-consumable electrode. The arc temperature is typically around 11,000° F. Typical shielding gasses are Argon (Ar), Helium (He), Nitrogen (N) or a mixture of the two. As with GMAW, the filler material usually is the same composition as the base metal.

GTAW is easily performed on a variety of materials, from steel and its alloys to aluminum, magnesium, copper, brass, nickel, titanium, etc. Virtually any metal that is conductive lends itself to being welded using GTAW. Its clean, high-quality welds often require little or no post-weld finishing. This method produces the finest, strongest welds out of all the welding processes. However, it’s also one of the slower methods of arc welding.
Co₂ welding equipment and process

Objectives: At the end of this lesson you shall be able to
• state the main difference between shielded metal arc welding and co₂ welding
• state the principle of co₂ welding.

Introduction to Co₂ welding: Fusion welding of metal plates and sheets is the best method of joining metals because in this process the welded joint will possess the same properties and strength as the base metal.

Without a perfectly shielded arc and molten puddle, the atmospheric oxygen and nitrogen will get absorbed by the molten metal. This will result in weak and porous welds.

In shielded metal arc welding (SMAW) the arc and molten metal are protected/shielded by the gases produced by the burning of the flux coated on the electrode.

The above mentioned shielding action can be done by passing an inert gas such as argon, helium, carbon-dioxide through the welding torch-gun. The arc is produced between the base metal and a bare wire consumable electrode fed continuously through the torch.

Principle of GMA welding: In this welding process, an arc is struck between a continuously fed consumable bare wire electrode and the base metal. The heated base metal, the molten filler metal and the arc are shielded by the flow of inert/noninert gas passing through the welding torch/ gun. (Fig.1)

If an inert gas is used to protect the arc produced by a consumable metal electrode, this process is called Metal Inert Gas Welding (MIG).

When carbon-dioxide is used for shielding purposes, it is not fully inert and it partly becomes an active gas. So Co₂ welding is also called as Metal Active Gas (MAG) welding.

MIG/MAG welding is a name with respect to gas used for shields purpose.
On the other hand Gas Metal Arc Welding is the common name.

Basic equipment for a typical GMAW semiautomatic setup (Fig 2)
• Welding Power Source - provides welding power.
• Wire Feeders - controls supply of wire to welding gun.
• Supply of Electrode Wire.
• Welding Gun - delivers electrode wire and shielding gas to the weld puddle.
• Shielding Gas Cylinder - provides a supply of shielding gas to the arc.
Selection of the welding process

Objectives: At the end of this lesson you shall be able to
• list the factors considered for selecting welding process
• state the advantages and disadvantages of welding process.

Selection of the welding process

The selection of the joining process for a particular job depends upon many factors. There is no one specific rule governing the type of welding process to be selected for a certain job. A few of the factors that must be considered when choosing a welding process are

• Availability of equipment
• Respectiveness of the operation
• Quality requirements (base metal penetration, consistency, etc)
• Location of work
• Materials to be joined

• Appearance of the finished product
• Size of the parts to be joined
• Time available for work
• Skill experience of workers
• Cost of materials
• Code or specification requirements

General guidelines for selecting one process over another

When selecting one process over the others, it is often useful to examine the principal of each type of welding covered in this lesson.

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<tr>
<th>Welding process</th>
<th>Advantages</th>
<th>Disadvantages</th>
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</thead>
<tbody>
<tr>
<td>SMAW</td>
<td>Cheap</td>
<td>Major post-weld cleaning</td>
</tr>
<tr>
<td></td>
<td>Portable (no gas required)</td>
<td>Relatively 'dirty' method of welding (sparks/fumes)</td>
</tr>
<tr>
<td></td>
<td>Versatile (can weld various metals &amp; thicknesses)</td>
<td>Requires moderate skill</td>
</tr>
<tr>
<td>GMAW</td>
<td>Fastest of all 3 processes</td>
<td>Requires shielding gas</td>
</tr>
<tr>
<td></td>
<td>Versatile (can weld various metals &amp; thicknesses)</td>
<td>Minor post-weld cleaning</td>
</tr>
<tr>
<td>GTAW</td>
<td>Highest quality welds</td>
<td>Requires shielding gas</td>
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<tr>
<td></td>
<td>No post-weld cleaning</td>
<td>Slowest of all 3 processes</td>
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<tr>
<td></td>
<td>Versatile (can weld various metals &amp; thicknesses)</td>
<td>Requires high degree of operator skill</td>
</tr>
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</table>
Objectives: At the end of this lesson you shall be able to

- Explain the low pressure and the high pressure systems of oxy-acetylene plants and systems
- distinguish between low pressure and high pressure blowpipes
- State the advantages and disadvantages of both systems.

Oxy-acetylene plants: An oxy-acetylene plant can be classified into:

- high pressure plant
- low pressure plant

A high pressure plant utilizes acetylene under high pressure (15 kg/cm) (Fig 1)

Dissolved acetylene (acetylene in cylinder) is the commonly used source. Acetylene generated from a high pressure generator is not commonly used.

A low pressure plant utilizes acetylene under low pressure (0.017 kg/cm) produced by the acetylene generator only. (Fig 2)

The terms low pressure and high pressure systems used in oxy-acetylene welding refer only to acetylene pressure, high or low.

Types of blowpipes: For the low pressure system, a specially designed injector type blowpipe is required, which may be used for high pressure system also.

In the high pressure system, a mixer type high pressure blowpipe is used which is not suitable for the low pressure system.

To avoid the danger of high pressure oxygen entering into the acetylene pipeline an injector is used in a low pressure blowpipe. In addition a non-return valve is also used in the blowpipe connection on the acetylene hose. As a further precaution to prevent the acetylene generator from exploding, a hydraulic back pressure valve is used between the acetylene generator and the blowpipe.

Advantages of high pressure system: Safe working and less chances of accidents. The pressure adjustment of gases in this system is easy and accurate, hence working efficiency is more. The gases being in cylinder are perfectly under control. The D.A cylinder is portable and can be taken easily from one place to another place.

The D.A cylinder can be fitted with a regulator quickly and easily, thus saving time. Both injector and non-injector type blowpipes can be used. No license is required for keep the D.A cylinder.

Sequence of steps

Slowly open the cylinder valve.
Open the shut-off valve or pressure reducing valve
Open the valve on torch.
Slowly screw in the adjusting screw. (The locking bolt opens.)

Watch the working pressure gauge.

Turn the adjusting screw until the desired pressure is reached. There is an equilibrium between the bottom adjusting spring and the pressure of the gas on the membrane, which is amplified by the spring of the locking pin.

**Care and maintenance of regulators**

Check the cylinder connection and crack the cylinder before fixing the regulator. (Fig 3)

Open the cylinder valve slowly and allow the gas to pass to the regulator (cylinder) content gauge.

Loosen the pressure screw.

Do not use oil in regular connections. (Fig 4)

Do not fix the oxygen and acetylene regulators close together (Fig 5)

Do not wind the hose on the regulators (Fig 6)

Use hose-clips before connecting to the regulator.

Use soap water to check the leakage in the acetylene regulator connections and plain water on the oxygen regulator connections. (Fig 7)
Gas welding torch its type and construction

Objectives: At the end of this lesson you shall be able to
- State the uses of the different types of blowpipes
- describe the working principle of each type of blowpipe
- explain its care and maintenance.

Types
There are two types of blowpipes.
High pressure blowpipe or non-injector type blowpipe
Low pressure blowpipe or injector type blowpipe.

Uses of blow pipes: Each type consists of a variety of
designs depending on the work for which the blowpipe is
required. i.e gas welding, brazing, very thin sheet welding,
heating before and after welding, gas cutting.

Equal or High pressure blowpipe (Fig 1): The H.P.
blowpipe is simply a mixing device to supply approximately
equal volume of oxygen and acetylene to the tip, and is
fitted with valves to control the flow of the gases as required.
i.e the blow pipes/ gas welding torches are used for welding
of ferrous and non-ferrous metals, joining thin sheets by
fusing the edges, preheating and post heating of jobs,
brazing, for removing the dents formed by distortion and for
gas cutting using a cutting blow pipe.

The equal pressure blow pipe (Fig.1) consists of two inlet
connections for acetylene and oxygen gases kept in high
pressure cylinders. Two control valves to control the
quantity of flow of the gases and a body inside which the
gases are mixed in the mixing chamber (Fig 2). The mixed
gases flow through a neck pipe to the nozzle and then get
ignited at the tip of the nozzle. Since the pressure of the
oxygen and acetylene gases are set at the same pressure
of 0.15 kg/cm² they mix together at the mixing chamber
and flows through the blow pipe to the nozzle tip on its
own. This equal pressure blow pipe/torch is also called as
high pressure blow pipe/torch because this is used in the
high pressure system of gas welding.

A set of nozzles is supplied with each blowpipe, the
nozzles having holes varying in diameters, and thus giving
various sized flames. The nozzles are numbered with their
consumption of gas in litres per hour.

Important caution: A high pressure blowpipe
should not be used on a low pressure system.

Low pressure blowpipe (Fig 3)
This blowpipe has an injector (Fig 3) inside its body through
which the high pressure oxygen passes. This oxygen
draws the low pressure acetylene from an acetylene
generator into a mixing chamber and gives it the necessary
velocity to get a steady flame and the injector also helps
to prevent backfiring.

The low pressure blow pipe is similar to the equal pressure
blow pipe except that inside its body an injector with a very
small (narrow) hole in its centre through which high
pressure oxygen is passed. This high pressure oxygen
while coming out of the injector creates a vaccum in the
mixing chamber and sucks the low pressure acetylene
from the gas generator (Fig.4)

It is usual for the whole head to be interchangeable in this
type, the head containing both the nozzle and injector. This
is necessary, since there is a corresponding injector size
for each nozzle.

The L.P. blowpipe is more expensive than the
H.P. blowpipe but it can be used on a high
pressure system, if required.
Care and maintenance

Welding tips made of copper may be damaged by careless handling.

Nozzles should never be dropped or used for moving or holding the work.

The nozzle seat and threads should be absolutely free from foreign matter in order to prevent any scoring/scratch on the fitting surfaces when tightening on assembly.

The nozzle orifice should only be cleaned with a tip cleaner specially designed for this purpose. (Fig 5, 6 & 7)

At frequent intervals the nozzle tip should be filed to remove any damage to the tip due to the excessive heat of the flame and the molten metal.

The inlet for acetylene has left hand thread and that for oxygen has right hand thread. Take care to fit the correct hose pipe with the blow pipe inlet. At frequent intervals, put off the flame and dip the blow pipe in cold water.
Types of welding joints (butt and fillet)

Objectives: At the end of this lesson you shall be able to
- illustrate and name the basic welding joints
- explain the nomenclature of butt and fillet welds.

Basic welding joints (Fig 1)
The various basic welding joints are shown in Fig 1.
The above types mean the shape of the joint, that is, how the joining edges of the parts are placed together.

Types of weld: There are two types of weld.(Fig 2)
- Groove weld/butt weld
- Fillet weld

Nomenclature of butt and fillet weld (Figs 3 and 4)
Root gap: It is the distance between the parts to be joined. (Fig 3)
Heat affected zone: Metallurgical properties have been changed by the welding heat adjacent to weld.
Leg length: The distance between the junction of the metals and the point where the weld metal touches the base metal ‘toe’. (Fig 5)
Parent metal: The material or the part to be welded.
Fusion Penetration: The depth of fusion zone in the parent metal.(Fig.3 and 4)

Reinforcement: Metal deposited on the surface of the parent metal or the excess metal over the line joining the two toes. (Fig 6)

Root: The parts to be joined that are nearest together. (Fig 7)
**Root face:** The surface formed by squaring off the root edge of the fusion face to avoid a sharp edge at the root. (Fig 8)

**Root run:** The first run deposited in the root of a joint. (Fig 9)

**Root penetration:** It is the projection of the root run at the bottom of the joint (Fig.6 and 9)

**Run:** The metal deposited during one pass. Fig.9.

The second run is marked as 2 which is deposited over the root run. The third run is marked as 3 which is deposited over the second run.

**Sealing run:** A small weld deposited on the root side of a butt or corner joint (after completion of the weld joint). (Fig 10)

**Backing run:** A small weld deposited on the root side of the butt or corner joint (before welding the joint). Fig.6

**Throat thickness:** The distance between the junction of the metals and the midpoint on the line joining the two toes. (Fig 5)

**Toe of weld:** The point where the weld face joins the parent metal. (Fig 5 & 6)

**Weld face:** The surface of a weld seen from the side from which the weld was made. (Fig 5 & 6)

**Weld junction:** The boundary between the fusion zone and the heat affected zone. (Fig 3 & 4)

**Fusion face:** The portion of a surface which is to be fused on making the weld. (Fig 11)

**Fusion zone:** The depth to which the parent metal has been fused. (Fig 11)
Purpose of root gap, tacking and key hole in the weld joint during welding

Objectives: At the end of this lesson you shall be able to
• explain the purpose of the root gap kept in the joint before welding
• state the purpose of tacking the job pieces before welding and state the importance of key hole during welding.

Gap: root gap or root opening in welding joints

Before welding, the joining parts of the assembly are kept apart for some specific distance. (Fig 1) This distance is called root gap or root opening.

Purpose: The purpose is to obtain the required depth of fusion or complete penetration to the entire depth of the joint during welding. (Fig 2)

The arc has a limitation. It melts only to a certain depth in the base metal. This limit is equal to or less than the diameter of the electrode used. So if root gap is not given the base metal may not be fused till the bottom of the joint. So root gap is essential while welding.

Tack welds: A tack weld is a short weld used to help assembly and to maintain the position of parts during welding.

Tack welds should be between three and four times the plate thickness, upto a maximum length of 35mm at the ends of the joint. (Fig 3 and 4)

For intermediate tack welds the length should be between two and three times the plate thickness, up to a maximum length of 35mm.

Pitch of tack welds: For mild steel plates of 3mm thickness, the pitch (i.e. distance between centres) of tack welds in butt joints should be 150mm. The pitch should be increased by about 15mm for each 1mm increase in plate thickness, upto maximum of 600mm for thicknesses of 33mm and above.

For lengths less than twice the normal pitch distance, end tack welds only are required. The above pitch distances should be doubled for fillet-welded T-joints.

Tack welds are done on the rear side of the joint and not on the welding side. (Fig.3 and 4)

Purpose: To maintain the root gap and alignment of the assembly parts and for controlling of distortion during welding, tacking is necessary. (Fig 5)
Objectives: At the end of this lesson you shall be able to
• explain the necessity of edge preparation
• describe the edge preparation for butt and fillet welds.

Necessity of edge preparation: Joints are prepared to weld metals at less cost. The preparation of edges are also necessary prior to welding in order to obtain the required strength to the joint. The following factors are to be taken into consideration for the edge preparation.

- The welding process like SMAW, oxy-acetylene welds, Co₂, electro-slag etc.
- The type of metal to be jointed, (i.e.) mild steel, stainless steel, aluminium, cast iron etc.
- The thickness of metal to be joined.
- The type of weld (groove and fillet weld)
- Economic factors

The square butt weld is the most economical to use, since this weld requires no chamferring, provided satisfactory strength is attained. The joints have to be bevelled when the parts to be welded are thick so that the root of the joints have to be made accessible for welding in order to obtain the required strength.

In the interest of economy, bevel butt welds should be selected with minimum root opening and groove angles such that the amount of weld metal to be deposited is the smallest. "J" and "U" butt joints may be used to further minimise weld metal when the savings are sufficient to justify the more difficult and costly chamferring operations. The "J" joint is usually used in fillet welds.

A root gap is recommended since the spacing allows the shrinking weld to draw the plates freely together in the butt joint. Thus, it is possible to reduce weld cracking and minimise distortion and increase penetration, by providing a root gap for some welded joints.

Method of edge preparation: The joining edges may be prepared for welding by any one of the methods mentioned below.

- Flame cutting
- Machine tool cutting

Importance of keyhole during welding: Keyhole is one of the product of welding technique while welding single run weld (corner & butt) or root run in corner and Vee groove welds.

It is a little hole (like a keyhole) at the leading edge of the crater right under the tip of the electrode. (Fig. 6)
- Machine grinding or hand grinding
- Filing, chipping

**Types of edge preparation and setup**

Different edge preparations generally used in arc welding are shown in Fig 1 below.

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**Basic welding joints and position**

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

- name the basic welding joints from drawings
- state the basic welding positions from drawings.

**Basic welding joints** (Fig 1)

The following are the basic welding joints.
- Butt joint
- Lap joint
- Tee joint
- Corner joint
- Edge joint

The above types indicate the shape of the joints and how the joining edges of parts are placed together. (Joint designs are very important in fabrication work).

**Basic welding positions** (Fig 2)

The following are the important basic welding positions
- Flat or downhand position
- Horizontal position
- Vertical position
- Overhead position

Welding action takes place in the molten pool, formed in the welding joint or the welding line.
The position of the welding joint line in respect of the ground axis indicates the welding position.

All joints can be welded in all positions.

Gases and gas cylinders description, kinds, main difference and uses

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

• name the different types of gases used in gas welding
• state the different types of gas flame combinations
• state the temperatures and uses of the different gas flame combinations.

In the different gas welding processes, the welding heat is obtained from the combustion of the fuel gases.

All the fuel gases require oxygen to support combustion.

As a result of the combustion of the fuel gases and oxygen, a flame is obtained. This is used to heat the metals for welding. (Fig 1)

Fuel gases used in welding

The following are the gases used as fuel for welding.

- Acetylene gas
- Hydrogen gas
- Coal gas
- Liquid petroleum gas (LPG)

Supporter of combustion gas

All gases burn with the help of oxygen. Hence it is known as the supporter of combustion.

Different gas flame combinations

Oxygen + Acetylene = Oxy - Acetylene gas flame
Oxygen + Hydrogen = Oxy - Hydrogen gas flame
Oxygen + Coal = Oxy - coal gas flame
Oxygen + LPG = Oxy - LP gas flame

Temperature and uses of gas flame combinations

Oxy-acetylene gas flame (Fig 2)

Flame temperature: 3100° C to 3300° C

The Oxy - Acetylene gas flame is used for welding all ferrous and non-ferrous metals and their alloys, gas cutting, gouging, steel brazing, bronze welding, metal spraying and powder spraying.
Oxy - Hydrogen gas flame (Fig 3)
Flame temperature: 2400°C to 2700°C
This flame has carbon and moisture effect. It is only used for gas cutting of steel, and for heating.

Oxy-coal gas flame (Fig 5)
Flame temperature: 1800°C to 2200°C
This flame has carbon effect in the flame and is used for silver soldering and brazing.

The most commonly used gas flame combination is OXY - ACETYLENE.

Oxy-liquid petroleum gas flame (Fig 4)
Flame temperature: 2700°C to 2800°C
It has carbon and moisture effect in the flame. It is used only for brazing, silver soldering and underwater gas cutting of steel.

Oxygen gas cylinder
Objectives: At the end of this lesson you shall be able to
- name different gas cylinders
- explain the constructional features of oxygen gas cylinder and the method of charging.

Definition of a gas cylinder: It is a steel container, used to store different gases at high pressure safely and in large quantity for welding or other industrial uses.

Types and identifications of gas cylinders: Gas cylinders are called by names of the gas they are holding. (Table 1)
Table 1
Identification of gas cylinders

<table>
<thead>
<tr>
<th>Name of gas cylinder</th>
<th>Colour coding</th>
<th>Valve threads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>Black</td>
<td>Right hand</td>
</tr>
<tr>
<td>Acetylene</td>
<td>Maroon</td>
<td>Left hand</td>
</tr>
<tr>
<td>Coal</td>
<td>Red (with name coal gas)</td>
<td>Left hand</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Red</td>
<td>Left hand</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Grey (with black neck)</td>
<td>Right hand</td>
</tr>
<tr>
<td>Air</td>
<td>Grey</td>
<td>Right hand</td>
</tr>
<tr>
<td>Propane</td>
<td>Red (with larger diameter and name propane)</td>
<td>Left hand</td>
</tr>
<tr>
<td>Argon</td>
<td>Blue</td>
<td>Right hand</td>
</tr>
<tr>
<td>Carbon-di-oxide</td>
<td>Black (with white neck)</td>
<td>Right hand</td>
</tr>
</tbody>
</table>

Gas cylinders are identified by their body colour marks and valve threads. (Table 1)

Oxygen gas cylinder: It is a seamless steel container used to store oxygen gas safely and in large quantity under a maximum pressure of 150 kg/cm², for use in gas welding and cutting.

Constructional features of oxygen gas cylinder (Fig 1)

The cylinder valve has a pressure safety device, which consists of a pressure disc, which will burst before the inside cylinder pressure becomes high enough to break the cylinder body. The cylinder valve outlet socket fitting has standard right hand threads, to which all pressure regulators may be attached. The cylinder valve is also fitted with a steel spindle to operate the valve for opening and closing. A steel cap is screwed over the valve to protect it from damage during transportation. (Fig 1)

The cylinder body is painted black.

The capacity of the cylinder may be 3.5m³– 8.5m³.

Oxygen cylinders of 7m³ capacity are commonly used.

Charging of gas in oxygen cylinder: The oxygen cylinders are filled with oxygen gas under a pressure of 120-150 kg/cm². The cylinders are tested regularly and periodically. They are annealed to relieve stresses caused during ‘on the job’ handling. They are periodically cleaned using caustic solution.
**Dissolved acetylene gas cylinder**

**Objectives:** At the end of this lesson you shall be able to
- describe the constructional features of the DA gas cylinder and the method of charging
- state the safety rules for handling gas cylinders
- explain the safe procedure to be followed in handling an internally fired DA cylinder.

**Definition:** It is a steel container used to store high pressure acetylene gas safely in dissolved state for gas welding or cutting purpose.

**Constructional features** (Fig 1): The acetylene gas cylinder is made from seamless drawn steel tube or welded steel container and tested with a water pressure of 100kg/cm². The cylinder top is fitted with a pressure valve made from high quality forged bronze. The cylinder valve outlet socket has standard left hand threads to which acetylene regulators of all makes may be attached. The cylinder valve is also fitted with a steel spindle to operate the valve for opening and closing. A steel cap is screwed over the valve to protect it from damage during transportation. The body of the cylinder is painted maroon. The capacity of the DA cylinder may be 3.5m³–8.5m³.

The base of the DA cylinder (curved inside) is fitted with fuse plugs which will melt at a temperature of app. 100°C. (Fig 2) In case the cylinder is subjected to high temperature, the fuse plugs will melt and allow the gas to escape, before the pressure increases enough to harm or rupture the cylinder. Fuse plugs are also fitted on the top of the cylinder.

**Method of charging D A gas cylinder:** The storage of acetylene gas in its gaseous form under pressure above 1kg/cm² is not safe. A special method is used to store acetylene safely in cylinders as given below.

The cylinders are filled with porous substances such as:
- pith from corn stalk
- fuller’s earth
- lime silica
- specially prepared charcoal
- fibre asbestos.

The hydrocarbon liquid named acetone is then charged in the cylinder, which fills the porous substances (1/3rd of total volume of the cylinder).

Acetylene gas is then charged in the cylinder, under a pressure of app. 15 kg/cm².

The liquid acetone dissolves the acetylene gas in large quantity as safe storage medium; hence, it is called dissolved acetylene. One volume of liquid acetone can dissolve 25 volumes of acetylene gas under normal atmospheric pressure and temperature. During the gas charging operation one volume of liquid acetone dissolves 25x15=375 volumes of acetylene gas under 15kg/cm² pressure at normal temperature. While charging cold water will be sprayed over the cylinder so that the temperature inside the cylinder does not cross certain limit.

**Safety rules for gas cylinders**

- Oxy-acetylene equipment is safe if it is properly handled, but it may become a great destructive power if handled carelessly. It is important that the operator be familiar with all the safety rules before handling gas cylinders.
- Check leakage before use.
- Open cylinder valves slowly.
- Never fall or trip over gas cylinders.
- A valve broken in the oxygen cylinder will cause it to become a rocket with tremendous force.

Keep the cylinders free of oil, grease or any type of lubrication.
Keep the gas cylinders away from exposure to high temperature.

Remember the pressure in the gas cylinders increases with the temperature.

Store full and empty gas cylinders separately in a well ventilated place.

Mark the empty cylinders (MT/EMPTY) with chalk.

If a cylinder leaks due to defective valve or safety plug, do not try to repair it yourself, but move it to a safe area with a tag to indicate the fault and then inform the supplier to pick it up.

When the cylinders are not in use or they are being moved, put on the valve protection caps.

Cylinders should always be kept in upright position and properly chained when in use.

Close the cylinder valves both when they are full or empty.

Never remove the valve protection cap while lifting cylinders.

Avoid exposing the cylinders to furnace heat, open fire or sparks from the torch.

Never move a cylinder by dragging, sliding or rolling it on its sides.

Never apply undue force to open or close a cylinder valve.

Avoid the use of hammer or wrench.

Always use a proper cylinder (or spindle) key to open or close the cylinder valves.

Do not remove the cylinder key from the cylinder valve when it is in use. It may be needed immediately to close the gas in case of emergency.

Smoking or naked lights should be strictly prohibited near gas cylinders.

Never strike an arc or direct gas flame on a gas cylinder.

Safety procedure for handling an internally fired dissolved acetylene (D A ) cylinder

In the case of severe backfire or flashback the D A cylinder may catch fire.

Close the blowpipe valve immediately (oxygen first).

No damage will occur to the cylinder if the backfire is arrested at the blowpipe.

The signs of severe backfire or flashback are:
  – a squealing or hissing noise in the blowpipe
  – a heavy black smoke and sparks coming out of the nozzle
  – overheating of the blowpipe handle.

To control this:
  – close the cylinder valves
  – disconnect the regulator from the cylinder valve
  – check the hosepipes and blowpipe before re-use.

If the cylinder catches fire externally due to the leakage of gas at the connection:
  – close the cylinder valve immediately (wearing asbestos gloves as a safety measure)
  – use carbon dioxide fire extinguisher to extinguish the fire
  – rectify the leakage thoroughly before putting into further use.

If the cylinder becomes overheated due to internal or external fire:
  – close the cylinder valve
  – detach the regulator from the cylinder
  – remove the cylinder to an open space, away from smoking or naked light
  – cool the cylinder by spraying with water
  – inform the gas cylinder supplier immediately.

Never keep such defective cylinders with the other cylinders.
Setting up parameter for arc welding machine

Objectives: At the end of this lesson you shall be able to
• select and set the electrode and current according to the plate thickness.

Electrode size and AMPS used

The following will serve as a basic guide of the amp range that can be used for different size electrodes. Note that these ratings can be different between various electrode manufactures for the same size rod. Also the type coating on the electrode could effect the amperage range. When possible, check the manufactures info of the electrode you will be using for their recommended amperage settings.

<table>
<thead>
<tr>
<th>Electrode</th>
<th>AMP</th>
<th>Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16&quot;</td>
<td>20 - 40</td>
<td>Up to 3/16&quot;</td>
</tr>
<tr>
<td>3/32&quot;</td>
<td>40 - 125</td>
<td>Up to 1/4&quot;</td>
</tr>
<tr>
<td>1/8</td>
<td>75 - 185</td>
<td>Over 1/8&quot;</td>
</tr>
<tr>
<td>5/32&quot;</td>
<td>105 - 250</td>
<td>Over 1/4&quot;</td>
</tr>
<tr>
<td>3/16&quot;</td>
<td>140 - 305</td>
<td>Over 3/8&quot;</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>210 - 430</td>
<td>Over 3/8&quot;</td>
</tr>
<tr>
<td>5/16&quot;</td>
<td>275 - 450</td>
<td>Over 1/2&quot;</td>
</tr>
</tbody>
</table>

Note: The thicker the material to be welded, the higher the current needed and the larger the electrode needed.
Arc welding electrodes

Objectives: At the end of this lesson you shall be able to
• explain arc welding electrode
• state the types of electrodes
• explain the coating factor
• describe the characteristics of flux coating on electrode
• explain the functions of flux coating during welding.

Introduction: An electrode is a metallic wire of standard size and length, generally coated with flux (may be bare or without flux coating also) used to complete the welding circuit and provide filler material to the joint by an arc, maintained between its tip and the work. (Fig 1)

Different types of electrodes used are given in the Electrode chart.

Method of flux coating:
– Dipping
– Extrusion

Dipping method: The core wire is dipped in a container carrying flux paste. The coating obtained on the core wire is not uniform resulting in non-uniform melting; hence this method is not popular.

Extrusion method: A straightened wire is fed into an extrusion press where the coating is applied under pressure. The coating thus obtained on the core wire is uniform and concentric, resulting in uniform melting of the electrode. (Fig 2) This method is used by all the electrode manufacturers.

Coating factor (Fig 3): The ratio of the coating diameter to the core wire diameter is called the coating factor.

Coating factor = \( \frac{\text{Coating dia of electrode}}{\text{Core wire dia. of electrode}} \)

It is 1.25 to 1.3 for light coated,
1.4 to 1.5 for medium coated,
1.6 to 2.2 for heavy coated, and above 2.2 for super heavy coated electrodes.

Types of flux coating
– Cellulosic
– Rutile
– Iron powder
– Basic coated

Cellulosic electrode: Cellulosic electrode coatings are made of materials containing cellulose, such as wood pulp and flour. The coating on these electrodes is very thin and the slag in easily removed from deposited welds. The coating produces high levels of hydrogen and is therefore not suitable for high-strength steels. This type of electrode is usually used on DC+ and suited to vertical down welding.

Rutile electrodes: Rutile electrodes, are general-purpose electrodes have coatings based on titanium dioxide. These electrodes are widely used in the fabrication industry as they produce acceptable weld shape and the slag on deposited welds is easily removed. Strength of deposited welds is acceptable for most low-carbon steels and the majority of the electrodes in this group are suitable for use in all positions.
Basic or hydrogen-controlled electrodes: Basic or hydrogen-controlled electrode coatings are based on calcium fluoride or calcium carbonate. This type of electrode is suitable for welding high-strength steels without weld cracks and the coatings have to be dried. This type of electrode is suitable for welding high-strength steels without weld cracks and the coatings have to be dried. This drying is achieved by backing at 450°C holding at 300°C and storing at 150°C until the time of use. By maintaining these conditions it is possible to achieve high strength weld deposits on carbon, carbon manganese and low alloyed steels. Most electrodes in this group deposit welds with easily removable slags, producing acceptable weld shape in all positions. Fumes given off by this electrode are greater than with other types of electrodes.

Iron powder electrodes: Iron powder electrodes get their name from the addition of iron powders to the coating which tend to increase efficiency of the electrode. For example, if the electrode efficiency is 120%, 100% is obtained from the core wire and 20% from the coating. Deposited welds are very smooth with an easily removable slag; welding positions are limited to horizontal, vertical fillet welds and flat or gravity position fillet and butt welds.

Composition/characteristics flux: The coating of the welding electrodes consists of a mixture of the following substances.

Alloying substances: These substances compensate for the burning of manganese, ferro-silicon. The alloying substances are:

- ferro-manganese
- ferro-silicon
- ferro-titanium.

Arc stabilising substances: These are carbonates known as chalk and marble. These are used for the stabilisation of the arc.

Deoxidizers: These substances prevents porosity and make the welds stronger. The deoxidising substances are iron oxide, lamitite, magnetite.

Slag forming substances: These substances melt and floats over the molten metal and protect the hot deposited weld metal from the atmospheric oxygen and nitrogen. Also due to the slag covering the weld metal is prevented from fast cooling. The slag forming substances are clay, limestone.

Fluxing/cleaning substances: These substances remove oxides from the edges to be welded and controls the fluidity of the molten metal. The cleaning substances are lime stone, chlorides, fluorides.

Gas forming substances: These substances form gases which aid the transfer of metal. They also shield the welding arc and weld pool. The substances are wood flour dixtorine and cellulose.

Binding and plasticizing substances: These substances help the applied coating to grip firmly around the core wire of the electrode.

These are sodium and potassium silicates.

Purpose or function of flux coating: During welding, with the heat of the arc, the electrode coating melts and performs the following functions.

- It stabilizes the arc.
- It forms a gaseous shield around the arc which protects the molten weld pool from atmospheric contamination.
- It compensates the losses of certain elements which are burnt out during welding.
- It retards the rate of cooling of the deposited metal by covering with slags and improves its mechanical properties.
- It helps to give good appearance to the weld and controls penetration.
- It makes the welding in all positions easy.
- Both AC and DC can be used for the welding.
- Removes oxide, scale etc. and cleans the surfaces to be welded.
- It increases metal deposition rate by melting the additional iron powder available in the flux coating.

Types of electrodes for ferrous and alloy metals

Mild steel electrode: Mild steel is characterized by carbon content not exceeding 0.3%. Mild steel electrode core wire contains various alloying elements.

- Carbon 0.1 to 0.3% (Strengthening agent)
- Silicon above 0.5% (Deoxidizes, prevents weld metal porosity.)
- Manganese 1.65% (Increases strength and hardness.)
- Nickel (Increases strength and notch toughness.)
- Chromium (Increases tensile strength and hardness. Lowers the ductility.)
- Molybdenum 0.5% (Increases hardness and strength.)

Indian Standard System laid down in IS:814-1991 a classification and coding of covered electrodes for metal arc welding of mild steel, and low alloy high tensile steel. Mild steel and low alloy high tensile steel electrodes are classified into seven recognised groups, depending upon...
the chemical composition of the flux coating.

**Stainless steel electrodes:** Selecting proper electrodes depends primarily on the composition of the base metal to be welded.

These electrodes are available with either lime or titanium coatings. The lime coated electrode is used only with DC reverse polarity. Titanium coated electrodes can be used in AC and DC reverse polarity, and will produce smoother and stable arc.

The coding system for stainless steel electrodes differs somewhat from that for the M.S. electrode. The I.S.5206 - 1969 specification for corrosion-resisting chromium and chromium-nickel steel covered electrodes will give full details.

During welding, the electrode will tend to get red hot quickly. To avoid this, 20 to 30% lower current than what is used for ordinary M.S. electrode is recommended.

**Special purpose electrodes:**
- Deep penetration electrodes
- Contact electrodes or iron powder electrodes
- Cutting and gouging electrodes
- Underwater welding and cutting electrodes
- Low hydrogen electrodes.

**Deep penetration electrodes:** These electrodes are used to get deep penetration in the joints. Deep penetration occurs because of the very strong stream of gas produced by the burning of the cellulosic materials in the flux coating.

Butt joints on heavy sections are welded without edge preparation using these electrodes.

The depth of the penetration will be more than to the core wire diameter of the electrode used.

**Contact electrodes** (Iron powder): These electrodes contain a large amount of iron powder in their coatings. Therefore the arc ignites very easily. These electrodes are also called ‘touch type’ electrodes. While using this type of electrodes a large amount of weld metal is deposited per unit time.

**Cutting and gauging electrodes:** The cutting electrodes are of a tubular type. While cutting, air is sent through the centre at high pressure to cut ferrous metals. The gouging electrodes can make ‘U’ grooves on the ferrous metals.

**Underwater welding and cutting electrodes:** These electrodes are used to cut and weld metals under the water. The coating having an external coating of varnish by ‘lacquer’ polishing or ‘celluloid ’ helps to insulate and protect the electrodes when immersed in water for welding or cutting purpose.

**Low hydrogen electrodes:** Hydrogen controlled electrodes shall be such that the diffusible hydrogen content of the deposited metal will be low. This electrode is used with DC reverse polarity and can be used in all welding positions. These electrodes help to get a weld without cracks.

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**Coding of electrodes**

**Objectives:** At the end of this lesson you shall be able to
- explain the necessity of coding electrodes
- describe the electrode coding as per BIS, AWS and BS.

**Necessity of coding electrodes:** Electrodes with different flux covering give different properties to the weld metal. Also electrodes are manufactured suitable for welding with AC or DC machines and in different positions. These conditions and properties of the weld metal can be interpreted by the coding of electrodes as per Indian Standards.

The chart shown at the end of this lesson gives the specification of a particular electrode and also shows what each digit and letter in the code represents. By referring to this chart any one can know whether an electrode with a given specification can be used for welding a particular job or not.

Classification of electrodes shall be indicated by the IS: 814-1991 coding system of letters and numerals to indicate the specified properties or characteristics of the electrode.

**Main coding:** It consists of the following letters and numerals and shall be followed in the order stated:

a) a prefix letter ‘E’ shall indicate a covered electrode for manual metal arc welding, manufactured by extrusion process;

b) a letter indicating the type of covering;

c) first digit indicating the ultimate tensile strength in combination with the yield stress of the weld metal deposit;

d) second digit indicating the percentage elongation in combination with the impact values of the weld metal deposited;

e) third digit indicating welding position(s) in which the electrode may be used and

f) fourth digit indicating the current condition in which the electrode is to be used.
Additional coding: The following letters indicating the additional properties of the electrodes may be used, if required:

a) letters $H_1$, $H_2$, $H_3$ indicating hydrogen controlled electrodes

b) letters J, K and L indicating increased metal recovery as ‘Effective Electrode Efficiency’ as per IS:13043:91. Specification in the followings range:

\[ J = 110 - 129 \text{ percent}; \]
\[ K = 130 - 149 \text{ percent}; \text{ and} \]
\[ L = 150 \text{ percent and above}. \]

c) letter ‘X’ indicating the radiographic quality

Different standards used in coding of electrodes

They are:

1 I.S. (814 - 1991)
2 A.W.S.
3 B.S.

Indian system of coding of electrodes according to IS : 814-1991

Type of covering: The type of covering shall be indicated by the following letters.

- A - Acid
- B - Basic
- C - Cellulosic
- R - Rutile
- RR - Rutile, heavy coated
- S - Any other type not mentioned above

Strength characteristics: The combination of the ultimate tensile strength and the yield strength of the weld metal deposited shall be indicated by the digits 4 and 5. (See Table 1.)

<table>
<thead>
<tr>
<th>Designating digit</th>
<th>Ultimate tensile strength N/mm²</th>
<th>Yield strength Min N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>410-510</td>
<td>330</td>
</tr>
<tr>
<td>5</td>
<td>510-610</td>
<td>360</td>
</tr>
</tbody>
</table>

Elongation and impact properties: The combination of percentage elongation and impact properties of all weld metal deposited for the two tensile ranges (See Table 1) shall be as given in Table 2.

<table>
<thead>
<tr>
<th>Designation digit</th>
<th>Percentage elongation (Min) on 5.65/So</th>
<th>Impact strength (Min)/at °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No elongation and impact requirements</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>47J+27°C</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>47J+0°C</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>47J-20°C</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>27J-30°C</td>
</tr>
</tbody>
</table>

Welding position: The welding position or positions in which the electrode can be used as recommended by the manufacturer shall be indicated by the appropriate designating digits as follows.

1 All positions
2 All positions except vertical down
3 Flat butt weld, flat fillet weld and horizontal/vertical fillet weld
4 Flat butt weld and flat fillet weld
5 Vertical down, flat butt, flat fillet and horizontal and vertical fillet weld
6 Any other position or combination of positions not classified above

Where an electrode is coded as suitable for vertical and overhead position it may be considered that sizes larger than 4 mm are not normally used for welding in these positions.

An electrode shall not be coded as suitable for a particular welding position unless it is possible to use it satisfactorily in the position to comply with test requirements of this code.

Welding current and voltage conditions: The welding current and open circuit voltage conditions on which the electrodes can be operated as recommended by the manufacturer shall be indicated by the appropriate designating digits as given in Table 3.
For the purpose of coding an electrode, for any of the current conditions under 5.5 shall be of size 4 mm or 5 mm and shall be capable of being operated at that condition satisfactorily within the current range recommended by the manufacturer.

**Hydrogen controlled electrodes:** The letters H₁, H₂ and H₃ shall be included in the classification as a suffix for those electrodes which will give diffusible hydrogen per 100 gm when determined in accordance with the reference method given in IS: 1806:1986 as given below.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Diffusible Hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₁</td>
<td>Up to 15 ml diffusible hydrogen</td>
</tr>
<tr>
<td>H₂</td>
<td>Up to 10 ml diffusible hydrogen</td>
</tr>
<tr>
<td>H₃</td>
<td>Up to 5 ml diffusible hydrogen</td>
</tr>
</tbody>
</table>

**Table 3**

**Welding current and voltage conditions**

(Clause 5.5)

<table>
<thead>
<tr>
<th>Digit</th>
<th>Direct current: recommended electrode polarity</th>
<th>Alternating current: open circuit voltage, V, Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>–</td>
<td>Not recommended</td>
</tr>
<tr>
<td>1</td>
<td>+ or –</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>–</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>+ or –</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>–</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>+</td>
<td>70</td>
</tr>
<tr>
<td>7</td>
<td>+ or –</td>
<td>90</td>
</tr>
<tr>
<td>8</td>
<td>–</td>
<td>90</td>
</tr>
<tr>
<td>9</td>
<td>+</td>
<td>90</td>
</tr>
</tbody>
</table>

**Example 1**

The classification for the electrode EB 5426H1JX

The frequency of the alternating current is assumed to be 50 or 60 Hz. The open circuit voltage necessary when electrodes are used on direct current is closely related to the dynamic characteristics of the welding power source. Consequently no indication of the minimum open circuit voltage for direct current is given.

**Increased metal recovery:** The letters J, K and L shall be included in the classification as a suffix for those electrodes which have appreciable quantities of metal powder in their coating and give increased metal recovery with respect to that of core wire melted, in accordance to the range given in 5.0.2 (b).

The metal recovery shall be determined as ‘Effective Electrode Efficiency (Eₑ) as per the method given in IS 13043:1991.

**Radiographic quality electrodes:** The letter ‘X’ shall be included in the classification as a suffix for those electrodes which deposit radiographic quality welds.
Example 2

The classification for the electrode ER 4211

<table>
<thead>
<tr>
<th>Covered electrode</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of covering</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Strength</td>
<td>2</td>
</tr>
<tr>
<td>characteristics</td>
<td></td>
</tr>
<tr>
<td>(UTS = 410 – 510 N/mm² and YS = 330 N/mm² min.)</td>
<td></td>
</tr>
<tr>
<td>Elongation and impact properties</td>
<td>1</td>
</tr>
<tr>
<td>(Elongation = 22 % min. and impact = 47 J min. at 0°C)</td>
<td></td>
</tr>
<tr>
<td>Welding position</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Welding current and voltage conditions</td>
<td></td>
</tr>
<tr>
<td>(D ± and A 50)</td>
<td></td>
</tr>
</tbody>
</table>

**AWS codification of carbon steel and low alloy steel coated electrodes**

Chart - 1 shows the details of AWS coding of an electrode.

In the chart, E stands for electrode. It means that it is a stick electrode.

The first two digits are very important. They designate the minimum tensile strength of the weld metal that the electrode will produce.

The third digit indicates the welding positions.

The last digit in the code indicates the kind of flux coating used.

**BS codification of carbon steel and low alloy steel covered electrodes (BS 639 : 1976 equivalent to ISO 2560)**

As shown in chart 2, E stands for covered MMA electrode.

The first two digits indicate tensile strength and yield stress.

The next two digits indicate elongation and impact strength.

The letter after the first 4 digits indicates the type of covering.

The first 3 digits after the letter indicating the type of covering shows electrode efficiency.

The fourth digit after the letter indicating the type of covering shows the welding position.

The fifth digit after the letter indicating the type of covering indicates current and voltage.

In the case of rutile covered electrodes, the digits indicating the electrode efficiency after the letter indicating the types of covering will not be given as shown in chart 1.

Chart 2 shows an electrode coding with electrode efficiency.
AWS CODIFICATION OF CARBON STEEL AND LOW-ALLOY STEEL COATED ELECTRODES

Electrode

First digit
Second digit
Third digit
Fourth digit

First two digits indicate tensile strength of the deposited weld metal in 1000 PSI

Fourth digit (0 to 8) indicate the type of flux coating.
0 Cellulose sodium, or iron oxide mineral
1 Cellulose potassium
2 Titania sodium
3 Titania potassium
4 Iron powder titania
5 Low hydrogen lime - sodium
6 Low hydrogen lime - potassium
7 Iron oxide plus iron powder
8 Low hydrogen lime plus iron powder
9 A number left over for peculiar coating. This number is rarely used.

Third digit indicates the welding positions for electrodes.
1 All position
2 Flat & horizontal
3 Flat & down hand
FOUR DIGITS CODIFICATION

EXAMPLE: AWS – E 6013.

Electrode

* Tensile strength 60,000 psi

All position electrode

Titania potassium

FIVE DIGITS CODIFICATION

Electrode

* Tensile strength 110,000 psi.

All position electrode

Low hydrogen lime plus iron powder

* To get the tensile strength of the weld in p.s.i., the number given here should be multiplied by 1000.
Example (1) Covered electrode for manual metal arc welding having a rutile covering of medium thickness and depositing weld metal with the following minimum mechanical properties. (BS 639)

**Tensile Strength**: 500 N/mm²

**Elongation**: 23 %

**Impact strength**: 71 J at +20 °C, 37 J at 0 °C, 20 J at -20 °C.

It may be used for welding in all positions. It welds satisfactorily on alternating current with a minimum open-circuit voltage of 50 V and on direct current with positive polarity.

**The complete classification for the electrode** would therefore be E 43 21 R 1 3 and the compulsory part would be E 43 21 R.

<table>
<thead>
<tr>
<th>Covered electrode for manual metal arc welding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength</td>
<td></td>
</tr>
<tr>
<td>Elongation and impact strength</td>
<td></td>
</tr>
<tr>
<td>Covering</td>
<td></td>
</tr>
<tr>
<td>Welding positions</td>
<td></td>
</tr>
<tr>
<td>Current and voltage</td>
<td></td>
</tr>
</tbody>
</table>

Example (2) An electrode for manual metal arc welding having a basic covering, with a high efficiency and depositing weld metal containing 8 ml of diffusible hydrogen per 100 g of deposited weld metal with the following minimum mechanical properties.

**Yield stress**: 380 N/mm²

**Tensile strength**: 560 N/mm²

**Elongation**: 22 % Also a minimum elongation of 20%

**Impact strength**: 47 J at -20 °C with an impact value of 28 J at -20 °C

**Nominal efficiency**: 158%

It may be used for welding in all positions except vertical down, direct current only.

**The complete classification for the electrode** would, therefore, be E 51 33 B 160 2 0 (H) and the compulsory part would be E 51 33 B.

<table>
<thead>
<tr>
<th>Covered electrode for manual metal arc welding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength and yield stress</td>
<td></td>
</tr>
<tr>
<td>Elongation and impact strength</td>
<td></td>
</tr>
<tr>
<td>Covering</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
</tr>
<tr>
<td>Welding positions</td>
<td></td>
</tr>
<tr>
<td>Current and voltage</td>
<td></td>
</tr>
<tr>
<td>Hydrogen controlled</td>
<td></td>
</tr>
</tbody>
</table>
Selection and storage of electrodes

Objectives: At the end of this lesson you shall be able to
• select a suitable electrode to weld a particular job
• state the necessity of baking a coated electrode
• store and handle the electrode properly for better weld quality.

Selection/choice of electrodes

Selection of an electrode is very important in order to get a joint welded with the required strength.

Selection factors

Properties of base metal: Top quality weld should be as strong as the base metal.

Select an electrode that is recommended as per the properties of the base metal. (Fig 1)

<table>
<thead>
<tr>
<th>BASE METAL</th>
<th>ELECTRODE SELECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Steel</td>
<td>MEDIUM COATED RUTILE M.S. ELECTRODE</td>
</tr>
<tr>
<td>Medium Carbon Steel</td>
<td>HEAVY COATED LOW HYDROGEN M.S. ELECTRODE</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>COLUMBIAN BASED STAINLESS STEEL ELECTRODE</td>
</tr>
<tr>
<td>Copper</td>
<td>HEAVY COATED BRONZE ELECTRODE</td>
</tr>
</tbody>
</table>

The size of the electrode depends on:

‐ thickness of metal to be welded
‐ edge preparation of joints
‐ root run, intermediate or covering run
‐ welding position
‐ welder’s skill.

Never use a larger dia. electrode than the thickness of base metal.

Joint design and fit up

Select:

‐ deep penetration electrodes for insufficiently bevelled joints
‐ medium penetration electrodes for open and sufficiently bevelled joints. (Fig 2)

Welding position: Electrodes are manufactured for different positions, to produce better welds.

Select an electrode as per the welding position. (Fig 3)

Welding current: Electrodes are available for use with:

‐ AC or DC (straight or reverse polarity)
‐ AC and DC (both).

Select as per the availability of the welding machine.

Production efficiency: The deposition rate of electrode is important in production work. So select an iron powder electrode for production work.

Faster the weld, lower the cost.

Select the electrode, which is designed for the particular production work.

Usage and storage of electrodes

Electrodes are costly, therefore, use and consume every bit of them.

Do not discard STUB ENDS more than 40-50 mm length. (Fig 4)
Electrode coating can pick up moisture if exposed to atmosphere.

Store and keep the electrodes (air tight) in a dry place.

Heat the moisture affected/prone electrodes in an electrode drying oven at 110 - 150°C for one hour before using. (Fig 5)

Remember a moisture-affected electrode:
- has rusty stub end
- has white powder appearance in coating
- produces porous weld.

Always pick up the right electrode that will provide:
- good arc stability
- smooth weld bead
- fast deposition
- minimum spatters
- maximum weld strength
- easy slag removal.

Storage of electrodes: The efficiency of an electrode is affected if the covering becomes damp.
- Keep electrodes in unopened packets in a dry store.
- Place packages on a duckboard or pallet, not directly on the floor.
- Store so that air can circulate around and through the stack.
- Do not allow packages to be in contact with walls or other wet surfaces.
- The temperature of the store should be about 5°C higher than the outside shade temperature to prevent condensation of moisture.
- Free air circulation in the store is as important as heating. Avoid wide fluctuations in the store temperature.
- Where electrodes cannot be stored in ideal conditions place a moisture-absorbent material (e.g. silica-gel) inside each storage container.

Drying electrodes: Water in electrode covering is a potential source of hydrogen in the deposited metal and thus may cause:
- Porosity in the weld
- Cracking in the weld.

Indications of electrodes affected by moisture are:
- White layer on covering.
- Swelling of covering during welding.
- Disintegration of covering during welding.
- Excessive spatter.
- Excessive rusting of the core wire.

Electrodes affected by moisture may be dried before use by putting them in a controlled drying oven for approximately one hour at a temperature around 110 - 150°C. This should not be done without reference to the conditions laid down by the manufacturer. It is important that hydrogen controlled electrodes are stored in dry, heated conditions at all times.

Warning: Special drying procedures apply to hydrogen controlled electrodes. Follow the manufacturer’s instructions.
Safety precautions in handling gas cutting plant

Objectives: At the end of this lesson you shall be able to
• State the general safety precautions in oxy-acetylene plants.
• State the safety rules for handling gas cylinders.
• State the safety practices for handling gas regulators and hose-pipes.
• State the safety precautions related to blow pipe operations.
• State the safety required during gas cutting operation.

To be accident-free, one must know the safety rules first and then practise them as well. As we know can accident starts when safety ends.

Ignorance of rules is no excuse!

In gas welding, the welder must follow the safety precautions in handling gas welding plants and flame-setting to keep himself and others safe.

Safety precautions are always based on good common sense.

The following precautions are to be observed, to keep a gas welder accident-free.

General safety

Do not use lubricants (oil or grease) in any part or assembly of a gas welding plant. It may cause explosion.

Keep all flammable material away from the welding area. Always wear goggles with filter lens during gas welding. (Fig 1)

Always wear fire resistant clothes, asbestos gloves and apron.

Never wear nylon, greasy and torn clothes while welding. Whenever a leakage is noticed rectify it immediately to avoid fire hazards (Fig 2)

Keep the work area free from any form of fire.

Safety gas Cylinders

Do not roll gas cylinders or use them as rollers. Use a trolley to carry the cylinders.

Close the cylinder valves when not in use or empty. Keep full and empty cylinders separately.

Always open the cylinder valves slowly, not more than one and a half turn.

Use the correct cylinder keys to open the cylinders. Do not remove the cylinder keys from the cylinders while welding. It will help to close the cylinders QUICKLY in the case of a back-fire or flash-back.

Always use the cylinders in an upright position for easy handling and safety.

Even a small leakage can cause serious accidents.

(Always keep fire-fighting equipment handy and in working order to put out fires. (Fig 3)
Always crack the cylinder valves to clean the valve sockets before attaching regulators (Fig 4)

Safety for rubber hose pipes (Fig 5)
Inspect the rubber hose pipes periodically and replace the damaged ones.
Do not use odd bits of hose pipes / tubes.
Do not replace the hose pipes for acetylene with the ones used for oxygen.

Always use a black hose pipes for oxygen and maroon hosepipes for acetylene.

Safety for regulators
Prevent hammer blows to the gas cyclinders and ensure that water, dust and oil do not settle on the cylinders.
One right hand threaded connection for oxygen and left hand threaded connection for acetylene.

Safety for blowpipes
When a blowpipe is not in use put out the flame and place the blowpipe in a safe place.
When flame snaps out and backfires, quickly shut both the blowpipe valves (oxygen first) and dip in water.
Method of handling cutting torch—description, parts, function and uses

Objectives: At the end of this lesson you shall be able to
• explain the principle of gas cutting
• describe the cutting operation and its application.

Introduction to gas cutting: The most common method of cutting mild steel is by an oxy-acetylene cutting process. With an oxy-acetylene cutting torch, the cutting (oxidation) can be confined to a narrow strip and with little effect of heat on the adjoining metal. The cut appears like a saw-cut on a wooden plank. The method can be successfully used to cut ferrous metals i.e. mild steel.

Non-ferrous metals and their alloys cannot be cut by this process.

Principle of gas cutting: When a ferrous metal is heated to red hot condition and then exposed to pure oxygen, a chemical reaction takes place between the heated metal and oxygen. Due to this oxidation reaction, a large amount of heat is produced and cutting action takes place.

When a piece of wire with a red hot tip is placed in a container of pure oxygen, it bursts into flame immediately and is completely consumed. Fig 1 illustrates this reaction. Similarly in oxy-acetylene cutting the combination of red hot metal and pure oxygen causes rapid burning and iron is changed into iron oxide (oxidation).

By this continuous process of oxidation the metal can be cut through very rapidly.

The iron oxide is less in weight than the base metal.

Also the iron oxide is in molten condition called slag. So the jet of oxygen coming from the cutting torch will blow the molten slag away from the metal making a gap called ‘Kerf’. Fig 2

Cutting operation (Fig 2): There are two operations in oxy-acetylene gas cutting. A preheating flame is directed on the metal to be cut and raises it to bright red hot or ignition point (900°C app.). Then a stream of high pressure pure oxygen is directed on to the hot metal which oxidises and cuts the metal.

The two operations are done simultaneously with a single torch.

The torch is moved at a proper travel speed to produce a smooth cut. The removal of oxide particles from the line of cut is automatic by means of the force of oxygen jet during the progress of cut.

300 litres of oxygen are required to oxidize one kilogram of iron completely. The ignition temperature of steel for gas cutting is 875°C to 900°C.
**Application of cutting torch:** Oxy-acetylene cutting torch is used to cut mild steel plates above 4mm thickness. The M.S plate can be cut to its full length in straight line either parallel to the edge or at any angle to the edge of the plate. Bevelling the edges of a plate to any required angle can also be done by tilting the torch. Circles and any other curved profile can also be cut using the cutting torch by using a suitable guide or template.

Fig.3 to Fig.7 shows the guides used to cut straight lines, bevel and small circles.

**Cutting torch guides:** Guides are sometimes used during oxy acetylene cutting.

They can be either a roller guide, double support or spade guide with single support.

Cutting guides are held onto the nozzle of the cutting torch by tightening a clamp bolt. The clamps, where they are fitted, are adjusted so the inner cones of the preheat flames are approximately 2-3mm above the surface of the metal to be cut. The tip of the cutting nozzle is held at distance of 5-6mm above surface of the plate being cut.
Oxy-acetylene cutting equipment

Objectives: At the end of this lesson you shall be able to
• explain the features of the oxy-acetylene cutting equipment, its parts and cutting torch
• describe the oxy-acetylene cutting procedure
• differentiate between cutting and welding blowpipes.

Cutting equipment: The oxy-acetylene cutting equipment is similar to the welding equipment, except that instead of using a welding blowpipe, a cutting blowpipe is used. The cutting equipment consists of the following.

- Acetylene gas cylinder
- Oxygen gas cylinder
- Acetylene gas regulator
- Oxygen gas regulator (Heavy cutting requires higher pressure oxygen regulator.)
- Rubber hose-pipes for acetylene and oxygen
- Cutting blowpipe

(Cutting accessories i.e. cylinder key, spark lighter, cylinder trolley and other safety appliances are the same as are used for gas welding.)

The cutting torch (Fig 1): The cutting torch differs from the regular welding blowpipe in most cases; it has an additional lever for the control of the cutting oxygen used to cut the metal. The torch has the oxygen and acetylene control valves to control the oxygen and acetylene gases while preheating the metal.

The nozzle of the cutting blowpipe has one hole in the centre for cutting oxygen and a number of holes around the circle for the preheating flame. (Fig 3)

Oxy-acetylene cutting procedure: Fix a suitable size cutting nozzle in the cutting blowpipe. Ignite the cutting torch the same way as was done in the case of the welding blowpipe. Set the neutral flame for preheating. To start the cut, hold the cutting nozzle at angle 90° with the plate surface, and the inner cone of the heating flame 3 mm above the metal. Preheat the metal to bright red before pressing the cutting oxygen lever. If the cut is proceeding correctly, a shower of sparks will be seen to fall from the underside of the plate. Move the torch steadily on the punched line. If the edge of the cut appears to be too ragged, the torch is being moved too slowly. For a bevel cut, hold the cutting torch at the desired angle and proceed as is done in making a straight line cut. At the end of the cut, release the cutting oxygen lever and close the control valves of the oxygen and acetylene. Clean the cut and inspect.

Difference between cutting blowpipe and welding blowpipe: A cutting blowpipe has two control valves (oxygen and acetylene) to control the preheating flame and one lever type control valve to control the high pressure pure oxygen for making the cut.

A welding blowpipe has only two control valves to control the heating flame. (Fig 2)
The nozzle of the welding blowpipe has only one hole in the centre for the heating flame. (Fig 4)

The angle of the welding nozzle with the neck is 120°.

The cutting nozzle size is given by the diameter of the cutting oxygen orifice in mm.

The welding nozzle size is given by the volume of oxy-acetylene mixed gases coming out of the nozzle in cubic meter per hour.

Operating data for cutting mild steel

<table>
<thead>
<tr>
<th>Cutting nozzle size - mm</th>
<th>Thickness of plate (mm)</th>
<th>Cutting oxygen pressure Kg/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>3 - 6</td>
<td>1.0 - 1.4</td>
</tr>
<tr>
<td>1.2</td>
<td>6 - 19</td>
<td>1.4 - 2.1</td>
</tr>
<tr>
<td>1.6</td>
<td>19 - 100</td>
<td>2.1 - 4.2</td>
</tr>
<tr>
<td>2.0</td>
<td>100 - 150</td>
<td>4.2 - 4.6</td>
</tr>
<tr>
<td>2.4</td>
<td>150 - 200</td>
<td>4.6 - 4.9</td>
</tr>
<tr>
<td>2.8</td>
<td>200 - 250</td>
<td>4.9 - 5.5</td>
</tr>
<tr>
<td>3.2</td>
<td>250 - 300</td>
<td>5.5 - 5.6</td>
</tr>
</tbody>
</table>

Care and maintenance: The high pressure cutting oxygen lever should be operated only for gas cutting purposes.

Care should be taken while fitting the nozzle with the torch to avoid wrong thread. Dip the torch after each cutting operation in water to cool the nozzle.

To remove any slag particles or dirt from the nozzle orifice use the correct size nozzle cleaner Fig.5. Use an emery paper if the nozzle tip is damaged to make it sharp and to be at 90° with the nozzle axis.
# Oxy-acetylene hand cutting - piercing hole and profile cutting

**Objectives:** At the end of this lesson you shall be able to
- explain the special types of nozzles for gas cutting and their application
- describe the parts of a cutting equipment and their functions
- explain troubleshooting and the remedy of the faults in oxygen cutting.

## Table of some common cutting torch tips and their uses

<table>
<thead>
<tr>
<th>Number of preheat orifices in cutting torch tips</th>
<th>Number of preheat orifices in cutting torch tips</th>
<th>Degree of preheating</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td>2</td>
<td>Medium</td>
<td>For straight line or circular cutting of a clean plate.</td>
</tr>
<tr>
<td><img src="image2.png" alt="Image" /></td>
<td>2</td>
<td>Light</td>
<td>For splitting angle iron, trimming plates and sheet metal cutting.</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td>2</td>
<td>Light</td>
<td>For hand cutting rivet heads and machine cutting 30 deg. bevels.</td>
</tr>
<tr>
<td><img src="image4.png" alt="Image" /></td>
<td>2</td>
<td>Light</td>
<td>For straight line and shape cutting clean plate.</td>
</tr>
<tr>
<td><img src="image5.png" alt="Image" /></td>
<td>4</td>
<td>Medium</td>
<td>For rusty or painted surfaces.</td>
</tr>
<tr>
<td><img src="image6.png" alt="Image" /></td>
<td>2</td>
<td>Heavy</td>
<td>For cast iron cutting and preparing Vee for cast iron welding.</td>
</tr>
<tr>
<td><img src="image7.png" alt="Image" /></td>
<td>2</td>
<td>Very heavy</td>
<td>For general cutting; also for cutting and stainless steel.</td>
</tr>
<tr>
<td><img src="image8.png" alt="Image" /></td>
<td>4,6,6</td>
<td>Medium</td>
<td>For grooving, flame machining, gouging and removing imperfect welds.</td>
</tr>
<tr>
<td><img src="image9.png" alt="Image" /></td>
<td>6</td>
<td>Medium</td>
<td>For grooving, gouging or removing imperfect welds.</td>
</tr>
<tr>
<td><img src="image10.png" alt="Image" /></td>
<td>6</td>
<td>Medium</td>
<td>For machine cutting 45° deg. bevel or hand cutting rivet heads.</td>
</tr>
<tr>
<td><img src="image11.png" alt="Image" /></td>
<td>6</td>
<td>Heavy</td>
<td>Flared cutting orifices provide a large oxygen stream of low velocity for rivet head removal (washing).</td>
</tr>
</tbody>
</table>
**Special purpose nozzle:** For profile cutting, different types of nozzles are used for cutting metals in different shapes.

Nozzles used for cutting profiles are shown in Fig 1.

**Cutting torch:** Fig 2 Oxygen and fuel gas are mixed and then the gas is carried to the tip of the orifice to form 'preheat' flames. If oxygen is carried directly to the tip it oxidises the metal and blows it away to form the cut.

**Method of piercing a hole:** Hold the cutting blowpipe at right angles on the point where the hole is to be made. The point will be brightened. Release the cutting oxygen slowly. Raise the torch, tilt the nozzle slightly to the left and right directions so that the sparks may not foul the nozzle. Thus the hole may be pierced.

For cutting of the profile hold the blowpipe head in such a way that the oxygen stream is directed by the correct tilting of the blowpipe. It is obvious that the angle between the nozzle and the plate must remain constant and this poses the greatest difficulty for the beginners.

Position of the preheating flame as related to the plate surface is very important.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acetylene gas valve</td>
<td>To adjust the flow rate of acetylene gas.</td>
</tr>
<tr>
<td>2</td>
<td>Oxygen hose joint</td>
<td>To connect with the oxygen hose.</td>
</tr>
<tr>
<td>3</td>
<td>Acetylene gas hose joint</td>
<td>To connect with the acetylene gas hose.</td>
</tr>
<tr>
<td>4</td>
<td>Oxygen conduit</td>
<td>To lead oxygen.</td>
</tr>
<tr>
<td>5</td>
<td>Acetylene gas conduit</td>
<td>To lead acetylene gas.</td>
</tr>
<tr>
<td>6</td>
<td>Grip</td>
<td>To hold the torch.</td>
</tr>
<tr>
<td>7</td>
<td>Preheating oxygen valve</td>
<td>To adjust the preheating flame.</td>
</tr>
<tr>
<td>8</td>
<td>Cutting oxygen valve</td>
<td>To adjust the cutting oxygen flow rate.</td>
</tr>
<tr>
<td>9</td>
<td>Injector</td>
<td>To mix the acetylene gas with oxygen.</td>
</tr>
<tr>
<td>10</td>
<td>Cutting oxygen conduit</td>
<td>To lead the cutting oxygen.</td>
</tr>
<tr>
<td>11</td>
<td>Mixed gas conduit</td>
<td>To lead the mixture of acetylene gas and oxygen.</td>
</tr>
<tr>
<td>12</td>
<td>Torch head</td>
<td>To attach the nozzle.</td>
</tr>
</tbody>
</table>
**Troubleshooting**

<table>
<thead>
<tr>
<th>Object</th>
<th>Trouble</th>
<th>Part to be checked</th>
<th>Method</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torch</td>
<td>Gas leakage</td>
<td>Hose joint</td>
<td>Soap water or water</td>
<td>Tighten further or replace. At the beginning of the work.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Valve &amp; regulator</td>
<td>Soap water or water</td>
<td>Replace the torch. At the beginning of the work.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cutting tip attach-</td>
<td>Soap water or water</td>
<td>Tighten further or replace. At the beginning of the work.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ing part</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suction of</td>
<td>Injector</td>
<td>Plug the fuel gas hose mouth with your finger.</td>
<td>Replace. Periodical check for the low pressure torch.</td>
</tr>
<tr>
<td></td>
<td>Acetylene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preheating</td>
<td></td>
<td></td>
<td>Clean or replace. At the beginning of the work or at random.</td>
</tr>
<tr>
<td></td>
<td>flame shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cutting oxygen</td>
<td></td>
<td></td>
<td>Clean or replace. At the beginning of the work or at random.</td>
</tr>
<tr>
<td></td>
<td>flow</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Care and maintenance:** The cutting oxygen orifice should be cleaned at regular intervals by using different size wire of nozzle cleaner. (Fig 4)

**Characteristics of analysis of cutting:** This analysis has been made on referring to the cutting face and the formation of cut in this surface.

This can be analysed as shown in the figure. (Fig 5)

**Safety in gas cutting process**

**Objectives:** At the end of this lesson you shall be able to
- describe the safety precautions to be followed for handling gas cutting equipment
- explain the safety precautions to be followed by the operator
- state the safety required during gas cutting operation.

**Equipment safety:** Safety precautions for gas cutting equipment are the same as those adopted in the case of gas welding equipment.

**Safety for the operator** (Fig 1)

Always use safety apparel for the:
In case the flammable material is difficult to remove, suitable fire resisting guards/partitions must be provided.

Protect yourself and others from the flying sparks.

Ensure that the metal being cut is properly supported and balanced so that it will not fall on the feet of the operator or on the hoses.

Keep the space clear underneath the cutting job so as to allow the slag to run freely, and the cutting parts to fall safely.

Be careful about flying hot metal and sparks while starting a cut. Containers which hold combustible substances should not be taken directly for cutting or welding. (Fig 2) Wash the containers with carbon tetrachloride and caustic soda before welding or cutting and fill them with water before repairing.

Keep fire-fighting equipment handy and ready.

Common faults in gas cutting

Objectives: At the end of this lesson you shall be able to
- explain the common faults in cutting
- describe the causes and remedies
- explain the method of good gas cutting.

Common faults in cutting

(Fig 1) The tip is too high off the steel. The top edge is heated or rounded, the cut face is not smooth, and often the face is slightly bevelled where preheat effectiveness is partially lost due to the tip being held so high. The cutting speed must be reduced because of the danger of losing the cut.

(Fig 2) Extremely slow cutting speed. Pressure marks on the cut face indicate too much oxygen for the cutting conditions. Either the tip is too big, the cutting oxygen pressure is too high, or the speed is too slow as shown by the rounded or beaded top edge. On reducing the cutting oxygen volume to the correct proportions for the thickness of the cut, the pressure marks will recede toward the bottom edge until they finally disappear.
(Fig 3) Tip too close to the steel. The cut shows grooves and deep drag lines, caused by an unstable cutting action. Part of the preheat cones burned inside the kerf, where normal gas expansion affected the oxygen cutting stream.

(Fig 4) Too much cutting oxygen. The cut shows pressure marks caused by too much cutting oxygen. When more oxygen is supplied than can be consumed in oxidation, the remainder flows around the slags, creating gouges or pressure marks.

(Fig 5) Too much preheating. The cut shows a rounded top edge caused by too much preheat. Excess preheating does not increase the cutting speed, it only wastes gases.

(Fig 6) Poor quality bevel cut. The most common fault is gouging, caused by either excessive speed or inadequate preheat flames. Another fault is a rounded top edge caused by too much preheat, indicating excessive gas consumption.

(Fig 7) Slightly too fast a cutting speed. The drag lines on this cut incline backwards, but a ‘drop cut’ is still attained. The top edge is good; the cut face is smooth and slag-free. This quality is satisfactory for most production work.

(Fig 8) Slightly too slow a cutting speed. The cut is of high quality although there is some surface roughness caused by the vertical drag line. The top edge is usually slightly beaded. This quality is generally acceptable, but faster speeds are more desirable because the labour cost for this cut is too high.

In a good cut, the edges are square, and the lines of cut are vertical. (Fig 9)
Gas cutting machines (oxy-acetylene)

**Objective**: At the end of this lesson you shall be able to
- identify the different types of gas cutting machines.

### Straight line and circle cutting machines

These machines are used for regular, straight and circle cutting.

**Straight line cutting (Fig 1)**

**Large circle cutting (Fig 2)**

**Small circle cutting (Fig 3)**

### Profile cutting machines

These are used to cut any shape required for fabrication.

A profile cutting machine with a magnetic roller for multi-cutting heads is shown in Fig 5.

It is also called as cross-carriage cutting machine.

A profile cutting machine with magnetic roller for single cutting head is shown in Fig 4.

It is also called as radial arm cutting machine.

Profile cutting machines are also available with an electronic control and scanning head.

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*CG & M: Fitter (NSQF Level -5) - Related Theory for Exercise 1.4.60*
Pipe cutting machines

These are used for circumferential cutting or beveling of pipes.

A simple pipe cutting arrangement using a hand cutting blowpipe is shown in Fig 7.

The pipe is rotated by hand.

The pipe cutting machine with manual control shown in Fig 8 is rotated by hand around the pipe.