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General Technical Specification
of
Bhilai Steel Plant, SAIL

ENGINEERING PROJECTS (INDIA) LIMITED
(A GOVT. OF INDIA ENTERPRISE)
Core-3, Scope Complex, 7, Institutional Area,
Lodhi Road, New Delhi-110003
TEL NO: 011-24361666 FAX NO. 011-24363426
GENERAL SPECIFICATION
FOR
ELECTRICAL SYSTEM
(GS – 03)

MECON LIMITED
RANCHI - 834002

No. MEC/S/1901/11/38/00/00/F1889/R2

JULY, 2007
## CONTENTS

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Chapter No.</th>
<th>Contents</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td></td>
<td>Contents</td>
<td>2</td>
</tr>
<tr>
<td>2.0</td>
<td>1.01</td>
<td>General</td>
<td>7</td>
</tr>
<tr>
<td>3.0</td>
<td>1.01.01</td>
<td>Standards</td>
<td>7</td>
</tr>
<tr>
<td>4.0</td>
<td>1.01.02</td>
<td>Climatic Conditions</td>
<td>7</td>
</tr>
<tr>
<td>5.0</td>
<td>1.01.02.01</td>
<td>Environmental condition</td>
<td>7</td>
</tr>
<tr>
<td>6.0</td>
<td>1.01.02.02</td>
<td>Ambient conditions of shop units</td>
<td>8</td>
</tr>
<tr>
<td>7.0</td>
<td>1.01.03</td>
<td>Standard Voltage levels</td>
<td>9</td>
</tr>
<tr>
<td>8.0</td>
<td>1.01.03.01</td>
<td>Symmetrical short circuit ratings</td>
<td>10</td>
</tr>
<tr>
<td>9.0</td>
<td>1.01.03.02</td>
<td>Permissible variations</td>
<td>10</td>
</tr>
<tr>
<td>10.0</td>
<td>1.01.04</td>
<td>Criteria for selection of voltage levels for motors &amp; Power devices</td>
<td>11</td>
</tr>
<tr>
<td>11.0</td>
<td>1.01.05</td>
<td>Design criteria &amp; reliability conditions</td>
<td>11</td>
</tr>
<tr>
<td>12.0</td>
<td>1.01.05.01</td>
<td>Power Distribution system</td>
<td>11</td>
</tr>
<tr>
<td>13.0</td>
<td>1.01.06</td>
<td>Cabling</td>
<td>12</td>
</tr>
<tr>
<td>14.0</td>
<td>1.01.07</td>
<td>Motor starting and permissible voltage dips</td>
<td>13</td>
</tr>
<tr>
<td>15.0</td>
<td>1.01.08</td>
<td>Maximum Demand of MCC</td>
<td>13</td>
</tr>
<tr>
<td>16.0</td>
<td>1.01.09</td>
<td>Incomer rating selection for MCC</td>
<td>14</td>
</tr>
<tr>
<td>17.0</td>
<td>1.01.10</td>
<td>Outgoing Feeder Selection for MCC</td>
<td>14</td>
</tr>
<tr>
<td>18.0</td>
<td>1.01.11</td>
<td>Power Factor Compensation</td>
<td>15</td>
</tr>
<tr>
<td>19.0</td>
<td>1.01.12</td>
<td>Cable selection</td>
<td>15</td>
</tr>
<tr>
<td>20.0</td>
<td>1.01.12.01</td>
<td>Incomers of MCC / PDB / MLDB</td>
<td>15</td>
</tr>
<tr>
<td>21.0</td>
<td>1.01.12.02</td>
<td>Motors</td>
<td>15</td>
</tr>
<tr>
<td>22.0</td>
<td>1.01.12.03</td>
<td>Illumination System</td>
<td>15</td>
</tr>
<tr>
<td>23.0</td>
<td>1.01.12.04</td>
<td>Automation System</td>
<td>16</td>
</tr>
<tr>
<td>24.0</td>
<td>1.01.12.05</td>
<td>General</td>
<td>16</td>
</tr>
<tr>
<td>25.0</td>
<td>1.01.13</td>
<td>Ventilation and Air Conditioning</td>
<td>16</td>
</tr>
<tr>
<td>26.0</td>
<td>1.01.13.01</td>
<td>Substation building, MCC Rooms and Cable Cellar</td>
<td>17</td>
</tr>
<tr>
<td>27.0</td>
<td>1.01.13.02</td>
<td>Electrical rooms with electronic equipment / Central Control rooms</td>
<td>17</td>
</tr>
<tr>
<td>28.0</td>
<td>1.01.13.03</td>
<td>Small local Control Rooms/pulpits</td>
<td>17</td>
</tr>
<tr>
<td>29.0</td>
<td>1.01.13.04</td>
<td>Cable tunnels</td>
<td>17</td>
</tr>
<tr>
<td>30.0</td>
<td>1.01.13.04</td>
<td>General</td>
<td>18</td>
</tr>
<tr>
<td>31.0</td>
<td>1.01.14</td>
<td>Variable Speed AC Drives.</td>
<td>18</td>
</tr>
<tr>
<td>32.0</td>
<td>1.01.15</td>
<td>Control Philosophy</td>
<td>18</td>
</tr>
<tr>
<td>33.0</td>
<td>1.01.15.01</td>
<td>General</td>
<td>18</td>
</tr>
<tr>
<td>34.0</td>
<td>1.01.15.02</td>
<td>Modes of operation</td>
<td>19</td>
</tr>
<tr>
<td>Section</td>
<td>Subsection</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>35.0</td>
<td>1.01.16</td>
<td>Spares Philosophy</td>
<td>21</td>
</tr>
<tr>
<td>36.0</td>
<td>1.01.17</td>
<td>Uninterrupted Power Supply (UPS)</td>
<td>21</td>
</tr>
<tr>
<td>37.0</td>
<td>1.01.18</td>
<td>Colour coding of equipment</td>
<td>22</td>
</tr>
<tr>
<td>38.0</td>
<td>1.01.19</td>
<td>Drawings and documents</td>
<td>22</td>
</tr>
<tr>
<td>39.0</td>
<td>1.02</td>
<td>EQUIPMENTS</td>
<td>23</td>
</tr>
<tr>
<td>40.0</td>
<td>1.02.01</td>
<td>TRANSFORMER</td>
<td>23</td>
</tr>
<tr>
<td>41.0</td>
<td>1.02.02</td>
<td>VCB (Transformer Isolation)</td>
<td>32</td>
</tr>
<tr>
<td>42.0</td>
<td>1.02.03</td>
<td>415V Switchgear</td>
<td>36</td>
</tr>
<tr>
<td>43.0</td>
<td>1.02.04</td>
<td>LT busduct</td>
<td>45</td>
</tr>
<tr>
<td>44.0</td>
<td>1.02.05</td>
<td>Power Distribution Board (PDB)</td>
<td>48</td>
</tr>
<tr>
<td>45.0</td>
<td>1.02.06</td>
<td>Motors &amp; Field devices</td>
<td>49</td>
</tr>
<tr>
<td>46.0</td>
<td>1.02.06.01</td>
<td>Low voltage squirrel cage induction motors</td>
<td>49</td>
</tr>
<tr>
<td>47.0</td>
<td>1.02.06.02</td>
<td>Low voltage slip ring induction motors</td>
<td>51</td>
</tr>
<tr>
<td>48.0</td>
<td>1.02.06.03</td>
<td>Roller Table Motors (Torque motors)</td>
<td>54</td>
</tr>
<tr>
<td>49.0</td>
<td>1.02.06.04</td>
<td>High voltage squirrel cage induction motors</td>
<td>54</td>
</tr>
<tr>
<td>50.0</td>
<td>1.02.06.05</td>
<td>Synchronous Motors</td>
<td>57</td>
</tr>
<tr>
<td>51.0</td>
<td>1.02.06.06</td>
<td>LT Inverter Duty Motor</td>
<td>59</td>
</tr>
<tr>
<td>52.0</td>
<td>1.02.06.07</td>
<td>DC Electromagnetic brake</td>
<td>63</td>
</tr>
<tr>
<td>53.0</td>
<td>1.02.06.08</td>
<td>Field Switches</td>
<td>64</td>
</tr>
<tr>
<td>54.0</td>
<td>1.02.06.09</td>
<td>Power Resistance</td>
<td>64</td>
</tr>
<tr>
<td>55.0</td>
<td>1.02.07</td>
<td>Individual Drive Control Level</td>
<td>65</td>
</tr>
<tr>
<td>56.0</td>
<td>1.02.07.01</td>
<td>Variable Frequency Drive (VFD)</td>
<td>65</td>
</tr>
<tr>
<td>57.0</td>
<td>1.02.07.02</td>
<td>AC Line Reactor</td>
<td>73</td>
</tr>
<tr>
<td>58.0</td>
<td>1.02.07.03</td>
<td>Load Commutated Inverter (LCI)</td>
<td>73</td>
</tr>
<tr>
<td>59.0</td>
<td>1.02.08</td>
<td>Intelligent type MCC</td>
<td>75</td>
</tr>
<tr>
<td>60.0</td>
<td>1.02.09</td>
<td>Stand Alone Starter</td>
<td>83</td>
</tr>
<tr>
<td>61.0</td>
<td>1.02.10</td>
<td>Soft Starter</td>
<td>86</td>
</tr>
<tr>
<td>62.0</td>
<td>1.02.11</td>
<td>Specifications of major components</td>
<td>91</td>
</tr>
<tr>
<td>63.0</td>
<td>1.02.11.01</td>
<td>Moulded Case Circuit Breaker (MCCB)</td>
<td>91</td>
</tr>
<tr>
<td>64.0</td>
<td>1.02.11.02</td>
<td>AC Contactors</td>
<td>92</td>
</tr>
<tr>
<td>65.0</td>
<td>1.02.11.03</td>
<td>Current transformers</td>
<td>93</td>
</tr>
<tr>
<td>66.0</td>
<td>1.02.11.04</td>
<td>Control transformers</td>
<td>93</td>
</tr>
<tr>
<td>67.0</td>
<td>1.02.11.05</td>
<td>Indicating instruments</td>
<td>93</td>
</tr>
<tr>
<td>68.0</td>
<td>1.02.11.06</td>
<td>Thermal Overload Relays</td>
<td>94</td>
</tr>
<tr>
<td>69.0</td>
<td>1.02.11.07</td>
<td>Magnetic Overload Relays</td>
<td>94</td>
</tr>
<tr>
<td>70.0</td>
<td>1.02.11.08</td>
<td>Push Buttons</td>
<td>95</td>
</tr>
<tr>
<td>71.0</td>
<td>1.02.11.09</td>
<td>Indicating Lamps</td>
<td>95</td>
</tr>
<tr>
<td>72.0</td>
<td>1.02.11.10</td>
<td>Miniature Circuit Breakers (MCB)</td>
<td>96</td>
</tr>
<tr>
<td>73.0</td>
<td>1.02.11.11</td>
<td>Selector Switches</td>
<td>97</td>
</tr>
<tr>
<td>74.0</td>
<td>1.02.12</td>
<td>Local Control Stations</td>
<td>97</td>
</tr>
<tr>
<td>Section</td>
<td>Subsection</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>75.0</td>
<td>1.02.13</td>
<td>Control Desk</td>
<td>98</td>
</tr>
<tr>
<td>76.0</td>
<td>1.02.14</td>
<td>Control System Concept And Philosophy</td>
<td>100</td>
</tr>
<tr>
<td>77.0</td>
<td>1.02.15</td>
<td>Automation System</td>
<td>101</td>
</tr>
<tr>
<td>78.0</td>
<td>1.02.15.01</td>
<td>General</td>
<td>101</td>
</tr>
<tr>
<td>79.0</td>
<td>1.02.15.02</td>
<td>Programmable Logic Controller (PLC)</td>
<td>111</td>
</tr>
<tr>
<td>80.0</td>
<td>1.02.15.03</td>
<td>Human Machine Interface (HMI), Work Station &amp; Engineering Station</td>
<td>120</td>
</tr>
<tr>
<td>81.0</td>
<td>1.02.15.04</td>
<td>Server</td>
<td>122</td>
</tr>
<tr>
<td>82.0</td>
<td>1.02.15.05</td>
<td>Software</td>
<td>123</td>
</tr>
<tr>
<td>83.0</td>
<td>1.02.16</td>
<td>Large Screen Display System</td>
<td>126</td>
</tr>
<tr>
<td>84.0</td>
<td>1.02.17</td>
<td>Uninterrupted Power Supply</td>
<td>127</td>
</tr>
<tr>
<td>85.0</td>
<td>1.02.18</td>
<td>Electronic Weighing System</td>
<td>135</td>
</tr>
<tr>
<td>86.0</td>
<td>1.02.19</td>
<td>CABLES</td>
<td>141</td>
</tr>
<tr>
<td>87.0</td>
<td>1.02.19.1</td>
<td>HT Cables</td>
<td>141</td>
</tr>
<tr>
<td>88.0</td>
<td>1.02.19.1.i</td>
<td>33 kV kV(UE) XLPE cables</td>
<td>141</td>
</tr>
<tr>
<td>89.0</td>
<td>1.02.19.1.ii</td>
<td>6.6 / 11 kV (UE) XLPE cables</td>
<td>142</td>
</tr>
<tr>
<td>90.0</td>
<td>1.02.19.2</td>
<td>LT CABLES</td>
<td>143</td>
</tr>
<tr>
<td>91.0</td>
<td>1.02.19.2.i</td>
<td>1.1 kV Power Cable</td>
<td>143</td>
</tr>
<tr>
<td>92.0</td>
<td>1.02.19.2.ii</td>
<td>1.1 KV Grade Control Cable</td>
<td>144</td>
</tr>
<tr>
<td>93.0</td>
<td>1.02.19.2.iii</td>
<td>1.1 KV Grade Screened /Special Cable</td>
<td>145</td>
</tr>
<tr>
<td>94.0</td>
<td>1.02.19.2.iv</td>
<td>Heat resistant cable</td>
<td>147</td>
</tr>
<tr>
<td>95.0</td>
<td>1.02.19.2.v</td>
<td>Trailing cable</td>
<td>147</td>
</tr>
<tr>
<td>96.0</td>
<td>1.02.19.2.vi</td>
<td>Flame Retardant Low Smoke (FRLS) Cables</td>
<td>148</td>
</tr>
<tr>
<td>97.0</td>
<td>01.02.20</td>
<td>EOT Cranes</td>
<td>148</td>
</tr>
<tr>
<td>98.0</td>
<td>1.02.21</td>
<td>Erection Specification</td>
<td>164</td>
</tr>
<tr>
<td>99.0</td>
<td>1.02.21.01</td>
<td>Guidelines for design of system and engineering the layout of electrical equipment.</td>
<td>164</td>
</tr>
<tr>
<td>100.0</td>
<td>1.02.21.01.01</td>
<td>General</td>
<td>164</td>
</tr>
<tr>
<td>101.0</td>
<td>1.02.21.01.02</td>
<td>Electrical premises</td>
<td>164</td>
</tr>
<tr>
<td>102.0</td>
<td>1.02.21.01.03</td>
<td>Control rooms/pulpits</td>
<td>165</td>
</tr>
<tr>
<td>103.0</td>
<td>1.02.21.01.04</td>
<td>Cable tunnels</td>
<td>165</td>
</tr>
<tr>
<td>104.0</td>
<td>1.02.21.01.05</td>
<td>Cable shafts</td>
<td>166</td>
</tr>
<tr>
<td>105.0</td>
<td>1.02.21.01.06</td>
<td>Clearances inside the electrical rooms</td>
<td>166</td>
</tr>
<tr>
<td>106.0</td>
<td>1.02.21.01.07</td>
<td>Transformer rooms</td>
<td>167</td>
</tr>
<tr>
<td>107.0</td>
<td>1.02.21.02</td>
<td>Guide-line for erection of Electrical equipment and accessories</td>
<td>167</td>
</tr>
<tr>
<td>108.0</td>
<td>1.02.21.02.01</td>
<td>General</td>
<td>167</td>
</tr>
<tr>
<td>109.0</td>
<td>1.02.21.02.02</td>
<td>Rotating machines</td>
<td>168</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>110.0</td>
<td>1.02.21.02.03</td>
<td>Sheet metal enclosed panels, open control panels, control desks and boxes</td>
<td>169</td>
</tr>
<tr>
<td>111.0</td>
<td>1.02.21.02.04</td>
<td>Static converters</td>
<td>170</td>
</tr>
<tr>
<td>112.0</td>
<td>1.02.21.02.05</td>
<td>Transformers and reactors</td>
<td>170</td>
</tr>
<tr>
<td>113.0</td>
<td>1.02.21.02.06</td>
<td>Battery installation</td>
<td>171</td>
</tr>
<tr>
<td>114.0</td>
<td>1.02.21.02.07</td>
<td>Busbar</td>
<td>171</td>
</tr>
<tr>
<td>115.0</td>
<td>1.02.21.02.08</td>
<td>Crane Trolley Lines</td>
<td>171</td>
</tr>
<tr>
<td>116.0</td>
<td>1.02.21.02.09</td>
<td>Resistance Box</td>
<td>171</td>
</tr>
<tr>
<td>117.0</td>
<td>1.02.21.02.10</td>
<td>Cables Installations</td>
<td>172</td>
</tr>
<tr>
<td>118.0</td>
<td>1.02.21.02.11.1</td>
<td>Laying in tunnels/surface ducts/on structures</td>
<td>172</td>
</tr>
<tr>
<td>119.0</td>
<td>1.02.21.02.11.2</td>
<td>Structures for cable laying</td>
<td>173</td>
</tr>
<tr>
<td>120.0</td>
<td>1.02.21.02.11.2</td>
<td>Cable Joint/termination accessories</td>
<td>176</td>
</tr>
<tr>
<td>121.0</td>
<td>1.02.21.02.12</td>
<td>Exposed conduits</td>
<td>177</td>
</tr>
<tr>
<td>122.0</td>
<td>1.02.22</td>
<td>Earthing and lightning protection</td>
<td>177</td>
</tr>
<tr>
<td>123.0</td>
<td>1.02.22.01</td>
<td>Earthing</td>
<td>179</td>
</tr>
<tr>
<td>124.0</td>
<td>1.02.22.02</td>
<td>Conductor sizes for ground connections</td>
<td>179</td>
</tr>
<tr>
<td>125.0</td>
<td>1.02.22.03</td>
<td>Earthing electrodes</td>
<td>179</td>
</tr>
<tr>
<td>126.0</td>
<td>1.02.22.04</td>
<td>Lightning protection</td>
<td>180</td>
</tr>
<tr>
<td>127.0</td>
<td>1.02.23</td>
<td>Repair network</td>
<td>181</td>
</tr>
<tr>
<td>128.0</td>
<td>1.02.23.01</td>
<td>General</td>
<td>181</td>
</tr>
<tr>
<td>129.0</td>
<td>1.02.23.02</td>
<td>Switch socket outlets</td>
<td>181</td>
</tr>
<tr>
<td>130.0</td>
<td>1.02.23.03</td>
<td>Cables</td>
<td>181</td>
</tr>
<tr>
<td>131.0</td>
<td>1.02.24</td>
<td>Ventilation and Air-Conditioning of Electrical Premises/Control Rooms</td>
<td>182</td>
</tr>
<tr>
<td>132.0</td>
<td>1.02.24.01</td>
<td>General</td>
<td>182</td>
</tr>
<tr>
<td>133.0</td>
<td>1.02.24.02</td>
<td>Switchgear rooms, MCC rooms, Cable cellar</td>
<td>182</td>
</tr>
<tr>
<td>134.0</td>
<td>1.02.24.03</td>
<td>Electrical rooms with electronic equipment</td>
<td>182</td>
</tr>
<tr>
<td>135.0</td>
<td>1.02.24.04</td>
<td>Central Control rooms, Rooms for PLC, Servers, Computers and Level-1/2 automation system equipment.</td>
<td>183</td>
</tr>
<tr>
<td>136.0</td>
<td>1.02.24.05</td>
<td>Small local Control Rooms/pulpits</td>
<td>183</td>
</tr>
<tr>
<td>137.0</td>
<td>1.02.24.06</td>
<td>Cable tunnels and basements</td>
<td>183</td>
</tr>
<tr>
<td>138.0</td>
<td>1.02.25</td>
<td>Testing</td>
<td>183</td>
</tr>
<tr>
<td>139.0</td>
<td>1.02.25.01</td>
<td>Type &amp; Routine</td>
<td>184</td>
</tr>
<tr>
<td>140.0</td>
<td>1.02.25.01.01</td>
<td>Transformers</td>
<td>184</td>
</tr>
<tr>
<td>141.0</td>
<td>1.02.25.01.02</td>
<td>Busduct</td>
<td>184</td>
</tr>
<tr>
<td>142.0</td>
<td>1.02.25.01.03</td>
<td>Power Control Centre and LT switchgear</td>
<td>185</td>
</tr>
<tr>
<td>143.0</td>
<td>1.02.25.01.04</td>
<td>Load Break Isolator</td>
<td>185</td>
</tr>
<tr>
<td>144.0</td>
<td>1.02.25.01.05</td>
<td>Current Transformer and voltage transformer</td>
<td>185</td>
</tr>
<tr>
<td>145.0</td>
<td>1.02.25.01.06</td>
<td>Final Test of Materials of Grounding and lightning</td>
<td>186</td>
</tr>
<tr>
<td></td>
<td>System</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>146.0</td>
<td>1.02.25.01.07 Cables</td>
<td>186</td>
<td></td>
</tr>
<tr>
<td>147.0</td>
<td>1.02.25.01.08 Motors</td>
<td>187</td>
<td></td>
</tr>
<tr>
<td>148.0</td>
<td>1.02.25.01.09 Site tests and checks</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>149.0</td>
<td>1.02.25.01.09.01 General</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>150.0</td>
<td>1.02.25.01.09.02 Trial Run Test</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>151.0</td>
<td>1.02.25.01.09.03 Acceptance test</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>152.0</td>
<td>1.02.25.01.09.04 Site Tests</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>153.0</td>
<td>Appendix – Selection of Power Components &amp; Wiring for Continuous Duty Cage Motor Drives</td>
<td>192</td>
<td></td>
</tr>
<tr>
<td>154.0</td>
<td>1.02.26 Illumination</td>
<td>193</td>
<td></td>
</tr>
</tbody>
</table>
10.0 ELECTRICAL

1.01 General

1.01.01 Standards

The design, manufacture, assembly and testing as well as performance (including safety, earthing and other essential provisions) of equipment and accessories covered under this specification shall, in general, comply with the latest issue of:

- Latest applicable Standards and Codes of Practices published by Indian Standards Institution (BIS).
- Latest IPSS (Interplant Standards for Steel Industry)
- Latest Indian Electricity Rules & statutory requirements of Central Govt. and State Govt.

In case, the tenderer is not in a position to comply fully with certain IS / IPSS specifications or in respect of certain items for which there are no IS / IPSS specifications, the tenderer may base his proposals on IEC recommendations or other reputed national or international standards subject to the approval of the Purchaser.

The components and materials used and the equipment supplied shall conform to high standards of design, engineering and workmanship and shall be suitable for efficient operation and reliable service in steel plant conditions.

All equipments supplied and all work done including system design and detailed engineering shall also comply with the statutory requirements of Govt. of India and the respective governments of state in which the plant is situated. The installation shall also confirm to Indian Electricity Act and Indian Electricity Rules.

In case of any contradiction between the data given in the Technical Specification (TS) and this General Technical specification (GTS), data given in the Technical specification (TS) shall prevail.

1.01.02 Climatic Conditions

1.01.02.01 Environmental condition

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Environmental condition</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Maximum ambient temp.</td>
<td>50 deg. C</td>
</tr>
<tr>
<td>2.0</td>
<td>Maximum Humidity</td>
<td>100 % does not occur simultaneously with maximum temperature.</td>
</tr>
<tr>
<td>3.0</td>
<td>Height</td>
<td>Less than 1000 M.</td>
</tr>
<tr>
<td>Sl.No</td>
<td>Area</td>
<td>Data</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>1.01.02</td>
<td>Ambient conditions of shop units</td>
<td>Generally following maximum ambient temperature shall be considered in different units of the integrated steel plant.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Environmental condition</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>Environment</td>
<td>Dusty &amp; Corrosive</td>
</tr>
</tbody>
</table>

### 1.01.02.02

**Ambient conditions of shop units**

Generally following maximum ambient temperature shall be considered in different units of the integrated steel plant.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Area</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Coke Ovens &amp; Byproduct Plant</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Battery cellar</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Battery Top</td>
<td>+ 60 Deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>Coal Tower, Intermediate &amp; End benches</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>4.</td>
<td>Pusher Car &amp; Loco</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>5.</td>
<td>Guide Car &amp; Charging Car</td>
<td>+ 60 Deg. C</td>
</tr>
<tr>
<td>B.</td>
<td>Blast furnace</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Cast house</td>
<td>+ 60 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Furnace proper</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>Stock house</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>4.</td>
<td>Pump house</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>5.</td>
<td>Stove area</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>6.</td>
<td>GCP area</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>7.</td>
<td>Other areas</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>C.</td>
<td>Steel Melting Shop</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Converter Bay</td>
<td>+ 60 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Mixer Bay</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>Other areas</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>D.</td>
<td>Continuous Casting Shop</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Casting bay</td>
<td>+ 60 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Withdrawal, straightening and gas cutting areas</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>Other areas</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>E.</td>
<td>Hot rolling mills</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Generally</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Finishing bays</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>3.</td>
<td>Foundry</td>
<td>+ 55 Deg. C</td>
</tr>
<tr>
<td>4.</td>
<td>Auxiliary Shops</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>F.</td>
<td>Other areas</td>
<td>+ 50 Deg. C</td>
</tr>
<tr>
<td>G.</td>
<td>Electrical rooms</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>HT/LT substation &amp; MCC rooms (ventilated)</td>
<td>+ 45 Deg. C</td>
</tr>
<tr>
<td>2.</td>
<td>Cable basements / tunnels (ventilated)</td>
<td>+ 45 Deg. C</td>
</tr>
<tr>
<td>H.</td>
<td>Control Rooms</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Control rooms – Air conditioned</td>
<td>+ 24 Deg. C</td>
</tr>
</tbody>
</table>

Equipment selection and de-rating shall generally be based on ambient temperature of 50 Deg.C. For specific areas and shops, the ambient temperature conditions indicated above shall be taken into consideration and equipment shall be suitably de-rated accordingly.
The equipment offered should be suitable for smooth, efficient and trouble free service in the tropical humid climate prevailing at plant site and under the ambient temperature conditions indicated above for the different shops and areas. In hot areas of higher temperature conditions, the equipment shall be adequately protected against damage from radiant heat and hot air.

The equipment shall be designed to give efficient and reliable performance under heavy steel plant conditions and shall be such that the risks of accidental short-circuits due to animals, birds or vermins are avoided.

1.01.03 Standard Voltage levels:

In case the standard voltage levels to be adopted in the plant are specified in the Technical specification, it shall be followed. In absence of any details indicated in the Technical Specification, the following standard voltage levels shall be adopted.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Description</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HT AC</td>
<td>11 KV / 6.6 KV , 3 phase, 50 Hz, unearthed neutral</td>
</tr>
<tr>
<td>2.</td>
<td>LT AC</td>
<td>415V, 3 Phase, 50 Hz, 4 wire, solidly earthed</td>
</tr>
<tr>
<td>3.</td>
<td>AC control and signaling voltage</td>
<td>240V, AC ±10% obtained using suitable control transformers with auto changeover facility.</td>
</tr>
<tr>
<td>4.</td>
<td>DC supply voltage</td>
<td>220 Volts / 110 Volts</td>
</tr>
<tr>
<td>5.</td>
<td>DC control and signaling voltage</td>
<td>220 Volts / 110 Volts</td>
</tr>
<tr>
<td>6.</td>
<td>Control voltage for HT switchgear equipment</td>
<td>110 V DC from battery in HT S/S area. 220 V DC from battery in MSDS area.</td>
</tr>
<tr>
<td>7.</td>
<td>Special socket outlets for portable lamps</td>
<td>24V, single phase, 50 Hz, AC obtained through suitable transformers</td>
</tr>
<tr>
<td>8.</td>
<td>DC Electro-magnetic brakes</td>
<td>220V, DC, obtained through individual rectifiers</td>
</tr>
<tr>
<td>9.</td>
<td>Solenoid valves</td>
<td>24V DC, unearthed</td>
</tr>
<tr>
<td>10.</td>
<td>Machine tools lighting</td>
<td>24 V AC</td>
</tr>
<tr>
<td>11.</td>
<td>Sockets for Welding purposes</td>
<td>415V, 100A, 3 pin plus earth with plug interlocked switch</td>
</tr>
<tr>
<td>12.</td>
<td>Sockets for hand tools</td>
<td>240V, 15A, 2 pin plus earth with plug interlocked switch</td>
</tr>
<tr>
<td>13.</td>
<td>Illumination system</td>
<td>240 V AC for general application. 24 V AC for confined &amp; semi confined area. (as per IPSS).</td>
</tr>
<tr>
<td>14.</td>
<td>PLC power supply</td>
<td>240 V AC, 50 Hz, obtained through UPS (for processor, RIO chassis,</td>
</tr>
</tbody>
</table>
### Sl.No | Description | Data
--- | --- | ---
15. | Monitoring and signaling in electronic installations, mimic panels | 24 V, DC (Through PLC output for PLC control boards / desks)
16. | PLC DI interrogation voltage | 24 V DC
17. | PLC DO voltage | 24 V DC

### 1.01.03.01 Symmetrical short circuit ratings:

The three phase symmetrical short-circuit ratings of the switchgear at the different voltage levels shall be as follows unless specifically indicated in the Technical specification:

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Description</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>11 kV switchgear</td>
<td>40 kA for 3 sec.</td>
</tr>
<tr>
<td>2.</td>
<td>6.6 kV switchgear</td>
<td>40 kA for 3 sec.</td>
</tr>
<tr>
<td>3.</td>
<td>415 V switchgear</td>
<td>50 kA for 1 sec.</td>
</tr>
</tbody>
</table>

### 1.01.03.02 Permissible variations:

The system / unit / plant / equipment shall be designed so as to be suitable for the following variations in voltage and frequency unless specifically indicated in the Technical specification:

<table>
<thead>
<tr>
<th>Description</th>
<th>Voltage</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permissible variations with rated performance, rated current and control effectiveness maintained</td>
<td>For LT system: +10% &amp; -15% For HT system: +6% &amp; -9%</td>
<td>Frequency variation for both HT &amp; LT shall be +4%, -6%</td>
</tr>
<tr>
<td>Permissible variations with changes in rated Current / torque but without any undesirable effect on performance</td>
<td>+/- 10%</td>
<td>+/- 3%</td>
</tr>
<tr>
<td>Permissible variations for control and regulation equipment</td>
<td>+/- 15%</td>
<td>+6%, -6%</td>
</tr>
</tbody>
</table>
### Criteria for selection of voltage levels for motors & Power devices:

- AC squirrel cage induction motors of ratings up to 200 kW and slip ring motors up to 250 kW shall be fed at LT, 415V, 3 phase, 4 wire, 50 Hz with DOL.
- AC motors of ratings in excess of 200KW upto 1000 KW and beyond 1000 KW shall be connected to 6.6 KV U/E and 11 KV U/E power supply system respectively for DOL starting. The HT voltage level shall be as specified in the Technical specification.
- AC squirrel cage induction motors of ratings up to 200kW may be fed at LT, 415V, 3 phase 4 wire 50 Hz, with VFD where speed control is required.
- For motor rating more than 200 KW up to 1000 KW shall be provided with VFD where speed control is required, the rated voltage of the motor shall be 690 V.
- Soft starters with DOL bypass shall be provided for drives ratings ranging from 90 KW to 200 KW where full torque load starting and speed variation is not required.

### Design criteria & reliability conditions:

#### Power Distribution System

The power distribution system shall meet the following guidelines:

- Suitable numbers of 415V LT Substation (LTSS) shall be provided for feeding different Motor control centers and auxiliaries power distribution boards as required for the plant.
- The MCC / PDB / MLDB shall be fed from LTSS.
- Suitable numbers of 415V Motor control centers shall be provided for feeding power supply to motors of rating 90 KW and below.
- Field located Power supply panels (MCB DB / Local Starter Panels) shall be fed from MCC.
- Electronic relays with display (for motor rating of 37 KW and above) shall be considered in place of thermal overload relays as follows:
  - Electronic over load relay protection for motors below 15 KW for crane application and for reversible drives. Electronic over load relay / MPCB protection for motors below 15 KW for other application
  - EOCR for OC & EF, unbalance protection for motors rated 18.5 KW to 90 KW
  - Composite motor protection relay with OL, OC, EF, unbalanced & locked rotor protection with digital display for motor rated 110 KW and above.
  - EOCR shall be used only for non-intelligent feeders.
- Motor of rating above 90 KW shall be provided with independent Motor control Panel (MCP) which shall be fed directly from LTSS. Power devices like MCCB,
Contactors, intelligent motor control relays / microprocessor based MPR (for non intelligent controllers) etc. shall be located in independent MCPs. Each MCP shall be located in MCC room by the side of the respective group MCC.

- VFD’s shall be provided for process fans / pumps as per technological requirement
- A dedicated MCC with two incomers (one from PCC and other from DG set or any emergency power source) and bus coupler shall be provided for catering to all emergency loads of the shop/unit.
- MCCB, contactor and overload relay rating for the low voltage general purpose induction motors shall be selected as per type-2 coordination chart of selected manufacturer. However the minimum contactor rating shall be 32A.
- All the important drives (all 6.6 KV, 11 KV & 690 V motors) should be provided with suitable CBM systems such as vibration monitoring, current signature, temperature etc. Information from CBM systems to be interfaced to HMI system as well as plant-wide CBM system.

1.01.05.02 The capacities of the transformer shall be selected as per the following guidelines:

- MD of MCC, shall be calculated as per the guidelines given in clause no. 1.01.08 of the General Technical Specifications.
- Load factor of 0.9 shall be considered for motors being fed from 415V LTSS. The load factor shall be applied on the kW rating of motors. Only working motors shall be considered.
- Load of lighting transformer shall be considered as per the kVA rating of transformer.
- Where ACDB is provided along with the LTSS, then load of ventilation system with 0.9 load factor shall be considered.
- Diversity factor of 1.1 shall be used on the summation of MDs of various MCCs, motors, lighting transformers and ACDB.
- Spare capacity of 20% shall be provided for future use.
- Each LTSS shall be fed from two identically rated transformers.
- In case of outage of any transformer, the remaining transformer shall be loaded up to 80% of their rating.
- Transformer shall be selected from standard rating of 1000/2000 KVA only
- It shall be ensured that when all the loads are in operation and the largest motor is started, the voltage drop at the motor terminals shall not be more than 15%.

1.01.05.03 The rating of outgoing feeders of LTSS shall be selected from standard circuit breakers ratings of 800A, 1000A & 1600 A only considering the load requirement and derating factors due to ambient temperature as well as for the mounting of the component in the switch board. CTs shall be selected considering the actual loads.

1.01.05.04 11kV / 6.6 kV panel mounted load break switches with earthing switches of adequate rating shall be provided before feeding the transformer. Transformer pens shall also be provided with push button station for switching ON/OFF the corresponding 11kV / 6.6 kV upstream feeding circuit breaker.

In case of transformer of rating 5 MVA and above, following arrangement shall be followed:

- LBS (isolator) shall be provided in the transformer room, when transformer is fed from remote HT switchboard.
- Lockable type PB shall be provided in transformer room when transformer is fed from HT switchboard located in the same building.
1.01.05
AC squirrel cage induction motors shall be used for drives requiring speed control.

For all electrical machines wherever strip wound coils are used, detail drawing is to be provided in soft copy.

Use of DC motors, AC slip ring motors shall be avoided to the extent possible.

Manufacturing drawing for parts – stator coils, slip ring, brush, brush holder in slip ring motor’s and drawings of parts of – armature coil, commutator, brush and brush holder in DC machine shall be provided in soft copy.

Sizes of conductors used in motors shall be preferred sizes as per IS.

Sufficient spares of parts of all electrical machines shall be provided.

1.01.06
Cabling

Tenderer shall note the following regarding cabling:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Requirement</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Inter shop cable routing</td>
<td>Through overhead cable gallaries / structure or walkable cable tunnel.</td>
</tr>
<tr>
<td>2.0</td>
<td>Substation building</td>
<td>RCC cable basement of minimum 3.0 metres clear height.</td>
</tr>
<tr>
<td>3.0</td>
<td>MCC room</td>
<td>RCC cable trench / false floor at bottom of MCC</td>
</tr>
</tbody>
</table>
| 4.0    | Illumination system cable laying in all units. | 1. Unarmoured FRLS cables through MS black conduits in open area.
|        |                              | 2. Armoured FRLS without conduit in covered area. |
|        |                              | 3. Unarmoured FRLS cables through concealed MS black conduits in buildings like control room, office building etc. |

1.01.07
Motor starting and permissible voltage dips:

- Voltage dip on starting of the largest L.T. motor shall be limited to 15% of the nominal voltage at the motor terminals.

- Maximum allowable voltage drop in any feeder under steady state condition shall be maintained as follows:

  - Total voltage drop during running : 6%
  - LTSS to motor : 6%
  - LTSS to MCC/PDB/MLDB if in same building : 2%
  - MCC to motor for above case : 4%
  - LTSS to MCC/PDB/MLDB if in different building : 3%
  - MCC to motor for above case : 3%

Voltage drop at the terminal of other equipment shall be as per the minimum voltage required for proper functioning of the equipment recommended by their manufacturers.
1.01.08 Maximum Demand of MCC

Maximum demand (MD) of the MCC shall be calculated considering the following:

1. Working load of the MCC shall be calculated based on the motor kW rating.
2. The load factor shall be considered as follows:
   - For continuous drives – 0.9
   - For intermittent drives like sump pumps etc. – 0.6
   - For electrically actuated valves / dampers – 0.2
   - For maintenance loads like hoists, cranes etc. - 0.4
3. Welding and utility socket loads shall not be considered for calculation of maximum demand.
4. Load factor shall be applied on the kW rating of motor.
5. Diversity factor shall be considered as one.
6. Spare feeders shall also be considered for calculation of maximum demand as per guidelines indicated in Sl. No.2
7. Load of power supply feeders shall be corresponding to the load being fed with 0.9 load factor.
8. Cyclic load shall be converted to continuous load and shall be used for MD without load factor. (e.g. 22kW motor at 40% duty factor will have continuous load as 22x\sqrt{0.4})
9. 20% spare capacity shall be included in maximum demand for future use.

1.01.09 Incomer rating selection for MCC

1. All ACB I/C shall be intelligent type having standard protocol for communication
2. Incomer of the MCC shall be ACB / MCCB having fault level of 50 kA for 1 sec. MCCB shall be provided for ratings 630A and below. Standard ratings of ACB / MCCB shall be provided.
3. Continuous current rating of the incomer shall be corresponding to MD of the MCC.
4. In case of PMCC where MCC is directly fed from transformer, Continuous current rating of Incomer shall be equal to current rating of transformer.
5. In case ACB / MCCB is rated for 40 deg.C then continuous de-rated current in enclosure and for ambient temperature shall be more than MD / transformer current rating.
6. Main bus bar rating of MCC shall be equal to incomer rating.
7. Voltage rating of the breaker shall be equal to the incomer voltage of the system with rated tolerance (as mentioned in the relevant chapter).
8. Each MCC shall be provided with manual operated, draw out two nos.of incomers and one no. of bus coupler . Incomers and bus coupler shall be ACB / MCCB. ACB / MCCB shall be provided with overload, short circuit, earth fault and under voltage releases.
9. Each incomer and bus coupler shall be provided with indicating lamps for each phase for incoming supply and digital ammeter and voltmeter for measuring current in each phase and line to line voltages of MCC bus. ON, OFF and TRIP indicating lamps shall also be provided.
10. Incomer and bus coupler shall be mechanically interlocked in such a way that at any given time only two breakers can be closed. Electrical interlocks shall be provided as follows:
When both incomer ACBs / MCCBs are ON then bus coupler ACB / MCCB can not be switched ON.

When incoming power to one of the incomer is not available then bus coupler can be switched ON manually.

When incoming power to the incomer breaker is restored then incomer can be switched on manually and bus coupler will trip automatically.

Bus coupler closing is not permitted if the incomer trips on fault.

1.01.10 Outgoing Feeder Selection for MCC

1 Motor feeders shall be provided with MCCB, contactor, electronic thermal overload relay (with indication lamp for motor rating 37 KW and above) and other auxiliary equipment like selector switch, indicating lamps, auxiliary contactors etc. as per requirement (for non intelligent MCC).

2 Overload protection device shall be electronic overload relay as indicated in specification. In case electronic overload relay is provided then MCC module shall be provided with indicating lamps.

3 Motor control panel (MCP) for motor ratings above 90 KW shall be provided with motor protection numerical relay (for non intelligent MCC) as per specification. Other components same shall be same as motor feeders of MCC.

4 Power supply feeders shall be provided with MCCB and ammeter.

5 All PDB feeding non-critical loads shall be single fed system.

1.01.11 Power Factor Compensation

In case power factor correction at LT level is specified in specification then APFC shall be provided in PMCC / LTPDB. The capacitor bank shall be so designed that the overall power factor of the system shall be 0.95.

1.01.12 Cable selection

.01 Incomers of MCC / PDB / MLDB

- Cable size for incomer of MCC & PDB shall be selected on the basis of current rating corresponding to MD and voltage drop.
- Cable size for incomer of MLDB shall be selected on the basis of current rating corresponding to lighting transformer and voltage drop.
- The standard size of the cable shall be 3.5 x 240sq.mm. of type AYFY as per IS:1554 (A2XFaY for XLPE insulated cables as per IS : 7098 Part-1).
- For calculating the current rating of power cables de-rating factor of 0.65 shall be used.

.02 Motors

- Cable size for LT motors shall be selected on the basis of rated nameplate current and starting & running voltage drop as per specification.
- Cable size for HT motors shall be selected on the basis of rated nameplate current, starting & running voltage drop as per specification and short circuit capacity of the system. The cable size shall be calculated based on the breaker opening time of 0.35 seconds.
- Minimum size of cable for LT motors shall be 4x6sq.mm. of type AYRY as per IS:1554 and maximum size of cable shall be 3.5 x 185 sq.mm. of type AYFY as per
IS:1554. In case copper conductor cables are used then the maximum & minimum size of cable shall be one size lower than as indicated above for aluminium cables.

- For motors rated up to 2.2 kW and actuators of motors of valves and dampers cable size of 4x2.5sq.mm. of type YRY as per IS:1554 shall be used.
- For calculating the current rating of power cables de-rating factor of 0.65 shall be used.

.03 Illumination System

- The minimum size of the cable for feeding power to SLDB or MCBDB having 32A incomer shall be 4x25sq.mm of type AYFY/AYY as per IS:1554.
- Cable size for MCBDB to light fittings shall be 2x2.5sq.mm. or 4x2.5sq.mm as per the configuration of fittings. The cable type shall be YRY/YY as per IS: 1554.
- In case of concealed wiring, single core, PVC insulated, stranded copper conductor wire of size 1.5sq.mm in MS conduit shall be used. For utility sockets, cable size shall be 4sq.mm.
- Laying of cables shall be decided as per details indicated in the specification.
- Energy efficient smart lighting fixtures and controls to be used for buildings.

.04 Automation System

- All control cables connecting I/Os from field to marshalling panel of PLC or remote I/O panel shall be of stranded copper conductor of type YRY as per IS: 1554 and of size 1.5 sq. mm. minimum for PLC I/O or as suitable.
- Communication bus shall be laid in GI pipe. The route for redundant communication bus shall be different.

.05 General

- Minimum size of the cables used in LT power circuits shall be 6sq.mm per core if with aluminium conductor or 4sq.mm per core if with copper conductor. Maximum cable size shall be 240sq.mm for incomers to MCCs, PCCs etc. The minimum cable size selected for applications in the power circuits of cranes and other moving mechanisms shall be 6sq.mm per core copper. All power cables shall be 3.5 / 4 cores.
- For power supply to moving mechanisms subject to vibrations, flexible copper cables preferably of single core should be used. In these cases, a separate core should be provided for earthing. For hoists with flexible / festoon cable system, power supply shall be through butyl rubber / EPR insulated PCP/CSP sheathed flexible cables. Cables used for circuits of tacho generators, brakes, solenoids, field windings and secondary windings of measuring transformers shall be copper conductor with cross-sectional area not less than 2.5sq.mm per core.
- For control circuits, PVC insulated and PVC sheathed multicore cables with copper conductors having a minimum cross-sectional area of 2.5sq.mm per core shall be used. The number of cores may be standardized as 3, 5, 7, 10, 14, 19, and 24.
Each core of control cable with 7 core and above shall be numbered at every 1-meter interval.

- For signals like mA and mV, special screened/shielded cables shall be used.
- 20% spare cores shall be provided with minimum 1 spare core in multi-core control and signal cables.

### 1.01.13 Ventilation and Air Conditioning

The various electrical rooms of the plant shall be provided with ventilation and air conditioning facilities, as indicated below. Air dryer units to be provided wherever air is being used for purging/cleaning purposes.

#### .01 Substation building, MCC Rooms and Cable Cellar

All HT/LT substations, switch gear rooms and MCC rooms, cable basement/cellars which do not house any electronic equipment but contain only electrical equipment, shall be pressurized up to 2-3mm water column with cooled air washer system to maintain the room temperature at 45 deg.C irrespective of ambient temperature. Suitable capacity fan and pumps (1W+1S) shall be provided for each unit.

#### .02 Electrical rooms with electronic equipment / Central Control rooms

The electrical rooms housing electronic equipment like PLC, computers, Servers, Level –II systems, Remote I/Os, AC and DC variable speed drives, soft starters, UPS, electronic weighing panels, telephone exchange equipment etc. shall be installed in air-conditioned environment with pressurization to maintain the following conditions:

- Room temperature : Shall not be more than 35deg.
- Relative humidity : 50 to 60%
- Pressurization : 2-3 mm WC
- Temperature gradient : 2 Deg. C/h

For central control rooms standby air conditioners shall also be provided.

Separate room, as part of control room shall be provided with window AC units.

#### .03 Small local Control Rooms/pulpits

The small control rooms/pulpits shall be air-conditioned to maintain the following conditions:

- Room temperature : 24Deg. C
- Relative humidity : 50-60%
- Pressurization : 2-3 mm WC

#### .04 Cable tunnels
These shall be ventilated with fresh filtered air to maintain exit air temperature at 40deg.C.

Cable tunnel ventilation shall be sectionalized to maximum length of 150 m.

Temperature rise shall be limited to 3-5 deg.C above atmospheric dry bulb temperature subject to a maximum of 40deg.C at the exit of air from these premises.

Partition door between basement and the cable tunnel shall be air tight and of fire retardant material.

All cable tunnels shall be properly ventilated.

.05 General

Necessary ducting with air diffuser shall be provided.

Ventilation and air conditioning system shall be interlocked with fire detection system for safety.

Airtight double door arrangement shall be provided for electrical rooms, control rooms and basement.

1.01.14 Variable Speed AC Drives.

1. Continuous current of AC drives shall be decided as indicated below:
   - For continuous duty drives (variable torque drives) like pumps fans etc.: – 115% of motor full load rated current.
   - For motion control drives and intermittent duty drives: 150% of motor full load current.
   - For constant torque drives and multi motor drives like moving machines, hoisting etc.: – 150% of the summation of rated motor current for multi motor drives and rated motor current for hoisting drives.

2. All AC drives shall be rated for 380 – 480V, three phase with voltage variation as specified.

3. Isolation transformer shall be provided for drive more than 75 KW and line reactor shall be provided for drive less than 75 KW in incoming (line) side.

4. For 4 quadrant operation applications active front end, low harmonics, regenerative AC drive shall be provided for main drives, process cranes and major auxiliary drives.

5. For crane applications in hot areas where ambient is more than 50 deg.C thyristor converters (ASTAT or SIMOTRAS) shall be used.

6. Current rating of AC drive as innumerated above shall be calculated after de-rating to specified ambient temperature.

1.01.15 Control Philosophy

.01 General

Adequate and appropriate automation systems shall be designed and engineered using state-of-art and field proven technology to facilitate monitoring, control and all other functions associated with operation of all the plant/shop units through user-friendly human-machine interfaces.

The Automation system shall be designed with geographical & functional distribution of hardware in a multi-level hierarchy, viz. Level-0, Level-1, level-2, level-3 etc, as
applicable, to meet specific plant requirements for monitoring, control, process visualization & optimization of all the plants/ shop units.

The automation system shall be structured in general, considering the following hierarchical levels:

- **Level - 0**
  
  This level, also called field level, is functionally responsible for generation, transmission & conversion of signals for the process parameters compatible to the higher level equipment as well as signal based activation for the final control elements.

  This level is realized based on the primary sensing elements, proximity switches, converters, microprocessor based intelligent systems and final control elements. The components of this level shall be grouped and distributed geographically around the plant as per main process equipment location.

- **Level-1**
  
  This level, also called supervisory level, is functionally responsible for supervision of the individual process equipment & functions, monitoring, control, visualization and regulation of process parameters to the desired level based on the signals generated from the field level. This level is also responsible for processing of signals for generating compatible control commands to control the process parameters by activation of the final control elements.

  This level is realized based on the controllers & systems, input & output systems, data base units, data communication, visualization system (HMI stations) and interface units for connectivity to the other levels of the automation system. In addition to routine PID functions, advanced process optimization functions comprising special control algorithms, mathematical computations etc. will be able to permit distribution of control and data acquisition functions throughout the entire plant.

- **Level-2**
  
  This level is functionally responsible for the process control functions through the Level-1 automation system by process guidance & optimization and control of process parameters to the desired level of perfection based on the available signals from the supervisory level. This level is also called process control level and is responsible for generating set points / control commands to the Level-1 equipment based on the pre-loaded process specific mathematical models. This level is realized based on the process computer & its own data base units, input & output systems, data communication systems, visualization system (HMI stations) and interface units for connectivity to the other levels of the automation system. Level-2 automation system has been covered under a separate General Specification.

  The Level-1 automation shall basically comprise:

  - A Programmable Logic Controller (PLC) based automation system

02 Modes of operation
The following modes of operation shall be provided, it shall be in line with changes suggested in respective TS.

A. Local

Local Control Station (LCS) shall be provided for all motor and actuator drives. LCS shall have required numbers of push buttons for operation of drive. In Local Mode, operation of single drive / equipment from LCS shall be provided. This mode of operation will generally be for test and repair purposes. To enable the testing of individual equipment all the interlocks shall be bypassed in this mode. However all critical equipment / drives shall be provided with hard-wired interlocking in MCC.

However for failsafe operation, potential free contact of Push Button from LCS and a potential free contact of field safety sensor shall be hard wired to MCC for safety reasons.

Drive can not be started from any place if the selector switch is in OFF position.

B. Remote

In Remote mode, the equipment can be started from control room only. This remote mode is further divided into following three modes:

- Operator mode
- Auto mode
- Computer mode (Level-2 system)

Once the remote mode of operation is selected then from HMI with help of key board / mouse / soft keys above three modes of operation can be selected.

Operator Mode

Under this mode it shall be possible to monitor & control the plant based on set points / commands given by operator through keyboard and the control, sequential operation of various mechanisms in the required sequence shall be executed by PLC with all interlocks. In this case all the changes / operations are operator initiated.

Auto Mode
This is the **normal mode** of operation of the plant. In this mode, the desired values (set point) of the parameters of process control loop will be set via keyboard of the HMI and sequencing and logic functions will remain operative through the PLC as per application software.

There shall be a provision for group start of drives in individual section with the required interlocks, logic and sequencing between the individual drives.

**Computer Mode**

In this mode the entire plant will be controlled through level-2 system. All the required set points will be generated by level-2 computer as per the mathematical model calculations based on the inputs received from the field. In case of failure of the level – 2 system all the set points will be automatically shift to operator mode of operation.

### 1.01.16 Spares Philosophy

The spare philosophy for various equipment shall be as follows:

1. LTSS, MCC, PDB and MLDB shall be provided with 20% spare feeders or one of each type whichever is higher with minimum of two numbers *in each section*
2. LDB, MCBDB for lighting and MCB DB for utility sockets shall be provided with minimum 9 nos. of spare feeders.
3. DC MCB DB shall be provided with 8 nos. of spare feeders.
4. ACDB of UPS shall be provided with 40% spare feeders.
5. 20% spare terminals shall be provided in each module of MCC, MCP and each ACB panel.
6. 20% spare terminals shall be provided in all junction boxes, LCS and local control panels / local starters.
7. Control desk and control cabinet shall be provided with 30% spare terminals.
8. Marshalling panel of MCC and PLC shall be provided with 30% spare terminals.
9. Relay panels / relay modules shall have 20% spare relays of each type fully wired up to the terminal blocks.
10. 20% spare interposing relays fully wired up to the terminal blocks shall be provided in PLC panels.
11. 10% spare components of each type shall be provided in each control desk /control cabinet / signaling panel.
12. Spare I/O philosophy for PLC shall be as follows:

   - Min. of 20 % of I/O modules used (with at least one module of each type) for input and output shall be offered as spare for each programmable controller and the same shall be mounted and wired to the terminal block in the cubicle suitably.
   - No. of spare Channel per card  shall be 20 %.
   - Provision shall be provided with empty slots for future expansion for 20% I/O modules.
   - Minimum 50 % spare memory capacity shall be available in the system for Purchaser’s use after loading of application and system software.
01 nos. of DI & DO card per PLC shall be provided as spare.

1.01.17 **Uninterrupted Power Supply (UPS)**

UPS shall meet the following requirements:

1. Hot standby dual redundant UPS system shall be provided. Each UPS shall be rated for full capacity and under normal condition one UPS shall be sharing the total load. In case of failure of any UPS second UPS shall take the full load.
2. Spare capacity of UPS shall be 60%.
3. Load factor or diversity factor shall not be considered while calculating the load on UPS.
4. Two separate power supply from different sources shall be provided to UPS – one for UPS and the other for Bypass.
5. Bypass supply to equipment shall be through constant voltage transformer.
6. UPS and SMF batteries shall be located in air conditioned room.

1.01.18 **Colour coding of equipment**

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>DESCRIPTION OF EQUIPMENT</th>
<th>COLOUR</th>
<th>PAINT SHADE NO. AS PER IS 5 : 1991</th>
<th>EQUIVALENT RAL CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td><strong>MOTORS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>11 kV/6.6 kV motors</td>
<td>Traffic Grey A</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td>2.</td>
<td>415 V LT AC motors</td>
<td>Silver Grey</td>
<td>631</td>
<td>7030</td>
</tr>
<tr>
<td>II.</td>
<td><strong>MOUNTED ELECTRICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Equipment installed on or along with motors viz. Tacho generators, brake etc.</td>
<td>Same as that of motor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Equipment installed on mechanism but separate from motor viz. Limit switches, pull chord switches, belt sway switches, speed switches, load cells, photo electric relays etc.</td>
<td>Traffic Grey A</td>
<td>631</td>
<td>7042</td>
</tr>
<tr>
<td>III.</td>
<td><strong>CONTROL GEAR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Drive panels, soft starter panels , UPS panels, PLC, Relay panels, MCC, PDB, MLDB, LDB, etc. including crane control panels</td>
<td>Light grey</td>
<td>631</td>
<td>7035</td>
</tr>
<tr>
<td>2.</td>
<td>Lighting distribution and power distribution board</td>
<td>Light grey</td>
<td>631</td>
<td>7035</td>
</tr>
<tr>
<td>3.</td>
<td>Fire fighting panel</td>
<td>Post office red</td>
<td>538</td>
<td>3002</td>
</tr>
<tr>
<td>4.</td>
<td>Local control box, Junction box</td>
<td>Light grey</td>
<td>631</td>
<td>7035</td>
</tr>
<tr>
<td>5.</td>
<td>Control desk</td>
<td>Light grey</td>
<td>631</td>
<td>7035</td>
</tr>
<tr>
<td>6.</td>
<td>Pulpit equipment</td>
<td>Light grey</td>
<td>631</td>
<td>7035</td>
</tr>
<tr>
<td>7.</td>
<td>Telecommunication panel</td>
<td>Smoke gray</td>
<td>692</td>
<td>7014</td>
</tr>
<tr>
<td>IV.</td>
<td><strong>MISCELLANEOUS EQUIPMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Junction boxes</td>
<td>Light grey</td>
<td>631</td>
<td>7035</td>
</tr>
<tr>
<td>2.</td>
<td>Conduit/pipe pull boxes</td>
<td>Light grey</td>
<td>631</td>
<td>7035</td>
</tr>
<tr>
<td>3.</td>
<td>Light fittings</td>
<td>Light grey</td>
<td>631</td>
<td>7035</td>
</tr>
</tbody>
</table>
## 1.01.19 Drawings and documents :-

All the electrical drawings shall be prepared on CAE (computer aided engineering) packages e.g. Si–Graph or any equivalent software package. The package shall have the facility to connect all the relevant drawings with ERP / SAP package. It must be OODB(Object Oriented Data Based) type.

The package shall have the facility to interface the most different systems in the plant establishment and operational process. It shall have the facility to accommodate the mechanical, civil, structural drawings also.

### 1.02 EQUIPMENTS

#### 1.02.01 DRY TYPE TRANSFORMER

**.1 Standards**
Transformers shall comply with the following Indian Standards.

- **IS: 2026 (1977/1981) -** Power Transformers
  - Parts (I, II, III & IV)

- **IS: 11171(1985) -** Dry Type Transformers

- **IEC : 60726 -** Dry Type Transformers

**.2 Mechanical Design**

- **.01** Transformer enclosure shall be welded/ bolted sheet steel construction, free standing, with suitable size of louvers backed with wire mesh. Base shall be suitably reinforced to prevent any distortion during lifting. Base channels shall be provided with flat wheels with pulling eyes and lifting hooks to facilitate handling.

- **.02** All fasteners and bolts etc. shall be galvanised or zinc passivated. All surfaces to be painted shall be thoroughly cleaned, made free from rust and given a primary coat of rust resisting paint followed by two finishing coats of approved shade. Paint shall be suitable to withstand specific climatic conditions.

- **.03** The transformer shall be provided with separate weatherproof HV/LV terminal boxes and disconnecting links on the side of transformer so as to facilitate withdrawal of transformer without disturbing the HT and LT cables connected to transformer.

- **.04** Tank shall be suitably designed to withstand harmonics available in the system as well as generated by the transformer.
.3 ELECTRICAL DESIGN

i) The transformer shall be cast resin dry type transformer, AN cooled suitable for indoor installation (in a covered room).

ii) Generally as per IS 2026 – Part 1, 2 & 4 of 1977 and Part 3 of 1981.

iii) 3 phase, core type, cast resin.

iv) Rated output, voltage ratio, vector group shall be as specified in technical particulars for design.

v) Rated frequency 50 Hz, ± 6%.

vi) Insulation level shall be designed according to the voltages specified below.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>11 kV System</th>
<th>6.6 kV System</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Nominal system voltage (kV)</td>
<td>11</td>
<td>6.6</td>
</tr>
<tr>
<td>2.</td>
<td>Max. system voltage (kV)</td>
<td>12</td>
<td>7.2</td>
</tr>
<tr>
<td>3.</td>
<td>One minute power frequency withstand voltage (kV)</td>
<td>35</td>
<td>28</td>
</tr>
<tr>
<td>4.</td>
<td>Peak impulse test withstand voltage (kV)</td>
<td>75</td>
<td>60</td>
</tr>
</tbody>
</table>

vi) Transformers shall be capable of delivering rated current at an applied voltage up to 105% of rated voltage without exceeding the temperature limits.

vii) Overload capacity of the transformer shall be as per IS 6600 - 1972 unless otherwise specified.

viii) Shall be operable at its rated capacity at any voltage within ± 10% of rated voltage of the particular tap.

ix) Permissible maximum temperature at rated output and principal tap at the ambient temperature of 50°C

<table>
<thead>
<tr>
<th></th>
<th>Windings (by resistance method)</th>
<th>110°C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Core and other adjacent parts of winding</td>
<td>110°C</td>
</tr>
<tr>
<td></td>
<td>Core and other parts not adjacent of winding</td>
<td>Within safe limits of core and adjacent materials</td>
</tr>
</tbody>
</table>

x) Transformers shall be designed to withstand the thermal and dynamic stresses due to short circuits at its terminals or symmetrical/ asymmetrical fault on any winding. Short circuit withstand capacity for the bolted fault at the terminals shall not be less than 5 second duration with respect to fault level specified.
xi) The maximum temperature at the end of the short circuit duration shall not be more than 250°C with the temperature prior to short circuit corresponding to maximum permissible overload.

xii) Transformer shall be designed for minimum no-load and load losses within the economic limit.

xiii) Designed for suppression of harmonics, especially 3rd and 5th.

01. MAGNETIC CIRCUIT

i) Low loss CRGO silicon steel shall be used.

ii) Laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.

iii) CRGO sheets shall be coated with insulation varnish compatible with the sealing liquid.

iv) Insulation to withstand annealing temperature as high as 850 Deg. C and shall reduce eddy current to minimum.

v) Ducts to be provided to ensure adequate cooling.

vi) Core, framework and clamps arranged and tightened to securely hold laminations in order to prevent any settling or displacement in case of heavy shocks during transport, handling or short circuits.

vii) Flux density under specified over voltage or frequency conditions shall be within the maximum permissible for the laminations. However it shall not exceed 1.6 tesla.

viii) Transformers shall be designed to withstand 110% over fluxing corresponding to rated voltage.

ix) Magnetising current shall be maximum 1% of the rated current.

02. WINDINGS

i) Material shall be electrolytic grade copper.

ii) Shall be subjected to shrinkage treatment.

iii) Completed core and winding to be vacuum dried in full vacuum, impregnated immediately, then dried before casting in resin.

iv) Shall be braced to withstand shocks due to rough handling and forces due to short circuit, switching or other transients.

v) Permanent current carrying joints in winding and leads shall be brazed.

vi) Coils shall be supported using dried and high-pressure compressed wedge type insulation spacers.

vii) Insulating materials shall be compatible with transformer liquid under all service conditions.

viii) Leads to the terminal board and bushings shall be rigidly supported.
03. **INSULATION**
   i) Inter-turn and inter-coil insulation shall be designed such that di-electric stress is uniformly distributed throughout the windings under all operating conditions.
   ii) The winding shall be provided with class F insulation or better (as applicable to dry type transformer as per IS: 2026 part – II). However, temperature rise in winding and core shall be limited to class B insulation.

04. **OFF CIRCUIT TAP SWITCH**
   i) Bolted link type within enclosure, with easy accessibility.
   ii) Designed for sustained over current of at least 150% of the rated current of the winding
   iii) Capable of repeated operation and withstanding short circuit forces
   iv) Tap position configuration diagram shall be provided.
   v) Inspection/operation / or repair shall not require removal of transformer core from its enclosure.
   vi) Shall not occupy any intermediate position between clearly marked tap position.

05. **TERMINATIONS**
   It shall be possible to withdraw the transformer easily after disconnecting the connections without disturbing the cable terminations. Cable termination box shall be bolted type and supported from bottom so that after withdrawing the transformer, it remains at its same position.
   Winding shall be brought out and terminated on external /cable boxes as specified in the Technical Particulars.
   i) **Cable termination**
      a) Air insulated cable end box suitable for the type and number of cables specified.
      b) Air insulated disconnection chamber with inspection opening
      c) Compression type brass cable glands with finned copper lugs of non soldering crimped type.
      d) Bolted type gland plated (non magnetic material wherever specified).
      e) Sealing kits with associated accessories like stress reliving, insulating type, bi-fencing boot, HT insulating tape etc.
   ii) **Bus duct termination**
a) When bus duct termination is specified, flanged throat shall be provided to suit the bus duct. Flange ends and inspection openings shall have weather proof gaskets.

06. Bushings
ii) Minimum rated current of line end bushings shall be 1.5 times rated current of the corresponding windings.
iii) Clamps and fittings made of steel or malleable iron shall be hot dip galvanized.
iv) Bushings rated 400 amps and above shall have non-magnetic clamps and fittings only.
v) Bushing shall be solid porcelain type.
vi) Neutral bushings shall be provided as required for earthing of neutral point. This shall be connected to brass/tinned copper bar and brought to outside the body through porcelain insulator.

07. NEUTRAL CURRENT TRANSFORMERS
i) Removable at site without opening transformer enclosure cover/active part.
ii) Secondary leads shall be brought to a weatherproof terminal box and from there to the Marshalling box with 4 sq.mm copper armoured cable.

08. WINDING TEMPERATURE INDICATOR
i) Local winding temperature indicator (WTI) shall have a 150-mm diameter dial type indicator with a manual reset maximum reading pointer. There shall be two potential free contacts for alarm and trip signals. The settings for closing/opening of each contact shall be independently adjustable. Contact rating at DC11, 110V DC shall be minimum 5 Amps. The device shall be complete with lamp temperature sensing element, image coil, calibration device, aux. CTs etc. as required and shall be operated by RTD element.
ii) Temperature indicator dials shall have linear gradations to clearly read atleast every 2°C. Accuracy shall be better than ±1.5%.

09. MARSHALLING BOX
i) All outgoing connections from the transformer viz temperature indicators, level indicators CT secondaries, fault contacts for annunciation, etc. shall be wired to a Marshalling Box.
ii) Degree of protection of enclosure shall be IP52 for indoor and IP55 for outdoor type respectively.
.10 **RATING PLATE**
Each transformer shall be provided with a rating plate giving the details as per IS:2026 (Part-I). The marking shall be indelible and the rating plate shall be located on the front side. Exact value of transformer % impedance, as determined by tests shall be engraved on it and also on the final submission of name plate drawing.

.11 **NOISE**
Noise level shall be low and shall be within limit depending on the rating of the transformer as per IEEE-141.

.12 **Earthing**
  i) All metal parts of the transformer with the exception of individual core lamination core bolts and clamping plates shall be maintained of fixed by earthing.
  ii) Two nos. of tinned copper earthing terminals shall be provided.
  iii) One end of bushing CTs shall be earthed.

.13 **List of Fittings and Accessories**
  i)  Off-circuit tap switch as specified.
  ii)  Dial type winding temperature indicators operated by RTD elements.
  iii)  Bushing CTs as specified.
  iv)  Bi-directional rollers/flanged wheels with loading arrangement.
  v)   Lifting lugs and jacking pads
  vi)  Rating and diagram plates.
  vii) Earthing terminals.
  viii) Inspection cover
  ix)  Identification plate
  x)  Pockets for thermometer for winding temperature indicator.
  xi)  HV, LV and Neutral bushings
  xii) Marshalling box.

.4 **TESTS**
The equipment shall be subjected to all the routine tests at the manufacturer works in accordance with latest version of IS2026 Part I and III or, the relevant IPSS (where specified), in presence of purchaser or his representative.

Test of all equipment shall be conducted as per latest BIS. Test shall also confirm to International Standards IEC/VDE/DIN/BS.

The tenderer shall submit type test certificates for similar equipment supplied by him elsewhere. In case type test certificates for similar equipment is not available, the same
shall be conducted in presence of Purchaser or his representative if Purchaser so desires, without any financial implications to purchaser.

The transformer should pass the non-hygroscopic test according to DIN VDE-0532 and confirm to class E2 to prevent formation of moisture creepage path and resulting in failure of transformer.

The transformer should withstand the extreme load variation without any cracking of the casting. For this test certificate according to DIN VDE 0532 is to be furnished.

All the equipment shall be tested at site to know their condition and to prove suitability for required performance. The site tests and acceptance tests to be performed by manufacturer are detailed below.

The manufacturer shall be responsible for satisfactorily working of complete integrated system and guaranteed performance.

Acceptance tests to be conducted at site:

i) Assembly inspection/ Painting check
ii) Measurement of winding resistance
iii) Measurement of voltage ratio and check of voltage vector relationship
iv) Measurement of no-load current.
v) Measurement of insulation resistance/ polarizatation index.
vi) Certification for on-load/ off-load tap changer
vii) Final documentation check

.5 DRAWINGS & DOCUMENTS

The suppliers shall supply the following drawings / documents and manuals.

i) List of drawings
   a) Overall General arrangement drawing
   b) Rating and diagram plate
   c) GA of Marshalling box
   d) Wiring drawing of Marshalling box
   e) H.V. cable box assembly
   f) L.V. busduct assembly
   g) QAP, Internal Test Certificates and Inspection Certificates

ii) Instruction manuals for erection, testing and commissioning.
   a) Instruction manual shall give step by step procedure for:
      - Erection, testing and commissioning
      - Operation
      - Maintenance and
      - Repair
   b) Operation and Maintenance Manual
- Recommended procedure for routine maintenance
- Tests for checking of proper functioning
- Diagnostic trouble shooting/ fault location charts

c) Storage, conservation and re-commissioning Manual
d) Safety Manual

Note : - Instruction manuals shall contain:

a) Manufacturer’s catalogues with ordering specification for all items
b) List of consumables with specifications, brand names and annual consumption figures
c) Procedure for ordering spares.
d) Drawings relevant for erection, operation, maintenance and repair of the equipments.

iii) List of special tools and tackles

.6 TECHNICAL PARTICULARS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>1000/ 2000 kVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Part II - 1977</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Part III - 1981</td>
</tr>
<tr>
<td></td>
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<td>Part IV - 1977</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IS 11171 - 1985</td>
</tr>
<tr>
<td>2.</td>
<td>Type</td>
<td>Three phase, core type, cast resin dry type</td>
</tr>
<tr>
<td>3.</td>
<td>Duty</td>
<td>Indoor, installed in room</td>
</tr>
<tr>
<td>5.</td>
<td>Voltage HV/LV</td>
<td>6.6 or11 / 0.433 kV</td>
</tr>
<tr>
<td>6.</td>
<td>Frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>7.</td>
<td>No. of phase</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>Continuous rating</td>
<td>1000/2000 kVA</td>
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<tr>
<td>9.</td>
<td>Conductor</td>
<td>Copper</td>
</tr>
<tr>
<td>10.</td>
<td>Insulation class</td>
<td>Class F or better</td>
</tr>
<tr>
<td>11.</td>
<td>Cooling</td>
<td>AN</td>
</tr>
<tr>
<td>12.</td>
<td>Winding connection</td>
<td>Delta / Star</td>
</tr>
<tr>
<td>13.</td>
<td>Vector group</td>
<td>DYn 11</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Particulars</td>
<td>1000/ 2000 kVA</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>14.</td>
<td>Neutral grounding</td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>15.</td>
<td>System earthing</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>HV</strong></td>
<td>Unearthed</td>
</tr>
<tr>
<td></td>
<td><strong>LV</strong></td>
<td>Effectively earthed</td>
</tr>
<tr>
<td>16.</td>
<td>Percentage impedance</td>
<td>5% or 6.25% (as applicable)</td>
</tr>
<tr>
<td>17.</td>
<td>Termination</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>HV</strong></td>
<td>Cable end box suitable for termination of XLPE aluminium cables, with air insulated disconnecting chamber</td>
</tr>
<tr>
<td></td>
<td><strong>LV</strong></td>
<td>Suitable for termination of Busduct with disconnecting chamber</td>
</tr>
<tr>
<td>18.</td>
<td>Temperature rise over 50°C ambient temp</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>a)</strong> In winding (measured by Resistance method)</td>
<td>80°C</td>
</tr>
<tr>
<td></td>
<td><strong>b)</strong> Core and other adjacent parts of winding</td>
<td>80°C</td>
</tr>
<tr>
<td></td>
<td><strong>c)</strong> Core and other parts not adjacent of windings</td>
<td>Within safe limit of core and adjacent materials.</td>
</tr>
<tr>
<td>19.</td>
<td>Bushing mounted CT's</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT in LV Neutral bushing for standby E/F protection</td>
<td>Ratio : 500/5 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class : 10P15</td>
</tr>
<tr>
<td>20.</td>
<td>Off circuit tap changer</td>
<td>Bolted Link type</td>
</tr>
<tr>
<td></td>
<td><strong>a)</strong> Range</td>
<td>±5%</td>
</tr>
<tr>
<td></td>
<td><strong>b)</strong> Total tap positions</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td><strong>c)</strong> Taps above nominal voltage</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>d)</strong> Taps below nominal voltage</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>e)</strong> Voltage per step variation</td>
<td>2.5 %</td>
</tr>
<tr>
<td></td>
<td><strong>f)</strong> Tap change controls</td>
<td>Manual</td>
</tr>
<tr>
<td>21.</td>
<td>Impulse test withstand voltage</td>
<td>As per IS 2026, Part III – 1981</td>
</tr>
<tr>
<td>22.</td>
<td>One minute dry and wet power frequency withstand voltage</td>
<td>- do -</td>
</tr>
<tr>
<td>23.</td>
<td>Short circuit level on HV side</td>
<td>40 kA for 3 Seconds</td>
</tr>
<tr>
<td>24.</td>
<td>Time duration to withstand 3 phase short circuit at secondary terminals, without any injury.</td>
<td>5 Secs.</td>
</tr>
<tr>
<td>25.</td>
<td>Auxiliary supply voltage</td>
<td>240 V AC</td>
</tr>
<tr>
<td>26.</td>
<td>Parallel operation</td>
<td>Suitable for parallel operation with transformers of similar ratings</td>
</tr>
<tr>
<td>27.</td>
<td>Overload capacity</td>
<td>As per IS 6600 –1972</td>
</tr>
<tr>
<td>28.</td>
<td>Paint &amp; Paint shade</td>
<td>Epoxy based (Shade 632 as</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Particulars</td>
<td>1000/ 2000 kVA</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td>per IS – 5)</td>
<td></td>
</tr>
</tbody>
</table>

1.02.02 VCB (Transformer Isolation)

1.02.02.01 **6.6/ 11 kV CIRCUIT BREAKER (WITHOUT PROTECTION & METERING) PANEL**

The 6.6/ 11kV circuit breaker panel shall be totally enclosed dust and vermin proof, sheet metal clad, floor mounted, free standing, indoor type and shall house circuit breakers, bus bars, control equipment, heat shrinkable cable termination, current transformers, potential transformers, instruments, relays, annunciation system and other accessories. This factory assembled HT circuit breaker panel shall be with fully draw out type breaker carriage, compartmentalised design with pressed sheet steel (thickness not less than 2.0 mm) and with IP-4X class of enclosure. All doors other than cable chamber shall be of hinged and lockable type with neoprene gaskets at all joints and the cable chamber shall be fixed with nuts and bolts. Additional wire mesh guards and gaskets shall be provided for cable chamber. Two separate earthling terminals shall be provided for cable chamber. Two separate earthing terminals shall be provided for HT panels. The HT panel shall be provided with metallic automatic safety shutters or those made of fibre glass of suitable insulation, which cover automatically the isolating contacts when circuit breaker is withdrawn from service position. Ventilation openings shall be provided where essential and shall have suitable screen protection.

Salient technical parameters to which the Circuit breaker panel shall conform are as follows:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service voltage</td>
<td>6.6/ 11 kV +6%, -9%</td>
</tr>
<tr>
<td>System Frequency</td>
<td>50 Hz +4%, -6%</td>
</tr>
<tr>
<td>Degree of enclosure protection</td>
<td>IP 4X</td>
</tr>
<tr>
<td>Fault level in MVA</td>
<td>450/ 750MVA for 3 seconds</td>
</tr>
<tr>
<td>Type of CB</td>
<td>Sulphur hexa fluoride (SF6)/ Vacuum Circuit Breaker (VCB)</td>
</tr>
<tr>
<td>Rating</td>
<td>1250A</td>
</tr>
<tr>
<td>No. of poles</td>
<td>3</td>
</tr>
</tbody>
</table>
### General Features of 6.6/ 11kV Circuit Breakers

1) 6.6/ 11kV circuit breakers envisaged in the specification shall be designed to control and protect the power distribution system. The circuit breaker shall conform to IS:13118-1991 and IEC publication 56.

2) The circuit breaker shall be maintenance free and shall have adequate capacity, insulation and mechanical strength to withstand
   a) In-rush magnetising currents of transformers
   b) Starting currents of drives
   c) Transient surges developed during various abnormal operating conditions
   d) All electrodynamic stresses developed during abnormalities like faults in the system.
   e) Frequent start/stop duty of the industrial load. Normally, 2 (two) quick succession cold starts and one restart from hot condition or 3 starts per hour shall be considered for design duty.

3) Circuit breakers shall have three operational positions, such as "Service" "Test" and "Draw-out" position. It will be possible to achieve all the above three positions with cassettes front door closed. Mechanical indicators for all three positions shall be provided. The circuit breakers shall carry a single break per pole which shall be identical with the other 2 pole chambers of the breaker. Simultaneous closing of the three poles
of a breaker on a single closing command shall be ensured. All circuit
breakers shall preferably be interchangeable.

4) The 6.6/11kV breaker shall be provided with electrical and mechanical
trip free features and an emergency mechanical push to trip the breaker.
All the features of the equipment shall ensure complete safety of the
operation and shall be complete with approved safety devices to protect
against potential hazards to operating personnel or to the equipment
around. The design shall include all reasonable precautions and
provisions for the safety.

5) All 6.6/11kV breakers shall be provided with at least 4 potential free
Aux. contacts to be used by Employer for their interlocking/signaling
purposes. Contact arrangement may be 2 NO + 2 NC and these shall be
rated for 10 amp current duty on the control and auxiliary voltages (both
AC & DC). Further, the following features shall be ensured in each 6.6/
11kV breaker panel:
a) Control plugs provided shall be mounted in horizontal fashion.
b) Mini bus earthing with proper interlocks.
c) All supporting insulators shall have increased creepage distance
as per IS and shall suit highly polluted atmosphere of steel
industry.

2. Bus Bars

1) The Power Bus Bars of 6.6/11kV breaker panel shall be made of high
conductivity, electrolytic copper of purity 99.9% as per IS:613-1984 in
rectangular sections.

2) Horizontal and vertical bus bar shall be designed manufactured and
supported to withstand thermal and dynamic stress corresponding to
rated short time and peak withstand current as specified above.

Bus bar shall be sleeved with proper grade of insulating sleeves and of
proper colour code for each phase. Care shall be taken to obviate corona
formation at the joints and connections. All joints and connecting
terminals shall be tinned.
4) Bus bar shall be housed in a separate bus bar chamber with adequate air clearance and bushing. The insulators/bushing shall be cast resin type to offer higher mechanical strength, during short circuit fault.

5) The clearance between bus bars shall be maintained as per standard. The bus bar chamber shall be provided with detachable side covers for regular maintenance and inspection and have provision of extension on both sides.

.3 Cable Chambers
The cable end termination chamber for each panel shall have adequate space for the termination of required number, type and size of cables and shall be provided with suitable bracings to support the weight of the cables without undue stress on the terminals. These chambers shall be complete with all accessories and shall form integral part of the cubicle and shall be freely accessible for cable connection.

.4 Earthing of 6.6/11kV Breaker panel
The following norms shall be adopted for earthing of HT breaker panel:

1) The 6.6/11kV outgoing cable shall be accessible to provide external earthing on opening the backside lower cover of the panel.

2) Continuous copper earth bus bar shall be provided. However, the cross section shall be checked to carry the peak short circuit and short time fault current of the system.

3) Earthing bus bar shall be positively connected/welded with 6.6/11kV breaker panel, individual functional units and non current carrying metallic units.

4) Hinged door shall be earthed through stranded copper galvanized earthing braid.

5) For positive earthing of withdrawable units, silver plated copper strapping earthing contacts of "make before"/"break after" type shall be used ensuring earth continuity from "service" to "test" position of draw-out type breakers on both the sides.

1.02.03 415V Switchgear

1.02.03.01 General
The 415V switchboard shall comprise air circuit breakers & shall be metal clad, indoor type floor mounted (in fully drawout execution). Switchboard shall be in single tier execution for incomers & buscouplers & two tiers for outgoing feeders.

Relative position of incomers shall be as per the equipment layout requirement.

Sheet steel shall be CRCA of minimum 2.0 mm thickness.

Circuit breaker shall be mounted on fully drawout truck with service, test and isolated positions and complete with following safety interlocks and safety shutters with padlock facility:

- It shall not be possible to move the truck in or out of cubicle when the breaker is closed.
- CB compartment door shall be mechanically interlocked so that it will not be possible to close the CB in plug position when the door is open.
- It shall not be possible to push the truck in close position if either of the safety shutter is not free and not in close position.

The position of various control switches, push buttons, levers etc. requiring manual operation, shall be at a height not less than 450mm and shall not exceed 1850mm from the finished floor level.

Name plate for each incoming bus coupler, and outgoing feeder at front and back, both on the fixed portion of the panel.

All panels shall have space heater with switch and cubicle illumination lamp with door switch.

All breakers of similar rating shall be interchangeable.

1.02.03.02 Insulation Level
- Rated insulation voltage 1100 V
- One minute power frequency withstand voltage:
  - 2.5 kV for power circuits
  - 2 kV for control circuits
- Clearance in air (minimum):
  - Phase to phase - 25.4 mm
  - Phase to earth - 19.0 mm

1.02.03.03 Short Circuit Strength
- Rated short time withstand current not less than the system short circuit level specified for 1sec.
- Rated peak withstand current not less than 2.1 times the system short circuit level.

1.02.03.04 Busbars
- Busbars made of EC grade aluminium alloy equivalent to E91E WP as per IS 5082, 1981, size adequate for specified rated continuous and SC current.
- Jaw contact to be mounted on ACB and fixed contact to be mounted on the bus side (as per the manufacturer’s standard).
- Three phase, neutral (with atleast 50% rating of main buses) and continuous earth bus. Bus bar shall be provided with proper grade & colour of heat shrinkable sleeve.
- Rating of horizontal buses shall be same as that of incomer circuit breakers and
vertical run shall be same as that of outgoing breaker rating

- Temperature rise of bus bars shall not be more than 40 deg. C above an ambient of 50 deg. C.

1.02.03.05 Protection Requirements

- One auxiliary relay for each transformer incipient faults :
  a) Buchholz - alarm (63X)
  b) Oil temp. high alarm (490X)
  c) Winding temperature high alarm (49 X)
  d) Buchholz trip (63Y)
  e) Oil temp. high - trip (490Y)
  f) Winding temp. high trip (49Y)
- For the above faults, contacts to be made available for inter tripping primary side breaker also.
- All other protections as specified.

1.02.03.06 Construction Features (Mechanical Design)

- Sheet steel clad, floor mounted, free standing design, non-dust proof construction
- Extension bus links properly spaced for terminating single cables of size 120 sq. mm and above as well as for terminating multiple cables of all sizes.
- Where more than one cable have to be terminated per unit, the arrangement shall permit connection and disconnection of individual cables separately without disturbing other cables.
- Double, compression type brass cable glands and crimping type, tinned, heavy duty copper lugs suitable for the type, size and number of cables to be terminated, to be supplied with the switchboard for all LT power and control cables.
- The interior of the switchboard shall be finished with ‘OFF WHITE’ paint shade.
- All the panels shall be of uniform depth.
- All panels shall be supplied with base channels.
- The enclosure class shall be IP52 or better.

1.02.03.07 Relays

- Flush mounted
- Mechanically operated flag indicators with all relays capable of being reset without opening casing
- Shall withstand impulse voltage in accordance with IS/IEC recommendation.
- Test facility by plug from panel front.
- CT secondary shall be shorted on relay withdrawal.
- Diagram plate at the back of case to identify connections.
- The relay shall be microprocessor based numerical and communicable type.

1.02.03.08 Circuit Breaker

01. Electrical Features

- Air break triple pole (4 pole in case of DG power incomer) drawout type conforming to IS 13947.
- Identical tripping/closing coil rating shall be provided as per the supplier's standard.
- Rated continuous current as specified.
- Symmetrical breaking capacity and 1 second rating of the breaker not less than the system short circuit level specified.
- Making capacity 2.55 times breaking capacity.
- Performance category : P2
• Auxiliary contacts : 6 NO + 6 NC minimum, convertible from NO to NC and vice versa at site.

Ratings:

<table>
<thead>
<tr>
<th>Continuous</th>
<th>10 amps</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 11</td>
<td>4 amps at 240 V</td>
</tr>
<tr>
<td>DC 11</td>
<td>0.5 amps at 110 V</td>
</tr>
</tbody>
</table>

02. Operating Mechanism
- Manual or power operated mechanism as applicable
- Spring charged stored energy mechanism to ensure high speed closing and tripping independent of the operating forces.
- Anti pumping and trip free feature
- Emergency tripping by mechanically operated trip push button (shrouded to prevent accidental closing) acting directly on the trip bar.
- Closing operation of the breaker to charge the tripping spring, ready for tripping.
- Mechanical indication to show:
  ⇒ Closing spring charged
  ⇒ Breaker ON/OFF/TRIP
- Breaker to close only when spring fully charged
- Non-reset type operation counter
- For manually operated breakers:
  ⇒ Independent manual charging of closing spring and closing by handle.
  ⇒ Alternatively, closing by mechanical push button with spring previously charged by handle.
- For electrically operated breakers:
  ⇒ Charging of closing spring by motor
  ⇒ closing by closing coil
  ⇒ spring charging motor and closing coil suitable for rated control voltage (240 AC unless otherwise specified).
  ⇒ One opening and one closing operation without control supply.
  ⇒ Provision also for manual closing with spring charging motor automatically decoupled as soon as charging handle is inserted.

03. Drawout Features
- 3 distinct positions viz. service, test, and isolated with the door closed.
- Mechanical position indication and locking/latching facility for all 3 positions.
- Power connections - self-aligning, plug-in type.
- Control connections - sliding or plug socket type, mechanically coded, to prevent wrong insertion, continuous rating 16 amps minimum.
- Automatic safety shutters to prevent accidental contact with live parts when the breaker is withdrawn.

04. Safety Interlocks
- It shall not be possible to close the breaker in any intermediate position other than the 3 fixed positions.
- With the breaker closed, it shall not be possible to rack it in from any of the 3 position to another.
- Mechanical stopper to prevent accidental falling while withdrawing.
- It shall not be possible to rack in the breaker from isolated to 'test' position with the door open together with provision for defeat of this interlocking, however, it shall be possible to close the door only when the breaker is brought back to 'isolated' position.
• It shall be possible to open the door only when
  ⇒ breaker is OFF and
  ⇒ is in 'Isolated' position.
• Remote closing of breaker is not permitted with door open.
• Insertion of breaker into 'Service' position shall not be possible if the shutters are
  not free.

05. Internal Control Wiring
• Control wiring by 1100V grade PVC insulated, single core copper conductor of
  minimum cross section 2.5 sq. mm
• Flexible wires, protected against mechanical damage for wiring to door-mounted
  devices.
• Wires identified at each end in accordance with schematic diagrams by interlocked
  type ferrules.
• Colour code for control wiring:
  - AC – black
  - Earth wire - Green
  - DC – light grey
  - Trip circuit - Red

• All connections external to a feeder, all the auxiliary contacts of the LT breaker,
  and all spare contacts of the relays shall be wired on to the terminal blocks.
• Interconnection between panels of adjacent shipping sections to be brought out to
  a separate terminal block, wires for interconnection properly labeled, looped and
  bunched inside the panel for connection at site.
• Not more than two connections shall be carried out on one terminal.

06 External Terminations
06.1 Control Terminations
• 650V grade multiway terminal blocks of non-tracking moulded plastic complete
  with insulated barriers, stud type terminals, washers, nuts and lock nuts and
  identification strips.
• Power and control terminals segregated.
• Control terminals of minimum rating 10 amps suitable to receive 2.5 sq. mm
  copper conductor.
• 20% spare terminals in each control terminal block.

06.2 Power Terminations
• Suitable for accepting cables/bus trunking as specified in the technical particulars.
• All spare contacts wired upto terminal block of the panels
  a) Protective relays - withdrawable type
  b) auxiliary, timer relays - fixed type

07.0 Microprocessor based releases
07.01 General
• The control unit shall be interchangeable on site for adaptation to changes in the
  installation.
• Sensors shall be non-magnetic or of the Rogosky type for accurate current
  measurements.
• The control unit shall measure the true RMS value of the current.
• The control unit shall comprise a thermal memory to store temperature-rise data in
  the event of repeated overloads or earth faults. It shall be possible to disable this
  function if necessary.
07.02 Protection
- The control unit shall offer the following protection functions as standard:
  1. Long-time (LT) protection with an adjustable current setting and time delay;
  2. Short-time (ST) protection with an adjustable pick-up and time delay;
  3. Instantaneous (INST) protection with an adjustable pick-up and an OFF position.
  4. Earth-fault protection with an adjustable pick-up and time delay.

- Current and time-delay settings shall be indicated in amperes and seconds respectively on a digital display. Acknowledgement that the setting change should translate to the trip threshold.

07.03 Measurements
- An ammeter with a digital display shall indicate the true RMS values of the currents for each phase.
- An LCD Screen should continuously display the most heavily loaded phase apart from the load level on the three phases.
- A maximeter shall store in memory and display the maximum current value observed since the last reset. The data shall continue to be stored and displayed even after opening of the circuit breaker.
- The control unit shall measure voltages and calculate power and energy values.
- These values shall be displayable on the screen and updated every second. The minimum and maximum values shall be stored in memory.

07.04 Communication
- The circuit breaker shall be capable of communicating the following data through a bus:
  - Circuit-breaker status (open/closed, connected/disconnected/test, tripped on a fault, ready to close);
  - Control-unit settings, including protection setting parameters.
  - Tripping causes;
  - The measurements processed by the control unit: current, voltage, frequency & power(active & reactive).
- It shall be possible to remotely modify circuit-breaker settings:
  - Settings within the range defined by the switches on the front panel of the control unit;
  - Settings of the protection functions and the alarms.
- It shall be possible to remotely control the circuit breaker of identified feeders only.(Viz. all incomers & buscouplers)
- Communications functions shall be independent of the control unit.

08. Indicating Instruments (Analog Meters)
- Taut band type
- Size
  - Incomer and sectionalizer: 144 sq. mm
  - Outgoing: 96 sq. mm
- Flush mounting: in front of the cubicle
- Accuracy class - 1.0
- Ammeters shall be compatible with CTs of 5A secondary and read actual currents.
- For motor feeders ammeters shall have suppressed scale upto 6 times of full load current after 1.2 times of full load current and shall have red mark on full load current.
value.

09. **Protective Devices**

All control circuits shall be individually fed by MCBs with built in thermal and magnetic releases. HRC fuses shall be provided for protection of spring charged motors of electrically operated breakers.

10. **Contactors**

Contactors shall break without damage 8 times rated current upto 100 amp rating and 6 times rated current for above 100 amp rating. Continuous current shall not exceed 2 amp and initial pick up shall be limited to 9 amp. Class of insulation shall be E or better. Drop out voltage shall be 45-65% of rated voltage and pick up shall be 85-110% contactor duty shall be AC3 unless otherwise specified in design parameters.

11. **Annunciation Scheme**

- Shall be static type.
- Hooter and bell shall be provided for trip & alarm indication respectively.
- Number of points shall be as per list.
- Shall have facilities for test, reset and accept.
- Shall consists of annunciation windows, relay blocks warning bell, emergency hooter, push buttons etc.
- All windows shall have two bunch LED in parallel.
- All accessories including actuator (if respective scheme is in Contractor's scope) shall be provided.
- Sequence of operation shall be as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Audio</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>On occurrence of fault</td>
<td>ON</td>
<td>Flashing</td>
</tr>
<tr>
<td>On accepting</td>
<td>OFF</td>
<td>Steady ON</td>
</tr>
<tr>
<td>On resetting (fault cleared)</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>On resetting (fault persists)</td>
<td>OFF</td>
<td>Steady ON</td>
</tr>
</tbody>
</table>

12. **Control Supply**

- Suitable arrangement for 240V AC reliable control supply of adequate rating shall be provided in each 415V switchboard.
- Two 240V AC feeders shall be provided in each board for control and annunciation purpose.
- Shunt trip shall be suitable for operation on 240V AC.
- Shall have supervision facility, alarm shall be provided for non availability of any one of the control supply.
- MCBs shall be provided on incoming sides of supplies.
- Control buses of two sections shall be connected through sectionalising switch.
- Indication lamps shall be connected to 240V AC supply.
- Isolation arrangement shall be provided on each panel to facilitate fault location and testing. Separate fuses shall be provided for spring charging motors, for indication lamps and for closing/tripping circuits of each cubicle.

13. **Inter Tripping**

- Provision shall be made for tripping of incomer LT breaker on tripping of upstream HT breaker.
- Provision for tripping of upstream HT breaker on fault tripping of LT incomer breaker shall also be provided.
14. **Indicating Lamps**
   i) LED cluster type.
   ii)LEDs used shall be of the colour of the lamp.
   iii)Color shall be as follows:

<table>
<thead>
<tr>
<th>State</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>RED</td>
</tr>
<tr>
<td>OFF</td>
<td>GREEN</td>
</tr>
<tr>
<td>CIRCUIT HEALTHY</td>
<td>WHITE</td>
</tr>
<tr>
<td>FAULT/WARNING</td>
<td>AMBER</td>
</tr>
<tr>
<td>SPRING CHARGED</td>
<td>BLUE</td>
</tr>
</tbody>
</table>

15. **Control and Selector Switches**
   - Control switches for circuit breaker ON/OFF control 3 position spring return to neutral with lost motion device and pistol grip handle.
   - Other control and selector switches - stay put type with wing type knobs.

16. **Push Buttons**
   - Contact Rating :
     | State       | Rating                          |
     |-------------|---------------------------------|
     | Continuous  | 10 amps                         |
     | AC 11       | 1.5 amps at 240V                |
     | DC 11       | 0.5 amps at 110 V DC, L/R - 40 ms|
   - Colour:
     | State       | Color                          |
     |-------------|--------------------------------|
     | ON          | RED                            |
     | OFF         | GREEN                          |
     | ACCEPT      | BLUE                           |
     | RESET       | BLACK                          |
     | TEST        | YELLOW                         |

17. **Protective Earthing**
   - Continuous earth bus of minimum size 50 x 6 mm copper or equivalent aluminium /galvanized steel section, designed to carry the peak short circuit and short time fault current as specified.
   - Provided at the bottom extending throughout the length of the board, bolted/brazed to the frame work of each panel with an earthing terminal at each end, for terminating external earth conductor.
   - Vertical earth bus for earthing individual functional units.
   - All non-current carrying metal work (including metallic cases of instruments and other panel mounted components) effectively bonded to the earth bus.
   - Hinged doors earthed through flexible earthing braid.
   - Looping of earth connection, resulting in loss of earth connection to other devices, when the loop is broken, not permitted.
   - Withdrawable units provided with self-aligning, spring loaded, silver plated copper scrapping earth contacts of make before/break after type ensuring earth continuity from service to the test position.

18. **Breaker Handling Truck**
   - One for each switchboard, for withdrawing the breakers from the switchboard.
   - Height of platform adjustable to suit the levels at which the breakers are mounted.
   - Adequate mechanical strength for handling the largest breaker.
   - Guide rails and stops.
   - Incomer shall have analog meter (96 x96 mm) to measure line voltage/ bus voltage & current (New point)
19. **Auto Changeover Scheme**

- Usually both the incomers shall be ‘ON’ with bus-coupler in the ‘OFF’ condition.
- In case of failure of one of the supply feeders (say by upstream fault), it will be sensed by the under-voltage relay which in turn will trip the incoming breaker after a pre-set time delay.
- Through the normally closed auxiliary contacts of the tripped incoming breakers, the bus-coupler breaker shall close provided the other section is “Healthy”.
- The automatic transfer scheme shall be such that the automatic closing of the bus section can be done only once and in case the bus coupler breaker trips during auto changeover, no further auto closing shall be permitted. Auto changeover shall not take place if the incomer breaker trips on fault. The restoration of power shall be manual.
- The automatic transfer circuit shall be controlled through an auto manual changeover switch.

20. **Technical Particulars**

<table>
<thead>
<tr>
<th>LT Switchboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal system voltage</td>
</tr>
<tr>
<td>System earthing</td>
</tr>
<tr>
<td>Short time rating</td>
</tr>
<tr>
<td>Making capacity</td>
</tr>
<tr>
<td>Control supply</td>
</tr>
<tr>
<td>Configuration</td>
</tr>
<tr>
<td>Colour code</td>
</tr>
<tr>
<td>Busbar rating</td>
</tr>
<tr>
<td>Enclosure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Circuit Breakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetrical breaking current</td>
</tr>
<tr>
<td>Making capacity</td>
</tr>
<tr>
<td>Short time rating (for 1 second)</td>
</tr>
<tr>
<td>Rating for incomers and buscouplers</td>
</tr>
<tr>
<td>Rating for outgoing</td>
</tr>
<tr>
<td>Closing mechanism</td>
</tr>
<tr>
<td>Incomer &amp; bus sectionalizer</td>
</tr>
<tr>
<td>Outgoing</td>
</tr>
<tr>
<td>Tripping mechanism</td>
</tr>
<tr>
<td>Control supply</td>
</tr>
<tr>
<td>No. of auxiliary contacts</td>
</tr>
<tr>
<td>Termination</td>
</tr>
<tr>
<td>Incomer</td>
</tr>
<tr>
<td>Outgoing</td>
</tr>
<tr>
<td>Finish paint</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feeder Arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomer &amp; buscoupler</td>
</tr>
<tr>
<td>(Mounted in single tier arrangement)</td>
</tr>
</tbody>
</table>
### Outgoings
(Mounted in two tier arrangement)

<table>
<thead>
<tr>
<th>Feeder requirement</th>
<th>Air circuit breakers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To be decided by the tenderer</td>
</tr>
</tbody>
</table>

| Colour identification | LT switchboard colour identification shall be change from RYB to YGR |

21. Schedule of Components

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Schedule of components equipment specification</th>
<th>Type of Feeder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>B/C</td>
</tr>
<tr>
<td>1.</td>
<td>415V,50kA air circuit breaker with:</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- independent, motorized, spring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- charged mechanism, with electrical/manual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ON/OFF control mechanism</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- shunt trip</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ON/OFF indicator</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>415V,50kA air circuit breaker with:</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- independent, manual, spring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- charged mechanism</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- shunt trip</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- mechanical ON/OFF indicator</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Microprocessor based intelligent type direct</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>acting O/C, S/C &amp; E/F release with</td>
<td></td>
</tr>
<tr>
<td></td>
<td>measurement control &amp; data transfer facility.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Microprocessor based direct acting O/C, S/C</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&amp; E/F release with measurement &amp; data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>transfer features without remote control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>facility.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Control switch ON/OFF with spring</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>return to neutral</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Multifunction meter</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>Current transformer, class 1.0 for</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>metering</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Microprocessor based motor protection</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>relay</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>ON/OFF/Trip on Fault/Trip circuit healthy</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>lamps</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Auxiliary relays flag indication for</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>buchholz trip and alarm and oil temperature</td>
<td></td>
</tr>
<tr>
<td></td>
<td>trip and alarm signals and winding temp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>alarm and trip signals</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Auto changeover scheme with under voltage</td>
<td>Between incomers &amp; bus couplers</td>
</tr>
<tr>
<td></td>
<td>relay, check synchronization relay, PT etc.</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Set of relays, contactors, timers, etc.</td>
<td>As per Requirement</td>
</tr>
<tr>
<td></td>
<td>for annunciation scheme</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Set of relays, contactors, timers for</td>
<td>As per Requirement</td>
</tr>
<tr>
<td></td>
<td>auto changeover scheme</td>
<td></td>
</tr>
</tbody>
</table>
### Schedule of Components Equipment Specification

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Feeder</th>
<th>B/C</th>
<th>Incomer</th>
<th>Out going ACB Feeder</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.</td>
<td>Impulse switch for tripping 6.6 kV or 11kV breaker</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>15.</td>
<td>Two position, two contacts stay put switch with pistol grip handle for closing permission of upstream 6.6 kV or 11kV breaker</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>16.</td>
<td>ON/OFF indication lamp for upstream breaker</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>17.</td>
<td>Inter tripping push button to trip the upstream breaker</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>18.</td>
<td>Analog Voltmeter with selector switch</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>19.</td>
<td>Analog Ammeter</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

### LT BUSDUCT

#### 1.02.04 Electrical Design

- **i)** Electric power supply (Unless otherwise specified) 415V, 3 phase, 50 Hz system.
- **ii)** Insulation level
  - Rated Voltage: 415 V
  - Rated insulation voltage: 1100V
  - One minute power frequency voltage: 2.5 kV
  - Clearance in air (minimum)
    - Phase to phase (mm): 25.4 mm
    - Phase to earth (mm): 19.0 mm
  - Neutral grounding: Solidly grounded
- **iii)** Short circuit strength
  - Rated short time withstand current not less than the system short circuit level specified for 1 Sec duration.
  - Rated peak withstand current not less than 2.1 times the system short circuit level.
- **iv)** Rated current
  - Rated continuous current as specified while in enclosure and at specified ambient temperature with maximum temperature of bus bars limited to 90 deg. C
  - Neutral bus where specified with rating not less than half the rating of phase bus.

#### 02. General Arrangement

- Rectangular, non-segregated phase, totally enclosed type.
- Comprising of following sections, as applicable, to make the installation complete and to match with the terminal equipment:
  - Switchgear lead-in section with flexible hood.
  - Straight section in standard length
  - Matching section (length as required)
  - Transformer lead-in section
  - Corner sections (horizontal and vertical)
  - Phase cross-over section, if required, to match phase sequence of boards.
- 240V AC space heater to be provided at suitable intervals and wired to external
terminal box with heat resistant cables.
- Silica gel breathers at appropriate locations.
- Horizontal bends to be avoided by positioning the switchboard incomers at appropriate place.

03. Construction Details
- Degree of protection for enclosure IP 52 or better for indoor installation, and IP55 for outdoor part.
- Enclosure material: Aluminum sheet, as specified of minimum thickness 2.0 mm for sheet steel & 2.5 mm for Aluminum.
- Enclosure construction rectangular welded construction.
- Maximum temperature of enclosure under rated operating conditions limited to 75 deg. C
- Bolted covers with gaskets for easy inspection and access to insulators and bus bar joints.
- Gasketed (Neoprene) connections between adjacent sections of metallic enclosure.
- Rubber bellows at each end to take care of vibrations.
- Provision for mounting on brackets.
- Seal off bushings shall be provided for busduct with indoor & outdoor part.
- The outdoor part shall be provided with sloping top.
- Seal off bushings shall be provided for busduct with indoor & outdoor part.
- Supply of painted MS supporting structures with necessary hardware shall be included in the scope of supply.
- Surface treatment.
  Two coats of epoxy paint for outdoor and synthetic enamel paint for indoor application, preceded by de-rusting, cleaning chemically, degreasing, pickling in acid, cold rinsing, phosphating, passivating and spraying with two coats of zinc oxide primer.
- Shade of paint:
  - Interior: Black
  - Exterior: Light grey shade 631 of IS-5 (unless otherwise specified) for outdoor part, Shade 632 of IS-5 (unless otherwise specified) for outdoor part.

04. Busbars and connections
- Material EC grade aluminium alloy equivalent to E91E WP conforming to IS 5082, 1981; or high conductivity electrolytic grade copper as per IS-613, 1984.
- Final operating temperature of both bus bars and joints under continuous operation in enclosure limited to 90 deg. C by thermometer method.
- Bus bar shall be as per IS-5082, IS-13947 & IS-5578.
- Phase identification by colour at ends and at regular intervals.
- Busbar joints of bolted type, with zinc bichromated high tensile steel bolts, nuts and spring washers. Bus-bar joint shall be chamfered as per the manufacturer’s practice.
- Busbar surfaces to be tinned at joints and coated with oxide inhibiting grease prior to jointing.
- Copper busbar surface should be tinned.
- Flexible connections for termination on equipment.
- Expansion joints on straight runs with joints staggered in adjacent phases.
- Bimetallic joints for jointing between dissimilar metals.
- Busbar support insulators of non-hygroscopic material, having high impact and
di-electric strength, with an anti-tracking contour.

05. **Protective earthing**
- Aluminium earth bus of size 50 x 10 mm running throughout the length of the busduct, positively connected to the body of the busduct.
- Provision at each end of busduct for terminating external earth conductor.

06. **Technical particulars for Design**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Application</td>
<td>Indoor</td>
</tr>
<tr>
<td>2.</td>
<td>Rated system voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>3.</td>
<td>System earthing</td>
<td>Solidly earthed</td>
</tr>
<tr>
<td>4.</td>
<td>Rated continuous current as specified ambient conditions (in enclosure)</td>
<td>4000 A</td>
</tr>
<tr>
<td>5.</td>
<td>Rated short time withstand current (kA.rms) and its duration</td>
<td>50 kA for 1 Sec.</td>
</tr>
<tr>
<td>6.</td>
<td>Rated peak withstand current (peak)</td>
<td>105 kA</td>
</tr>
<tr>
<td>- Busbars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Enclosure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Busbar material</td>
<td>Aluminium/Copper</td>
</tr>
<tr>
<td>9.</td>
<td>Neutral bus</td>
<td>To be provided</td>
</tr>
<tr>
<td>10.</td>
<td>Earth bus material</td>
<td>Aluminium</td>
</tr>
<tr>
<td>11.</td>
<td>Earth bus size</td>
<td>2 nos. 50 x 10</td>
</tr>
<tr>
<td>12.</td>
<td>Supporting insulators</td>
<td>SMC/FRP</td>
</tr>
<tr>
<td>13.</td>
<td>Busduct enclosure material</td>
<td>Aluminium</td>
</tr>
<tr>
<td>14.</td>
<td>Busduct enclosure material thickness</td>
<td>2.5 mm</td>
</tr>
<tr>
<td>15.</td>
<td>Busduct support structure</td>
<td>To be provided</td>
</tr>
<tr>
<td>16.</td>
<td>Overall (approximate) length of busduct (to be finalized, during detailing) including bends flanges etc.</td>
<td>8 m per set</td>
</tr>
<tr>
<td>17.</td>
<td>Type</td>
<td>Phase non-segregated type</td>
</tr>
<tr>
<td>18.</td>
<td>Maximum voltage at which busduct can operate</td>
<td>1100V</td>
</tr>
<tr>
<td>19.</td>
<td>One minute power frequency withstand voltage(kV)</td>
<td>2.5</td>
</tr>
<tr>
<td>20.</td>
<td>End connections</td>
<td>Copper flexibles</td>
</tr>
<tr>
<td>21.</td>
<td>Clearance:</td>
<td></td>
</tr>
<tr>
<td>- Phase to phase</td>
<td></td>
<td>25.4 mm, 19 mm.</td>
</tr>
<tr>
<td>- Phase to earth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>Accessories:</td>
<td>To be provided</td>
</tr>
<tr>
<td>- Space heater with thermostat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Silica gel breather</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Busbar support structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Enclosure Protection class</td>
<td>IP-52</td>
</tr>
<tr>
<td>24.</td>
<td>Paint-Shade</td>
<td></td>
</tr>
<tr>
<td>- Interior</td>
<td>Black Shade 631 of IS:5</td>
<td></td>
</tr>
<tr>
<td>- Exterior</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

102.05 **Power Distribution Board (PDB)**
- 415V, 3 phase, 4 wire, 50 kA (short time rating for 1 sec.) indoor type.
- Board shall be single front, metal clad, front matched dust and vermin proof, fully compartmentalized and extensible on both sides, IP51 type enclosure.
- Degree of protection for enclosure IP 52 or better for indoor installation, and IP55 for outdoor part.
- Shall have base channel of size ISMC 75.
- Shall have isolated busbar chamber for main busbar at the top, running through out the length of the board. Chamber shall have removable cover.
- Cable alley shall have sufficient space for aluminium power cables and bottom cable chamber shall be left free completely isolated from the vertical busbars.
- Busbars shall have same cross section through out the length. Rating of the neutral busbar shall be 50% of the main busbar. Earth bus bar shall run in bottom chamber throughout the length of the panel.
- Shall have moulded case circuit breaker triple pole, air break type with independent manual quick make and quick break type. MCCB shall be capable of breaking rated current at .3 pf at rated voltage. MCCB shall withstand the fault current envisaged for 415V system.
- All feeders shall have ON/OFF lamps and 96 sq.mm size ammeter.
- Incomers of board and outgoing shall be MCCBs with E/F protection.

1.02.06 MOTORS & FIELD DEVICES

01. Low voltage squirrel cage induction motors:

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Standard</td>
<td>IPSS 1-03-001 / IS 325 / IEC 34 &amp; IEC 72</td>
</tr>
<tr>
<td>2.0</td>
<td>Constructional Features</td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Frame size &amp; rating</td>
<td>As per IS 325</td>
</tr>
<tr>
<td>(ii)</td>
<td>Motor body</td>
<td>Grey iron casting as per IS:210-1978</td>
</tr>
<tr>
<td>(iii)</td>
<td>Motor Feet</td>
<td>Integrally cast with the stator</td>
</tr>
<tr>
<td>(iv)</td>
<td>Body Design</td>
<td>Prevent breakage or other failures due to vibrations normally encountered in heavy industries.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motors shall be of weather proof construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Designed to operate in the humid air stream.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drain plugs to be provided.</td>
</tr>
<tr>
<td>(v)</td>
<td>Protection for Motor &amp; Bearing</td>
<td>IP - 55  (with canopy for motor if installed outdoor)</td>
</tr>
<tr>
<td>(vi)</td>
<td>Shaft ends &amp; Extension</td>
<td>Cylindrical as per requirement Proper drilling and tapping shall be provided for mounting of tachos for speed feedback (if required) Crane motor in 225 and above frame sizes shall have tapered shaft (1:10) ( New point)</td>
</tr>
</tbody>
</table>
(vii) **Bearings**
- For motor of rating up to 5 kW, ball bearings shall be used for both DE & NDE end.
- For ratings above 5 kW, the DE end shall be provided with roller bearing and NDE end shall be provided with ball bearing.
- Bearings for motors shall be of C3 clearance.
- Bearings shall be suitable for running of motor in either direction.

(viii) **Hazardous Area safety design**
- As per requirement

(ix) **Canopy**
- To be provided for all outdoor motors.

(x) **Greasing point**
- At DE & NDE sides.

(xi) **Paint shade**
- Light grey shade 631 as per IS:5 or RAL 7030 (grey).

(xii) **Direction of Rotation**
- For crane and mill duty motors: reversible
- For general purpose continuous duty motor: Bidirectional (New point)

### 3.0 Terminal box

(i) **Location**
- Location on top preferably

(ii) **Suitability**
- 4 Core Aluminium Cable
- Extension shall be done to receive the aluminium cables to avoid cramping of the cables in the terminal box.

(iii) **Rotation**
- 4 X 90 deg.

(iv) **Earthing stud**
- Inside Terminal Block

### 4.0 Cooling

- TEFC
- Effective irrespective of direction of rotation

### 5.0 Quality of operation

(i) **Vibration intensity**
- Shall be limited as per IS 12075-1986.

(ii) **Noise level**
- As per IS: 12065-1987

(iii) **Balancing**
- Motors shall be dynamically balanced with full key on the shaft-end and fan

### 6.0 Electrical design

(i) **Power Supply**
- 415 V +10 & -15%
- 50 Hz +/- 6%
- 3-phase, 4-wire AC
- 50 kA for 1 second, solidly earthed.

(ii) **Starting**
- DOL

(iii) **Min Voltage for Start & Run**
- 85% of rated voltage at terminal

(iv) **Starting Torque**
- >= 160% Rated Torque

(v) **Breakdown or pullout torque**
- Minimum 275% of the rated torque

(vi) **Starting current**
- <= 600% Rated current

(vii) **Duty**
- S1/......or as specified in TS
- For crane duty S5 40% with 150 start/hour.
- For conveyer application S-3 and 6 starts/hr
- For continuous duty: efficiency class EFF-1.

(viii) **Starts/Hour permissible**
- 3 equally spread or 2 in quick succession from cold or one hot start, under rated load condition.

(ix) **Max speed permissible**
- 120% over speed for 2 minutes

(x) **Overload capacity**
- Capable of withstanding 60% Overload for 15 sec.

(xi) **Efficiency**
- All continuous duty motor (S1-100%) shall be of high
efficiency confirming to eff2 class as per IEEMA-19-2000.

(xii) Derating
Motor designed at 50 deg.C shall be derated suitably for mentioned ambient temperature.

(xiii) Motor connections
Motor with frame size 90 shall be connected in star and of frame sizes more than 90 shall be connected in delta.
For delta connected motors 6 leads shall be brought out.

(xiv) Insulation
Class F

(xv) Minimum temperature rise
Permissible temperature rise Limited to class 'B' (120 deg absolute)

(xvi) Torque Type
Normal / High / High slip type / Stall Torque type (as required for the specific application)

(xvii) Space Heater
Out door motors above 45 kW
Indoor Motor above 110 kW

(xviii) No. of Poles
4 pole (unless specific drive requirement or economics call for other poles).

(xix) Testing
As per approved QAP during engineering stage.

(xx) Mounting
Normally horizontally foot mounting.
Other type of mounting as per specific requirement.

02. Low voltage slip ring induction motors (Only for cranes and mill duty) :-

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Standard</td>
<td>IPSS:1-03-001-92, IPSS 1.03-004-93, IS 325, IEC 34 &amp; IEC 72</td>
</tr>
<tr>
<td>2.0</td>
<td>Application</td>
<td>Slip ring induction motors shall be used only for drives of charging cranes. Slip ring motors shall be employed for intermittent duty drives requiring frequent switching operations and speed control and for heavy drive applications requiring high starting torque and meeting frequent overload conditions.</td>
</tr>
<tr>
<td>3.0</td>
<td>Constructional Features</td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Frame size &amp; rating</td>
<td>As per IS 325 Use of motors in frame sizes above 400 shall be avoided on cranes.</td>
</tr>
<tr>
<td>(ii)</td>
<td>Motor body</td>
<td>Grey iron casting as per IS:210-1978</td>
</tr>
<tr>
<td>(iii)</td>
<td>Motor Feet</td>
<td>Integrally cast with the stator</td>
</tr>
<tr>
<td>(iv)</td>
<td>Body Design</td>
<td>- Prevent breakage or other failures due to vibrations normally encountered in heavy industries.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Motors shall be of weather proof construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Designed to operate in the humid air stream</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Drain plugs to be provided.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- All motors to have continuously rated slip rings.</td>
</tr>
</tbody>
</table>
(v) Protection for Motor & Bearing | IP55 degree of protection as per IS : 4691.

(vi) Shaft ends & Extension
- Shall be of high grade steel.
- Cylindrical as per requirement
- Proper drilling and tapping shall be provided for mounting of tachos for speed feedback (if required) in non drive end or shaft shall be extended with different diameter and length.
- Tapered shafts for all crane drive motors shall be provided. Motors in 225 and above frame size shall have tapered shaft (1:10).
- Provision of double identical shaft extension (cylindrical & taper) to be made (in case of requirement for a particular application).

(vii) Slip rings
- All motors to have continuously rated slip rings.
- Phosphor bronze or steel slip rings shall be provided. Cast iron slip-rings shall not be used.
- Brush holders shall be in a complete assembly unit.
- Slip ring unit shall have a cover with inspection window.
- For higher range of motors, separate disc is provided between the slip ring and rotor windings to prevent carbon dust ingestion into windings.

(viii) Bearings
- For motor of rating upto 5 kW, ball bearings shall be used for both DE & NDE end.
- For ratings above 5 kW the DE end shall be provided with roller bearing and NDE end shall be provided with ball bearing.
- Bearings for motors shall be of C3 clearance.
- Bearings shall be suitable for running of motor in either direction.

(ix) Hazardous Area safety design | As per requirement

(x) Canopy | To be provided for all outdoor motors.

(xi) Greasing point | At DE & NDE sides for online greasing facility without dismantling the motor.

(xii) Paint shade | Light grey shade 631 as per IS:5 or RAL 7030 (grey).

4.0 Terminal box

(i) Location | On top preferably

(ii) Suitability
- 4 Core Aluminium Cable
- Extension shall be done to receive the aluminium
cables to avoid cramping of the cables in the terminal box.

| (iii) | Rotation | 4 X 90 deg. |
| (iv) | Earthing stud | One earthing stud shall be provided in the terminal box and two terminals on mounting feet. |
| (v) | Stator and rotor connections | Separate and distinctly marked terminal box to be provided for stator and rotor connections. |
| (vi) | Protection class | IP 55 in all the cases. |
| (vii) | Cable glands | Suitable for double compression type cable glands. |

### 5.0 Cooling

- TEFC design only
- Effective irrespective of direction of rotation
- The cooling code of motor is IC 411 as per IS : 6362.

### 6.0 Quality of operation

| (i) | Vibration intensity | Shall be limited as per IS 12075-1986. |
| (ii) | Noise level | As per IS: 12065-1987 |
| (iii) | Balancing | Motors shall be dynamically balanced with full key on the shaft- end and fan |

### 7.0 Electrical design

| (i) | Power Supply | • 415 V +10 & -15%  
• 50 Hz +/- 6%  
• 3-phase, 4-wire AC,  
• 50 kA for 1 second, solidly earthed. |
| (ii) | Starting | DOL or thyristor converter (ASTAT or SIMOTRAS or equiv.) Soft starter feature through static voltage control/VVVF as per application |
| (iii) | Min Voltage for Start & Run | 80 % of rated voltage at terminal |
| (iv) | Breakdown or pullout torque | Pull out torque of the intermittent duty motors to be not less than 300% of the rated torque at 40% duty factor. |
| (vi) | Starting current | <= 600% Rated current |
| (vii) | Duty | Duty cycle shall not be less than S4-40% , with a minimum of 150 starts per hour (600 starts / hour for charging cranes and other process cranes) . For conveyor application S-6 duty. |
| (viii) | Starts/Hour permissible | Mechanically and electrically shall be suitable for the required number of switching / reversals or starts per hour. |
| (ix) | Max speed variation | 250 % of rated synchronous speed at high accelerating rates and rapid reversals . |
| (x) | Max speed | 250 % of rated speed or 2000 rpm whichever is less . |
| (xi) | Rated synchronous speed | Motors shall be of low synchronous speed for ease of dynamic balancing of hoist rotating unit . The motor speed preferably shall be as follows :  
Upto 37 KW :
- <= 1000 rpm  
Above 37 KW upto 90 KW :
- <= 750 rpm  
Above 90 KW :
- <= 600 rpm |
| (xii) | Overload capacity | 1.5 times the rated current for 2 minutes |
| (xiv) | Void | |
| (xvi) | Derating | Motor designed at 50 deg.C shall be derated suitably for mentioned ambient temperature. |
| (xvii) | Insulation | Class H |
03. Roller Table Motors (Torque motors)

1.0 Standard              IPSS 1-003-007-85
1.0 Duty & type           All travel mechanism shall have roller table duty motors.
2.0 Insulation class      Class H insulation. temperature rise limited to class F.
3.0 Maximum speed         All roller table duty motors shall have a maximum speed of 1000 RPM.
4.0 Cooling               Shall be TENV type only. IC 410.
5.0 Temperature sensor    Roller table motor (Torque motor) shall have built in PTC thermistors.
6.0 Locked rotor withstand time Ability to withstand locked rotor conditions for minimum 1 min. under hot conditions. The motors shall meet the process requirement also.
7.0 Control system        All the roller table motors shall be inverter duty in case of VFD control otherwise RDOL.

04. High voltage squirrel cage induction motors

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Standard</td>
<td>IPSS 1-03-018/IS 325</td>
</tr>
<tr>
<td>2.0</td>
<td>Constructional Features</td>
<td></td>
</tr>
<tr>
<td>i).</td>
<td>Frame size &amp; rating</td>
<td>As per IS 325</td>
</tr>
<tr>
<td>ii)</td>
<td>Stator Frame</td>
<td>Fabricated Steel / High grade cast Iron</td>
</tr>
<tr>
<td>iii)</td>
<td>Stator Core</td>
<td>Laminated sheets of high grade low loss silicon steel</td>
</tr>
</tbody>
</table>
iv) Motor body | Grey iron casting as per IS:210-1978
v) Casing Feet | Integral with the motor frame
vi) Body Design | Prevent breakage or other failures due to vibrations normally encountered in heavy industries
viii) Shaft | Forged Steel shaft
ix) Bearings (below 1000kW) | Anti-friction Bearing with Regreasing facility & with grease quantity controllers
x) Bearings (1000kW & above) | Pedestal type sleeve bearing with forced oil lubrication. (Arrangements to be incorporated to prevent lubricating oil from reaching the windings)
| | Bearing temperature, lubricating oil temperature and pressure to be measured and monitored.
x) Vibration monitor | Shall be provided at the DE end of motor bearing
xi) Pedestals insulation | Against circulating shaft currents
xii) Hazardous Area safety design | NA / as specified
xiii) Indication of direction of rotation | By Arrow blocks on non-driving end
xiv) RTD & BTD (PT100 type) | All motors shall be provided with Bearing (DE & NDE) temperature detectors and 6 nos. stator winding temperature detectors, RTDs for monitoring alarm and trip conditions. RTD’s shall be of PT100 type (duplex).
| | Analog input cards shall be provided in PLC for online monitoring of bearing (DE & NDE) and winding temperature of HT motors above 1000 KW.
| | For HT motors, temperature of each RTD (for winding / bearing) shall be wired to PLC system and limit value contacts for alarm and tripping shall be generated in the PLC along with the display of all parameters of the motor including the winding and bearing temperature.
xv) Vibration monitoring | Vibration monitoring (online) shall be provided at the DE end of motor bearing for motors of ratings 1000 kW and above and it should be connected to PLC for online monitoring.
xvi) Paint shade | Light grey, shade no. 631 as per IS 5

3.0 Terminal box
i) Protection | IP - 55
ii) Type | Phase segregated
iii) Location | As per requirement 1 no. each on opposite sides of motor.
iv) Winding star point | Winding star point shall be kept outside in the motor for more than 200 KW HT motor and other
<p>| | | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
</table>
|   |   | important HT motor.  
|   |   | - In case no differential protection is required, star point of the winding may be formed inside the neutral terminal box to be provided on one side of the motor. The phase segregated terminal box shall be placed on other side of the motor. |
| v) | Suitability | Termination of XLPE cables with heat shrinkable cable end seals.  
|   |   | - Each terminal box to have two inlets to accommodate any parallel cables as required. |
| vi) | Reversible | To suit cable entry from Top / Bottom |
| vii) | Earthing stud | Inside TB for protective earth conductor termination |
| viii) | No. of terminal boxes | Separate for Space heaters, RTDs / BTDs, Vibration monitor etc |
| ix) | Fault withstand (Min.) | Rated Short circuit level of the system voltage for 0.25 sec |
| 4.0 | Cooling | TEFC / CACA / CACW  
|   |   | CACW system shall be complete with temperature and pressure monitoring devices. |
| 5.0 | Quality of operation |   |
| i) | Vibration intensity | Limited to 37.5 micron peak to peak. |
| ii) | Noise level | Continuous noise level should not exceed 85 db A at a distance of 1.0 m from the motor body as per IS: 12065-1987. |
| iii) | Balancing | Dynamically balanced with full key on shaft end and fan |
| 6.0 | Electrical design |   |
| i) | Efficiency | High efficiency design of 96% at Full load |
| ii) | Starting | DOL |
| iii) | Min Voltage for Start & Run | 80% of rated voltage at terminal |
| iv) | Starting Torque | As specified in application |
| v) | Starting current | <= 600% Rated current |
| vi) | Duty | S1 |
| vii) | Starts permissible | 3 successive start from cold condition OR 2 successive start from hot condition. |
| viii) | Starts / hour | 3 equally spread in normal Voltage, Frequency & Load |
| ix) | Max speed permissible | 150% rated for 2 minutes |
| x) | Differential protection | Required for 1000 kW & above |
| xi) | Insulation | Class F & confirming to IEC 34 - 15/1990 |
| xii) | Insulation Material | Cast resin rich / VPI |
| xiii) | Minimum temperature rise | Permissible temperature rise Limited to class 'B' (120 deg absolute) |
| xiv) | Space Heater | Required & automatically off during RUN |
| xv) | No. of Poles | 4 (or as mentioned specifically) |
| xvi) | Locked rotor current withstand time | 5 sec longer than starting time under rated load condition. |
| xvii) | Surge protection | As specified |
| xviii) | Operational design | Suitable to VCB Breaker |
| xix) | Motor winding and inter turn insulation, connections and | Shall be fully insulated using mica insulation. For such motors surge absorbers (with non-linear resistance) |
leads: shall be provided within 10 to 15 meters from the motor terminals to limit the over voltages.
OR
In case mica is not provided in motor insulation, both surge capacitors and surge absorbers (with non-linear resistance) shall be provided within 10 to 15 mtrs from the motor terminals to limit the over voltages and rate of rise of voltage.

### 05. Synchronous Motors

#### 2.0 Constructional Features

| i) | Frame size & rating | As per IS 325 |
| ii) | Stator Frame | Fabricated Steel / High grade cast Iron |
| iii) | Stator Core | Laminated sheets of high grade low loss silicon steel |
| iv) | Motor body | Grey iron casting as per IS:210-1978 |
| v) | Casing Feet | Integral with the motor frame |
| vi) | Body Design | Prevent breakage or other failures due to vibrations normally encountered in heavy industries |
| vii) | Protection for Motor & Bearing | IP – 55 as per IS 4691-1985 |
| viii) | Shaft | Forged Steel shaft |
| ix) | Bearings (below 1000kW ) | Anti-friction Bearing with Regreasing facility & with grease quantity controllers |
| vii) | Vibration monitor | Shall be provided at the DE end of motor bearing |
| x) | Pedestals insulation | Against circulating shaft currents |
| xi) | Hazardous Area safety design | NA / as specified |
| xii) | Indication of direction of rotation | By Arrow blocks on non-driving end |
| xiv) | RTD & BTD ( PT100 type) | All motors shall be provided with Bearing (DE & NDE) temperature detectors and 6 nos. stator winding temperature detectors, RTDs for monitoring alarm and trip conditions. RTD’s shall be of PT100 type (duplex). Analog input cards shall be provided in PLC for online monitoring of bearing (DE & NDE) and winding temperature of HT motors above 1000 KW . For HT motors, temperature of each RTD (for winding / bearing) shall be wired to PLC system and limit value contacts for alarm and tripping shall be generated in the PLC along with the display of all parameters of the motor including the winding and bearing temperature. |
### 3.0 Terminal box

**i)** Protection  
IP - 55

**ii)** Type  
Phase segregated

**iii)** Location  
- RHS viewed from DE / On top  
- 01 nos. each on opposite sides of motor in case of Differential Protection (or not) / Neutral TB opposite to main TB

**v)** Suitability  
- Termination of XLPE cables with heat shrinkable cable end seals.  
- Each terminal box to have two inlets to accommodate any parallel cables as required.

**vi)** Reversible  
To suit cable entry from Top / Bottom

**vii)** Earthing stud  
Inside TB for protective earth conductor termination

**viii)** No. of terminal boxes  
Separate for Space heaters, RTDs / BTDs , Vibration monitor etc

**ix)** Fault withstand (Min.)  
Rated Short circuit level of the system voltage for 0.25 sec

### 4.0 Cooling

TEFC / CACA / CACW  
CACW system shall be complete with temperature and pressure monitoring devices.

### 5.0 Quality of operation

**i)** Vibration intensity  
Limited to 37.5 micron peak to peak.

**ii)** Noise level  
Continuous noise level should not exceed 85 db A at a distance of 1.0 m from the motor body as per IS: 12065-1987.

**iii)** Balancing  
Dynamically balanced with full key on shaft end and fan

### 2.0 Design

Motors shall be of cylindrical design with brush less excitation system and automatic voltage and power factor regulation.

### 3.0 Power factor

0.9 or better.

### 4.0 Motor winding

Motor stator winding braced for full voltage starting. Squirrel cage type winding with short circuited rotor bars for producing starting torque and accelerating torque to bring the synchronous motor upto the speed. All the three windings stator, rotor and exciter shall be VPI (Vacuum pressure impregnation).

### 5.0 Bearings

Small frame size motors shall have endshield bearings and large motors shall have pedestal bearings.
6.0 Cooling
All the three modes of cooling arrangement as per requirement
- Open air (for the areas where air is relatively clean e.g water supply pump houses)
- Air to water (in closed cooling circuit)
- Air to air cooling (ID fan etc.) . A shaft mounted fan or a separate fan to be provided for air circulation .

7.0 Excitation method
Brushless excitation system (Integral exciter and rotating rectifier assembly to eliminate the need for brushes and slip rings both on exciter and motor respectively) .

8.0 Automatic system power factor correction.
Motor field to have micro processor based thyristor controlled static excitation system (for automatic system power factor correction).

9.0 Motor synchronism protection
Field monitor relay to be provided for monitoring the power factor of the system which in turn trips the motor and the exciter field off if synchronism is not achieved within a specific length of time or if the motor pulls out of step .

10.0 Insulation class
Class F insulation for field windings as well as for stator with temperature rise limited to 70 deg. C (as measured by resistance method) over an ambient of 50 deg. C.

11.0 Locked rotor withstand time
Motors shall be capable of withstanding locked rotor current for atleast 5 second longer than starting time under rated load condition.

12.0 Starting method
DOL / Auto transformer starting method / Load commutated inverter (LCI)

13.0 Space Heater
Space heater to be provided.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Type</td>
<td>AC Squirrel cage induction motor. Inverter Duty</td>
</tr>
<tr>
<td>2.0</td>
<td>Standard</td>
<td>IPSS 1-03-001/IS 325. NEMA Standard MG1-1993 Part 31, or the latest revision in so far as it is applicable.</td>
</tr>
<tr>
<td>3.0</td>
<td>Constructional Features</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Frame size &amp; rating</td>
<td>As per IS 325</td>
</tr>
</tbody>
</table>
### STEEL AUTHORITY OF INDIA LIMITED
#### BHILAI STEEL PLANT
##### GENERAL TECHNICAL SPECIFICATION

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Motor body</td>
<td>Grey iron casting as per IS:210-1978</td>
</tr>
<tr>
<td>C</td>
<td>Motor Feet</td>
<td>Integrally cast with the stator</td>
</tr>
</tbody>
</table>
| D | Body Design | - Prevent breakage or other failures due to vibrations normally encountered in heavy industries.  
    - Motors shall be of weather proof construction.  
    - Designed to operate in the humid air stream. |
| E | Protection for Motor & Bearing | IP - 55 |
| F | Motor Shaft | Shall be provided with an external recessed slinger at the drive end of the motor to provide additional (minimum IP-54) protection from moisture and foreign material. |
| G | Shaft ends & Extension | - Cylindrical as per requirement  
    - Shaft shall be extended for encoder / tacho. mounting, accordingly suitable hole shall be drilled and tapped. |
| H | Internal Encoder | Motors with speed variation of 1000:1 at constant torque shall have internal builtin encoder for speed feedback |
| I | Bearing | - Roller type bearing upto 5 kW.  
    - Ball Bearing at NDE end for above 5 kW.  
    - All motors shall have fully re-greaseable, anti-friction bearings.  
    - All motors shall have cast iron inner bearing caps.  
    - Bearings shall be oversized.  
    - All motors shall have a charged lubrication system to inhibit moisture condensation.  
    - Standard motors shall have extended grease fittings on the opposite drive-end to facilitate re-lubrication. Grease ports shall be located on the periphery of the motor endshield.  
    - Motor shall be fitted with a shaft slinger or V ring seal on the drive end for a minimum of IP-54 protection (to help protection of bearing from ingress of dust, dirt or fluids). |
| J | Hazardous Area safety design | NA |

### 4.0 Terminal box

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Location</td>
<td>RHS viewed from DE / On top</td>
</tr>
<tr>
<td>B</td>
<td>Suitability</td>
<td>- 4 Core Aluminium Cable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>C</td>
<td>Rotation</td>
<td>4 X 90 deg.</td>
</tr>
<tr>
<td>D</td>
<td>Earthing stud</td>
<td>Inside Terminal Block</td>
</tr>
</tbody>
</table>
| E | Miscellaneous | - Shall be gasketed between the terminal box halves.  
- The conduit box shall be field convertible to cast iron.  
- External screws and bolts shall be grade five, hex heads and be plated to resist corrosion. |

5.0 Cooling
- TEFC, Effective bi-directional  
- TENV (for roller table duty)  
- Motor with 1000:1 speed range and constant torque shall have external fan.  
- External fan motor shall be 3 phase, 415 V AC  
- Thermistors shall be provided in the windings.

6.0 Quality of operation
A | Vibration intensity | - Shall be limited as per IS 12075-1986.  
- Shall not exceed .08 inches / second velocity. |
B | Noise level | As per IS: 12065-1987 |

7.0 Electrical design
A | Power Supply | 415 V ±10 & - 15% , 50 Hz +/- 6%, 4-wire AC, 50 kA for 1 second, solidly earthed. |
B | Starting | Variable Frequency Drive |
C | Service factor | - 1.0 for VFD power.  
- 1.15 for sine wave power. |
D | Peak transient voltage | 1600 V |
E | Minimum rise time | 0.1 microsecond |
F | Starting Torque | 200 % rated torque for 1 minute below base speed |
G | Constant horsepower operation | 1.5 times base speed. |
H | Duty | Application dependent |
I | Max speed permissible | 150 % rated for 2 minutes |
J | Derating for VFD | As per above mentioned standard |
K | Insulation | Class H limited to class F. |
L | Load Type | Constant Torque / Variable Torque (As per application) |
M | Space Heater | - Out door motors above 45 kW  
- Indoor Motor above 110 kW |
N | No. of Poles | 4 / 6 / 8 |

8.0 Operating Characteristics
A | Operation with variation in the | Motors shall operate successfully under running |
<p>| | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>voltage or the frequency conditions at rated load with variation in the voltage or the frequency not exceeding the following conditions:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>· +/-10% rated voltage at rated constant V/f ratio except for specific torque boost situations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motors shall operate successfully under running conditions at rated load and V/f ratio when the voltage unbalance at the motor terminals does not exceed one percent.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B Torques Motors shall meet or exceed the minimum locked rotor (starting) and breakdown torques specified in NEMA Standard MG1 Part 12 for Design B for the rating specified when on sine wave power.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Operating speed range - Zero to base speed in case of VT. - 1000: 1 for CT (with blower cooling) - 10:1, 6:1, 4:1 for CT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D Locked rotor (starting) currents Shall not exceed NEMA Design B values for the specified rating on 5:1 constant torque or less and variable torque motors. NEMA Design A values are allowed for 6:1 constant torque or higher value constant torque rated motors. Motors shall be capable of a 20 second stall at six times full load current without injurious heating to motor components.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E Efficiency - Shall have a nameplate minimum and nominal full load efficiency for motors when tested in accordance with NEMA standard MG1 Part 12, IEEE Test Procedure 112 Method B, using accuracy improvement by segregated loss determination including stray load loss measurements.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.0 Motor location Outdoor / indoor installation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0 Painting For indoor motors: Total thickness of painting shall be 140 microns. For outdoor motors: Total thickness of painting shall be 240 microns.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.0 Nameplate - Shall be of corrosion resistance stainless steel. - In addition to standard nameplate information following informations shall be included: o Nominal efficiency. o Bearing identification numbers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07. DC Electromagnetic brake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.0 Standard</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>220V DC</td>
</tr>
</tbody>
</table>

| 3.0 Application | Suitable for steel mill duty having long mechanical life. |

<table>
<thead>
<tr>
<th>4.0 Duty</th>
<th>Shunt brake for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Continuous duty</td>
</tr>
<tr>
<td></td>
<td>- Intermittent duty</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series brake for</th>
</tr>
</thead>
<tbody>
<tr>
<td>- One hour duty (mill duty)</td>
</tr>
<tr>
<td>- Half hour duty (crane duty)</td>
</tr>
</tbody>
</table>

| 5.0 Mounting | Floor mounting, two shoes, self-aligning, quick acting with self-lubricating robust bearings. |

| 6.0 Brake shoe lining | Lining of tough heat resistant material with countersunk fixing rivets to prevent rubbing against the brake wheel. |

<table>
<thead>
<tr>
<th>7.0 Shoe adjustment and indications</th>
<th>Facility for brake torque adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lining wear indication</td>
</tr>
</tbody>
</table>

| 8.0 Coil | Insulation : Class F |

| 9.0 Braking Torque rating | Minimum 150% of the motor FLT |

<table>
<thead>
<tr>
<th>10.0 Temperature limit for brake magnet and brake drum</th>
<th>Brake magnet :</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- The magnet shall not become heated, during operation, to a temperature exceeding 150 deg. C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brake drum :</th>
</tr>
</thead>
<tbody>
<tr>
<td>- The temperature of the drum during working of the brake shall not exceed 200 deg. C</td>
</tr>
</tbody>
</table>

| 11.0 Limit switch | Limit switches to be provided for contact feedback used for interlocking, indications etc. |

<p>| 12.0 Safety for fail safe operation | Electrically released and spring applied for fail safe operation (gravity operated counterweight type are not acceptable) |</p>
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.0</td>
<td>Maintainability of brake coil</td>
<td>Brake coil connection brought to appropriate terminal box for ease in maintenance and terminals covered for protection against accidental touch.</td>
</tr>
<tr>
<td>14.0</td>
<td>Residual magnetic gap adjustment</td>
<td>To increase the residual magnetic gap for reducing brake application time anti magnetic shim shall be provided.</td>
</tr>
<tr>
<td>15.0</td>
<td>Brake panel</td>
<td>Necessary rectifier and brake forcing equipment shall be included for DC electro-magnet brakes used with AC system.</td>
</tr>
<tr>
<td>16.0</td>
<td>Installation of brake panel</td>
<td>DC electromagnetic brake panel shall be installed in MCC room</td>
</tr>
</tbody>
</table>

### 08. Field Switches

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Enclosure protection</td>
<td>All field switches to have enclosure class IP-65 in covered area &amp; IP-67 in open area.</td>
</tr>
<tr>
<td>2.0</td>
<td>Contacts</td>
<td>Minimum separate contacts 2NO &amp; 2NC for interlocks and as required for process.(with external JB)</td>
</tr>
</tbody>
</table>

### 09. Power Resistance

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Resistor design</td>
<td>To meet arduous heavy duty industrial and steel works application, unbreakable, rigid, resilient &amp; rust less.</td>
</tr>
<tr>
<td>2.0</td>
<td>Material</td>
<td>Fechrall edge wound</td>
</tr>
<tr>
<td>3.0</td>
<td>Duty rating</td>
<td>10 minutes rating of BS: 587 and conforming to IPSS No. 1-10-002-82 and addendum No 1 to IPSS (March 1985).</td>
</tr>
<tr>
<td>4.0</td>
<td>Construction</td>
<td>Every turn of every grid is fully supported so that adjacent turns and adjacent grids can neither vibrate nor distort so as to make mutual contact. The complete grid is spot welded to its neighbors thus eliminating slacken support due to heating and cooling and is mounted on mica insulated high tensile steel tie-rod and mica creepage washers. A tripping point is formed on each grid by a hole in the welded portion which is double thickness and absolutely flat. All grids shall have either zinc alloyed or cadmium plated surface for permanent weather proofing. Highest quality mica and porcelain insulated terminals are to be used</td>
</tr>
</tbody>
</table>
throughout. The thermal loading of the resistance box should be uniform.

5.0 Painting
All metal works for the housing shall be degreased, derusted and passivated before applying two coats of stove enamel.

6.0 Terminals
The terminals shall be easily accessible at the lower most stack.

7.0 Enclosure class
IP-30 or better for outdoor application and IP-11 for indoor application.

8.0 Testing
Testing shall be carried in accordance to BS: 587.

9.0 Power resistors for crane control
Shall be of Fechal edge wound resistance boxes. The element design shall be either circular (Russian design) or elliptical (BHEL design). Punched grid resistance boxes shall not be used for crane control.

1.02.07 Individual Drive Control Level
01. Variable Frequency Drive (VFD)

1.0 Basic design particulars
- Digital control technology with vector control (with/without PG as per requirement).
- IGBT based with sine coded PWM control.
- VFD shall communicate to basic automation system on system communication bus.
- Suitable for variable torque or constant torque applications requiring harmonic control as defined by IEEE 519-1992.
- The drive shall have an internal EMC filter capable of meeting the Second Environment levels for the EMC directive without the need for additional components.
- Shall confirm to IEC 146 - International Electrical Code.
- For 4 quadrant operational drives, active front end type VFD shall be provided.
- Where speed control is desired for production and quality control VFD isto be provided.
- Where speed control is not required sof t starter or motor intelligent controllers are to be provide.

2.0 Drive controller
- Software configurable to either V/Hz (single or multi
<table>
<thead>
<tr>
<th></th>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
</table>
|   | motor) mode or Sensorless Dynamic Torque Vector mode (single motor). | - Full, closed loop flux vector control shall be available for constant torque applications.  
- Operating the drive with motor disconnected.  
- Adjustable PWM carrier frequency within a range of 3 – 15 KHz.  
- Suitable for use on both CT & VT loads.  
- Multiple programmable stop modes including - Ramp, Coast, DC-Brake, Ramp-to-Hold and S-curve.  
- Multiple acceleration and deceleration rates. |

<table>
<thead>
<tr>
<th></th>
<th>Type of connection</th>
<th>Description</th>
</tr>
</thead>
</table>
| 3.0 | Three full wave diode rectifiers supplied by phase shifted, three phase AC to provide a fixed DC voltage. | - DC bus inductor on all ratings  
- DC link capacitors  
- Insulated Gate Bipolar Transistor (IGBT) power section, shall be rated for variable / constant torque applications. The power section shall use vector dispersal pulsewidth modulated (PWM) IGBT gate control algorithm and soft switching IGBT’s to reduce motor terminal dv/dt and allow longer cable length from drive to motor without output filters.  
- The Main Control Board shall be the same for all ratings to optimize spare parts stocking and exchange  
- Common control connection for all ratings. |

<table>
<thead>
<tr>
<th></th>
<th>Overload capacity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>110% of the rated current for 1 minute , 30 seconds at 150% (with inverse characteristics proportional to time) for variable torque applications. Repetition interval shall not be less than 9 minutes</td>
<td>- 150% of the rated current for 1 minute overload , 30 seconds at 200% (with inverse characteristics proportional to time) and 200% of rated current for 0.5 sec. for constant torque applications . Repetition interval shall not be less than 60 minutes .</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Efficiency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>More than 97% or better at full speed and full load.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Input power supply</th>
<th>Description</th>
</tr>
</thead>
</table>
| 6.0 | 415 V AC +10% & -15% | - 3 phase .  
- 50 Hz  + / - 6 %  
- 4 wire neutral earthed system . |

<table>
<thead>
<tr>
<th></th>
<th>Voltage variation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.0</td>
<td>Voltage variation of (+/-) 0.1 % with an input variation of +10% - 15% .</td>
<td></td>
</tr>
</tbody>
</table>
- Steady state regulation of (+/-) 0.25% guaranteed against 100 to 200% load disturbance and +6% & -6% input supply frequency variation.
- The drive should be designed to operate on an AC supply, which may contain line notching, and up to 10% harmonic distortion.

8.0 Environmental conditions

8.1 Storage ambient temperature range Upto to 70º C (-40º to 158ºF).

8.2 Operating ambient temperature range without derating. IP42 & above : 0º C to 50º C (0º to 122º F)

8.3 Relative humidity Upto 100% non-condensing.

8.4 Operating elevation Up to 1000 Meters (3,300ft) without derating.

8.5 Shock 15G peak for 11ms duration

8.6 Vibrations Suitable to withstand vibrations more than 0.5g.

9.0 Reference

9.1 Input reference voltage O +/- 10 V DC / 0 – 10 V DC / 4 – 20 mA.

9.2 Reference signals The drive should be capable of the following speed reference signals
- Digital MOP
- Jog
- HIM (Program/Control panel)
- Analog Input signals
- Preset Speeds
- Communication module commands
All reference signals may have a trim signal applied to them for finer resolution and accuracy. Trim source and amount should be programmable.

9.3 Loss of reference The drive should be capable of sensing the reference loss conditions.
In the event of loss of an analog input reference signal, the drive should be user programmable to the following
- Fault the drive
- Alarm and maintain last reference
- Alarm and go to preset speed
- Alarm and go to minimum speed
- Alarm and go to maximum speed
- Alarm and maintain last output frequency
Signal loss detection should be available regardless of the function of the analog input.

10.0 Output

10.1 Output voltage From 0 to rated motor voltage.

10.2 Output frequency 0.5 - 400 Hz.

10.3 Output Waveform Sinusoidal
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.4</td>
<td>Output frequency resolution</td>
<td>0.01 Hz.</td>
</tr>
<tr>
<td>11.0</td>
<td>Reflected wave</td>
<td>Maximum of 3.15 times the bus voltage or 1600V, whichever is less, up to cable lengths of 200 metres.</td>
</tr>
<tr>
<td>12.0</td>
<td>Starting torque</td>
<td>150 % / 0.3 Hz. (without PG)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>150 % / 0 RPM (with PG)</td>
</tr>
<tr>
<td>13.0</td>
<td>Torque accuracy</td>
<td>+ / - 5 % .</td>
</tr>
<tr>
<td>14.0</td>
<td>Speed control accuracy</td>
<td>+ / - 0.02 % .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IR compensation to be provided for drive without PG .</td>
</tr>
<tr>
<td>15.0</td>
<td>Ramp rate</td>
<td>- Linear acceleration and deceleration adjustable independently from 0 to 3600 seconds .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Provision of remotely selectable Accel / Decel settings should be accessible through digital inputs also.</td>
</tr>
<tr>
<td>16.0</td>
<td>Main power components in incoming AC side</td>
<td>- ACB / MCCB with 50 KA rating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Matching input isolation transformer / line reactor for harmonic and noise suppression .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- For input isolation transformer , the K factor shall be 4.0 or less.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- AC line surge suppression network .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Input contactor .</td>
</tr>
<tr>
<td>17.0</td>
<td>Converter – Inverter Equipment</td>
<td>- Diode / Thyristor bridge for AC/DC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- DC link circuit with reactor/capacitor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- IGBT bridge for Inverter for DC/AC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Harmonic transformer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Main PLC to take care of interlocking and sequencing etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Mimic panel (where drive is HT)</td>
</tr>
<tr>
<td>18.0</td>
<td>Load side components</td>
<td>- Filter network</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Electronic over-load relay for each motor (with display).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Line contactors in output side (if required).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Output reactor / terminator (if required)</td>
</tr>
<tr>
<td>19.0</td>
<td>Terminal blocks</td>
<td>- Separate for control and power wiring.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Power terminal blocks to withstand a minimum of 90  ºC and marked for both inputs and outputs .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Uniform color-coding to be followed for cabling, TB, etc.</td>
</tr>
<tr>
<td>20.0</td>
<td>By-pass Arrangement</td>
<td>By-pass arrangement shall be provided to operate the motor in case of failure of VFD.</td>
</tr>
<tr>
<td>21.0</td>
<td>Diode Bridge</td>
<td>Minimum ratings of Diode cells.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- PIV rating : 2.5 times the peak value of line voltage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- dv/dt rating : 200V/microsecond for voltage control and 1000V/microsecond for inverter control.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- di/dt rating : 100A / microsecond.</td>
</tr>
<tr>
<td>22.0</td>
<td>Input / Outputs</td>
<td>- Hard-Wired I/O</td>
</tr>
</tbody>
</table>
- Hardwired I/O should be provided via separate I/O cards
  - **Standard I/O Card**
  - The “Standard I/O board should consist of both digital and analog I/O. It should be available in two versions; one for 115/240 VAC digital I/O and one for 24V AC/DC digital I/O.
  - **Analog I/O**
  - Differentially isolated ±10V (bi-polar) / 20mA analog inputs.
  - **Digital Outputs**
  - Relay outputs – Minimum 04 nos.
  - Contact output ratings should be 240V AC / 24V DC, Maximum 2.0 Amp

23.0 **Protective features**

AC line surge suppression network and overvoltage protection.
- Under voltage in supply network
- Phase sequence protection and monitoring
- Single phase failure
- Motor loss
- Under voltage in DC bus
- Over voltage in DC bus
- Over speed protection in the event that the output frequency exceeds the maximum reference by a specified amount.
- Over load
- Earth fault
- Instantaneous over current
- Transformer fault, If applicable
- Cooling fan failure
- Stall monitor for motor alarms
- Controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit and annunciation of the fault condition.

24.0 **Annunciations**

Following faults shall be annunciated in keypad of the drive / HMI.
- AC line surge suppression network and overvoltage protection.
- Under voltage in supply network
- Phase sequence protection and monitoring
- Under voltage in DC bus
- Over voltage in DC bus
- Over speed monitor
- Over load
- Earth fault
### Meters
- Output voltmeter and ammeter with selector switches.
- Input volt meter and ammeter with selector switches.
- Output frequency meter (digital type).
- KW meter for drive ratings above 200 KW.
  All digital display shall be programmable.

### Other features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>26.1 Bus Regulation</strong></td>
<td>DC Bus regulation should be available to reduce the possibility of drive overvoltage trips due to regenerative conditions.</td>
</tr>
<tr>
<td><strong>26.2 Load dependent current limit</strong></td>
<td>Programmable current limit from .1 amps to 150% of drive rated amps. Current limit to be active for all drive states; accelerating, constant speed and decelerating.</td>
</tr>
<tr>
<td><strong>26.3 Dynamic Braking</strong></td>
<td>The drive shall have an internal, built in 7th IGBT for use as a dynamic braking chopper. This IGBT shall have enough capacity to handle greater than or equal to 100% regeneration power from the output, continuously. The drive shall also have a “drive mounted” dynamic braking resistor for low level braking applications and interactive software to protect the “internally” mounted resistor from abuse.</td>
</tr>
<tr>
<td><strong>26.4 Fault Memory</strong></td>
<td>16 nos. of faults to be stored on FIFO basis for fault analysis.</td>
</tr>
<tr>
<td><strong>26.5 Ride Through</strong></td>
<td>The control logic should be capable of &quot;riding through&quot; a power outage of at least 0.5 seconds in duration. The inverter section should be shut off after an 18% drop in bus voltage to conserve power for the drive logic.</td>
</tr>
</tbody>
</table>
| **27.0 Selector switches**       | - Local / Remote.  
- Auto / Manual.  
- Main / Bypass.  
  All the selector switches shall be of 10 A rating. |
| **28.0 Pushbuttons**             | - Trip reset.  
- Start. |
| 29.0 | Lamps | - Emergency stop.  
- Drive ready.  
- Drive trip.  
- R, Y, B phase power ON.  
- Control supply ON.  

All the lamps shall be of cluster LED type having low voltage glow protection. |
| 30.0 | Regulation & control facilities | - Reference speed setter  
- Ramp generator  
- Speed feed back  
- Current feed back  
- Flying start  
- Trigger module  
- Pulse transformers  
- Logic control module  
- Sequence module  
- PID control  
- Zero speed / over speed monitor as applicable  
- Momentary power loss restart.  
- Auto tuning.  
- Current limiter  
- Skip Frequency  
- Counter current / regenerative braking unit as applicable  
- Active electronic components used shall be of industrial grade hermetically sealed.  
- Output signals for fault alarm, frequency arrival, running signal. |
| 32.0 | Remote control facilities | - Shall have transducer to monitor the outputs like motor speed at remote place / HMI.  
- Facility to accept speed reference from HMI / engineering station. |
| 33.0 | Auto / Manual Mode | - The HIM should utilize the ALT function key to transfer the drive from Automatic mode to Manual mode and back.  
- When in Auto mode, the drive to receive its frequency command from the programmed source.  
- When in Manual mode, control of the frequency command to be transferred to the HIM speed control keys (or potentiometer).  
- The user should have the choice of preloading the HIM with the current “auto” frequency reference before transferring control to allow for smooth transitions without speed “jumps.” |
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.0</td>
<td>Communication Bus</td>
</tr>
<tr>
<td>35.0</td>
<td>Test points</td>
</tr>
<tr>
<td>36.0</td>
<td>Operator panel</td>
</tr>
<tr>
<td>37.0</td>
<td>Membrane keypad</td>
</tr>
<tr>
<td>38.0</td>
<td>LCD display</td>
</tr>
<tr>
<td>39.0</td>
<td>Construction features</td>
</tr>
</tbody>
</table>
| 40.0    | Enclosure and ventilation | - Enclosure conforming to IP-42 or better with weather proof enclosures. - Units shall be provided with cooling fans and louvers at the
bottom sides with filters. 
- All louvers shall have fine mesh filter behind them.
- Ventilation through individual ventilation ducts from bottom not acceptable.
- For larger drives cooling fans of drives shall be powered from different power source.

<table>
<thead>
<tr>
<th>02. AC Line Reactor</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 No. of phases</td>
<td>03</td>
</tr>
<tr>
<td>2.0 Input power supply</td>
<td>- 415 V AC + 10% &amp; -15%</td>
</tr>
<tr>
<td></td>
<td>- 3 phase.</td>
</tr>
<tr>
<td></td>
<td>- 50 Hz +/- 6%</td>
</tr>
<tr>
<td></td>
<td>- 4 wire neutral earthed system.</td>
</tr>
<tr>
<td>3.0 Duty class</td>
<td>T2 as per IEEE-1973</td>
</tr>
<tr>
<td>4.0 Overload</td>
<td>- 125% for 2 hours</td>
</tr>
<tr>
<td></td>
<td>- 200% for 10 seconds</td>
</tr>
<tr>
<td>5.0 Standard</td>
<td>IS: 5553 (Part-2)</td>
</tr>
<tr>
<td>6.0 Insulation class</td>
<td>Class H</td>
</tr>
<tr>
<td>7.0 Impedance</td>
<td>3% / 5% (As per system calculation)</td>
</tr>
<tr>
<td>8.0 Maximum temperature rise</td>
<td>95 Deg. C</td>
</tr>
<tr>
<td>9.0 Ambient temperature</td>
<td>50 deg. C</td>
</tr>
<tr>
<td>10.0 Location</td>
<td>Normally in the drive panel (In a separate enclosure in case of large size)</td>
</tr>
<tr>
<td>11.0 Execution</td>
<td>IP 21</td>
</tr>
<tr>
<td>12.0 Termination</td>
<td>- Cables</td>
</tr>
<tr>
<td></td>
<td>- All termination should be brought out on 6 or 10 mm thick fibre glass strip.</td>
</tr>
<tr>
<td></td>
<td>- Terminal description should be engraved on termination strip</td>
</tr>
<tr>
<td>13.0 Cooling</td>
<td>AN</td>
</tr>
<tr>
<td>14.0 Winding Material</td>
<td>CRGO Si grade steel , Grade 51 or better</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td>Coils should be hot dipped and whole assembly should be dipped in varnish.</td>
</tr>
<tr>
<td></td>
<td>Clamping stud should be insulated from lamination.</td>
</tr>
<tr>
<td>15.0 Rating</td>
<td>Inductance : As per calculation</td>
</tr>
<tr>
<td></td>
<td>RMS current rating : As per calculation</td>
</tr>
<tr>
<td></td>
<td>Inductance : AS per calculation</td>
</tr>
<tr>
<td>16.0 Characteristic</td>
<td>Reactors will be linear upto 200% of rated current.</td>
</tr>
</tbody>
</table>

03. Load Commutated Inverter (LCI)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Standard</td>
<td>IEC 146-1-2</td>
</tr>
<tr>
<td>2.0</td>
<td>Power System Input</td>
<td>3 Phase AC, +/- 10% of rated voltage</td>
</tr>
<tr>
<td>3.0</td>
<td>Input voltage dip</td>
<td>30% of rated voltage without tripping</td>
</tr>
<tr>
<td>4.0</td>
<td>Frequency</td>
<td>50 Hz, +/- 6%</td>
</tr>
<tr>
<td>5.0</td>
<td>Operating environment</td>
<td>50 deg. C, with 95% RH non-condensing</td>
</tr>
<tr>
<td>6.0</td>
<td>Type of motor to be controlled</td>
<td>Synchronous motor</td>
</tr>
<tr>
<td>7.0</td>
<td>Efficiency</td>
<td>More than 99%</td>
</tr>
</tbody>
</table>
| 8.0 | Isolation transformer | - Indoor installation  
- Oil or dry type as per IEC 76-2  
- Typical winding configuration:  
  - 6 pulse LCI :– Delta-Wye  
  - Pulse LCI :– Delta-Delta-Wye  
- Taps : 2x2.5% above and below nominal voltage  
- Winding conductor : Copper  
- Insulation class : Class H (In case of dry type) |
| 9.0 | Bridge device | Thyristor |
| 10.0 | Configuration |   |
| (i) | Source bridge | AC fed 6 or 12 pulse SCR, regenerative with N+1 devices |
| (ii) | Load bridge | 6 or 12 pulse output configuration with with N+1 devices |
| 11.0 | Output speed control range | 10 – 160% of rated speed |
| 12.0 | Overload | 150% overload for 1 minute / every 10 minutes (for CT loads)  
110% overload for 1 minute / every 10 minutes (for VT loads) |
| 13.0 | Control | • Forced commutation below 10% of rated speed  
• Load commutated above 10% of rated speed  
• Torque regulated  
• 4 quadrant speed control  
• Volt / Frequency control  
• Field excitation control  
• Programmable acceleration / deceleration ramps |
| 14.0 | Control accuracy | Without tacho  
| (i) | Speed regulation | 0.1 %  
| (ii) | Max. starting torque | 0.75 PU  
| (iii) | Max. forward speed | 1.0 PU  
| (iv) | Max. reverse speed | 0.5 PU  
| (v) | Constant HP speed range | Base to top  
| (vi) | Constant torque speed range | 0.1 to base  
| 15.0 | Torque reversal principal | DC link voltage reversal by firing of anti-parallel thyristors in the bridge  
No contactor is to be provided for the same |
| 16.0 | Protection | • Overcurrent  
• Overvoltage  
• Earthfault  
• Over temperature  
• Motor bearing and winding temperature measuring and protection |
| 17.0 | Cooling | • Water cooled with deionized water  
• Redundant cooling pump with automatic control |
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18.0</td>
<td>Auxiliary power supply</td>
</tr>
<tr>
<td>19.0</td>
<td>Reliability</td>
</tr>
<tr>
<td>21.0</td>
<td>Loudness</td>
</tr>
</tbody>
</table>
| 22.0 | I/O | • Standard I/O’s as per manufacturer.  
  • In addition to standard I/O’s, a dedicated PLC in the drive panel for sequencing and interlocking of all the hardware interlocks of the LCI. |
| 23.0 | Metering | • Analog meters mounted on drive panels.  
  • For remote monitoring required transducers/converters for transmission of signals in HMI. |
| 24.0 | Feedback devices | • Encoder for position feedback  
  • Tacho for speed feedback |
| 25.0 | Communication bus | • Profibus / Controlnet / Modbus compatibility.  
  In case of making compatible with PLC communication bus, required hardware and software to be provided. |
| 26.0 | Cable entry | • Top or bottom cable entry with no additional cubicle |

### 1.02.08 INTELLIGENT TYPE MCC :-

**A. General**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1.0 | Type | Metal clad.  
  Non drawout type |
| 2.0 | Construction | Modular construction.  
  Fully compartmentalized with metal / insulating material partition. |
| 3.0 | Enclosure class | IP52  
  IP 54 for non intelligent MCC’s installed in non airconditioned environment. |
| 4.0 | Type of execution | Single front. |
| 5.0 | Mounting | Floor mounting.  
  Free standing with ISMC 75. |
| 6.0 | Installation | Indoor. |

**B. Constructional Features :-**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1.0 | Sheet steel  
  Thickness | 2.0 mm for load bearing members.  
  1.6 mm for non load bearing members.  
  Material | CRCA |
| 2.0 | Cable entry  
  Incomer :- | Bottom cable entry.  
  Outgoing :- | Bottom cable entry. |
| 3.0 | Design | • Separate cable alley.  
  • Extendable at both ends.  
  • Rear access through removable rear hinged cover door |
on one side and screwed at other side.
- All the components shall be accessible from front.
- Motor controller shall be flush mounted on the respective door.
- Interchangeable facility of same type of feeder modules
- Each module to have covering at the bottom.
- ACB cubicle door shall close when the ACB is in isolated position.

4.0 Interlocking & protection
- Module door interlocked with main power isolating devices.
- Power circuit isolation device to have pad locking in the OFF position with door closed.

5.0 Operating height
- Minimum: \( \leq 300 \text{mm} \)
- Maximum: \( \leq 2000 \text{mm} \)

6.0 Gland plate
- Undrilled removable bottom gland plates (3 mm thick)

7.0 Miscellaneous
- Neoprene rubber gasket shall be provided for all the doors, removable covers & between adjacent covers
- Lifting hooks for all the shipping sections
- Doors shall have concealed hinges.

8.0 Labelling
- Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of:
  - 25-50 mm for MCC panel in front and back side of the panel.
  - 5 mm for components and module name plates.
- Danger board on front and rear sides in English, Hindi.

9.0 Earthing
- Two separate earthing terminals will be provided.
- Bolted joints with tooth spring washers for good earth continuity.
- Earth bus to run in all cable alley of the panel.

10. Shipping length
- To be limited to 2.4 M.

11. Limiting dimensions
- Width of MCC: \( \leq 800 \text{mm} \)
- Width of Module: \( \leq 500 \text{mm} \)
- Width of Cable alley: \( \leq 300 \text{mm} \)
- Height of module: \( \leq 400 \text{mm} \) (min)
- Depth of MCC: \( \leq 600 \text{mm} \), maximum
- However depth of incoming ACB panel will be 1200 mm (minimum).

12. Paint shade
- Shade No. 631 as per IS-5:1992. or RAL 7035

13. Panel space heater
- In each panel with thermostat, MCB.

C. Busbars

(i) Main horizontal & vertical busbars
| 1.0 | Arrangement | Three phase & neutral. |
| 2.0 | Material | High conductivity electrolytic aluminium alloy confirming to grade E91E as per IS-5082 -1981. |
| 3.0 | Phase Busbar Rating | Shall be able to carry continuously the connected load (considering diversity factor) plus a 25% margin. Max. current density shall be: -
| | | 1.0 A/sq.mm for Aluminium |
| | | 1.5 A/sq.mm for Copper. |
| 4.0 | Neutral Busbar Rating | 50 % of phase busbar rating |
| 5.0 | Short circuit rating | 50 kA for 1 sec. |
| 6.0 | Busbar configuration | Red-yellow-blue from front to back or top to bottom or left to right as viewed from front. |
| 7.0 | Busbar insulation | Heat shrinkable PVC |
| | | R,Y,B coloured sleeves for phases |
| | | Black for neutral. |
| 8.0 | Busbar supporting insulators | Non-hygroscopic |
| | | Flame retarded |
| | | Track resistant |
| | | High strength |
| | | Sheet moulded compound or equivalent polyester fibre glass moulded type. |
| 9.0 | Max. temp. rise of bus | Not to exceed 40 deg. C. above ambient of 50 deg.C. |
| 10. | Air clearance for bare busbar | Phase to phase: - 25.4 mm (minimum) |
| | | Phase to earth: - 19.0 mm (minimum) |
| 11.0 | Joints and tap off points | Busbar joints and tap off points shall be shrouded and bolted (with cadmium coated bolts with plain and spring washers and locknuts). |
| | | Bimetallic connectors for connection between dissimilar metals. |
| | | Antioxide grease for all bus connections. |
| 12.0 | Neutral bus isolation | Through disconnecting link. |
| 13.0 | Vertical busbar | Rear side |

**Earth bus**

| 1.0 | Material | GI. |
| 2.0 | Size | Minimum 50 x 6 mm with extension at both ends |

**Control bus**

| 1.0 | Material | Copper. |
### Insulation level

| 1.0 | Rated insulation voltage | 1100 V |
| 2.0 | Impulse withstand voltage | 4 kV as per IS-13947 (Part I) 1993 |
| 3.0 | One minute power frequency withstand voltage | 2.5 kV for power circuit & 500 V for control circuit |

### Pollution Degree

| 1.0 | Pollution Degree | Pollution Degree 3  
As per IS-13947 (Part-1) : 1993 ;  
unless otherwise stated |

### Intelligent Controllers

| 1. Type | Modular type |
| 2. Wiring | Contacts from components (breakers , contactors ,) shall be hardwired to I/O terminal block of the controller.  
All the potential transformer PT’s , protection CT’s (phase CT and neutral CT) shall be hard wired directly to the controller or the controller module shall have built-in CT and PT for protection & metering purpose . |
| 3. Power supply | Separate power supply source (240 V AC ) from UPS through MCB (for controller only).  
Separate power supply for (interrogation voltage) from MCC itself . |
| 4. Inputs and outputs | The controller shall have :-  
Minimum 12 digital and 4 analog inputs  
( For increasing the number of I/O’s extended module can be added ) .  
Minimum 4 relay outputs ( 240 V AC , 10 A ) . |
| 5. Functions in controller | Protection  
Control  
Metering  
Annunciations |
| 9. Fault memory | Faults to be stored in memory on FIFO sequence. |
| 10. LED indications | Controller healthy  
Controller fault |
### Controller power supply healthy

<table>
<thead>
<tr>
<th>11. Communication</th>
<th>Each motor controller (motor / feeder) unit shall communicate on the communication bus (Devicenet / Modbus / Profibus) with PLC directly or through Data concentrator / CN2DN converter or any equivalent module / converter. The communication protocol (bus) for intelligent MCC and package PLC shall be same for ease of communication.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Communication Port</td>
<td>2 nos. RS 485 serial port</td>
</tr>
<tr>
<td>13. Communication configuration</td>
<td>Trunk line configuration (with dual redundancy) in horizontal wireways. Drop line configuration (with dual redundancy) in vertical wireways. Each Data concentrator / CN2DN converter or equivalent module shall communicate with PLC on higher level communication bus e.g Controlnet / Profibus / Modbus etc.</td>
</tr>
<tr>
<td>14. Communication speed</td>
<td>9.6 Kbps minimum (100 m distance)</td>
</tr>
<tr>
<td>15. No. of nodes (without repeaters)</td>
<td>Minimum 32 nos.</td>
</tr>
<tr>
<td>16. Control</td>
<td>From 16 character keypad and backlit LCD alphanumeric display provided on the controller. From HMI (located in control room). The keypad shall have the facility to start and stop the motor through a separate key (touch screen type) or separate PB’s are to be provided for the same on the front door of the module.</td>
</tr>
<tr>
<td>17. Software</td>
<td>All the configuration and monitoring shall be done through inbuilt software. All the required software required for operation and communication shall be provided with latest version available.</td>
</tr>
</tbody>
</table>

**F. Feeder arrangement**

<table>
<thead>
<tr>
<th>Incomers and Buscoupler</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Isolating Equipment</td>
<td>3 pole manual ACB</td>
</tr>
<tr>
<td></td>
<td>4 pole manual ACB (for DG source as second Incomer)</td>
</tr>
<tr>
<td></td>
<td>Both the Incomers and Buscoupler shall be drawout type.</td>
</tr>
<tr>
<td>2.0 Quantity</td>
<td>Two incomer</td>
</tr>
<tr>
<td>3.0 Bus coupler</td>
<td>Required.</td>
</tr>
<tr>
<td>4.0 Interlocking</td>
<td>Required. Normally only one Incomer shall be ON. After incoming power failure of any Incomer or ACB trips, second Incomer shall be made ON manually.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>5.0</strong></td>
<td><strong>Interlocking type</strong></td>
</tr>
<tr>
<td><strong>6.0</strong></td>
<td><strong>Indication Lamps</strong></td>
</tr>
<tr>
<td><strong>7.0</strong></td>
<td><strong>Meters and selector switches</strong></td>
</tr>
<tr>
<td><strong>8.0</strong></td>
<td><strong>Current transformer</strong></td>
</tr>
<tr>
<td><strong>9.0</strong></td>
<td><strong>Potential transformer</strong></td>
</tr>
<tr>
<td><strong>10.0</strong></td>
<td><strong>Relays (mounted in each ACB)</strong></td>
</tr>
</tbody>
</table>

**F. Outgoing feeder arrangements**

(i) **Motor Starter feeders**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0</strong></td>
<td><strong>Circuit breaker</strong></td>
<td>Three pole MCCB, Three pole ACB (for rating above 630 A).</td>
</tr>
<tr>
<td><strong>2.0</strong></td>
<td><strong>Power contactor</strong></td>
<td>AC3/AC4 as per requirement, 3 pole. Minimum 32 A at AC-3 duty. Contactor coil rating for 240 V AC, 2NO + 2NC auxiliary contacts. Mechanically interlocked for reversible drives.</td>
</tr>
<tr>
<td><strong>3.0</strong></td>
<td><strong>Auxiliary contactors</strong></td>
<td>Required nos. as per scheme.</td>
</tr>
<tr>
<td><strong>4.0</strong></td>
<td><strong>Control supply isolation device</strong></td>
<td>MCB</td>
</tr>
<tr>
<td><strong>5.0</strong></td>
<td><strong>Test PB</strong></td>
<td>Inside module for testing of power contactor when the module incoming power breaker is OFF</td>
</tr>
<tr>
<td><strong>6.0</strong></td>
<td><strong>Space heater power provision</strong></td>
<td>For motor feeders of 45 KW and above: Through separate MCB and interlock with main power contactor.</td>
</tr>
<tr>
<td><strong>7.0</strong></td>
<td><strong>Ammeter in LCS</strong></td>
<td>Interposing CT shall be provided in the feeder module for</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>motor rating 37 KW and above.</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **8.0 Thermal overload relay**  
(for non intelligent MCC’s) | **Electronic type (with indication for motors of rating 37 KW and above)** |
| **9.0 Motor controller** |   |
| **A. Protections** | Thermal overload  
Adjustable overload prealarm  
Earth fault  
Stalling  
Unbalance  
Short circuit  
Single phase prevention  
Under current  
Too many starts  
Under voltage  
Under voltage lockout  
Breaker or contactor failure alarm  
Trip failure alarm  
Over temperature  
Winding and bearing temperature (for motor of rating 160 KW and above). |
| **B. Display data** | Voltage  
Frequency  
Power factors  
Power consumption , KW  
Thermal capacity  
Temperature  
Phase and average Amp.  
Earth fault current  
% motor load  
% unbalance  
Peak current during starting  
Starting time  
Pre trip values |
| **C. Fault / alarm history description** | No. of trips  
No. of operations ( Forward / reverse)  
Hours run  
Hours run last start  
Kilowatt hours  
Kilowatt peak demand  
Alarm / trip history (with date and time) |
### (ii) Power supply feeders

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1.0 | Circuit breaker | Three pole MCCB.  
|     |                  | Three pole ACB (for rating above 630 A). |
| 2.0 | Indications     | ON/OFF/TRIP indication lamp. |
| 3.0 | Earth fault protection required | Yes |

### G. Panel wiring

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1.0 | Power / current transformer circuit | 1.1kV grade single core, black colour PVC insulated, stranded copper conductor of minimum size 2.5 sq.mm.  
|     |                  | For feeder rating 100A and above all the power circuit shall be through rigid busbar. |
| 2.0 | Control and potential circuit | 1.1kV grade single core  
|     | Black colour PVC insulated  
|     | Stranded copper conductor of minimum size 1.5 sq.mm. |
| 3.0 | Ferrules | Numbered plastic/ceramic ferrules.  
|     |            | Self locking type. |
| 4.0 | Marking | Wiring will be properly marked as per relevant IS. |
| 5.0 | Spare contacts | All spare contacts of relays selector switches & contactors will be wired up to the terminal block.  
|     |                  | Each component shall have at least one potential free spare contact. |
| 6.0 | Terminals | - Power & control terminals shall be segregated by insulating material like hylam/bakelite sheet.  
|     |            | - Power terminals will be stud type.  
|     |            | - Control terminals will be ELMEX type suitable for connecting two cores of 2.5 sq.mm wires.  
|     |            | - Minimum 20 % spare terminals will be provided.  
|     |            | - The minimum rating of control terminal shall be 10 Amps.  
|     |            | - Color coded wires, TB’s of different voltage rating to be provided.  
|     |            | - Uniform color-coding to be followed for cabling, TB, etc. |
| 7.0 | Cable glands | Double compression cable glands for receiving external power and control cables |

### H. Control Supply

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 1.0 | Control transformer | 1 nos. of 415V/240V control transformer of minimum 2.5 KVA in each section.  
|     |                  | Secondary unearthed. |
2.0 Input and output side isolation device

<table>
<thead>
<tr>
<th>Input side</th>
<th>MCCB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output side</td>
<td>MCB</td>
</tr>
</tbody>
</table>

3.0 Control supply changeover system

Control supply auto and manual changeover through contactor logic and through selector switch respectively (Sel.sw. shall have a contact rating of 25 A at 240 V AC)

1.02.09 STAND ALONE STARTER

A. General :-

1.0 Type
- Metal clad .
- Non drawout type.

2.0 Construction
- Modular construction .
- Fully compartmentalized with metal / insulating material partition.

3.0 Enclosure class
- IP52.

4.0 Type of execution
- Single front.

5.0 Mounting
- Floor mounting.
- Free standing with ISMC 75.

6.0 Installation
- Indoor.

B. Constructional Features :-

1.0 Sheet steel

<table>
<thead>
<tr>
<th>Thickness</th>
<th>2 mm for load bearing members.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>CRCA</td>
</tr>
</tbody>
</table>

2.0 Cable entry
- Incomer :- Bottom cable entry.
- Outgoing :- Bottom cable entry.

3.0 Design
- Rear access through removable rear hinged cover door.
- All the components shall be accessible from front .

4.0 Interlocking & protection
- Module door interlocked with main power isolating devices.
- Power circuit isolation device to have pad locking in the OFF position with door closed.

5.0 Operating height
- Minimum :- 300mm
- Maximum :- 2000 mm.

6.0 Gland plate
- Undrilled removable bottom gland plates (3 mm thick)

7.0 Miscellaneous
- Neoprene rubber gasket shall be provided for all the doors , removable covers & between adjacent covers .
- Lifting hooks for the panel .
- Doors shall have concealed hinges .

8.0 Labelling
- Clear legible identification labels (anodized aluminium with white letters engraved on black background ) with letter sizes of :-
  - 25-50 mm for panel .
  - 5 mm for components and module name plates.
  - Danger board on front and rear sides in English , Hindi and local language .

9.0 Earthing
- Two separate earthing terminals will be provided.
- Bolted joints with tooth spring washers for good earth continuity.

10.0 Paint shade
- Shade No. 631 as per IS-5:1992 equiv to RAL 7035 .
### General Technical Specification

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.0</td>
<td>Panel space heater</td>
</tr>
<tr>
<td><strong>C. Busbars</strong></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>Arrangement</td>
</tr>
<tr>
<td>2.0</td>
<td>Material</td>
</tr>
</tbody>
</table>
| 3.0 | Phase Busbar Rating | - Shall be able to carry continuously the connected load (considering all derating factors) plus a 25% margin.  
- Max. current density shall be  
  - 1.0 A/sq.mm for Aluminium  
  - 1.5 A/sq.mm for Copper. |
| 4.0 | Neutral Busbar Rating | 50% of phase busbar rating |
| 5.0 | Short circuit rating | 50 KA for 1 sec. |
| 6.0 | Busbar configuration | Red-yellow-blue from front to back or top to bottom or left to right as viewed from front. |
| 7.0 | Busbar insulation | Heat shrinkable PVC  
- R,Y,B coloured sleeves for phases  
- Black for neutral. |
| 8.0 | Busbar supporting insulators | - Non-hygroscopic  
- Flame retarded  
- Track resistant  
- High strength  
- Sheet moulded compound or equivalent polyster fibre glass moulded type. |
| 9.0 | Max. temp. rise of bus | Not to exceed 35 deg. C. above ambient of 50 deg.C. |
| 10.0 | Air clearance for bare busbar | Phase to phase: 25.4 mm (minimum)  
Phase to earth: 19.0 mm (minimum) |
| 11.0 | Joints and tap off points | - Busbar joints and tap off points shall be shrouded and bolted (with cadmium coated bolts with plain and spring washers and locknuts).  
- Bimetallic connectors for connection between dissimilar metals.  
- Antioxide grease for all bus connections. |
| 12.0 | Neutral bus isolation | Through disconnecting link. |
| 13.0 | Busbar access | Rear side |
| **(ii) Earth bus** | | |
| 1.0 | Material | GI. |
| 2.0 | Size | Minimum 50 x 6 mm with extension at both ends. |
| **(iii) Control bus** | | |
| 1.0 | Material | Copper. |
| 2.0 | Size | Minimum 25 x 3 mm. |
| **D. Insulation level** | | |
| 1.0 | Rated insulation voltage | 1100 V |
| 2.0 | Impulse withstand voltage | 4 KV as per IS-13947 (Part I) 1993 |
| 3.0 | One minute power frequency withstand voltage | 2.5 KV for power circuit & 500 V for control circuit |

**E. Pollution Degree**
<table>
<thead>
<tr>
<th><strong>F. Components</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 Pollution Degree</strong></td>
<td>Pollution Degree 3 as per IS-13947 (Part-1) : 1993 ; unless otherwise stated</td>
</tr>
<tr>
<td><strong>1.0 Isolating Equipment</strong></td>
<td>3 pole MCCB (upto 630A)</td>
</tr>
</tbody>
</table>
| **2.0 Indication Lamps** | LED type indicating lamps for:-  
- MCCB ON/OFF/TRIP.  
- Power ON R / Y / B . |
| **3.0 Meters and selector switches** | - 96 sq.mm size voltmeter with 7 position selector switches  
- 96 sq.mm size ammeter with 4 position selector switches |
| **4.0 Power contactor** | - AC3 duty of rated capacity |
| **5.0 Intelligent motor controller** | - As defined in clause no. 1.02.08 |
| **6.0 Motor protection relay (for non intelligent panel)** | - Microprocessor based.  
- Suitable for 5A & 1A  
- Protections  
  - Short circuit  
  - Overload  
  - Earth fault  
  - Stalling protection  
  - Undervoltage  
  - Overspeed  
  - No.of starts per hour (cold & hot)  
  - Communication facility with PLC.  
  - Memory for  
    - Storing fault history & trending |
| **7.0 Auxiliary contactors** | - Shall be provided for logic operation and operating sequence .  
- Shall have minimum 2NO+2NC auxiliary contacts. |

<table>
<thead>
<tr>
<th><strong>G. Panel Wiring</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 Power / current transformer circuit</strong></td>
<td>1.1 Kv grade single core , black colour PVC insulated , stranded copper conductor of minimum size 2.5 sq.mm.</td>
</tr>
<tr>
<td><strong>2.0 Control and potential circuit</strong></td>
<td>1.1 Kv grade single core , black colour PVC insulated , stranded copper conductor of minimum size 2.5 sq.mm.</td>
</tr>
</tbody>
</table>
| **3.0 Ferrules** | - Numbered plastic/ceramic ferrules.  
- Self locking type. |
| **4.0 Marking** | - Wiring will be properly marked as per relevant IS. |
| **5.0 Spare contacts** | - All spare contacts of relays selector switches & contactors will be wired upto the terminal block.  
- Each components shall have at least one potential free spare contacts. |
| **6.0 Terminals** | - Power & control terminals shall be segregated by insulating material like hylam / bakelite sheet.  
- Power terminals shall be stud type.  
- Control terminals shall be suitable for connecting two cores |
of 2.5 sq.mm wires.
- Minimum 20 % spare terminals shall be provided.
- The minimum rating of control terminal shall be 10 Amps.
- Color coded wires, TB's of different voltage rating to be provided .
- Uniform color-coding to be followed for cabling, TB, etc.

| 7.0 Cable glands | Double compression cable glands for receiving external power and control cables |

### I. Control Supply

<table>
<thead>
<tr>
<th>1.0 Control transformer</th>
<th>1 nos. of 415V/240V control transformer of minimum 2.5 KVA Secondary unearthed.</th>
</tr>
</thead>
</table>
| 2.0 Input and output side isolation device | Input side :: MCB  
Output side :: MCB |

#### 1.02.10 SOFT STARTER :-

<table>
<thead>
<tr>
<th>A. Design Criteria:-</th>
<th></th>
</tr>
</thead>
</table>
| 1.0 Incoming supply voltage | 415 V + 10 % & -15% ,  
50 Hz. +/- 6 %, 3 phase |
| 2.0 Control Supply | 240 V AC through control transformer.  
However there shall be provision of control supply of 110V/240 V AC through shorting links in control supply power terminal blocks . |
| 3.0 Output | Full wave in line control |
| 4.0 Device | IGCT/IGBT /Fast acting switching semi conductor device. |
| 5.0 Acceleration | Stepless |
| 6.0 Pump control | Starting :: 2 – 30 seconds  
Stopping :: 2 – 120 seconds |
| 7.0 Adjustable current limit | 500 % of In . |
| 8.0 Adjustments | - Dwell time at current limit with ramp continuation after acceleration .  
- Acceleration time adjustable current limit  
- Minimum voltage adjustment  
- Voltage stability adjustment.  
- Initial torque ramp time adjustment .  
- Kick start |
| 9.0 Overload tripping range | 100 – 130 %  
(as per manufacturer’s characteristic curve) |
| 10.0 Overload capacity | Continuous :: 115 %  
60 seconds :: 250 %  
30 seconds :: 300 %  
05 seconds :: 450% |
| 11.0 Other features | - Shall have facility to run in energy saving mode during light load operation of the drive |
- Shall have bypass mode. Motor can run in bypass mode in DOL.
- Soft starter mode or bypass mode can be selected through selector switch mounted on front side of the panel.
- In auto mode soft starter shall start/stop after getting command from PLC.
- Shall have the facility of kickstart.
- Shall be able to communicate to PLC on dual redundant communication bus. Accordingly suitable cards/modules shall be mounted.

### 12.0 Protections
- Short circuit
- Overload
- Under voltage protection
- Current monitoring in each phases
- Transient voltage suppressor (MOV)
- Heat sink overtemperature protection
- Over temperature switches on each pole.
- RC Snubber ckt.
- Semiconductor fuse to be provided before the soft starter controller.
- Single phase protection

### 13.0 LED Indications
- Power ON (green)
- RUN (amber)
- Fault (red)
- O/C trip (red)
- Phase loss trip (red)
- Auxiliary trip (red)

### B. General :-

#### 1.0 Type
- Metal clad.
- Non drawout type.

#### 2.0 Construction
- Modular construction.
- Fully compartmentalized with metal/insulating material partition.

#### 3.0 Enclosure class
IP52.

#### 4.0 Type of execution
Single front.

#### 5.0 Mounting
- Floor mounting.
- Free standing with ISMC 75.

#### 6.0 Installation
Indoor.

### C. Constructional Features :-

#### 1.0 Sheet steel
<table>
<thead>
<tr>
<th>Section</th>
<th>Details</th>
</tr>
</thead>
</table>
| Thickness        | - 2 mm for load bearing members.  
                  - 1.6 mm for non load bearing members.                                                                                                                                                               |
| Material         | CRCA                                                                                                                                                                                                   |
| 2.0 Cable entry  | - Incomer :- Bottom cable entry.  
                  - Outgoing :- Bottom cable entry.                                                                                                                                                                  |
| 3.0 Design       | - Rear access through removable rear hinged cover door.  
                  - All the components shall be accessable from front                                                                                                                                               |
| 4.0 Interlocking & protection | - Module door interlocked with main power isolating devices.  
                  - Power circuit isolation device to have pad locking in the OFF position with door closed.                                                                                                          |
| 5.0 Operating height | - Minimum :- 300mm  
                  - Maximum :- 2000 mm.                                                                                                                                                                                |
| 6.0 Gland plate  | Undrilled removable bottom gland plates (3 mm thick)                                                                                                                                                      |
| 7.0 Miscellaneous| - Neoprene rubber gasket shall be provided for all the doors, removable covers & between adjacent covers.  
                  - Lifting hooks for the panel.  
                  - Doors shall have concealed hinges.                                                                                                                                                               |
| 8.0 Labelling    | - Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of :-  
                  25-50 mm for panel.  
                  - 5 mm for components and module name plates.  
                  - Danger board on front and rear sides in English, Hindi and local language.                                                                                                                  |
| 9.0 Earthing     | - Two separate earthing terminals will be provided.  
                  - Bolted joints with tooth spring washers for good earth continuity.                                                                                                                                    |
| 10.0 Paint shade | Shade No. 631 as per IS-5:1992. / RAL 7035                                                                                                                                                               |
| 11.0 Panel space heater | In each panel with thermostat, fuse, switch.                                                                                                                                                              |
| **D. Busbars**   |                                                                                                                                                                                                     |
| 1.0 Arrangement  | Three phase & neutral.                                                                                                                                                                                  |
| 2.0 Material     | High conductivity electrolytic aluminium alloy confirming to grade E91E as per IS-5082 –1981.                                                                                                             |
| 3.0 Phase Busbar Rating | Shall be able to carry continuously the connected load (considering all derating factors) plus a 25% margin.  
                         Max. current density shall be |
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 A/sq.mm for Aluminium</td>
<td>1.5 A/sq.mm for Copper.</td>
<td></td>
</tr>
<tr>
<td>4.0 Neutral Busbar Rating</td>
<td>50 % of phase busbar rating</td>
<td></td>
</tr>
<tr>
<td>5.0 Short circuit rating</td>
<td>50 KA for 1 sec.</td>
<td></td>
</tr>
<tr>
<td>6.0 Busbar configuration</td>
<td>Red-yellow-blue from front to back or top to bottom or left to right as viewed from front.</td>
<td></td>
</tr>
<tr>
<td>7.0 Busbar insulation</td>
<td>Heat shrinkable PVC R,Y,B coloured sleeves for phases Black for neutral.</td>
<td></td>
</tr>
<tr>
<td>8.0 Busbar supporting insulators</td>
<td>Non-hygroscopic Flame retarded Track resistant High strength Sheet moulded compound or equivalent polyester fibre glass moulded type.</td>
<td></td>
</tr>
<tr>
<td>9.0 Max. temp. rise of bus</td>
<td>Not to exceed 35 deg. C. above ambient of 50 deg.C.</td>
<td></td>
</tr>
<tr>
<td>10.0 Air clearance for bare busbar</td>
<td>Phase to phase :- 25.4 mm (minimum) Phase to earth :- 19.0 mm (minimum)</td>
<td></td>
</tr>
<tr>
<td>11.0 Joints and tap off points</td>
<td>Busbar joints and tap off points shall be shrouded and bolted ( with cadmium coated bolts with plain and spring washers and locknuts). Bimetallic connectors for connection between dissimilar metals. Antioxide grease for all bus connections.</td>
<td></td>
</tr>
<tr>
<td>12.0 Neutral bus isolation</td>
<td>Through disconnecting link.</td>
<td></td>
</tr>
<tr>
<td>13.0 Busbar access</td>
<td>Rear side</td>
<td></td>
</tr>
</tbody>
</table>

**Earth bus**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Material</td>
<td>GI.</td>
</tr>
<tr>
<td>2.0 Size</td>
<td>Minimum 50 x 6 mm with extension at both ends.</td>
</tr>
</tbody>
</table>

**Control bus**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Material</td>
<td>Copper.</td>
</tr>
<tr>
<td>2.0 Size</td>
<td>Minimum 25 x 3 mm.</td>
</tr>
</tbody>
</table>

**Insulation level**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Rated insulation voltage</td>
<td>1100 V</td>
</tr>
<tr>
<td>2.0 Impulse withstand voltage</td>
<td>4 Kv as per IS-13947 (Part I) 1993</td>
</tr>
<tr>
<td>3.0 One minute power frequency withstand voltage</td>
<td>2.5 Kv for power circuit &amp; 500 V for control circuit</td>
</tr>
</tbody>
</table>

**Pollution Degree**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Pollution Degree</td>
<td>Pollution Degree 3 as per IS-13947 (Part-1) : 1993;</td>
</tr>
</tbody>
</table>
### G. Components

<table>
<thead>
<tr>
<th></th>
<th>Components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Isolating Equipment</td>
<td>3 pole manual ACB</td>
</tr>
<tr>
<td>2.0</td>
<td>Indication Lamps</td>
<td>LED type indicating lamps for: ACB ON/OFF/TRIP,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Incoming power R / Y / B, Auto / Remote / Local,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soft starter mode / bypass mode, Motor ON / OFF / TRIP.</td>
</tr>
<tr>
<td>3.0</td>
<td>Meters and selector switches</td>
<td>96 sq.mm size voltmeter with 7 position selector switches</td>
</tr>
<tr>
<td></td>
<td></td>
<td>96 sq.mm size ammeter with 4 position selector switches</td>
</tr>
<tr>
<td>4.0</td>
<td>Power contactor</td>
<td>AC3 duty of rated capacity.</td>
</tr>
<tr>
<td>5.0</td>
<td>Thermal overload relay</td>
<td>Electronic type CT operated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shall be connected in bypass mode.</td>
</tr>
<tr>
<td>6.0</td>
<td>Auxiliary contactors</td>
<td>Shall be provided for logic operation and operating sequence.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shall have minimum 2NO+2NC auxiliary contacts suitable for 5A DC.</td>
</tr>
<tr>
<td>7.0</td>
<td>Door mounted operating devices</td>
<td>Start / stop operating PB, Reset PB, Selector switches, Auto / Remote / Local</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soft starter mode / bypass mode.</td>
</tr>
</tbody>
</table>

### H. Panel Wiring

|   | Power / current transformer circuit   | 1.1Kv grade single core, black colour PVC insulated, stranded copper conductor of minimum size 2.5 sq.mm. |
|   | Control and potential circuit        | 1.1Kv grade single core Black colour PVC insulated                              |
|   |                                      | Stranded copper conductor of minimum size 1.5 sq.mm.                           |
| 3.0 | Ferrules                             | Numbered plastic/ceramic ferrules. Self locking type.                        |
| 4.0 | Marking                              | Wiring will be properly marked as per relevant IS.                           |
| 5.0 | Spare contacts                       | All spare contacts of relays selector switches & contactors will be wired upto the terminal block. Each components shall have at least one potential |
### 6.0 Terminals

Power & control terminals shall be segregated by insulating material like hylam / bakelite sheet.

All control field wiring terminals shall be front access.

Power terminals shall be stud type.

Control terminals shall be suitable for connecting two cores of 2.5 sq.mm wires.

Minimum 20% spare terminals will be provided.

The minimum rating of control terminal shall be 10 Amps.

Color coded wires, TB's of different voltage rating to be provided.

Uniform color-coding to be followed for cabling, TB, etc.

### 7.0 Cable glands

Double compression cable glands for receiving external power and control cables.

### I. Control Supply

#### 1.0 Control transformer

1 nos. of 415V/240 V control transformer of minimum 2.5 KVA.

Secondary unearthed.

#### 2.0 Input and output side isolation device

<table>
<thead>
<tr>
<th>Input side</th>
<th>Output side</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCB</td>
<td>MCB</td>
</tr>
</tbody>
</table>

### 1.02.11 Specifications of major components

#### 01. MOULDED CASE CIRCUIT BREAKER (MCCB)

<table>
<thead>
<tr>
<th>1.0</th>
<th>Reference standard</th>
<th>IS : 13947 (Part-2) : 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>Rated Current</td>
<td>As specified in SLD</td>
</tr>
<tr>
<td>3.0</td>
<td>MCCB for motor feeders</td>
<td>MCCBs for motor feeders shall be motor protection type conforming to type-2 co-ordination. (MCCB without overload not available. EOCR is being used)</td>
</tr>
<tr>
<td>4.0</td>
<td>Short circuit rating</td>
<td>50 kA (Minimum) (Ics=Icu)</td>
</tr>
<tr>
<td>5.0</td>
<td>Service Short circuit breaking capacity (Ics)</td>
<td>100% of rated ultimate short circuit breaking capacity (Icu)</td>
</tr>
<tr>
<td>6.0</td>
<td>Operating handle</td>
<td>Yes</td>
</tr>
<tr>
<td>7.0</td>
<td>Safety Door interlock</td>
<td>Door interlock</td>
</tr>
<tr>
<td></td>
<td>Padlocking in ON/OFF position</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------</td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td>Withstand capability</td>
<td>Rated short time with-stand current ($I_{cw}$) will be 12 times maximum rated operational current for 1 sec.</td>
</tr>
<tr>
<td>9.0</td>
<td>Utilisation category</td>
<td>AC23B</td>
</tr>
</tbody>
</table>
| 10.0 | Electrical features | - S/C, O/C, E/F protection for power supply feeders & crane trolley line feeder MCCB’s.  
- Features to minimise the let-through energy ($I^2t$) in the event of short circuit on load side.  
- Complete with continuous electronic / microprocessor based adjustable thermal and magnetic releases.  
- MCCB’s for motor feeders shall be of motor duty class with magnetic trip only. Overload protection shall be through electronic overload relays. |
| 11.0 | Auxiliary contacts | 1 NO + 1 NC  
Alarm contacts. |
| 12.0 | Miscellaneous | Can be used in load side or line side vice versa.  
Shunt trip coil. |

**02. AC CONTACTORS**

<table>
<thead>
<tr>
<th></th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Indoor within steel cubicle for maximum system voltage, starting of motors and miscellaneous loads</td>
</tr>
<tr>
<td>2.0</td>
<td>Standard</td>
</tr>
<tr>
<td>3.0</td>
<td>No. poles</td>
</tr>
</tbody>
</table>
| 4.0 | Operating type | Magnetic coil operated at 240 V AC.  
No economy resistors.  
Insulation for coils shall be class ‘E’ or better |
| 5.0 | Rating | 32A (Minimum), Rated for 125% of full load motor rated current for DOL motor feeders and 150% of motor rated current for RDOL motor feeders. |
| 6.0 | Interrupting capacity | Ten times the rated current for rated size upto 100A and eight times the rated current for larger sizes. |
| 7.0 | Duty | According to IEC 158-1  
- AC 1 duty: Non inductive or slightly inductive loads.  
- AC 2 duty: Slip ring motors: starting, plugging  
- AC 3 duty: Squirrel cage motors: starting, switching off motors during running  
- AC4 duty: Squirrel cage motors: Plugging, inching.  
Derated AC4 ratings shall be selected for inching and plugging operation of the drive (crane duty). |
| 8.0 | Utilisation category | AC23A for unidirectional motors  
|     |                     | AC24A for bi-directional motors |
| 9.0 | Aux. contact        | - Minimum 4 NO +4 NC contacts with minimum rating of  
|     | requirement         |   - 10A, 415 V.  
|     |                     |   - 2A, 220 V for rated duty DC-11.  
|     |                     |   - Shall have the facility of adding add-on contact blocks. |
| 10.0| Closing (pick-up)   | 85% to 110% |
| 11.0| Dropout             | Will not be higher than 75% and lower than 40% of rated control supply voltage |
| 12.0| Miscellaneous       | For RDOL feeders the power contactors shall be mechanically interlocked. |

03. Current transformers:

| 1.0 | Type | Bar type primaries and 5A (max) secondary with thermal and dynamic ratings corresponding to the units with which they are used. |
| 2.0 | Accuracy class | - Measuring CT accuracy class 1.0.  
|     |               | - Protective CT accuracy class 10 P 10. |

04. Control transformers:

| 1.0 | Type | Dry type, cast resin |
| 2.0 | Voltage | 415V/240V |
| 3.0 | Primary taps | +2.5%, +5% |

05. Indicating instruments:

| 1.0 | Basic details | - Shall not damage by passage of fault current or existence of over voltage for the maximum permitted duration of fault conditions.  
|     |               | - Ammeters for drives above 30 kW shall be CT operated.  
|     |               | - Voltmeters protected by fuses placed as close to the busbar as possible.  
|     |               | - Maximum reading 600% of IFL for motor feeders. |
| 2.0 | Mounting | Flush mounting, square dial with zero adjusting device for external operation. |
| 3.0 | Accuracy class | 1.5 |
| 4.0 | Size | Size of voltmeter and ammeter for incomer 144 x 144 mm |
for incoming feeders.
- Size of ammeter for motor feeders 96 x 96 mm.

06. Thermal Overload Relays.

<table>
<thead>
<tr>
<th>1.0</th>
<th>Standard</th>
<th>IEC:292-1</th>
</tr>
</thead>
</table>
| 2.0 | Basic details | - Electronic type (with indication for 37 KW motors and above)
- Triple pole
- Ambient temperature compensated
- Inverse time lag.
- Hand reset type.
- Bimetallic with adjustable setting and built-in single phase protection.
- Reset PB shall be operable from outside.
- Shall be able to withstand prospective short circuit current without damage or injurious heating till the motor protection MCCB clears the fault.
- Auto tripping shall be indicated on MCC.

<table>
<thead>
<tr>
<th>3.0</th>
<th>Contacts</th>
<th>1 NO + 1 NC contacts with minimum rating of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- 10A, 415 V for rated duty AC-11.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 2A, 220 V for rated duty DC-11.</td>
</tr>
</tbody>
</table>

07. Magnetic Overload Relays.

<table>
<thead>
<tr>
<th>1.0</th>
<th>Standard</th>
<th>IEC:292-1</th>
</tr>
</thead>
</table>
| 2.0 | Basic details | - Triple pole
- Ambient temperature compensated
- Adjustable time lag feature or of instantaneous type.
- Provided with a latch and hand reset feature or auto reset with flag indication.
- Adjustable current setting and time delay calibrated between nominal current and twice nominal current rating

<table>
<thead>
<tr>
<th>3.0</th>
<th>Contacts</th>
<th>1 NO + 1 NC contacts with minimum rating of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- 10A, 415 V for rated duty AC-11.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 2A, 220 V for rated duty DC-11.</td>
</tr>
</tbody>
</table>

08. Push Buttons

<table>
<thead>
<tr>
<th>1.0</th>
<th>Standard</th>
<th>IEC 60947</th>
</tr>
</thead>
</table>
| 2.0 | Basic details | - All push button switches including illuminated push buttons shall be of sturdy design
- Un-shrouded actuator for "START" application, Mushroom
- An actuator for "EMERGENCY STOP" application and key "STOP" application for "LOCK-OUT" application shall be provided.
- Mushroom actuator for Emergency Stop shall be latched type.
- Press to latch in operated position and turn-to-release in unactuated position.
- Double break parallel contact design or other suitable design feature enhancing contact reliability required in circuits with electronic interfaces involving low voltages and small currents shall be adopted.

<table>
<thead>
<tr>
<th>3.0</th>
<th>Size</th>
<th>22.4 mm diameter</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>4.0</th>
<th>Contact rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum 2 NO + 2 NC contacts with following current ratings.</td>
</tr>
<tr>
<td></td>
<td>• Continuous - 10 A</td>
</tr>
<tr>
<td></td>
<td>• AC 11 - 1.5 amps at 240V</td>
</tr>
<tr>
<td></td>
<td>• DC 11 - 0.5 amps at 110 V DC, L / R - 40 ms</td>
</tr>
<tr>
<td></td>
<td>All contact faces of contacts shall be of silver or silver alloy.</td>
</tr>
<tr>
<td></td>
<td>Facility of adding add on contact blocks to be provided</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.0</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Accept - Blue</td>
</tr>
<tr>
<td></td>
<td>• Test - Yellow</td>
</tr>
<tr>
<td></td>
<td>• Reset - Black</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6.0</th>
<th>Protection class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IP 66/67</td>
</tr>
<tr>
<td></td>
<td>The P.B. switches shall be with higher contact reliability, electronics compatibility.</td>
</tr>
</tbody>
</table>

09. Indicating Lamps

<table>
<thead>
<tr>
<th>1.0</th>
<th>Standard</th>
<th>IEC 60947</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>2.0</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED Cluster type</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.0</th>
<th>Basic details</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sufficient number of lamp grips shall be provided for easy replacement of lamps.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.0</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22.4 mm diameter</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4.0</th>
<th>Voltage level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Suitable for any of the following voltages as per the system requirement:</td>
</tr>
<tr>
<td></td>
<td>• 415V AC / 240V AC / 110V AC / 24V DC / 220V DC</td>
</tr>
<tr>
<td></td>
<td>All indicating lamps shall be suitable for continuous operation at 90 to 100 percent of their rated voltage.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.0</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For motor <code>ON</code>, valve/damper/gate <code>OPEN</code>, supply <code>ON</code>, breaker <code>CLOSE</code> : Red</td>
</tr>
<tr>
<td></td>
<td>For motor <code>OFF</code>, valve/damper/gate <code>CLOSE</code>, supply <code>OFF</code>, breaker <code>OPEN</code> : Green</td>
</tr>
<tr>
<td></td>
<td>Fault indication, over load, alarm condition, <code>SERVICE &amp; TEST POSITION</code> : Amber</td>
</tr>
</tbody>
</table>
indication.
- General purpose indication, : White
  motor `AUTO TRIP'.
Other colours may be adopted depending upon particular
application as approved by the Purchaser.

6.0 Protection class
   IP 66/67

7.0 Layout of indication
   lamps on boards / panels
   - Indicating lamps shall be located just above the associated
     push-button / control switches.
   - Red lamps shall invariably be located to the right of green
     lamps.
   - In case a white lamp is also provided, it shall be placed
     between red and green lamps along the centre line of
     control switch/ push button pair.
   - Blue and Amber should normally be located above the Red
     and Green lamps.
   - When associated with push buttons, red lamps shall be
     directly above the green push button and green lamp shall
     be directly above the red push button.

8.0 Legend plates
   Anodised aluminium

10. Miniature Circuit Breakers (MCB)

1.0 Type
   Heat resistant plastic moulded type

2.0 Ref. Standard
   IS: 8828 – 1978

3.0 Protections
   MCB’s shall be provided with
   - quick break trip-free mechanism
   - direct acting thermal overload
   - short circuit trip elements.

4.0 Short circuit capacity
   Not less than 9000A at 0.8pf

5.0 Mounting
   - DIN Channel mounting.
   - Single phase MCBs mounted adjacent to each other and
     connected to different phases will be provided with
     adequate insulated phase barriers.

6.0 Current Rating
   - The MCBs shall be selected from standard current
     ratings.(As per SLD)
   - Motor duty MCBs will be provided, if specified.
   - MCB shall be of C curve.

11. Selector Switches

1.0 Standard
   IEC 60947

2.0 Basic details
   - All control selector switches shall be of sturdy design.
   - Shall have modular construction with number of switching
     contacts for each position operated by a single shaft.
   - Inscription for each position shall be provided.
   - Stay-put or spring return arrangement shall be provided.
as per the circuit and control/operational requirement.
- The contacts shall be designed for higher contact reliability and electronics compatibility involving low voltage and small value of currents.
- The operating handle shall be robust and strong.
- One number of potential free switching contact for each position shall be provided as spare.
- Control switches for circuit breaker ON/OFF control 3 position spring return to neutral with lost motion device and pistol grip handle.
- Other control and selector switches - stay put type with wing type knobs.

<table>
<thead>
<tr>
<th>3.0</th>
<th>Contacts</th>
<th>2 NO + 2 NC contacts with minimum rating of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- All the selector switches shall be of 10 A rating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 25A for sturdy applications .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 1 NO &amp; 1 NC contact / poles shall be potential free for PLC inputs .</td>
</tr>
</tbody>
</table>

1.02.12 LOCAL CONTROL STATIONS

<table>
<thead>
<tr>
<th>1.0</th>
<th>Material</th>
<th>Sheet steel (CRCA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 mm thick</td>
</tr>
<tr>
<td>2.0</td>
<td>Mounting</td>
<td>Wall / structure mounted .</td>
</tr>
<tr>
<td>3.0</td>
<td>Enclosure class</td>
<td>IP-54 (for indoor installation)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IP-55 with canopy (for outdoor installation)</td>
</tr>
<tr>
<td>4.0</td>
<td>Door opening</td>
<td>Hinged type front door opening .</td>
</tr>
<tr>
<td>5.0</td>
<td>Cable gland</td>
<td>Removable undrilled .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To be provided on both top and bottom.</td>
</tr>
<tr>
<td>6.0</td>
<td>Internal wiring</td>
<td>2.5 mm , single core , stranded , black PVC insulated copper conductor .</td>
</tr>
<tr>
<td>7.0</td>
<td>No.of components like ON/OFF PB’s , selector switches etc.</td>
<td>As per scheme requirement.</td>
</tr>
</tbody>
</table>
| 8.0 | Contact details of components . | All the components like ON/OFF PB’s , selector switches etc. shall have 2NO + 2NC contacts / poles of 10 A rating.
|     |          | 1 NO & 1 NC contact / poles shall be potential free for PLC inputs . |
| 9.0 | Stop push button details | Stop push button shall be :-
|     |          | RED in colour.
|     |          | Mushroom headed.
|     |          | Press to lock and turn to release type . |
| 10.0 | Start push button details | Start push button shall be
|      |          | GREEN in colour. |
### 11.0 Lamp details (if any)
- **High density LED type**.

### 12.0 Location of selector switches
- Local / Remote selector switches shall be installed in the LCS.

### 13.0 Terminal blocks
- Shall be able to terminate wires of 2.5 sq.mm size.
- Not more than two wires shall be terminated in a single terminal block.
- Shall be mounted on D-channels.
- 30% spare terminals shall be provided.
- Colour of TBs for different voltages shall be different.
- Uniform color-coding to be followed for cabling, TB, etc.

### 14.0 Miscellaneous
- LCS shall act as field junction box also for wiring termination from Limit switches, PCS, BSS and other field devices.
- Facility for termination of minimum 5 nos. 19X2.5 core shall be provided.

### 15.0 Provision of ammeter
- For motors of more than 45 KW ammeters along with 4 position selector switches shall be provided.

### 16.0 Earthing
- Earthing studs shall be provided on two opposite sides.
- Internally the earthing studs shall be connected with the body through green colour PVC insulated copper flexible wire.

### 17.0 Paint

#### 1.02.13 CONTROL DESK

<table>
<thead>
<tr>
<th>Section</th>
<th>Item</th>
<th>Details</th>
</tr>
</thead>
</table>
| 1.0     | Material | - Sheet steel (CRCA)  
- 2.5 mm thick |
| 2.0     | Mounting | - Free standing  
- Floor mounting pedestal mounting or trunion mounting. |
| 3.0     | Enclosure class | - IP-52 (for indoor installation)  
- IP-55 (for outdoor installation in bays) |
| 4.0     | Door opening | - Hinged type front door opening  
- Hinged top cover with latching facilities in open position |
| 5.0     | Cable gland | - Removable undrilled  
- To be provided in bottom. |
| 6.0     | Internal wiring | 2.5 mm, single core, stranded, black PVC insulated copper conductor |
| 7.0     | Angle of inclination | 8 degrees |
| 8.0     | Components like ON/OFF PB’s, selector switches etc. | - Control switches, push buttons and indication devices mounted on top cover and wired upto terminal blocks using extra flexible appropriately insulated wires.  
- Numbers of components shall be as per scheme |
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0</td>
<td>Lamp test PB</td>
<td>To be provided</td>
</tr>
</tbody>
</table>
| 10.0 | Contact details of components | - All the components like ON/OFF PB’s, selector switches etc. shall have 2NO + 2NC contacts/poles of 10 A rating.  
- 1 NO & 1 NC contact/poles shall be potential free for PLC inputs. |
| 11.0 | Emergency stop push button details | - Emergency stop push button shall be installed on top right side of the control desk.  
- Emergency PB shall be:  
  o RED in colour.  
  o Mushroom headed.  
  o Press to lock and turn to release type. |
| 12.0 | Start push button details | - GREEN in colour.  
- Shrouded type. |
| 13.0 | Lamp details | High density LED type. |
| 14.0 | Terminal blocks | - Shall be able to terminate wires of 2.5 sq.mm size.  
- Not more than two wires shall be terminated in a single terminal block.  
- Shall be mounted on D-channels.  
- 30% spare terminals shall be provided.  
- Colour of TB’s for different voltages shall be different.  
- Uniform color-coding to be followed for cabling, TB, etc. |
| 15.0 | Spare switches | - At least 02 nos. of each types of switches and indication lamps are to be provided as spare in each desk.  
- Two numbers of drilled holes are to be provided. The holes shall be plugged with rubber cap. |
| 16.0 | Earthing | Earthing studs shall be provided on two opposite sides.  
Internally the earthing studs shall be connected with the body through green colour PVC insulated copper flexible wire. |
| 17.0 | Paint | Shade no. 631 of IS : 5 – 1992 or RAL 7032 |

### 1.02.14. CONTROL SYSTEM CONCEPT AND PHILOSOPHY

01 The electrical control system shall be laid on distributed hierarchical concept with a great extent of decentralization of control functions so that individual system shall be autonomous in operation as far as possible.
The system shall be sufficient to perform all the functions required of them & shall be designed to achieve high degree of accuracy of control functions.

Two hierarchical levels has been envisaged as indicated below:

- Individual drive control level (Level-0)
- Functional group control level (Level-1)

02 Individual drive control level (Level-0)

This shall comprise of motors, field devices, HT/LT Switchgears, Intelligent MCC's, Local control stations, speed control equipment etc. which are to be connected to Level-1 System.

03 Functional group control level (Level-1)

It shall comprise of Programmable Logic Controllers (PLC). The PLC's shall be provided for control, interlocking and sequencing of different drives. This shall also include HMI, visualization, alarms logging, reporting, trend curves, controlling of set points, etc. for the plant units.

Necessary interface to Level-2/3 System shall be provided.

04. Drive Control Requirement

All process drives shall be generally be controlled from Central control room through Operator workstations / VDU's and keyboards. Use of Control desks / Control Cabinets shall be restricted to specific drives / emergency operation only.

All drives shall be provided with sel.switch for local operation / maintenance. LCB's shall be provided with start & stop PBs, Local / Remote Selector switch, any other devices / lamps for the operation of the equipment. Stop PB shall be lockable type with key to release.

For HT motors, ammeter shall be provided on LCB. Interposing CT of secondary 1A shall be provided with purchaser's switchgear at the middle phase for remote metering.

All pumps shall be provided with dry running protections.

For all motors, drive status (ON/OFF, open/close, forward/reverse) tripping due to O/L, earth fault, equipment fault, process faults etc. shall be displayed in VDUs.

Where speed control of process drives are envisaged, the speed indicator shall be provided in VDU.
1.02.15. Automation System :-

01. General

<table>
<thead>
<tr>
<th>A. Automation System Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 System Architecture</strong></td>
</tr>
<tr>
<td>- Client server architecture</td>
</tr>
<tr>
<td><strong>2.0 Redundancy</strong></td>
</tr>
<tr>
<td>- Dual redundant CPU with hot standby mode (Application software based redundancy is not acceptable).</td>
</tr>
<tr>
<td>- Dual redundant communication bus with dual communication cards / dual redundant interface module for the communication bus and each I/O chassis to be installed in each I/O rack / scanner units and synchronizing modules.</td>
</tr>
<tr>
<td>- Two numbers of servers shall be provided with hot redundant mode.</td>
</tr>
<tr>
<td>- Power supply redundancy.</td>
</tr>
<tr>
<td>- Respective I/O rack shall act as a node to the I/O bus for interfacing with processor rack and shall not be interfaced through back plane extension between two or more I/O racks.</td>
</tr>
<tr>
<td><strong>3.0 Speed of comm. interface at I/O level</strong></td>
</tr>
<tr>
<td>Preferably 5 MBPS or better.</td>
</tr>
<tr>
<td>Data loss shall not be more than 4 %.</td>
</tr>
<tr>
<td><strong>4.0 Connecting ports</strong></td>
</tr>
<tr>
<td>- Cat.-5, UTP cable with provision for 2 nos. additional UTP ports.</td>
</tr>
<tr>
<td>- Two ports for connection to Level-2 network shall be considered for the network.</td>
</tr>
<tr>
<td><strong>5.0 Level-2 network communication bus</strong></td>
</tr>
<tr>
<td>In place of industrial ethernet, any other deterministic network of 10 MBPS or better (Bus based on open protocols at minimum 4 OSI layers) may also be considered in which case, separate gateway interface with two UTP ports with TCP/IP protocol on Ethernet shall be provided for Level-2 network.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. General</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 Control Philosophy</strong></td>
</tr>
<tr>
<td>- All process data acquisition &amp; monitoring functions, process control (PID), interlocking, logic &amp; sequence controls of drive and various systems shall be performed by the PLC.</td>
</tr>
<tr>
<td>- PLC’s shall be connected to two different bus levels in the network. It shall communicate with RIO’s, intelligent MCC’s, VFD’s, Soft starters, weigh panels etc. on Profibus / Modbus / Controlnet while with HMI’s and HMI cum ES on high speed Ethernet bus through server. The Ethernet switch provided shall be manageable type.</td>
</tr>
<tr>
<td>- The automation system shall cover all the sections of the entire plant.</td>
</tr>
<tr>
<td>- A separate server shall be provided for MIS terminals to be located in welfare building of the individual shop through communication link switch.</td>
</tr>
<tr>
<td>- Communication gateway shall be provided for communicating the system with plant network system of the plant.</td>
</tr>
<tr>
<td>- For displaying the alarms and faults in the mobile handset</td>
</tr>
</tbody>
</table>
of the authorized person a modem for GSM shall be provided in the network.
- PLC installed in mobile equipments like stacker cum reclaimer etc. shall communicate with the main server through wireless communication. All the required hardware and software shall be provided for the same.

<table>
<thead>
<tr>
<th>2.0</th>
<th>Data signals exchangeability with PLC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The PLC envisaged in this package shall exchange signals with RIO / Instrument panel / VFD / MCC’s / Weigh Feeder Panels / dedicated position control system panels (if any) / Level 2 system computers / other PLCs of the plant.</td>
</tr>
<tr>
<td></td>
<td>However all the critical equipment / drives shall be provided with hardwire interlocking in addition to the interlocks through PLC.</td>
</tr>
<tr>
<td></td>
<td>The Tenderer shall include multi-vendor connectivity with all requisite hardware, communication interfaces &amp; required software for exchange of signals with other PLCs of different make on high speed communication bus.</td>
</tr>
<tr>
<td></td>
<td>OPC server shall be provided for communication between the OEM PLC (of different make) and main system PLC.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.0</th>
<th>Operational control mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Provision of the visualisation of the system shall be through human-machine interface HMI, for the control and operation of the complete plant.</td>
</tr>
<tr>
<td></td>
<td>In addition to the normal workstations, at least two numbers of 42” or higher plasma/LCD display units and one overhead LCD projection system to be provided in each central control room.</td>
</tr>
<tr>
<td></td>
<td>Plasma/LCD display units along with AV switching unit to output AV signal from any machine in the control room.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4.0</th>
<th>Operational facilities in HMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The Graphic interface to the operator shall have the following minimum features with user friendly navigation keys.</td>
</tr>
<tr>
<td></td>
<td>· It shall be possible to display dynamic graphic of different section of plant on the TFT screen &amp; large display system.</td>
</tr>
<tr>
<td></td>
<td>· Graphic displays shall be field configurable only through engineering key-board with standard / user defined graphic symbols.</td>
</tr>
<tr>
<td></td>
<td>· Different plant sections dynamics shall be displayed on different pages.</td>
</tr>
<tr>
<td></td>
<td>· The graphic display on the HMI clients shall also include extensive process, system and equipment diagnostics in graphical form for troubleshooting. The PID and other such settings to be available on operator workstation for viewing and editing.</td>
</tr>
<tr>
<td></td>
<td>· Graphic display shall be interactive type through which it shall be possible to control process. Following process control functions will be initiated via the HMI:-</td>
</tr>
<tr>
<td></td>
<td>- Operation mode (Auto / Remote / Manual ) selection</td>
</tr>
<tr>
<td></td>
<td>- Control mode (Auto / Semi-Auto / Local ) selection.</td>
</tr>
<tr>
<td></td>
<td>- Selection of drive and control loops</td>
</tr>
<tr>
<td></td>
<td>- Set point selection.</td>
</tr>
<tr>
<td></td>
<td>- It shall also be possible to send motor start / stop and shutdown, valve open / close command, control mode selection command from this display.</td>
</tr>
</tbody>
</table>
- It shall be possible to go from any graphic page to related graphic page or any group view or alarm summary in single keystroke using soft key function.
- Process diagnostic system to provide status & fault signals of the process along with process error displays.
- The details of graphic screens shall be finalised as required during detailed engineering and commissioning.

<table>
<thead>
<tr>
<th>5.0</th>
<th>Operational menus in HMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Opening page with project description, name of supplier, name of consultant.</td>
</tr>
<tr>
<td></td>
<td>• Sub-menus like command menu, report menu etc.</td>
</tr>
<tr>
<td></td>
<td>• Command menu in the form of buttons for start and stop of each equipment / group of equipment.</td>
</tr>
<tr>
<td></td>
<td>• Operation mode</td>
</tr>
<tr>
<td></td>
<td>• Display of auto / local selection of each mechanism.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6.0</th>
<th>Reporting and data logging</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Summary of faults with description, date and time of occurrence.</td>
</tr>
<tr>
<td></td>
<td>• Shift wise, daily, monthly, yearly hierarchical logging of report/faults/data with process values / production figures and other process data. However, same shall be finalised by the Purchaser during detailed engineering process.</td>
</tr>
<tr>
<td></td>
<td>• Automatic log sheet – operation &amp; maintenance – shift &amp; day.</td>
</tr>
<tr>
<td></td>
<td>• The system shall comprise of a standard library of control, logic and computational functions that are preprogrammed and stored in memory. During the system configuration, user shall be able to select the appropriate functional blocks from the library, link them together, set the various inputs and tune parameters associated with each block.</td>
</tr>
<tr>
<td></td>
<td>• Real time recording of data for important equipment shall be provided (e.g high speed recorders etc.)</td>
</tr>
<tr>
<td></td>
<td>• All logging in ORDBMS. Logging and reporting also to be provided batch-wise, campaign-wise, etc. Reporting to include analysis tools.</td>
</tr>
<tr>
<td></td>
<td>• Historical data storage &amp; trending.</td>
</tr>
<tr>
<td></td>
<td>• Along with graphic generation, trending, and alarm generation, EVENT LOGGING also to be included. Event logging means data related to an event happening in the process or field. It will also include the user activities vis-à-vis operation through the automation system.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7.0</th>
<th>Mode of operation of the plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Local Mode</strong> :-</td>
</tr>
<tr>
<td></td>
<td>• Operation of single drive / equipment</td>
</tr>
<tr>
<td></td>
<td>• Start / Stop from LCS shall be done only for test and repair purposes.</td>
</tr>
<tr>
<td></td>
<td>• To enable the testing of individual equipment all the interlocks which are not at all necessary shall be withdrawn in this mode.</td>
</tr>
<tr>
<td></td>
<td>• However all personnel / equipment safety interlock are effective for safety reasons also in local mode.</td>
</tr>
</tbody>
</table>
|     | • LCS are provided for all motors , drives and
actuators for valve operation as near as possible.

B. Semi Auto :-
- Under this mode it shall be possible to monitor & control the plant based on set points / commands given by operator through keyboard (for individual equipments or individual group for group control drives) and the control, sequential operation of various mechanisms in the required sequence shall be executed by PLC i.e.; in this case all the changes are operator initiated.

C. Auto Mode :-
- This is the normal mode of operation of the plant. In this mode, the desired values (set point) of the parameters of process control loop will be set via keyboard of the HMI and sequencing and logic functions will remain operative through the PLC as per programme.
- There shall be a provision of group start of the individual sections.
- In the individual sections there shall be provision of interlocks, logic and sequencing between the individual drives.

8.0 Screen menu display
- Over view
- Group display
- Loop display
- Mimic display (dynamic)
- Alarm over view
- Alarm display
- Trend display (Dynamic display)
- Event displays (Dynamic display)
- Diagnostic & maintenance displays

However a dynamic mimic status pages shall be made available with security through web based portal for each respective packages. Location of the same shall be decided during detailed engineering (by BSP).

9.0 Process graphic displays with dynamic process variables
- Process status overview (On/Off status of process and plant)
- Operation status of Drives (Position and status of drives)
- Group display of Loops
- Control Loop display & Configuration of Control Loops
- Real time trending (Bar graph displays and / or numerical display)
- Historical trending. Historical trending for 7 days for 1 minute scan rate for all analog inputs
- Fault message indications
- Operational/ event message indication.
- Data and time synchronization on the complete HMI system shall be ensured.
10.0 Process graphic display operation

- High speed (1msec scan) recorder of 12 channels to be provided for real time recording of data for important equipment (at least 02 nos. for each packages).

- Graphic Display will contain static and dynamic components. The dynamic components display the actual state of the plant section. Dynamic components will be actual binary states (e.g. drive “on”) or actual values. Values will be represented as bar charts and/or numerical.

- Critical plant status will be highlighted by different colours or by blinking. Description in clear text will be provided to simplify Operator understanding.

- Double clicking on any of the control valve in any of the menu/submenu pages shall invoke the corresponding PID loop display screen with real time trend. PID loop display screen shall show controller facia and displaying status and parameters of each controller. Each facia shall be able to display process value, set value and the manipulated variable. The remote manual functions and change of set points under auto mode shall be possible to be performed from these facias.

- Graphics should also include very comprehensive diagnostics on process, plant, equipment, system etc., enabling the user to pinpoint exact reason of any problem faced.

- In case of Cascade/ Ratio control, it shall show all the controllers facia with the facility of maximising one of them. PID parameters can be changed only after validation of software password.

- Clicking on any mechanism like valve will invoke a small screen showing following (software lamps) indications for remote manual operation:
  - Local
  - Remote
  - Auto
  - Open (Blinking with opening color during opening)
  - Closed (Blinking with closing color during closing)
  - O/L Tripped
  - Torque switch actuated
  - Control supply Healthy
  - Valve Open Timer Time Out
  - Valve Close Timer Time Out
  - Local Stop

- Clicking on any mechanism like fan / pumps will invoke a small screen showing following (software LED) indications for remote manual operation:
  - Local
  - Remote
  - Auto
  - Run Feed-back
  - Elect. Fault

11.0 Colour Codes

- The display of the process will occur on full graphic color
<table>
<thead>
<tr>
<th>12.0</th>
<th>Trending</th>
</tr>
</thead>
</table>
|      | In any menu/ sub menu page double clicking on any tag will invoke the trend menu of that particular tag. Based on the selection by the Operator either Historical or Real Time Trend menu will be displayed. Provision shall be there so that Operator can add trends by entering the tag nos. , for another 7 nos. of tags in the same page ,using the same time base for comparison purpose. The Automation system must support historical process information recording and retrieval. This historical information shall be available for use in logs, trends, etc, requested at any operator console. Recorded process information shall include:  
  - Measured value  
  - Alarm status  
  - Setpoint or desired value  
  - Output value  
  - Control mode  

A distributed approach to historical recording is preferred to a dedicated unit. For both logging and historical trending the operator/ engineer must be able to specify the points to be recorded, the frequency with which the data is to be collected and the time base. Historical data should support the following protocols:  
  - OPC (Open Process Control)  
  - OLE (Object Linking and Embedding)  
  - OBDC (Open data base connectivity)  
  - API (Application Programming Interface)  

Sufficient online storage shall be included to accommodate the data base and alarm, event and historic data logs for monitoring 75% of analogue data for 24 hours at 10 sec. Trend rate. Display of trend shall have  
  - Operator scalable X-axis from 60 seconds to 24 hours (for 24 hours history, trend shall be stored as 10 seconds scan for each variable) |
### 13.0 Interlocking

The interlock scheme shall be as per the technological requirement based on process flow diagram, P&I diagram and functional chart.

- All emergency conditions like stop push button, emergency stop command, torque switches, level switches etc. shall be interlocked to the main power contactors of the drives.
- Provision of providing interlocking of different equipment (which are controlled from different PLC) based on I/O exchange from that PLC.
- Further the system shall be provided with pre-starting audio-visual alarm at equipment platform before starting of mobile equipments like conveyors, turret, tundish cars etc.
- Interfacing with subsystems: All outside auxiliaries and supporting units for process related system shall be interfaced.

However, all facilities to be provided in the central control room which shall be finalised during detailed engineering stage keeping in view the process / technological requirement.

### 14.0 Alarms and alarm management

- The use of multi-media system in HMI shall be envisaged for audio-visual signaling for faults & alarms.
- There shall be dedicated key as a provision for acknowledging the faults. The usability of the operator interface shall be further enhanced with features such as sound cards, touch screen, track balls etc.
- Alarm list / event list and operator action list and its logging for minimum one month.
- Alarm Performance
- Irrespective of Operator activity and choice of display, an alarm situation shall always have priority and shall be brought to the attention of the Operator, quickly and automatically.
- The display containing the alarm shall be selected by a single keystroke action. Alarms should automatically
update in the event of an alarm operating i.e. it should not require operator intervention to update alarms either on process mimics or alarm summary format.

- Alarm messages shall be time tagged to within 100 milliseconds (from detection at input card or receipt from data link) or less and are required to be displayed within two seconds of the field device operating. System resolution for the orderly detection of successive alarms shall enable those alarms to be displayed in order of occurrence, and/or priority.

- In order to facilitate easy recognition of alarm status by operators, annunciator colours and audio tones shall be easily distinguishable. All alarms and trips shall be annunciated by a screen message and an audible alarm.

- Critical process alarms shall come in the form of small size popup window on the HMI screen. Individual area wise alarm shall display in the corresponding HMI station.

- The alarms and trips shall flash in a highlighted form (e.g. reverse video) until acknowledged. When acknowledged from any HMI, the flashing and audible tone shall stop on all HMIs. When an alarm returns to normal, flashing shall return to normal on all HMIs provided the alarm has been acknowledged.

- Alarm Category Colours

- The following colours shall be used for the process control system screen alarms, on a black of gray background:
  - Fire & Gas : Red
  - ESD : Magenta
  - Fault alarm : White
  - Process alarm : Orange

- These are proprietary colours and shall be confirmed during detailed engineering. The use of yellow colour (traditionally a gas alarm) and green colour (associated with normal conditions) shall be avoided for alarms.

- Audible Alarm Category

- There shall be audible differentiation between the fire and gas alarms (noise X), and process alarms and faults (noise Y and Z), where X, Y and Z noises have to be defined.

- Analogue Alarms

- All process variables and composed points shall have the possibility of being assigned at least two levels of high and two levels of low alarm values. All control loops shall have the possibility of being assigned high and low
deviation alarm values. All alarms shall have a user-definable dead band. An alarm shall be provided when analogue signals are less than 3.8 mA or greater than 20.2 mA. Rate of change alarms and set point deviation alarms shall be provided.

- Filtering based on plant, equipment, time-span etc. shall be possible
- The system will be engineered such that it is anticipated that at least 4 levels of alarm priority will be used:
  - Low
  - Medium
  - High
  - Critical
- According to guidelines, which will be developed in detail engineering, the Alarm/ event logging facilities will be provided using Automation System based logging rather than printers.
- Discrete Alarms
  - All discrete inputs shall have the possibility of being assigned a change of state alarm. Discrepancy alarm indicating failure of control action shall be provided.
- Alarm Analysis
  - It shall be possible to inhibit alarms by point of priority when the initiating device is faulty or being maintained. While inhibited, the point must still be scanned and archived. The removal of the inhibit shall be logged. A summary display containing all inhibited points shall be provided on demand. Alarm inhibition shall be permitted from any of the work stations with level 3 or 4 access level only. Facilities shall be provided to mask out alarms from equipment (such as pumps) that is shutdown. These alarms shall be automatically or manually via keyboard, reinstated when the equipment is put back into service. Initiation and removal of inhibition shall be logged as an event and printed.
- Alarm Display
  - Alarm displays shall take the form of a summary display of all points in alarm, and/or integrate the alarm message with associated item, group or overview data. Alarms shall be listed in order of occurrence, and for specific alarm displays the most recent alarm shall be shown at the top of the display. All alarms shall be identified by tag, description and the date and time of the occurrence, in hours, minutes and seconds. A banner type display
showing a summary of alarms shall always be present at the top of the screen irrespective of main display.

- **Alarm Grouping and Priority**
  - Alarms from an area shall be capable of being grouped in one or more Alarm Groups. A minimum of 30 Alarm Groups shall be provided. At least four levels of alarm priority shall be available, with configurable presentation/ background colour. A global alarm acknowledge and reset facility shall be available. If unacknowledged, Alarm message stays on display until it is cleared.

- **Diagnostic Alarms**
  - The Automation System shall have a comprehensive self-diagnostic alarm information shall identify the faulty device down to board level, with its location and provide a diagnostic code. Individual circuit boards shall be provided with LED indicators or equivalent, to positively identify a faulty board. The failure of any single item of equipment shall not generate erroneous alarms.

- **Alarm Handling Capacity**
  - In addition to the alarms included in the point count, the Automation System shall be capable of handling alarms and status points received via any data link to which it is connected.

- **Alarm Flooding**
  - The Tenderer shall outline his approach, to overcome the problem of alarm flooding.

### 15.0 Configuration

- **For Instrumentation system a separate dedicated PLC shall be provided (as mentioned in TS).**
- **If the PLC is common for the process a separate dedicated remote I/O panel shall be provided for the instrumentation system.**

### 02. Programmable Logic Controller (PLC)

#### General Features

<table>
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<tr>
<th>1.00</th>
<th><strong>Power supply system</strong></th>
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<td>1.01</td>
<td>Power supply system</td>
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</table>

PLC system shall have two independent Input supply voltage:
- Two source of 240V AC single phase, 50 Hz from UPS for CPU and other required control modules, interrogation voltage and output voltage.
- Two nos. of redundant power supply modules in each chassis with diode ORing.
- One source of 240 V AC single phase, 50 Hz from MCC for
### 1.02 Built-in power supply units

- Suitable for the power supply system as specified above.
- Following power supply unit shall be provided for following units:
  - Redundant 24 V DC power supply units (with multiplying diodes for powering field instruments (2-wire transmitters).
  - Separate power supply modules, to be supplied by the Tenderer for each segment of Foundation Field bus system, shall be of Type 132: Non-I.S. power supply intended for feeding a non-I.S. barrier. Output voltage shall be 32 V DC maximum. Power supply module shall have in-built power conditioner. DP MCBs shall be provided for each segment of the Foundation Field bus system.
  - Redundant regulated power supply unit of proper rating shall be provided for special control module (if any required).

Following features shall be provided in the power supply unit mentioned above:
- Insulation level 2.5 KV for 1 minute.
- Protection against surge protection & short circuit
- Electronic over current protection with feedback feature.
- Thermostat protection against over temperature.
- Over voltage protection.
- Fuse protection in the input and output circuit.

### 2.0 Central processor unit

- Modular and plug-in type
- 32 bit microprocessor based
- PLC shall be able to scan and execute all close loops (approx. 40 PID loops) in less than 100 milliseconds and scan digital inputs in 50 milliseconds simultaneously.
- Execution time between 1 milliseconds to 3 milliseconds per 1K instruction or better.
- Provision to latch desired outputs.
- Provided with redundant hot standby CPU (with
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|   | appropriate communication module).  
- The CPU system shall have facility of bumpless transfer in case of failure of one.  
- CPU shall have crystal clock generator.  
- Redundant CPUs to have extensive in-scan synchronization. Time synchronization from designated time server  
- Peer to peer communication through I/O channels shall be possible.  
- Backup system communication (redundant communication bus) shall be provided.  
- The processor shall have proper communication modules (for each CPU) for communicating with redundant processor, remote I/O modules and for communicating with other communication bus protocols like ethernet bus / profibus / modbus / controlnet / field foundation bus etc. (no proprietary bus, for any sort of communication including fieldbus, to be used.  
- The processor shall have in-built provision for software timers, counters, examining input conditions, compare, compute, logical, conversion from/to BCD, bit manipulation, block memory manipulation, diagnostic, shift, sequencing, conditional jumping, subroutine instructions etc.  
- CPU shall be capable of handling PID functions including mathematical functions, weighing and batching functions.  
- CPU shall be capable of handling 30% additional (future) I/Os over and above 20% spares (installed) I/Os indicated in basic configuration diagram. Maximum CPU loading shall be limited to 60% for the intended applications.  
- The CPU shall have the facility of initializing a synchronizing pulse to the server periodically (Minimum once in a day).  
- CPU loading shall not exceed 60% .  |
| 3.0 | Timers | The timers shall be OFF delay, ON delay, retentive type timer with a range from few millisecond to few hours. Accuracy shall be +/- 0.1% of the set value.  |
| 4.0 | Counters | The counters shall be of counter up and counter down type. It shall have the range from 0000-9999.  |
| 5.0 | Memory units | - Modular and plug-in type  
   - Word length 32 bit  
   - Expandable in blocks of 4K Words  
   - Minimum size 20MB  
   - EPROM/RAM with battery power back-up  
   - Back-up battery shall be as follows: -  
     - Rechargeable Ni-Cd batteries with necessary charging circuit / Lithium or any other internationally acceptable type.  
     - Able to retain memory for a minimum of 1 year with no power applied to the controller.  |
| 6.0 | Input Units | - High density, modular, rack based (channel based I/O not acceptable) and plug-in type.  
   - Insulation level of 1.5 KV  |
- Input interrogation voltage 24 V DC.
- Individual fuse for each unit shall be provided for protection against cable fault/earth fault.
- For critical applications all inputs (analog, digital, others) to have individually isolated channels.

<table>
<thead>
<tr>
<th>6.1 Digital Input Modules</th>
<th>Digital input units shall have the following features :-</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>· 16 / 32 inputs per module.</td>
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<td>· Time delay of about 10 millisecond to filter out noise and contact bounce.</td>
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<td>· Optocoupler to galvanically isolate each input device from the decision making logic of the controller</td>
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<td>· LED status indication</td>
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<td>· BCD input units suitable for four digit input</td>
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<td></td>
<td>· Pulse inputs (Incremental encoder/digital tacho)</td>
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<td></td>
<td>· Absolute / incremental encoder inputs.</td>
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<td>· High speed counter type inputs</td>
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<td>· All the cards shall be compatible of receiving digital signals from field sensors and switches directly.</td>
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<td>· All the control modules / cards shall be lacquered</td>
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<tr>
<th>6.2 Analog Input Modules</th>
<th>Analog input units shall have the following features:</th>
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<tr>
<td></td>
<td>· Shall be 8 channels, rack based &amp; plug-in type.</td>
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<td>· Suitable for 4-20 mA / 0-10V DC / RTD / thermocouple / weighing signal inputs.</td>
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<td>· With necessary A/D converter having at least 12 / 14 bit resolution based on application.</td>
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<tr>
<td></td>
<td>· Suitable for J/K/S type thermocouples &amp; for PT100, 2-wire / 3 wire</td>
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<td></td>
<td>· Galvanically isolated differential inputs with insulation level of 1.5 kV.</td>
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<td></td>
<td>· For 4 – 20 mA analog inputs, fused TB with blowing fuse shall be provided.</td>
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<td>· Healthiness of every input shall be monitored &amp; LED indication shall be provided.</td>
</tr>
<tr>
<td></td>
<td>· Analog module shall have the facility to be configured in voltage or current mode and differential or single ended inputs mode.</td>
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<td></td>
<td>· Pulse/ frequency input module shall have range upto 50 kHz. For very high frequency applications, the range shall be upto 1 MHz.</td>
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<td></td>
<td>· All the cards shall be compatible of receiving analog signals from field sensors and switches directly. If not suitable converters shall be provided.</td>
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<tr>
<th>7.0 Output units</th>
<th>High density, modular, rack based (channel based I/O not acceptable) and plug-in type.</th>
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<tbody>
<tr>
<td></td>
<td>· Insulation level of 1.5 KV</td>
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<tr>
<td></td>
<td>· Individual fuse for each unit shall be provided for protection against cable fault/earth fault.</td>
</tr>
<tr>
<td></td>
<td>· For critical applications all outputs (analog, digital, others) to have individually isolated channels.</td>
</tr>
</tbody>
</table>
### 7.1 Digital Output Modules

Digital output units shall have the following features:
- 16 / 32 digital outputs per module.
- High Density modular and plug-in type.
- Isolated outputs with two separate terminals for each output.
- Rated for 24 V DC
- With insulation level of 1.5 KV
- The output module shall be able to drive interposing relays (24V DC coil), solenoids, annunciation lamps, LEDs, Instrumentation control equipments etc.
- Power devices like contactors etc. shall be actuated through interposing relays. The interposing relays shall be mounted in the same panel. Proper surge suppressor shall be mounted across the coil of the output relays. However as far as possible interposing relays to be avoided.
- Any special requirement e.g position control to control field devices shall be met by using separate interface modules.

- BCD output units shall be as follows:
  - Suitable for four-digit output.
  - Rated to drive seven segment LED displays
  - With insulation level of 1.5 KV

### 7.2 Analog Output Modules

Analog outputs shall have the following features:
- Shall be of 4 / 8 analog output channels.
- Suitable for 4-20 mA / 0-10V DC / +/-10V DC outputs
- With necessary D/A converters having 12 bit resolution
- With insulation level of 1.5 KV
- Each output shall be galvanically isolated.

### 8.0 Foundation Field Bus Interface Modules (FIM)

- The Foundation Field bus interface modules (FIM) of the PLCs shall be chassis based modules. These modules shall completely integrate Foundation Field bus devices with the PLC controller & HMI software. These FIM modules shall deliver system wide integration of data access, control, connections, diagnostics and alarms with the PLC system. LED indication of power, error condition & status shall be provided in each FIM module.
- PLC shall provide graphical support to the Field Bus Interface module to perform the functions of Link Active bus scheduler for a network. This will allow the system configuration engineer to see what's going on and shall provide complete flexibility to adjust schedules based upon the needs of the control scheme. PLC shall also support Back-up Link active scheduler.
- All Foundation Field bus (FF) devices (to be procured under separate Instrumentation package) shall be
registered with the Field bus Foundation at level ITK 4.0 or higher. Field bus interface modules & Field Bus Library manager shall be compatible with ITK 4.0 or higher version compliant devices. Tenderer shall also provide Field bus usage license. All FF devices provided shall be polarity insensitive. All FF cables shall be of Type A.

- The PLC offered shall be certified for the Foundation Field bus Host Inter operability Support Testing (HIST) from Foundation Field bus organisation. HIST procedures provide a common methodology for assessing host inter-operability with registered devices.
- PLC Software shall have the capability either to directly read Device description (DD), files from the Field bus devices and add these DDs/Files to the library for Off-line & On-line configuration, or it shall perform this task through a separate software tool, Field bus library manager. It shall be possible for PLC based automation system to upload field device configuration changes implemented in the field. Once the configuration information is stored in the automation system, it shall be possible to download it to any other similar device, whether a new or replacement device.
- In case of a new device added to a Foundation Field bus segment, its presence shall be immediately shown in that segment. Important information about the new device including tag name, address, model and revision shall be immediately available.
- Downloading new software to Foundation Field bus devices shall be possible from the PLC. There shall be no need to physically change the firmware and to disconnect or remove devices for updating to the latest available revision. It shall be possible to simultaneously download the latest firmware to multiple field devices.
- Each Foundation Field Bus interface module shall support minimum two segments.
- The Terminators shall be impedance matching modules to be used at or near each end of a segment. There shall be two terminators per segment. The terminators prevent distortion and signal loss and shall be supplied as a pre-assembled, sealed module. Tenderer shall provide the Terminators as per the requirement.
- The power for each Foundation Field bus segment shall be provided through a power conditioner to prevent the communication signal from being attenuated by the power supply & to eliminate cross talk between FF segments through a common power supply.
- Power supply modules to be supplied by the Tenderer shall be of Type 132: Non-I.S. power supply intended for feeding a non-I.S. barrier. Output voltage shall be 32 V DC maximum.
- For Field bus use, a power supply impedance matching network shall be provided. This shall be a resistive/inductive network and built into the Field bus power
supply module.

- Connectors as coupling devices shall be employed to connect the wire medium to a field bus device or to another section of wire. Standard field bus connectors shall be used. Specification shall be as per annexure A of the ISA physical layer standard and annexure A of the IEC physical layer standard.

- Couplers shall be the physical interface between segment and spur or segment and Field bus device. Field bus couplers shall be as specified in the IEC/ISA physical layer standard and provide one or several points of connection to a field bus segment.

- Grounding: The instrument signal conductors shall not be used as a ground. Instrument safety ground shall be made through a separate conductor outside of the signal cable. The conductor may be in the same cable as the instrument signal conductors and shield, but shall be located outside the shield within this cable. Field bus devices shall not connect either conductor of the twisted pair to ground at any point in the network. The Field bus signals are applied & preserved differentially throughout the network. Network cable shield shall be earthed/grounded in one location only, at the field termination assembly (Host) end. At any field instrument, cable shield shall not be connected to the instrument earth/ground or chassis. The cable shields from different networks shall not be attached together in a field junction box. This will create ground loop & noise onto the network.

- Lightning/ Surge protection: Surge protection shall be provided for all field devices. The surge protection shall consist of low capacitance silicon avalanche diodes or spark gaps, wired for both normal & common mode protection and connected to the electrical safety ground grid. Surge suppressors shall be so selected that they shall not measurably attenuate the FF signal. To avoid any chance of short circuit, surge suppression devices shall be connected through a series fuse.

Foundation Field bus Network/segment naming convention

The following recommended network/segment naming convention shall be followed:

# NN MM P

- #: Indicates the plant/area number to which the segment shall be connected.
- NN: Indicates the node number / controller name.
- MM: Indicates model number / card number.
- P: Indicates segment or port number.

Loop & Instrument Naming convention:

Loop & Instrument naming convention shall be decided during detail engineering.
Spur Naming convention :-
All spurs shall be labeled with Instrument tag name.

9.0 Additional features
- On-line replacement of any module shall be possible in such a way that the removal and addition of any module shall be possible without de-energizing the system. Further there shall not be any interruption in the system while replacing a faulty module except for the inputs / outputs which are being handled by the module.
- Fully pre-programmed connection of field devices with input units through ordinary multi-core copper control cables of 1.5 sq. mm size (twisted pair), up to a length of 500 m.
- Communication with computer in distributed hierarchical control system and operator consoles / display units.
- High speed communication among PLC and operator consoles/display units shall be provided through dual redundant TCP/IP Ethernet using ethernet cards (no propriety cards) on HMI station.
- Switch to disable all outputs of the controller during start-up / debugging.
- All the automation equipment shall be user configurable to a fail-safe state to avoid dangerous situations in case of any failures caused by power failure, communication failure, etc.
- Test sockets on input modules for input simulation
- Facility to be provided to hook up engineering station at each location of I/O (preferably).
- Serial interface, RS232C and better shall be provided
- Any special requirement to control field devices shall be met by using separate interface modules.
- The PLC system shall be immune to the following:-
  • Radio frequency interference
  • Electromagnetic interference (EMC compatible)
  • Power system spikes
The methods and standards followed for these features shall be furnished.
- All network cabling to be structured and to be tested and certified.
- Network teams from multiple switches to be employed for all the important machines (computers).

10.0 Mounted spares
- Min of 20 % of I/O modules used (with at least one module of each type) for input and output shall be offered as spare for each programmable controller and the same shall be mounted and wired to the terminal block in the cubicle suitably.
- No. of spare Channel per card shall be 20 %.
- 20 % spare memory capacity shall be provided
- Provision shall be provided with empty slots for future expansion for 20% I/O modules. Minimum 50 % spare memory capacity shall be built in the system after loading of application and system software.
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<td>11.0</td>
<td><strong>Self diagnostic features</strong></td>
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|   | - Parity errors, cycle errors and under voltage  
|   | - Failure in central processor unit, memory and power supply  
|   | - Indication of type of failure  
|   | - Automatic turning OFF of all outputs or optionally holding of all outputs in their last state on failure detection  
|   | - Fault detection upto card level  
|   | - Communication failures – all types  
|   | - Fuse failure indication for outputs |
| 12.0 | **Monitoring functions** |
|   | - Monitoring of internal voltages  
|   | - CPU Status monitoring  
|   | - Memory status monitoring  
|   | - I/O Status monitoring  
|   | - Address monitoring  
|   | - Bus & communication signal monitoring  
|   | - Broken sensor detection  
|   | - A milliammeter with selector switch shall be provided on panel front to monitor the earth leakage current |
| 13.0 | **Terminations** |
|   | - All inputs and output wired up to easily accessible terminal blocks rated for 660V  
|   | - Screened cables for mA signals from Instrumentation I/O rack and other field sensors to terminal blocks of PLC  
|   | - Control cables for contact signals from Instrumentation I/O rack to terminal blocks of PLC  
|   | - Suitable for terminating up to 2.5 sq. mm. copper conductor industrial control cables  
|   | - Fuse terminals for all input & output signals (with LED indication)  
|   | - Required test and maintenance equipment to be provided for maintenance and troubleshooting of FO and wireless communication  
|   | - Uniform color-coding to be followed for cabling, TB, etc  
|   | - As far as possible cross-ferruling to be used for all connections |
| 14.0 | **Earthing** |
|   | - Separate earthing bus for power / panel earthing and electronic earthing shall be provided. Minimum two numbers of electronic earth pits shall be provided for each set of PLC  
|   | - Electronic earthing bus shall be suitably insulated. Earthing requirements / earthing schemes for the equipment supplied shall be clearly indicated in appropriate drawings |
| 15.0 | **Constructional features** |
|   | - Unitised construction  
|   | - Floor mounted, free standing and indoor type  
|   | - Bottom cable entry through gland plate  
|   | - Sheet steel clad |
- Dust and vermin proof
- Anti vibration pads to be provided to withstand vibrations as per application.
- All modules plug-in type.
- Panel illumination with door interlock limit switch.
- Switch-socket outlet for maintenance.
- Suitable fans & inlet air filters shall be provided at the bottom/top of each panel for proper air circulation.
- Empty slots of the racks shall be provided with dummy cards for protection against dust & damage.
- Colour shade outside and inside shall be RAL 7035.
- All panels shall be of Rittal make.

| 16.0 Enclosure | - Conforming to IP-42 class in PLC room/control room.
- Conforming to IP-54 class for remote I/O cubicles located in shops/bays.
- Programmable controllers, even if housed in air-conditioned enclosure, shall be suitable for normal industrial environment and ambient temperature upto 50°C.
- Temperature while operating
  - Lower limit : 0 degree C
  - Upper limit : 60 degree C
- Temperature while not operating (storage)
  - Lower limit : 20 degree C
  - Upper limit : 75 degree C
- Relative humidity
  - Daily average 80 to 90% (8 hrs.) and 65 to 90% (16 hrs.)
  - Maximum 98%, not occurring simultaneously with maximum temperature. |

| 17.0 Data sheet to be furnished by the tenderer | Tenderer shall submit the data sheet of the PLC system. The following informations shall be at least mentioned in the data sheet:
- CPU processing speed
- I/O handling capacity
- CPU in built communication port
- CPU programming memory capacity
- Minimum scan time achievable
- CPU self and diagnostic features. |

03. **Human Machine Interface (HMI) Work Station & Engineering Station**
1.0 Type
- Shall be console type PC based colour graphic Work
  Station
- Commercial grade latest available in the market.
- Industrial grade latest available in the market (for
  installations in the plant bay e.g. on casting platform in
  MOP)
- In addition to the normal workstations, at least two
  numbers of 42” or higher plasma/LCD display units and
  one overhead LCD projection system to be provided in
  each central control room.

2.0 Interfacing card / module required
Proper interfacing card / module with related communication
protocol shall be installed in the programming unit so that it
can communicate with the network (i.e PLC processor ,
server , HMI , printers) smoothly

3.0 Programming Facilities
- Programming unit shall be suitable for developing
  programs in ladder diagram / block diagram / statement
  form / SFC.
- Programming unit shall have facility for loading the
  program from CD & DVD.
- The programming terminal shall be capable of developing
  multiple programs offline without connecting to the
  programmable controller. Upload and download of the
  program between PLC and program unit shall not require
  ‘compile’ before ‘download’.
- Engineering station shall have an integrated and
  development and configuration setup for all the drives ,
instruments , PLC/DCS , HMI etc.

4.0 System Configuration
- Industrial grade PC with Pentium CPU
- 19” TFT color monitor with 0.28 mm dot pitch 1280 * 1024
  resolution
- Dual Ethernet interface with LAN accessories for all PC
  based operator station
- 64 bit , 256 MB RAM, 80 GB Hard Disc drive & controller
- Combo Drive, Graphics Accelerator Card with minimum 8
  MB on board RAM, Keyboards, Track ball / Mouse, Tape /
  Data backup drive suitable for plugging in USB port.
- The computers shall be provided with minimum 3 serial
  ports & one parallel port, ethernet interface with
  accessories.

5.0 Functions
- Error detection and reporting.
- Fail safe / broken sensor information and alarm and their
  reset .
- Selection of highest / lowest signal from a group of
  accepted inputs and displaying the same
- Linearisation and other arithmetic calculation. Provision
  shall be kept for pressure and temperature correction to be
  computed for flow measuring loops.
- Built-in ambient temperature compensation for
  thermocouple inputs from field.
- Trending real time and historical (Trending shall be
| 6.0 Miscellaneous | Networking via Ethernet with Network diagnostic displays  
| 6.0 Miscellaneous | Ability to add optional packages (e.g. for data analysis)  
| 6.0 Miscellaneous | All the important drives should be provided with suitable CBM systems such as vibration monitoring, current signature, temperature etc. Information from CBM systems to be interfaced to HMI system as well as plant-wide CBM system.  
| 6.0 Miscellaneous | All equipment to have extensive diagnostic capability. This information to be used for generation of relevant diagnostic information on working and problems in the system.  
| 6.0 Miscellaneous | Extensive BOM covering all hardware, software, etc. should be provided.  
| 7.0 Printer | Latest appropriate model of HP Laser Printer to get hard copy of the program dump / data logging / alarm logging / event logging / data trending etc.  

04. Server :-

| 1.0 System Configuration | Industrial grade .  
| 1.0 System Configuration | Server grade Intel Xeon, Dual CPU (Resultant speed 3.06 GHz)  
| 1.0 System Configuration | 4 MB Cache memory.  
| 1.0 System Configuration | 512 MB RAM.  
| 1.0 System Configuration | 2 X 72 Hot swap SCSI HDD (RAIR level-1 Disc mirroring) .  
| 1.0 System Configuration | 1X1.44 MB FDD.  
| 1.0 System Configuration | Combo drive  
| 1.0 System Configuration | 2 Serial ports, 1 parallel port, 2 USB port (for all client as well server).  
| 1.0 System Configuration | Graphic accelerator card with minimum 8 MB onboard RAM)  
| 1.0 System Configuration | Dual Network interface.  
| 1.0 System Configuration | 19” TFT colour monitor  
| 1.0 System Configuration | Keyboard and Mouse.  
| 1.0 System Configuration | Operating system Windows 2000/NT.  

- Report generation and periodic logging.
- Developing of graphic symbol library as per ISA – 5.1 and 5.3. in addition to standard industrial symbols.
- Printing of alarm conditions with parameter identification.
- Online editing of :-
  - Scan sequence
  - Identification number
  - Engineering units
  - High and low alarm limits
  - Alarm dead bands
  - Addition / Deletion signals
  - Removal / introduction of analog and digital points in scanning.
2.0 Make

- Servers shall be of COMPAQ/DELL/IBM make.

3.0 HMI server

- HMI servers shall be redundant. Separate clustered/redundant servers to be considered for data servicing. The server to be of latest & proven specification at the time of implementation.

4.0

- Only client-server, multi-tier system to be used. No standalone workstations apart from emergency workstations. Number of operator stations and emergency workstations to be finalized during engineering stage and should have at least two and one hot spare respectively

05. Software:-

<table>
<thead>
<tr>
<th>1.0</th>
<th>System software (Windows Programming)</th>
<th>The PLC programming software shall be latest, Windows based, menu driven and shall support the following minimum :-</th>
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<tbody>
<tr>
<td></td>
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<td>- Cyclic, Time Controlled, Interrupt controls.</td>
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<td>- Retentive / Non Retentive Timers, Bi-Directional counters, latches, etc.,</td>
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<td>- Internal Flag generated by the PLC.</td>
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<td></td>
<td>- All Boolean Logic Functions</td>
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<td>- Data Transfer, Block Transfer</td>
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<td>- Sub Routines</td>
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<td></td>
<td></td>
<td>- Arithmetic functions &amp; formula Calculations</td>
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<td></td>
<td></td>
<td>- Communication functions with Remote I/O as well as Work stations</td>
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<td></td>
<td>- Closed loop PID control functions including nested and cascaded loops.</td>
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<td>- Output of PID controllers shall be 4-20 mA DC.</td>
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<td>- Control valve position (in 4 – 20 mA) shall be made available in PLC.</td>
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<td>- PID Controller shall have auto tuning facility</td>
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<td></td>
<td>- Totalisation of flow inputs.</td>
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<td></td>
<td>- Linearisation function blocks and other useful function libraries</td>
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<td></td>
<td>- Linearisation function block shall be such that a table of values (X against Y) can be entered in a menu driven manner and for any particular field input X, the value of Y can be calculated using the values of table by interpolation method. Maximum 30 point linearisation function block shall be considered. Below 30, point of linearisation shall be user selectable.</td>
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<td>- Built-in ambient temperature compensation for thermocouple inputs from field.</td>
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<td>- Broken sensor detection etc.</td>
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<td>- Simulation facility / software shall be supplied for programme testing without disturbing the working PLC.</td>
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<td>- Minimum no. of PID Control Loops: 40.</td>
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<td>- The complete PID blocks shall be transferred to HMI workstation in place of split bits.</td>
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<td></td>
<td>- All computer shall have anti-virus software.</td>
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<td></td>
<td></td>
<td>The Software shall be suitable for PC based Programming Unit.</td>
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<tr>
<td>Section</td>
<td>Description</td>
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<tr>
<td>2.0</td>
<td><strong>Application Programme software</strong>&lt;br&gt;- Shall be as per process control requirement.&lt;br&gt;- The application programme software shall be written in Ladder logic / block diagrams / statement form.&lt;br&gt;- Online programme editing facility shall be available.&lt;br&gt;- Troubleshooting manual for all application software, system software, configuration, hardware, network, etc. to be provided, spelling out possible causes, checks and measures for corrective action.</td>
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<td>3.0</td>
<td><strong>HMI software</strong>&lt;br&gt;- Window based, latest version (at the time of implementation) of HMI software.&lt;br&gt;- HMI software package shall have the facility to perform multitasking, data acquisition, supervisory control, monitoring, control development and routine software.&lt;br&gt;- HMI software shall also have the features for alarming, trending, data logging, production backup history, operator action list, creation of shift reports after every shift, online printing of events.&lt;br&gt;- Number of graphic pages shall not be a limit.&lt;br&gt;- HMI software shall have the facility of handling unlimited tags (Digital as well as analog).&lt;br&gt;- HMI software shall be capable of curve fitting, co-relation &amp; regression functions.&lt;br&gt;- In the engineering workstation &amp; servers, development version of HMI software &amp; Foundation Field bus system software (licensed versions) shall be provided.&lt;br&gt;- In the operator workstations, runtime version of HMI software &amp; Foundation Field bus system software (licensed versions) shall be provided.</td>
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<td>4.0</td>
<td><strong>Database Software</strong>&lt;br&gt;- ORACLE &amp; DEVELOPER 2000 / As required &amp; supported by the system offered.&lt;br&gt;- All logging (data, event, etc.) of HMI in ORDBMS.</td>
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<tr>
<td>5.0</td>
<td><strong>Operating System</strong>&lt;br&gt;- WINDOWS NT / 2000 (Service Pack – Latest at the time of supply)</td>
<td></td>
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<tr>
<td>6.0</td>
<td><strong>Testing</strong>&lt;br&gt;- All tests on software, hardware, network, communication, etc. shall be carried on the basis of a pre-agreed protocol clearly listing out steps involved in testing with its responsibility and minimum expected results as per specifications, engineering and other documents.&lt;br&gt;- Purchasers’ involvement in design of control philosophy development, application software and hardware combined, drawing up of software specifications, software development, off-line testing, etc. for both Level-I and Level-II system.&lt;br&gt;- Provisions to be made for off-line testing of Level-I and Level-II systems prior to actual deployment.</td>
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<tr>
<td>7.0</td>
<td><strong>Miscellaneous</strong>&lt;br&gt;- All software required for design, development, testing, reporting-by-exception to be included. Troubleshooting, simulation, etc. should be supplied with requisite number of licenses.</td>
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</tbody>
</table>

**06. Special tools and tackles for maintenance and troubleshooting:**
Test equipments, tools, software, etc. for all relevant hardware and/or software systems/subsystems shall be provided. Special tools to include tools in sufficient number for tracing, location, testing, jointing, fault location & rectification, termination etc. for all cables including special cables (network and FO cables) in all major units of the expansion projects. Tenderer shall indicate the list of special tools and tackles.

07. Documentation:

All drawings, designs, configurations, software, numbers, models etc. listed in TS and GTS are indicative and minimum only. Bidder may suggest a better and more comprehensive solution.

08. Standardization:

- Minimum make / type shall be considered to minimize inventory.
- All automation hardware, including that employed in various machines, analyzers etc., from single manufacturer. No more than two models to be used for systems with more than 24 I/Os. Both models to have same programming environment. All the hardware in individual systems should be from the same product series. All the automation hardware shall be interfaced to Ethernet network connecting the systems to HMI.

09. Training:

Training to be provided for at least the following levels:
- Hardware of Automation System (PLC) and its programming & troubleshooting.
- Training on Electro-Hydraulics – Servo, proportional, etc.
- HMI system – configuration, programming & troubleshooting.
- Client-server hardware, architecture, operating system, etc.
- Fieldbus communication – configuration, programming & troubleshooting.
- Networking & communication systems – Relevant toolkits, protocol analyzers, scopes, loggers, etc., for maintenance and troubleshooting, to be included.
- All the training to be conducted by OEM or its authorized training partner at a fully equipped training center with facilities where extensive hands-on exercises can be performed with system, identical to one under supply. Curriculum of each program to be finalized in consultation with client. Required number of trainees (minimum 15) to be covered through multiple programs on each topic. Most of the training to be conducted before use. (number of trainees shall be as per commercial contract)

10. Conference Room Gadgets:

All the shops shall have a conference room in the new welfare building. Following gadgets shall be provided in the conference room by the tenderer: -

- In conference room, ceiling mounted projector with automatic screen and good quality music system, also to be included. Projector and music system also to be interfaced thru AV switching unit to all the computers in the room.
Large Screen Display System :-

Large screen display screen system shall be provided in the control room of the plant. The display system shall have linear setup in the control room. The display system shall consist of a matrix of rear projection modules for high overall resolution, a controller unit based on either MS-Windows or Linux, and optional wall management software. Rear projection modules shall have DLP (Digital Light Processing) technology.

The system shall have following features :-

- High resolution to show large applications with several video or RGB sources.
- The system shall not be susceptible to environmental factors like heat, humidity, or vibration, which can cause an image to degrade over time. The system shall be zero hassle and minimal maintenance. All components are carefully chosen to provide high mean time between failure and minimal mean time to repair.
- The system shall have excellent module to module color uniformity.
- The system shall have high contrast image.
- Modular Design

The system shall be able to deliver a highly reliable and superior quality image display to the operator. The displays can be seamlessly integrated into any center. The modular concept shall also be applied within each module. System shall have separate fan-module, projection unit and illumination unit so that maintenance from the rear of the system is very easy. Filter and lamps can be replaced from the outside.

- Image optimization
- Builtin redundancy with hot standby configuration
- On screen menus

Size of the display system shall be 5m (length) x 3 m (width). Distance from the screen to operator shall be minimum 5 metres. The cube configuration shall be considered based on the above size of the screen. The display unit shall have following features:

- Full viewing angle : 180 degrees.
- Half gain angle (Horz. / vertical) : 35 deg. / 35 deg.
- Seam size screen : less than 0.2 mm
- Aspect ratio : 4:3

Operating condition:

- Humidity : upto 90 % non condensing
- Temperature : upto 50 deg. C.
- Optical dimming with dynamic feedback : Yes
- Power supply : 240 V AC, 50 Hz.
- EBU Colour triangle
• Inputs: Shall have all options of multi input module: DVI-D, DVI-I, Multi Sync RGB input (VGA upto UXGA), Video Input (PAL, NTSC, SECAM)

Projection unit shall have:
• Single chip DLP technology.
• High resolution
• High contrast.
• Ergonomic luminance
• Integrated optical dimmer

1.02.17. UNINTERRUPTED POWER SUPPLY

<table>
<thead>
<tr>
<th>1.0</th>
<th>Basic particulars for design:</th>
</tr>
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<tbody>
<tr>
<td>(i)</td>
<td>Input Voltage</td>
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<tr>
<td>(ii)</td>
<td>Input Frequency</td>
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<tr>
<td>(iii)</td>
<td>Output Voltage</td>
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<tr>
<td>(iv)</td>
<td>Output Voltage tolerance</td>
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<tr>
<td>(v)</td>
<td>Output Frequency</td>
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<td>(vi)</td>
<td>Output Voltage waveform</td>
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<td>(vii)</td>
<td>Harmonic Distortion</td>
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<tr>
<td>(viii)</td>
<td>Voltage Distortion</td>
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<tr>
<td>(ix)</td>
<td>Phase Displacement</td>
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<td>(x)</td>
<td>Transient recovery</td>
</tr>
<tr>
<td>(xi)</td>
<td>Maximum ambient</td>
</tr>
</tbody>
</table>

2.0 Basic details

(i) Duty type | True online continuous |
(ii) Reference standard | Features and performance in line with IEEE 446 |
(iii) Overload | 125% of the rated output for 10 minutes 150% of the rated output for 30 sec |
(iv) Configuration | With isolating transformer, rectifier, inverter unit and necessary DC batteries |
(v) Power device | Inverter power circuit shall comprise of IGBT using PWM control technique |
(vi) Redundancy | The system shall be of dual redundancy type in hot standby mode |
(vii) Static bypass | Automatic static bypass and common DC battery bank. The load shall normally be fed from the inverter. |
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<tr>
<td></td>
<td>In addition to static bypass switch, a manual changeover switch (MCCB) of adequate rating shall be provided to supply the load directly (bypassing the rectifier/charger, inverter, and static transfer switch) from the mains instead of through the UPS system.</td>
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</tr>
<tr>
<td>(viii)</td>
<td>Maintenance bypass</td>
<td>Maintenance bypass shall be provided in parallel to the static bypass line with an isolation device. The contacts of the isolation device shall be of ‘make before break’ type.</td>
</tr>
</tbody>
</table>
| (ix) | Battery bank | • Sealed maintenance free (SMF) batteries shall be provided for the battery bank.  
• The batteries shall be housed in a separate battery cabinet located adjacent to the UPS panel.  
• The battery power pack shall include SMF battery housed in a separate cabinet. Battery cells shall be mounted on slide-out trays for ease of maintenance.  
• A battery disconnect circuit breaker with undervoltage release (UVR) shall be included for isolation of the battery pack from the UPS module.  
• The UPS shall automatically be disconnected from the battery by opening the breaker when the battery reaches the minimum discharge voltage level.  
• Casters and leveling feet shall also be provided with the battery power pack cabinet for ease of installation.  
• The battery bank shall be installed in separate panel beside the UPS panel in the airconditioned environment located in the control room itself. |
| (x) | Battery backup | Battery shall be suitable to maintain the power supply for at least 30 minutes (throughout the total duration) in the event of mains failure with rated capacity of the UPS at full load. |
| (xi) | Battery management system | UPS shall have latest ‘Battery Management System’ to charge/discharge the entire battery automatically. |
| (xii) | UPS management | UPS shall have latest ‘UPS Management System’ to load/unload the UPS automatically. |
| (xiii) | AC DB | Necessary distribution board for distribution of power from UPS output to individual consumers. |
| (xiv) | Loading capability | UPS shall be capable of taking 100% non-linear loads. |
| (xv) | Interchangeability of sub assemblies | The UPS shall be constructed of replaceable subassemblies. PCB’s shall be plug-in type. Like assemblies and like components shall be interchangeable. |
| (xvi) | Noise level | Maximum noise level shall be less than 60 dB at a distance of 1 m from the body of the UPS. |
| (xvii) | Efficiency | The efficiency values of UPS under 50% unbalanced load & 100% linear loads shall be as near as possible to normal efficiency |
| (xviii) | Isolation transformer | The isolation transformer shall be of dry type and shall be provided on both input side, output side and static bypass side of the UPS |
| (xix) | Grounding | • The AC output neutral shall be electrically isolated from the UPS chassis.  
• The UPS chassis shall have an equipment ground terminal. Provisions for local bonding shall be provided.  
• Component mounted doors shall be separately earthed through 2.5 sq.mm PVC insulated green.green-yellow color flexible copper wire. |
| (xx) | Communication port | The UPS shall have inbuilt RS 485 port for display of online status of UPS on HMI. |
| 3.0 | Rectifier | • Dual rectifier with each unit rated for supplying both inverter load and battery charger load in different modes.  
• Rectifier unit shall consist of minimum six pulse bridge connection.  
• Active front end rectifier set to reduce the harmonic distortion.  
• With necessary smoothing reactor and filters  
• Automatic boost and float charging control.  
• Equalizing mode for compensating the charge lost by the battery after a discharge automatic changeover from equalizing mode to float mode and vice-versa. |
| 4.0 | Protective features | • Maximum current limiting.  
• Automatic reduction of current limit in the event of cooling fan failure.  
• Boost charging and float charging current limiting  
• Surge suppressor in output side of the UPS. |
| 5.0 | Inverter | • With input circuit consisting of battery contactor, battery filter and smoothing reactor.  
• DC/AC converter for voltage control.  
• Inverter proper and control electronics.  
• Series reactor and parallel filter.  
• Output transformer |
| 6.0 | Protection | • Abnormal output voltage (over voltage & under voltage).  
• Abnormal link voltage.  
• Over current on output.  
• Over current on input or commutating failure.  
• Low battery voltage.  
• High transformer temperature.  
• Auxiliary supply failure.  
• Fan failure  
• Logic failure  
• Clock failure |
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
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</table>
| **7.0 Static by-pass switch** | • Fast acting HRC fuse for inverter circuit and control circuit  
• Reverse power protection for parallel inverters.  
• Static switch automatically switches the load to the reserve power supply for the mains whenever there is failure in inverter supply to the load.  
• Fast acting inverter contactor shall connect the inverter output to the load.  
• High speed fuses shall be provided for protecting the thyristor against accidental overload. |
| **8.0 Indicating meters to be provided on the ACDB panel** | • Input voltmeter with selector switches.  
• Input ammeter with selector switches  
• DC voltmeter with selector switches  
• Centre zero type DC ammeter for measurement of charging/discharging current from the battery.  
Digital type meters shall be provided for the following:  
• AC output voltmeter with selector switch  
• Separate frequency meter to see Input and Output frequency.  
• AC output ammeter with selector switch  
• AC voltmeter with selector switch for bypass circuit.  
• AC ammeter with selector switch for bypass circuit.  
• Frequency meter for bypass circuit. |
| **9.0 MIMIC on UPS panels** | • MIMIC of the system power flow diagram as single-line diagram of the UPS shall be provided on UPS panels front door with long-life LED’s integrated within the single line diagram to indicate the operating status of different components/sections of the UPS. |
| **10.0 Display and Operating system** | • The UPS shall be provided with a microprocessor based keypad and display unit mounted on UPS panels front door for operating and viewing the UPS status for convenient and reliable user operation.  
• The monitoring functions such as metering, status and alarms shall be displayed on an alphanumeric LCD display.  
Additional features of the monitoring system shall include:  
• Menu-driven display with text format  
• Real time clock (time and date)  
• Alarm history with time and date stamp (minimum upto 16 faults in memory with FIFO sequence)  
• Battery back-up memory / condenser charged back up memory. |
| 11 | Metering | The following parameters shall be displayed:  
|    |          | • Input AC voltage line-to-line and line-to-neutral for each phase.  
|    |          | • Input AC current for each phase  
|    |          | • Input frequency  
|    |          | • Battery voltage status  
|    |          | • Battery charge/discharge current  
|    |          | • Output AC voltage  
|    |          | • Output AC current  
|    |          | • Output frequency  
|    |          | • Percent of rated load being supplied by the UPS  
|    |          | • Battery time left during battery operation. |

| 12 | Alarm Messages | • Input power out of tolerance  
|    |                | • Input phase rotation incorrect  
|    |                | • Incorrect input frequency  
|    |                | • Charger in reduced current mode  
|    |                | • Battery charger problem  
|    |                | • Battery failed test  
|    |                | • Low battery voltage warning or blown battery fuse  
|    |                | • High battery voltage  
|    |                | • DC bus overvoltage  
|    |                | • Bypass frequency out of range  
|    |                | • Load transferred to bypass  
|    |                | • Excessive retransfers attempted  
|    |                | • Static switch failure  
|    |                | • UPS output not synchronized to input power  
|    |                | • Input power single phased  
|    |                | • Input voltage sensor failed  
|    |                | • Inverter leg overcurrent in X-phase  
|    |                | • Output undervoltage  
|    |                | • Output overvoltage  
|    |                | • Output overcurrent  
|    |                | • System output overloaded  
|    |                | • Load transferred to bypass due to overload  
|    |                | • Fan failure  
|    |                | • Overtemperature shutdown  
|    |                | • An audible alarm shall be provided and activated by any of the above alarm conditions. |

| 13 | Status Messages | • Normal operation  
|    |                | • Load on maintenance bypass  
|    |                | • Load on UPS  
|    |                | • Load on static bypass  
|    |                | • System shutdown  
|    |                | • UPS on battery |

| 14 | Controls | • UPS start-up / shutdown shall be done by push button / rotary control switch  
|    |          | • Normal operation / bypass operations shall be done by a single rotary control switch.  
|    |          | • An advisory display and menu-driven user prompts writeup sticker (pasted inside the
panel door) shall be provided to guide the operator through system operation without the use of additional manuals.
- Pushbuttons shall be provided to display the status of the UPS and to test and reset visual and audible alarms.

15.0 Constructional features

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<td>The UPS system shall consist of a dedicated ACDB panel consisting of Incoming and Outgoing terminal blocks, MCCB’s, power and auxiliary contactors, isolation transformers.</td>
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</tbody>
</table>

(i) Isolation devices
- MCCB (upto 630A) in incoming side
- TPN/SPN MCB (of adequate rating) in outgoing side.
- Power circuit isolation device to have pad locking in the OFF position with the door closed

(ii) Installation
- Metal clad, indoor installation

(iii) Mounting
- Floor mounting with base channel of ISMC-75

(iv) Enclosure protection
- Totally enclosed dust and vermin proof.
- IP - 42

(v) UPS housing
- Each UPS system shall be housed in a separate cubicle, complete with an individual front and back access door with concealed type hinges.
- For UPS panel all the switches, indication lamps and meters shall be flush mounted on the respective compartment door.
- For ACDB panel the input MCCB’s and output MCB’s shall be operated from outside the panel door.

(vi) Back access
- Each panel shall have a door on back side. All the doors shall have neoprene gasket.
- Natural rubber gasket shall be provided between adjacent panel doors and removal covers.

(vii) Lifting hooks
- Lifting hooks for each panel shall be provided

(viii) Designation plate for UPS
- Inscription plate for each panel:
  - Name plate shall be provided at top centre of the UPS panel.
  - Name plates will be of Anodised Aluminium with white letters engraved on black background and in English language.
  - Letter height for UPS designation plate shall be in the range of 25-50 mm.
  - Individual components shall be identified with identification plate and shall match with the identification tags mentioned in the drawing.
  - Danger board shall be provided on front and rear side of the UPS both in Hindi, English languages.

(ix) Thickness of sheet steel (CRCA)
- Load bearing members: 2.0 mm
- Non load bearing member: 1.6 mm
| (x)  | Door earthing                                                                 | • Hinged door at front and back with flexible earthing connection. |
| (xi) | Cable entry                                                                  | • Incomer : Bottom cable entry  
• Outgoing : Bottom cable entry |
| (xii)| Gland plates                                                                 | • Undrilled removable bottom gland plates (3 mm thick) |
| (xiii)| Output power indication                                                     | • Auxiliary contactors shall be provided in output side of the UPS for potential free contacts for indication of UPS and non UPS power supply at different location.  
• Proper transducers shall be provided for voltage and frequency indication at different locations. |
| (xiv)| Cooling of panels                                                           | • Panels shall have fan installed vertically at top for forced air draft and louvers with screen protection in bottom.  
• Fans shall be powered from input supply of the UPS. Low velocity fans shall be used to minimize audible noise output.  
• The thermal design, along with all thermal and ambient sensors, shall be coordinated with the protective devices before excessive component or internal cabinet temperatures are exceeded.  
• The UPS shall be installed in air conditioned environment. |
| (xv) | Bolts, nuts & cable glands                                                   | • All bolts and nuts for terminations shall be cadmium coated.  
• Double compression cable glands for receiving external power & control cables.  
• Compartment door interlocked with the isolating device for safety with provision for defeating it by authorised person |
| (xvi)| Indicating lamps                                                            | • All indicating lamps shall be of LED cluster high density type. |
| (xvii)| Finish                                                                      | • Interior and exterior : RAL 7035 |
| (xviii)| Terminal block                                                         | • Terminal block for incoming cable shall be located in back side and outgoing cables shall be in front side of the ACDB panel.  
• All incoming terminal blocks shall be fully insulated for the working voltage.  
• The terminal blocks shall be sleeved color coded Red, Yellow, Blue, Black for R,Y,B,N respectively using heat shrinkable PVC sleeve.  
• All outgoing terminal blocks shall be sleeved color coded Red and Black for line and phase respectively using heat shrinkable PVC sleeve.  
• Colour coding shall be provided for TB’s and wires for different voltages level.  
• All the terminal blocks shall be shrouded.  
• Not more than two connections shall be made at one terminal.  
• Terminal blocks shall be suitable to connect |
two cores of minimum 2.5 sq.mm.
- There shall be 20% spare terminal blocks

| (xix) Minimum air clearance for bare busbars | Phase to phase: 25.4 mm
- Phase to earth: 19.0 mm |
|---------------------------------------------|

| (xx) Output power bus | The solid output power bus shall be of bare copper with a minimum rating of 100 A at 240 V AC (1 pair). |
|----------------------|

| (xxi) Earth bus | The main earth bus shall be of 50 x10 mm GI with extension at both ends of switchboard for connection to safety grounding network. Earth busbar shall run continuous throughout the UPS panel at bottom. |
|----------------|

| (xxii) Panel internal wiring | The panel internal wiring shall be carried out by 1100 V grade, single core, black color PVC insulated, stranded copper wire of following size
- Current transformer circuit: 4.0 sq.mm
- Control and potential circuit: 2.5 sq.mm
- Identification of wire shall be numbered by plastic/ceramic ferrules.
- Ferrules shall be self locking type. |
|--------------------------|

| (xxiii) Incoming Feeders | 3 pole MCCB.
- Ammeter with 4-position selector switch (three phases & OFF)
- Voltmeter with 4-position selector switch and fuses (three line-line & OFF)
- Current transformers (for metering)
- 3 nos. indicating LED type lamps (R,Y,B)
- 3 nos. indicating LED type lamps (CB ON-Red, CB OFF-Green, CB TRIP-Amber)
- Following protections are required for the MCCB controlled
- Incomers:
  - Overcurrent releases.
  - Short circuit.
  - Earth fault. |
|-------------------------|

| (xiv) Outgoing Feeders | Each outgoing feeder shall have followings:
- Outgoing feeders shall have SPN MCB
- MCB of 09 kA rating with Thermo-magnetic releases. |
|-----------------------|

| (xv) Testing | All routine tests shall be as per IS-8623 (Part-II) 1993
- Type test certificate shall be submitted. |
|-------------|

| (xiv) Documentation | Operation & maintenance manual
- Wiring diagram (internal panel showing individual components and flow of wires). |
|-------------------|
1.02.18 **Electronic Weighing System**

This section covers electrics for belt weigh feeders, loss in weigh feeders, load cell based bunker level measuring system & belt weigh scales.

1. Microprocessor based Individual Weighing Controller (IWCs) with digital display and keyboards – for Belt weigh feeders/ Loss in weigh feeders

2. VFD drive for speed control of AC motors of belt weigh feeders with necessary switchgears, incoming choke, output reactors if required, protective devices, communication links with IWC, input/output for remote start/stop, interlocking, indication lamps, controls, metering, potential free contacts for remote status indication like ON/OFF/TRIP/ converter fault (to be wired to PLCs), motor protective devices at field etc. Technical features of VFD drive shall be as per General specification for electrical system (GS-03).

3. Individual Belt Weigh feeder panels housing IWC (Intelligent weighing controllers) controller & VFD drive, DOL starters for vibrating hoppers interlocked with belt weigh feeders.

4. Microprocessor based Bin weight measuring panels with digital display and keyboards with auto taring and auto calibration facility. Bin Measurement panels housing IWC controller (IWC Controllers for more than one Bin can be combined in one panel.

5. Beltweigh scale panels (if any as per Mechanical scope) housing microprocessor based measuring indicator with digital display and keyboards with auto taring and auto calibration facility.

6. Provisions for Communication with PLC / DCS.

Belt Weight feeder IWC, Bin weigh measuring controller & Belt Weigh Scale IWC shall be able to communicate 100% with purchaser’s PLC/DCS on the plant communication bus as selected (like Profibus DP) by Tenderer.

7. Load cells, te cogenerators, field junction boxes, limit switches etc. for Belt weigh feeders, Bin level measuring systems, Belt weigh scales (if any).

8. Common local control station for Belt weigh feeders & Vibrating hoppers (as applicable) housing Local /Off/Auto selector switches, Start/stop push buttons, speed increase/decrease, TPH indicators etc.

9. Local Indicator panels for Bin weighing control & Belt weigh scales (if any)

10. LT AC motors for belt weigh feeders & vibrating hoppers.

11. Calibration weights for belt weigh feeders.

12. Supply of dummy load cells for various Bunkers (BLMS system)

13. Features for Belt slip detection in case of weigh feeders, like tail end tacho or other suitable measures shall be provided by Tenderer.
2.1 DESIGN BASIS FOR BELT WEIGH FEEDER/LOSS IN WEIGH FEEDER

The weighing system shall be designed, manufactured, assembled and tested in accordance with relevant OIML/NTEP Standard. Equipment shall comply with statutory requirement of Weights & Measures Deptt. Govt. of Chhatisgarh and Govt. of India. The equipment shall be of proven designed, imported and reputed make.

The consistency of the feed rate shall be guaranteed within +/- 0.5% of the set value within the operating range of 10% to 100% of rated capacity.

The weighing control shall be totally automatic with close loop control. The feed rates of different materials shall be calculated by the computer and set points of Belt weigh feeder shall be set by the computer through PLC. In case of computer failure manual setting (remote manual) and operation of feeders shall be possible.

Load cell shall be globally reputed make, confirming to OIML/NTEP Standard and preferably digital type, side mounted and easily replaceable type.

Weighing system shall be mounted in the horizontal portion of the conveyor with multi idler/weigh carriage system.

Equipments shall be provided with anti sway, anti sagging and anti slip devices.
Auto zero track, annunciation and diagnostic facility shall be provided.
Surge, radiation, EMF & RF protection devices shall be provided.
Test weights for different range of calibration should be provided with each equipment.
Redundant electronics shall be provided.
Special tools & tackles shall be provided with the equipment. Such as HBM/Molen load cell calibrator – 2 nos., Portable think Pad based software programmer – 2 nos.
Two years maintenance spares shall be included.
Compress air and high pressure water injection facilities to be provided for cleaning of weighing area.
Training on maintenance aspect is required for Inst. & Weightment personnel.

2.2 CONTROLLER PANELS OF BELT WEIGH FEEDERS/LOSS IN WEIGH FEEDER PANEL

The IWCs for control of Belt weigh feeders/ LIWs shall be microprocessor based having automatic weighing and calibration facilities. The system shall be complete with protection against overloading. Accuracy of Belt weigh feeders shall be +/-0.5% or better of preset feed rate.

It shall be possible to operate the Belt weigh feeders under the following modes:

Local - Volumetric
Local - Gravimetric
Remote - Gravimetric (remote manual/PLC automatic)

Under remote mode of operation, following control shall be possible.

Remote - From IWC panel
Remote- From HMI station at individual shop control room.
Microprocessor shall be provided with each IWC as per standard design/ system requirement. IWC shall generate signal for material feed rate in t/hours. The IWC shall compare the actual feed rate with the set point feed rate and generate a suitable correction for the VVVF converter of belt drive. The signal shall change the belt speed and accordingly provide the desired feed rate. It will be complete with auto calibration, auto tare, auto belt slip/ drift monitoring facilities etc. The stored values after calibration shall not change due to power failure.

Belt Weigh feeder panel housing above IWC & VFD drive shall also be provided with following control equipment /facilities.

- Main incoming MPCB/MCCB (50kA) for incoming power supply
- Control transformer (415/110V) with MPCB (50kA) at primary, MCBs at secondary.
- MPCB, Power contactor (min. 25A), thermal overload relay, necessary auxiliary contactors, ON/OFF/TRIP indication lamps for each motor of bin vibrating hoppers.
- Necessary Power supply units, conversion equipment.
- DP MCBs for incoming UPS power supply and its distribution to all panels.
- Panel illumination lamps (fluorescent tubular).
- Start/stop push button, selector switches as required.
- Power ON indication.
- Power and control terminals.

The IWC shall have following features (minimum)

- Actual flow rate indicator.
- Set rate feed indicator.
- Totalised amount indicator.
- Belt load indicator.
- Belt speed indicator.
- Deviation indicator.
- Fault messages (separate lamps).
- Operational mode selector switch for gravimetric/volumetric/calibration/ Automatic and Constringency mode selection.
- Auto taring & calibration.
- Load cell/Tacho filter time
- No motion alarm set.
- Material starvation signal
- Load sensor break
- Material over/under load alarm
- Gravimetric / volumetric deviation alarm
- Proportional band, Integral time, Derivative time (for Gravimetric / volumetric mode) for PID.
- Tantalizer value
- Tare value
- Load electrical value
- Speed electrical value

Following displays and messages shall be possible for all the operating and calibrating functions:

- Set point.
- Normal/Maintenance/Calibration modes.
- Actual feed rate.
- Belt load (Platform load).
- Belt speed.
- Totaliser value.
- Deviation error between set and actual feed rate.
- Service data such as measured value, controller output, control signal level etc.
- Event messages/fault messages.

The above shall be available on each IWC on digital display unit in central control room. Display and messages listed above shall also be made available on VDU of PLC/DCS.

**Panel Construction features.**

- Floor mounted, free standing.
- Dust and vermin proof.
- CRCA sheet steel clad.
- Minimum 2.0 mm thick for panels.
- Suitable to withstand vibrations to be encountered in steel plant applications.
- Cubicles with illumination lamps, door switches, space heaters and adequate sockets for soldering.
- All control blocks plug-in-type with necessary test sockets.
- Units shall be self contained and serviceable.
- Power wiring – Min 2.5 sq.mm. Cu
- Control wiring – Min 1.5 sq.mm. Cu
- The panel door shall be provided with toughened glass in front of controllers for viewing of display units without opening the panel door. All control devices and indicators shall be mounted on the front. Two numbers earthing studs shall be provided with the panel for external earthing. All power, control, and signal terminals of different voltages shall be segregated. 20% spare terminals shall be provided in the panel.

### 3.1 BIN/WEIGH HOPPER LOAD CELLS AND LEVEL MEASURING SYSTEM:

**Design Basis for Bin Level Measuring System**

Equipment shall comply with statutory requirement of Weights & Measures Deptt. of Govt. of India. Load cell shall be of globally reputed make, confirming to OIML/NTEP Standard & preferably digital type. Load cell shall be easily replaceable type, provided with safely devices from impact load, vibration and lifting arrangement facility. Lightning & Surge protection devices shall be provided in load cells, JBs, electronics & main electrical power supply. Load cells shall be of high precision strain gauge type, hermetically sealed, robust in design, shock proof and insensitive to overload, temperature, vibration, electrical noise etc. Enclosure class shall be IP 67 / IP 68.

Load cell shall be provided with ambient temperature compensating device upto 55 deg. C. Provision shall be kept to neutralise the error caused due to application of transverse forces. Max. Measurement error permitted is +/- 1%

Weighing system shall be auto zero & auto calibration facilities.

Test weight for calibration shall be provided.

The weighing system shall be hooked up with customer host computer and shall support remote monitoring on BSP’s Existing Plant Wide Network.

### 3.2 CONTROL PANEL FOR BIN LEVEL MEASUREMENT (BLM)/HOUSING IWC

Bin level measurement system shall be microprocessor based having automatic weighing, taring and necessary calibration facilities. The system shall be complete with protection against overloading. Accuracy of weighing +/-0.1% or better.
The controller shall have digital display and keyboards, indication, alarm, annunciation etc. It will be complete with auto calibration, auto tare facilities etc. The stored values after calibration shall not change due to power failure.

The controller shall be complete with built in power supply unit, CPU, program memory, A/D & D/A converters, etc. The above will be of modular design using standard PCBs and connectors. It should communicate actual weight/level, conditions for bin empty, level low, level high etc to Automation system.

One no. large display unit for outdoor display shall be provided.

Compress air and high pressure water injection facilities to be provided in weighing area.

4.1 BELT WEIGH SCALES

The IWPs for control of belt weigh scales shall be microprocessor based having automatic weighing and necessary calibration facilities. The system shall be complete with protection against overloading. Accuracy of belt weigh scale shall be +/-0.25% or better of flow rate.

Microprocessor as per standard design/ system requirement shall be provided each IWC. Microprocessor shall multiply load cells and conveyor speed signal in digital form to generate signal for material conveying rate in T/Hours. It will be complete with auto calibration, auto tare etc. The stored values after calibration shall not change due to power failure.

The following displays and messages shall be available for all the operating and calibrating functions:

- Conveying rate in TPH.
- Belt load (Platform load)
- Belt speed.
- Totaliser value.
- Service data such as measured value, controller output, control signal level etc.
- Event messages/fault messages.
- Auto taring & Error corrections.

The above shall be available on each IWC on digital display unit. Display and messages listed above will be made available on VDU of in central control room.

Panel Constructional feature

Shall be same as for Weigh feeder panels.

5.0 DIGITAL TECHGENERATORS

It will be of robust construction and designed to give guaranteed accuracy of feed rate. It shall generate consistent output pulses of positive or negative polarity as applicable by accepting shaft rotation. The output pulses shall be suitable for feeding into high impedance electronic circuit/instrument for digital measurement and control. The enclosure class shall be IP 67. It will be provided with ambient temperature compensating device.

Arrangement of mounting of techogenerators and its coupling with AC motor shall be decided considering ease of maintenance.

6.0 LOCAL CONTROL BOX (LCB) FOR BELT WEIGH FEEDERS/LOSS IN WEIGH FEEDER & LOCAL INDICATION BOXES FOR BLMS & BELT WIGHERS.
Each belt Belt weigh feeder/Loss in weigh feeder shall be supplied with a local box with following features.

- Sheet steel (2.0mm thick) construction.
- Wall/structure mounted type.
- Hinged door, dead front type.
- Enclosure class IP-55.
- To be painted as per standard procedure agreed.
- Internal wiring with 1.5 sq.mm copper conductor.
- The box shall be wall/structure mounted type and be complete with cable glands and lugs.

The LCB shall be provided with the following:

- Local – Off – Remote selector switch.
- Start/Stop push buttons
- Emergency stop push button (press to lock turn to release type)
- Increase/decrease PB for speed setting
- Feed rate actual (TPH meter – digital type).
- Start/stop push button for bin vibrator
- Indication lamps.
- Any other device required for satisfactory operation of BWFs to be decided during detailed engineering.

Each local indication box for BLMS/Weigh Scales shall have digital indication of Bunker level/feed rate.

7.0 LOAD CELLS

- Load cell shall be imported reputed make as per OIML / NTEP standards with surge protection.
- Compression type suitable for weigh hoppers and material presence detectors on charging conveyor.
- Enclosure class IP 67 / IP68
- Hermetically sealed, stainless steel precision strain gauge / digital type.
- Maximum usable load: 200%
- Destruction load: >500%
- 300% over load capacity.
- Suitable for maximum 70°C.
- Temperature compensation range: - 40°C to 70°C
- Capacity of the Load cell for BLMS system shall be as per details given under mechanical part. However, final rating of load cells shall have safety margin of minimum 150% of the rating calculated.
- Load cell accuracy 0.04%
- Combined error: ± 0.03%
- Excitation: 10 to 50 V dc
- Zero balance: ± 1% of R.O.
- Insulation resistance: >5000MΩ
- Complete with excitation source, transmitter, amplifier, junction boxes, special cables, etc.

1.02.19 CABLES:

1. HT Cables
   (i) 11 kV (UE) XLPE cables
<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Voltage Grade</td>
<td>11 kV (UE)</td>
</tr>
<tr>
<td>2.0</td>
<td>Duty type</td>
<td>Heavy duty</td>
</tr>
<tr>
<td>3.0</td>
<td>No. of cores</td>
<td>3 cores</td>
</tr>
</tbody>
</table>
| 4.0   | Reference standard                 | IS:8130 – 1984  
IS:5831 – 1984  
IS:3975 -1988  
IS:1554, part - 1, 1988  
IS:3961 (Part-II) - 1967.  
IS:7098 Part-I & II  
IEC-60502                                                                 |
| 5.0   | Conductor type                     | Compact circular stranded (rm/V) aluminum conductor, with conductor screening of extruded semi conducting material . Conductor construction class-2 as per IS 8130-1984. |
| 6.0   | Insulation type                    | XLPE insulated and insulation provided with shielding of extruded semi conducting compound over individual core followed by lapped semi conducting material and copper tape (non magnetic) metallic screen , cores stranded together with a holding tape provided with a common covering of extruded inner sheath of type ST2 compound . Thickness of the insulation shall be 5.5 mm for size 3x185 sq.mm as per table-2 IS 7098 (part-II) 1985. |
| 7.0   | Armour                             | Galvanized steel wire armoured  
For multi core cables , armouring shall be applied over the inner sheath by flat steel wires strips( formed wire).  
Round steel wire armouring can also be offered.  
For single core armoured cables non-magnetic armour consisting of hard drawn flat or round aluminium wires shall be provided. |
| 8.0   | Outer sheath                       | Overall PVC outer sheath of type ST-2 compound as per IS 5831/1984. Outer sheath should be applied with extrusion only cables to be ISI marked. Thickness of the outer sheath shall not be less than 3.6 mm for size 3x185 sq.mm as per table –5 of IS:7098 )part-II)/1985 & IS:10462 (part-I)/1983). The sheath shall be black in colour .  
Suitable chemicals shall be added into the PVC compound of the outer sheath to protect the cable against rodent and termite attack. |
| 9.0   | Miscellaneous                      | Copper screen shall be suitable to carry 1 KA E/F current for one second.  
For XLPE Cable  
Shall not be less than 29 at 27 ± 2 deg. C.  
Max. conductor withstand temperature during short circuit.  
250°C |

(i) 6.6 kV (UE) XLPE cables
<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Voltage Grade</td>
<td>6.6 kV (UE).</td>
</tr>
<tr>
<td>2.0</td>
<td>Duty type</td>
<td>Heavy duty</td>
</tr>
<tr>
<td>3.0</td>
<td>No. of cores</td>
<td>3 cores</td>
</tr>
</tbody>
</table>
| 4.0   | Reference standard                 | IS:8130 – 1984  
 IS:5831 – 1984  
 IS:3975 – 1988  
 IS:1554, part - 1, 1988  
 IS:3961 (Part-II) - 1967.  
 IS:7098 Part-I & II  
 IEC-60502                                                                                       |
| 5.0   | Conductor type                     | Compact circular stranded (rm/V) aluminum conductor, with conductor screening of extruded semi conducting material. Conductor construction class-2 as per IS 8130-1984. |
| 6.0   | Insulation type                    | XLPE insulated and insulation provided with shielding of extruded semi conducting compound over individual core followed by lapped semi conducting material and copper tape (non magnetic) metallic screen, cores stranded together with a holding tape provided with a common covering of extruded inner sheath of type ST2 compound. Thickness of the insulation shall be 5.5 mm for size 3x185 sq.mm as per table-2 IS 7098 (part-II) 1985. |
| 7.0   | Armour                             | Galvanized steel wire armoured. For multi core cables, armouring shall be applied over the inner sheath by flat steel wires strips (formed wire). Round steel wire armouring can also be offered. For single core armoured cables non-magnetic armour consisting of hard drawn flat or round aluminium wires shall be provided. |
| 8.0   | Outer sheath                       | Overall PVC outer sheath of type ST-2 compound as per IS 5831/1984. Outer sheath should be applied with extrusion only cables to be ISI marked. Thickness of the outer sheath shall not be less than 3.5 mm for size 3x185 sq.mm as per table –5 of IS:7098 (part-II)/1985 & IS:10462 (part-I)/1983. The sheath shall be black in colour. Suitable chemicals shall be added into the PVC compound of the outer sheath to protect the cable against rodent and termite attack. |
| 9.0   | Miscellaneous                      | Copper screen shall be suitable to carry 1 KA E/F current for one second.                                                                      |
| 10.0  | Temp. rise on continuous load      | 90 deg.C                                                                                                                                 |
| 11.0  | Oxygen index of outer sheath material for XLPE Cable | Shall not be less than 29 at 27 ± 2 deg. C.                                                                                                 |
| 12.0  | Temperature index                  | Not below 250°C.                                                                                                                             |
| 13.0  | Max. conductor withstand temperature during short circuit. | 250°C                                                                                                                                         |

2. **LT CABLES**
### 1.1 kV Power Cable

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Voltage Grade</td>
<td>1.1 kV grade</td>
</tr>
<tr>
<td>2.0</td>
<td>Duty type</td>
<td>Heavy duty</td>
</tr>
</tbody>
</table>
| 3.0    | No. of cores                  | - 3.5 / 4 core cables shall be used for motor feeders.  
- For other consumers or for power supply to other panel 4 core (upto conductor size of 50 sq.mm) or 3.5 core (for conductor size beyond 50 sq.mm) cables shall be used.                                                                                             |
| 4.0    | Reference standard            | IS:8130 – 1984  
IS:5831 – 1984  
IS:3975 -1988  
IS:1554, part - 1, 1988  
IS:3961 (Part-II) - 1967.  
IS:7098 Part-I & II  
IEC-60502                                                                 |
| 5.0    | Conductor type                | - Pain aluminium conductor.  
- All power cables of size 10 sq.mm and above shall have standard sector shaped (sm) or compact circular stranded (rm/V) or circular stranded (rm) aluminum conductors as applicable.  
- The conductors will be H2 or H4 grade.  
- The solid conductor shall be class - 1 and the stranded conductor will be class - 2.  
- The conductors shall be solid for conductor of nominal area upto and including 6 sq. mm. and stranded beyond 6 sq. mm. Conductors of nominal area less than 25 sq. mm. shall be circular or shaped. Cables with reduced neutral conductor shall have sizes as per Table 1 of IS 1554 (Part-1) -1988. |
| 6.0    | Insulation type               | - XLPE insulation  
- The insulation compound shall be conforming to IS:7098 (Part I) - 1988.                                                                                                                                                                                                 |
| 7.0    | Inner sheath                  | - For armoured / unarmoured cables a tough inner sheath of heat resisting PVC compound (wrapped / extruded as per size) ,Type ST2 as per IS 5831 .  
- Black in colour .                                                                                                                                                                                                 |
| 8.0    | Armour                        | - Galvanised steel wire armour shall be used for 3Cx10 sq.mm / 4Cx6 sq.mm cable.  
- Galvanised flat steel wires (strips) armour shall be used for bigger size cables.  
- Single core armoured cables are provided with non-magnetic armour consisting of hard drawn flat or round aluminium wires.                                                                 |
| 9.0    | Outer sheath                  | - For armoured / unarmoured cables a tough outer sheath of heat resisting PVC compound (Type ST2 as per IS 5831) .  
- Black in colour .                                                                                                                                                                                                 |
| 10.0   | Miscellaneous                 | - Minimum cross - sectional area of the power cable shall be 6 sq.mm in case of aluminium conductor and 2.5 sq.mm in case of copper conductor.                                                                                                                                       |
- Power cables shall be selected from core sizes of 6, 10, 16, 25, 50, 70, 120, 150, 240 & 300 sq.mm (Aluminium conductor).

| 11.0 | Temp. rise | Shall be limited to 90 deg.C. |
| 12.0 | Core identification | - Cable identification will be provided by embossing on the outer sheath the following:  
| | | • Manufacturer’s name & trade mark  
| | | • Voltage grade  
| | | • Year of manufacture  
| | | • Type of insulation  
| | | - R,Y,B for phases .  
| | | - Black for neutral (fourth core) |

(ii) 1.1 KV Grade Control Cable :-

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Voltage Grade</td>
<td>1.1 kV grade</td>
</tr>
<tr>
<td>2.0</td>
<td>Duty type</td>
<td>Heavy duty</td>
</tr>
<tr>
<td>3.0</td>
<td>No. of cores</td>
<td>As per requirement .</td>
</tr>
</tbody>
</table>
| 4.0   | Reference standard | IS:8130 – 1984  
| | | IS:5831 – 1984  
| | | IS:3975 – 1988  
| | | IS:1554, part - 1, 1988  
| | | IS:3961 (Part-II) - 1967.  
| | | IS:7098 Part-I & II  
| | | IEC-60502 |
| 5.0   | Cross sectional area | Shall be 1.5 / 2.5 sq.mm. (as per TS) |
| 6.0   | Conductor type | Solid annealed circular stranded copper conductor. |
| 7.0   | Insulation type | XLPE insulated |
| 8.0   | Inner and outer sheath | - Type ST-2 PVC shall be used for inner sheath .  
| | | - Type ST-2 PVC shall be used for outer sheath .  
| | | - Both inner and outer sheath shall be extruded type upto 7 core and after 7 core inner sheath shall be wrapped .. |
| 9.0   | Armour | - Galvanised steel wire armour shall be used for cables upto 14 cores .  
| | | - For cables having larger number of cores galvanised formed wire (steel strip) shall be used. |
| 10.0  | Spare Cores | - 3, 5 and 7 cores cables shall have at least one spare core, cables with 10 core and above shall have at least 2 spare cores. |
| 11.0  | Miscellaneous | - The Tenderer shall furnish necessary calculations to show that the selected cable satisfy the criteria including for voltage drop. |
| | | - Cables for temperature detectors shall be screened type of required technical parameters with core size not less 1.5 sq.mm. |
| 12.0  | Core identification | - Cable identification will be provided by embossing on the outer sheath the following:  
| | | • Manufacturer’s name & trade mark  
| | | • Voltage grade  
| | | • Year of manufacture  
| | | • Type of insulation  
| | | - Cores of the cables upto 5 cores shall be identified by |
- Colouring of insulation.
  - For cables having more than 5 cores, core identification shall be done by numbering insulation of core sequentially.
  - All the numbers shall be of same colour, which shall contrast with the colour of insulation.
  - Numbers shall be written in figures and words both.
  - The numerals shall be legible and indelible.
  - The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other.
  - When number is a single numeral a dash shall be blacked underneath.
  - If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral.
  - The spacing between consecutive numbers shall not exceed 100 mm.

(iii) 1.1 KV Grade Screened /Special Cable :-

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Voltage Grade</td>
<td>1.1 kV grade</td>
</tr>
<tr>
<td>2.0</td>
<td>Duty type</td>
<td>Heavy duty</td>
</tr>
<tr>
<td>3.0</td>
<td>No. of cores</td>
<td>As per requirement</td>
</tr>
<tr>
<td>4.0</td>
<td>Cross sectional area</td>
<td>Shall be 1.5 sq.mm.</td>
</tr>
<tr>
<td>5.0</td>
<td>Conductor type</td>
<td>Solid annealed circular stranded copper conductor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For twisted pair cables, the conductors shall be of stranded tinned copper having proper flexibility to provide limpness and extended flex-life as required for these small diameter cables.</td>
</tr>
<tr>
<td>6.0</td>
<td>Insulation type</td>
<td>PVC insulated, Type A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Type ST-1 PVC shall be used for inner sheath.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both inner and outer sheath shall be extruded type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outer sheath made of PCP (Chloroprene rubber), abrasion resistant, oil resistant and flame retardant conforming to IS:434 –1964 (Part - I), as amended upto date.</td>
</tr>
<tr>
<td>7.0</td>
<td>Screen</td>
<td>Tinned annealed copper mesh over metallised tape , in a close woven braid .</td>
</tr>
<tr>
<td>8.0</td>
<td>Shielding</td>
<td>Special aluminium foil to provide 100% shield coverage for optimum protection against radiated interference and ingress of audio and radio frequencies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It shall have shorting fold for metal to metal contact and isolation fold to prevent adjacent shields from shorting to one another, so as to improve the voltage breakdown characteristics. The drain wire shall be of stranded tinned copper wire of 0.518 sq. mm. (20 AWG) cross-section.</td>
</tr>
<tr>
<td>9.0</td>
<td>Spare Cores</td>
<td>20% spare cores but not less than 2 spares shall be provided in all the multi core cables .</td>
</tr>
<tr>
<td>10.0</td>
<td>Reference standard</td>
<td>As per relevant IS with latest amendments</td>
</tr>
</tbody>
</table>
11.0 Miscellaneous
- The Tenderer shall furnish necessary calculations to show that the selected cable satisfy the criteria including for voltage drop.
- Cables for temperature detectors shall be screened type of required technical parameters with core size not less 1.5 sq.mm.
- The special twisted paired cables shall be of the type to provide balanced signal transmission and shall have good noise immunity.

12.0 Core identification
- Cable identification will be provided by embossing on the outer sheath the following:
  - Manufacturer’s name & trade mark
  - Voltage grade
  - Year of manufacture
  - Type of insulation
- Cores of the cables upto 5 cores shall be identified by colouring of insulation.
- For cables having more than 5 cores, core identification shall be done by numbering insulation of core sequentially.
- All the numbers shall be of same colour, which shall contrast with the colour of insulation.
- Numbers shall be written in figures and words both
- The numerals shall be legible and indelible.
- The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other.
- When number is a single numeral a dash shall be blacked underneath.
- If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral.
- The spacing between consecutive numbers shall not exceed 100 mm.

(iv) Heat resistant cable

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Voltage Grade</td>
<td>1.1 kV grade confirming to IS: 9968 (Part-II)- 1988</td>
</tr>
<tr>
<td>2.0</td>
<td>Reference standard</td>
<td>IS: 6380</td>
</tr>
<tr>
<td>3.0</td>
<td>Duty type</td>
<td>Heavy duty</td>
</tr>
<tr>
<td>4.0</td>
<td>No. of cores</td>
<td>Single or multicore as per requirement</td>
</tr>
<tr>
<td>5.0</td>
<td>Cross sectional area</td>
<td>As per requirement</td>
</tr>
<tr>
<td>6.0</td>
<td>Conductor type</td>
<td>Annealed tinned copper conductor</td>
</tr>
<tr>
<td>8.0</td>
<td>Insulation type</td>
<td>Silicone rubber insulation</td>
</tr>
<tr>
<td>9.0</td>
<td>Shielding</td>
<td>Asbestos or glass braid and lacquered protection</td>
</tr>
<tr>
<td>11.0</td>
<td>Outer sheath</td>
<td>Flame retarded Oil resistant</td>
</tr>
<tr>
<td>12.0</td>
<td>Miscellaneous</td>
<td>As per requirement for working at higher temperature, nickel coating shall be done</td>
</tr>
<tr>
<td>13.0</td>
<td>Armouring</td>
<td>GI strip armoured as per requirement (as specified in</td>
</tr>
</tbody>
</table>
### (v) Trailing cable

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Voltage Grade</td>
<td>1.1 kV grade confirming to IS: 9968 (Part-II)- 1988</td>
</tr>
<tr>
<td>2.0</td>
<td>Reference standard</td>
<td>IS: 9968&lt;br&gt;IS: 8130&lt;br&gt;IS: 6380</td>
</tr>
<tr>
<td>3.0</td>
<td>Duty type</td>
<td>Heavy duty</td>
</tr>
<tr>
<td>4.0</td>
<td>No. of cores</td>
<td>Single or multicore as per requirement</td>
</tr>
<tr>
<td>5.0</td>
<td>Cross sectional area</td>
<td>As per requirement .</td>
</tr>
<tr>
<td>6.0</td>
<td>Conductor type</td>
<td>Highly flexible stranded tinned annealed high conductivity copper conductor</td>
</tr>
<tr>
<td>8.0</td>
<td>Insulation type</td>
<td>EPR (Ethylene-propylene Rubber)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For higher temperature zone, silicone rubber (trailing duty)</td>
</tr>
<tr>
<td>9.0</td>
<td>Shielding</td>
<td>Each individual core protected and covered and overall</td>
</tr>
<tr>
<td>11.0</td>
<td>Sheath</td>
<td>Poly-chloroprene rubber or chlorosulphorated polyethylene cable shall be conformed to IS: 9968 (Pt-I) - 1988. Flame retarded (for higher temperature area) Oil resistant</td>
</tr>
<tr>
<td>12.0</td>
<td>Miscellaneous</td>
<td>Shall have one additional core for earthing .</td>
</tr>
<tr>
<td>13.0</td>
<td>Armouring</td>
<td>GI wire armoured as per requirement and size (as specified in respective TS)</td>
</tr>
</tbody>
</table>

### (vi) Flame Retardant Low Smoke (FRLS) Cables

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Voltage Grade</td>
<td>1.1 kV grade</td>
</tr>
<tr>
<td>2.0</td>
<td>Reference standard</td>
<td>Category AF as per IS : 10810&lt;br&gt;ASTM-D 2863 (Critical Oxygen Index)&lt;br&gt;ASTM-D 2863 (Temperature Index)&lt;br&gt;ASTM-D 2843 (Smoke density)&lt;br&gt;IEC 754-1 (Acid gas generation)&lt;br&gt;IEEE-383 (Flammability test on group of cables)&lt;br&gt;Swedish chimney test SS 424175, class F3. (Flammability test)&lt;br&gt;IEC 332-1 (Flammability test)&lt;br&gt;IEC 332-3 (Flammability test)&lt;br&gt;IS 5831 (Fire resistant test)</td>
</tr>
<tr>
<td>3.0</td>
<td>Duty type</td>
<td>Heavy duty</td>
</tr>
<tr>
<td>4.0</td>
<td>No. of cores</td>
<td>Single or multicore as per requirement</td>
</tr>
<tr>
<td>5.0</td>
<td>Cross sectional area</td>
<td>As per requirement .</td>
</tr>
<tr>
<td>6.0</td>
<td>Conductor type</td>
<td>Annealed tinned copper conductor</td>
</tr>
<tr>
<td>8.0</td>
<td>Insulation type</td>
<td>XLPE insulation</td>
</tr>
<tr>
<td>11.0</td>
<td>Sheath</td>
<td>Specially designed with thermoplastic or thermosetting materials , superior resistance to ignition and flame propagation with smoke emission and toxicity or corrosive characteristics Flame retarded Oil resistant</td>
</tr>
<tr>
<td>12.0</td>
<td>Armouring</td>
<td>GI wire / strip armoured as per requirement and size (as specified in respective TS)</td>
</tr>
<tr>
<td>13.0</td>
<td>Test values</td>
<td>Critical Oxygen Index : Minimum 29</td>
</tr>
</tbody>
</table>
01.02.20 EOT Cranes

Trolley lines and power supply arrangements for cranes (DSL System)

Power to all the bays shall be fed from crane LTSS through PDB's installed in respective bays. Number of panels shall be decided as per requirement (to be indicated by the tenderer). Isolator (MCCB) for each feeding section will be provided in each bay.

All the PDB's shall have 02 incomers and 01 buscoupler. Normally both the incomers will be charged and buscoupler will be OFF. In case of power failure or any fault power will be fed from either of the incomers. Incomers, buscoupler and busbars shall be designed to take care of entire load of the cranes.

Crane trolley lines feeding cranes in major production units shall be sectionalized with two separate feeding points. Two fully rated MCCB / ACB shall be provided for each incomer feed point to crane DSL. Sectionalisers shall be provided between the two incoming ACBs with necessary padlocking arrangement.

Isolator (MCCB) panels shall be provided for the repair section for maintenance by the tenderer.

In case of circuit breaker rating more than 630A, ACB's shall be provided. All the ACB's shall be installed in a PDB which shall in turn be installed in the bay / shop floor. In case of circuit breaker rating is 630A or less, than the MCCB (as isolator) with earth fault protection and magnetic over current release shall be mounted in the respective column of the feeding bay in a separate enclosure at manheight level.

Signal lamps shall be provided just below the trolley lines at 60m intervals as well as at the beginning and end of each section/repair section to indicate whether the trolley lines are energized or not.

Insulation air gap between two sections of a sectionalised trolley line shall be minimum 50 mm for voltage levels upto 500V, but in no case should be greater than the length of the current collector on the crane.

Maintenance Bay

When two or more cranes are fed from the same trolley line, maintenance bays (repair sections) shall be provided with sectionalizing isolator so that repair or maintenance of any crane can be carried out without disturbing the operation of the other cranes. Necessary DSL arrangement for repair section shall be provided by Tenderer.

Isolator panels shall be provided for each repair section for maintenance. Dead zones shall
be provided with isolator arrangements to prevent collision between cranes and momentary paralleling to two incomer supplies. Incomer ACB's shall be provided with earth fault protection and magnetic over current release. The DB's shall be located suitably on the shop floor.

For end zones, minimum length of maintenance bay shall be 2 m plus the crane width. For middle zone, the length of hospital bay shall be 4 m plus the width of crane.

Repair section shall be provided with red lamp steady/flash ing fixtures at four corners. These fixtures shall be located at crane gantry with manual ON/OFF provision.

Boarding or access platform shall be arranged within the limits of each repair section for approach to be crane.

02. Trolley power conductors

The Power conductors or down shop lead (DSL) shall have 4 conductors, 3 phase, 4 trolley line system (3 power + 1 earth).

Trolley power conductors shall be of mild steel angel sections / rails.

For cranes/hoists upto 10 t capacity, the DSL shall have 50 x 50-x 6 mm MS angle. For cranes above 10t upto 100 t, the DSL shall have 75 x 75 x 6-mm MS angles. For cranes above 100 t, the DSL shall have to maintain rail size of 75 lb.

Expansion and section gaps shall be provided in rails at every 30m. The gaps shall be cut at an angle of 30 degree to the rail and shall be 50mm wide. The gaps shall be provided with flexible joints. The conductors shall be supported at 3000 mm intervals by insulators mounted on brackets welded to crane girders.

Looping cables shall be used in parallel with the conductor rails and aluminium equalising strips shall be provided, wherever necessary, for limiting the voltage drops. However, aluminium equalising strips shall not be used in the hot areas like slag / liquid steel / slab / slab yard etc. In such areas, copper cable looping shall be used.

In order to provide electrical continuity across the expansion joints the power conductors on both sides of the joints shall connected by stranded aluminum conductor jumper, fitted with steel Aluminum strap and lugs suitable for the steel angle sections.

The power supply feeder and trolley line conductors/looping cables shall be selected so as to limit the voltage drop to within 15% of the rated voltage at the crane motor terminals for the short time peak current corresponding to the starting of the largest capacity motor and the maximum continuous operating current of the rest on the system.

Expansion and section gaps shall be provided in rails at every 30m. The gaps shall be cut at an angle of 30 degree to the rail and shall be 50mm wide. The gaps shall be provided with flexible joints.

The section shall be straight, unbranded and smooth on the running surface. Joints between lengths of angles shall be welded and all welds shall be finished flush with parent metal. The conductors shall be painted with anticorrosive paint, except for contact surface. Parallel aluminum buses shall be provided as specified. The jointing of standard
lengths shall be made by 100% but welding and top surface finished smooth by grinding to get free movement of the current collectors.

03. Insulators and trolley line holders

The insulators used for the manufacture of trolley line holders shall be preferably steatite, tufnol or porcelain insulation material having substantial mechanical strength specifically against blows and vibrations. They shall be capable of withstanding the impact and shocks resulting from operation of the machine. The creepage distance of the insulators shall not be less than 80 mm.

The insulators used in the LT/AC system shall have the following minimum flashover value and mechanical strength:

- Dry flashover voltage: 25 kV
- Wet flashover voltage: 12 kV
- Ultimate mechanical strength: 1000 kg.

The trolley line holders shall generally conform to the design shown in the drawing to be furnished to the successful Tenderer. All sharp edges shall be ground smooth. The porcelain insulators shall be manufactured and tested as per IS: 1445 –1997

04. Supporting brackets

The trolley line conductors shall be mounted on holders. The holders shall be bolted on to brackets which in turn shall be welded on to crane girder at stiffeners at regular intervals. In normal run, intermediate type of brackets shall be used, but when sectionalizing gaps or expansion joints are provided, sectionalizing type of brackets shall be provided.

05. Steel to Aluminium straps

These are meant for connecting parallel aluminium bus, at expansion joints, power supply cables from load break switch. They shall be complete with MS cadmium coated bolt nuts, spring washers, lugs etc.

06. Signal lamp assembly

Signal lamp assembly shall be industrial, heavy duty dust tight and water proof in construction suitable for indoor or outdoor locations. The units shall comprise three lamps for three phase with red glass lens and reflectors. The lamp shall be provided with dropper resistance connected in series with the lamp and the resistance shall be rated for continuous inclusion in the circuit. Alternatively, a built-in transformer may be provided to suit the lamp voltage.

07. Aluminium parallel bus

These buses shall be of E.C. grade aluminium. They shall be free from any deformity in profiles.

08. Current Collectors

2 nos. current collector shall be provided per trolley line each rated for 100% of total rating. The collector shoe will be of heavy duty design and chamfered at both ends, each rated
for 100% of total crane rating. Double collectors on each earth trolley line shall be provided and these shall be different from those on power trolley line. Collector shall be multi hinged for self – aligning. Collector will be designed in such a way that load is transmitted not no the insulators but on the insulator stud to avoid damage to insulators.

09. Power distribution on crane

One adequately rated isolator (MCCB/ACB) with locking facility shall be provided immediately after current collectors on incoming line on the crane. The isolator shall be capable of carrying current of two largest motors.

Power from the isolator shall be taken to the air circuit breaker to be provided in operator’s cabin. In case of pendant operated cranes, this circuit breaker shall be located in protective panel located at bridge platform.

The breaker shall be provided with under voltage, over load and short circuit releases. The breaker shall also be with earth fault protection. The breaker can be closed only when:

- All master controller handles are in neutral position.
- None of the stator or directional contactors are in closed positions.
- Emergency corner switches not operated.
- Door/Gate switch are not actuated and gravity limit switch for hoist motion not operated. Power for lighting and magnet circuits shall be tapped from the incoming side of isolators near current collectors.

10. Power supply for CT. motion

Flexible trailing cable systems mounted on retracting support system shall be used. The system shall consist of insulated multi-conductor or several single conductor cable with permanent termination on the bridge and on the trolley. The flexible trailing cables shall have ample length and shall be supported by means of properly designed movable clamps. These clamps shall be fitted with rollers and shall run freely on a guide rail allowing relative movement of bridge and trolley without undue stress or wear on the suspended cable. Provision later stage in case of necessity. The flexible cable shall be butyl rubber or EPR insulated CSP sheathed type.

For rotating trolley cranes, power supply shall be through festoon cable arrangement slipring or cable basket. Cable reeling drum or cable basket shall be used for power supply to the magnet from the trolley. Two spare turns of cable provided on cable reeling drum. The cable reeling drum shall be directly driven by hoist mechanism, a clutch shall also be provided to disconnect the drum from hoist mechanism.

Flexible cables system mounted on latest PVC linked chain system in normal area & metallic chain systems in hot area. (New point)

11. Meters

Ammeter and voltmeter with selector switches shall be provided on the incoming line in operator's cabin.

Ammeter and voltmeter shall be provided on DC side for Electromagnets.
12. Control features

All controls shall be fully magnetic, operated through master controllers. All travel motions shall be provided with plain rotor resistance control with plugging. For long travel drives, the electrical control shall be grouped for the individual pair of motors separately in case of four motor drive and each pair of motors shall be able to drive the crane at reduced acceleration and speed. As an anti-skewing measure, out of a pair of motors for LT., if one drive motor trips, the other drive motor shall also be switched off. For pendant control, plugging shall be avoided for travel motion.

Brakes shall not be used for speed control.

Synchronization of separate drives where required shall be done with the used of solid state thyristor control.

For all hoist motions, except where creep speed is required, plain rotor resistance control shall be provided on all master controller notches in the hoisting direction. The rotor resistance shall be cut out gradually when moving from lower to higher notches such that current peak of 2 times the rated current is not exceeded. In the lowering direction of the motion, controlled lowering shall be provided using one/ two plugging notches, one single phasing notch and one/ two super synchronous power lowering notches. For obtaining creep speed, conventional methods like planetary gear system, DC. injection (where requirement calls for creep speed in lowering direction only) etc. may be offered.

Hoist control circuit shall also be provided with anti-drop feature i.e., whenever the master controller is brought back to zero position from higher notches in both directions, the motor shall automatically be connected to hoisting direction for some time (time adjustable through timers) to avoid the downward drift of the load. Brakes shall be clamped in zero position of the master controller.

13. External control of auxiliary hoist and CT of LRS Crane

Tenderer shall supply one no. of Ground Control Post in Pedestal for installation in PCM control room. The control post shall have following facilities:

a) Control on PB- This shall transfer the control of CT and auxiliary hoist from cabin, master controller to ground control post and will not allow LT motion from cabin.

b) For CT and aux. Hoist 4 push buttons each (total 8 PBs) shall be provided on ground control post for following application:

c) 10% speed of hoist & lower

d) 30% speed of hoist & lower

e) 10% speed of CT forward & reverse

f) 30% speed of CT forward & reverse

The control post shall be connected to the main control of cabin on crane through hear resistance flexible cable with copper conductor arrangement and plug and socket system. The socket shall be fixed to the cabin. The no. of pins for socket, no. of additional aux. Contactor, no. of cores for flexible cable to achieve the above control shall be decided by the Tenderer during detail engineering and shall be included in the scope of supply of Tenderer.
Further, Tenderer shall quote radio control system to achieve the above control requirement as an optional feature. Cost for the radio control option shall be indicated separately.

14. **Thyristor control drives**

Thyristor control shall be provided for all the cranes operating in areas where ambient temperature is more than 50 deg. C. Control shall be achieved through master controllers for each direction. Rated and creep speeds are to be provided in each direction i.e., hoisting and lowering. Creep speed shall be 10% or lower as per operational requirements of rated speed.

The thyristor regulator shall be fully controlled and suitable for four quadrant operation.

Speed control of the slipring motor shall be achieved through regulation of stator voltage with resistance in the rotor circuit, if necessary. The reversal of direction shall be through magnetic contactors which shall open and close at zero current.

The continuous rating of the thyristor converter shall be at least 2.0 times the motor rated current at the mechanical KW and the converter shall be designed and rated for load requirement taking care of peak currents during acceleration, normal operation and regeneration conditions. The dv/dt and di/dt rating of the thyristors shall be suitably selected.

The repetitive PIV rating of semi conductor devices shall not be less than 2.5 times the peak of normal system voltage. Thyristor bridges shall include R.C. snubber circuits across the thyristor, high speed semi-conductor fuses with micro-switches for monitoring of failure. Closed loop regulation suitable for the system with various feed back such as speed, current etc. shall be provided. Speed feed back shall be through tacho-generator of permanent magnet type mounted on the non-driving end of the motor shaft. The regulation shall include ramp generators, potentiometers for various setting, various regulators, signal conditioners, logic command module sequence, module, trigger module, zero and over speed monitor, torque less protection module etc. as per the requirements. The control and regulation equipment shall be able to maintain their rated performance and control quality even under conditions of variation of +10% and - 15% in voltage and +5% in frequency. A zero current sensing device shall be incorporated. The reversing of stator contactor shall be done at zero current. Braking down to zero speed shall be electrical with mechanical brake setting only at zero speed. Protective features like anti-drop etc. shall be incorporated to prevent load setting. The circuitry shall also provide for the protection against failure of motor torque such that the mechanical brake sets in such cases. All other features of conventional crane controls shall also be built into the scheme. The following shall also be provided on the A.C. side.

- Surge suppressor
- Over current protection
- Overload protection
- Single phase protection
- Phase sequence protection
- Ammeter and voltmeter with selector switches
- Isolating switches

Control and auxiliary supply shall be provided with separate transformer and under voltage protection.
The test shall be performed as per IEC : 146.

Details of the system offered shall be furnished along with necessary single line diagrams and block diagrams.

All the control modules shall be grouped in a sheet steel enclosure. The control module cards shall be made of epoxy glaze and suitable for plugging into the racks. The cards shall be locked into the rack, which carries a sealing bar and assists locking of the cards thereby cutting down on the wear of the printed circuit connector contacts which can be subjected to high rate or vibration and further avoid the disconnection of cards from the connector. The thyristor panel shall be suitably mounted so that little vibrations are reflected to the components and connection.

The cables for the thyristor controller and associated equipment shall be laid and clamped separately on the crane.

15. VFD control drives

VFD control shall be provided for cranes operating in areas where operating temperature is 50 deg. C . Control shall be achieved through master controllers for each direction. Rated and creep speeds are to be provided in each direction i.e., hoisting and lowering. Creep speed shall be 10% or lower as per operational requirements of rated speed.

The VFD shall be fully controlled and suitable for four quadrant operation (active front end type) . Other details of VFD shall be as per respective clause for VFD in the GTS.

16. Panels

There will be separate panels for each motion in addition to the protective panels and resistance panels.

All panels shall be of free-standing floor-mounting construction, suitable to withstand vibrations encountered on crane. Hinged doors shall be provided for closed type panels. Panels shall be front wired. Front wired live points of bottom most equipment shall be mounted at least 350 mm above the bottom cover of the panel. Panel shall be fabricated from 2.0 mm thick steel sheet.

Power and control terminals shall be segregated. 10% spare terminals shall be provided in each panel.

Equipment in the panel shall be so mounted that their removal or replacement from the front is easy.

Separate control panel for each motion shall be provided.

Panels shall be of closed type when mounted on bridge platform.

The panels shall be mounted along the girder facing the hand railing. Sufficient clearances shall be provided between the panels. A minimum clearance shall be provided in front of the panels for walkway and approach as per I.E. Rules. The panels shall be supported in the back from the girder to avoid vibrations. Open type panels may be used for installation
inside the box girders. In this case, adequate lighting and ventilation shall be provided for the room.

17. **Switchgears**

Each mechanism motor shall be provided with MCCB, contactors on stator and rotor sides, Electronic over load relays and suitably rated rotor resistances. In case of thyristor controlled drive, each mechanism motor shall be provided with breaker / switches, transformer, thyristor, rotor resistances, contactors on stator and rotor side etc. Each motor shall be fitted with a tacho-generator for speed feed back. The speed range shall be 0-160% of rated speed.

MCB shall be provided in the control circuit of each motion.

Each brake circuit shall be provided with a suitable contactor.

Rating of contactor selected for any mechanism shall be at least 50% higher than the respective motor full load current for the mechanism at 40% duty cycle. The minimum rating of the contactor used shall be 32A and the life of each contactor shall not be less than 10,000 hrs. of operation.

Reversible directional contactors shall be inter locked both mechanically and electrically.

18. **Motors**

Heavy duty reversible crane service, totally enclosed fan cooled, foot mounted, wound rotor motor conforming to latest edition of IS:325-1996 shall be used for various drives. Class of insulation shall be F/F (Stator/Rotor) with temperature rise limited to that for ‘B’ Pullout torque to the not less than 225% and 275% of full load torque corresponding to 40% CDF for class 1 & 2 and class 3 & 4 duty cranes respectively.

The main motor shall have following speed ranges:

a) Class M3 & M5 duty cranes:
   - Main & auxiliary hoist : 750 rpm
   - Long & cross travel : 1000 rpm

b) Class M7 & M8 duty cranes:
   - Main & auxiliary hoist : 600 rpm
   - Long & cross travel : 750 - 1000 rpm

All motors shall have the terminal box at top. Frame sizes shall conform to IEC Standards.

Horizontal foot mounted and with tapered shaft extension.

While selecting the motor rating following shall also be taken into consideration:

- Duty type S4 & S5
- Cyclic duty factor
- Number of switchings per hours
- Type of controls used
- Inertia of the motor and mechanism
- Ambient correction factor
- Service factor
- Derating for thyristor control
- Wind pressure

Maximum permissible operating speed shall be 250% of synchronous speed or 2000 rpm whichever is less. Over load capacity 150% of full load current for 2 minutes without damage or permanent deformation.

19. Brakes

Brakes shall be D.C. electromagnetic type, confirming to AISE standard. The brake coils shall be made of copper and of insulation class 'F'.

Brakes shall be designed to fail safe whenever the current is interrupted either intentionally or by failure of the main supply.

Brake circuit forcing shall be provided for D.C. brakes. D.C brake circuit shall be switched off on D.C. circuit for quick operation of brake.

A separate set of parking brake for L.T. motion shall be provided for each out door crane. Power supply for these brakes shall be obtained from protective panel.

20. Limit switches

Roller lever operated, resetting limit switches shall be provided for all travel motions. For each hoist motion, a rotary cam type over hoist and over lower, self resetting limit switch shall be provided. This limit switch shall have independently adjustable cams for hoisting and lowering motion. The cams shall have adjustability such that end limit can be set to within 100 mm of the hoisting or lowering motion. In addition to this, a back up ultimate limit switch of series/ shunt gravity type shall be provided to prevent over hoist. The later shall be of manual reset type. In case of cranes handling hot metal, the gravity limit switch shall preferably be of series type. Provision shall be made to bridge the gravity type limit switch contact by push button/ switch or any other means to lower the load. An indication shall be provided to the operator whenever this limit switch has operated. Suitable limit switch shall be provided for slack rope, gate/door opening, slew mechanism, grab closing/ opening etc. wherever necessary. Protection class of the limit switch shall be minimum IP 65.

21. Anti-Collision Devices

In cranes where two or more cranes are operating in the same bay( at same or different level ) all cranes shall be provided with suitable Anti- collision system. Anti-collision device shall be electronic type.

A sound signal shall be provided to the crane operator when they are at certain safe distance apart ( distance to be adjusted as a function of speed at site) and crane shall stop. After few seconds, it shall be possible to run the cranes towards each other ( or only one crane can move towards the other) till buffers of the cranes meet by providing ‘by pass’ in the operators cabin.

Anti-collision shall also be provided on trolley for twin trolley cranes along with suitable by pass arrangement.
22. **Resistances**

Air cooled, robust, heavy duty, corrosion resistant fechral edge wound resistance. Resistance shall be in single phase execution. In a particular box the rating of resistances shall be the same. Resistance shall have vibration proof only.

Rated for 10 minutes duty. Continuous duty rating of resistances shall be provided in case of hoist motions controlled by thyristor converters.

Maximum temperature (absolute temperature) of resistor elements shall be limited to 335 deg C at desired duty. Suitable tapping points shall be provided.

Resistance boxes shall be mounted in racks that permit independent removal of any selected box.

23. **Master controller**

Cam type master controller with joy stick type lever shall be used.

Separate master controllers for hoist, LT & CT shall be provided.

Duel master controller operated with single handle shall not be used.

Master controller for each motion controls shall have four/ five notches in each direction. Master controller for electro- shall have three positions i.e Lift- Off-Drop. It shall have spring return from drop position to Off position.

24. **Lighting, socket outlets, bells etc.**

Lighting shall be provided in operator’s cabin, stair cases, platforms and working areas.

Minimum 4 nos. 400 watts high pressure sodium vapour flood lights equally spaced (under crane girders) about the crane span shall be provided along with shock absorbing and anti-swing suspension arrangements. More numbers of fittings shall be provided if required for cranes with longer span and/or longer height of lift.

Fluorescent lamps with necessary fittings shall be used for operator’s cabin, staircases, platforms etc.

Adequate number of hand lamp socket outlets (2 Pin, 10A, 24V) and power socket outlets (3 Pin, 20A, 240V) shall be provided along with switches socket & switch shall be interlocked suitably. A hand lamp( 160W SLS lamp with enclosed type battery and wire guard) along with sufficient length (15m) of cable with a plug shall also be provided for each crane.

An alarm bell shall be provided on each crane.

25. **Electromagnets**

All magnets shall be suitable for steel plant application and shall be welded construction.
Magnets shall be rated for 230 V DC and suitable transformer – rectifier units shall be provided for feeding them. Rectifiers shall also be suitable protected by suitable protective device.

Magnets shall be class ‘H’ insulated, at least 50% rated, copper conductor would and shall have surge suppressor box and separate in terminal box for termination of cable. Magnets for production cranes handling hot products shall be 75% rated. Surge suppressor shall be compact, non-linear resistor silicon carbide thyrector, variator or metrosil type.

Each magnet shall be provided with suitable plug socket unit.

One earth terminal on magnet to be connected to spare core in magnet cable.

Wherever specified, a set of batteries, a battery charger, one annunciation system and other accessories shall also be provided along with magnet so that the magnet can hold the full load for atleast half an hour in case of power failure.

25. Equipment in operator’s cabin or on pendant unit

a) In case of pendant controlled crane following shall be included on the pendant unit:

<table>
<thead>
<tr>
<th>Push button for</th>
<th>Hoist slow, hoist fast, lower slow, lower fast, left cross traverse, right cross traverse, forward long travel, backward long travel, emergency stop conditions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch for</td>
<td>Lights and bells</td>
</tr>
<tr>
<td>Lamps for</td>
<td>Power ‘ON’ indication and emergency corner switch operation.</td>
</tr>
</tbody>
</table>

b) In case of cabin operated cranes:

The operator’s cabin shall contain the following:

- Master controllers for all the motions and magnet (wherever applicable).
- Emergency stop push button.
- Foot switch for alarm or bell.
- Switches for all lighting equipment on crane.
- Switches for air conditioner, exhaust fan and for cabin fan.
- A fire extinguisher.
- Insulating mat and operator’s chair.
- Cabin light.

Annunciation panel with indication lamps for power ‘ON’ control ‘ON’ emergency corner switch operated, ammeter and voltmeter with selector switches.

c) In case of master controller operated cranes :-

In this case there should be the facility of controlling the crane from the control pulpit.

All the control facility available in case of operating from the operator’s cabin is duplicated in the control pulpit through the cable.
d) Radio remote control :-

In this mode of control system, all the 3 motions
- Hoist.
- Cross travel.
- Long travel.
can be controlled.

The system shall have capability to provide range of 1.5 times the long travel distance of the crane.

In the case of signal failure, all motion shall come to a safe stop.

The system shall have facility of controlling speed in two steps :-

(i) Slow speed on the first step of the breaker contact / pushbutton of the radio remote control representing the first or second notch of the master controller.

(ii) Full speed on the second step of the breaker contact / pushbutton of the radio remote control representing the final notch of the master controller.

Transmitter :-

Transmitter shall have following features :-
- Constructed with sophisticated microprocessor technology and surface mounted electronics.
- Transmission type :- FM FSK
- Transmission speed :- 9.6 Kbps.
- Built in self test for all functions.
- Transmitter shall consist of switching breaker, dial switch and push buttons.
- Switching breaker shall be non locking to zero position or maintained function.
- Indications :-
  - Operation status
  - Battery status
  - Indicators that display information from crane.
  - PIN - code (Personal Identification Number)
  - Internal antenna.
  - Rechargeable battery.
  - Battery 7.2 V NiCd
  - Operating time :- About 8 hours.
  - Different operating frequencies (minimum 16 nos.)
  - Two hand upstart.
  - Stop push button.
  - Operating conditions :- Areas having large temperature variations, dusty, more vibrations, oil and humidity.
  - Operating temperature range :- Min. 10 deg.C to Max. 60 deg.C
  - Protection class : IP - 54.
  - Casing material : Polycarbonate / ABS plastic.

Receiver :-
Receiver shall have following features: -
- Upto 20 functions exclusive safety relays (for transmitting preset reference values to VFD in the crane).
- 2 safety relays (for control of main contactor)
- Power supply suitable for 240 V AC, .6 A.
- Minimum 16 different operating frequencies.
- Two redundant microprocessors for monitoring each others.
- Cyclically redundancy check check for high security of transmitted radio messages.
- Frequency scanning in the receiver.
- Memories last 10 users.
- Interlocking of the relays.
- Momentary or latched relay functions.
- Two hand up start (to avoid unintentional start).
- Protection class: IP - 65.
- Casing material: Aluminium profile for fast mounting on DIN rail.
- Operating temperature range: - Min. 10 deg.C to Max. 60 deg.C

26. Enclosure Class
   a) For indoor operations
      - Resistance boxes: IP : 11
      - Motors: IP : 55
      - All other electric equipment: IP : 54
   b) For outdoor operations
      - Resistance boxes: IP : 33 with canopy
      - Motors & panel: IP : 55 with canopy
      - All other electrical equipment: IP : 65 with canopy

27. Cables

Power cable suitable for 3 Phase, 4 wire, AC power supply system.

All cables shall have stranded copper conductors. Control wiring shall be with 2.5 mm2 copper; minimum size of power cable shall be 6.0 mm2. Fixed wiring on cranes shall be carried out with PVC insulated. PVC sheathed armoured cable or EPR insulated CSP sheathed cable or better.

All flexible cables (i.e. cables for magnet, trolley, feed, pendant unit etc.) shall have copper conductor, EPR insulation and CSP sheathing or better.

All cable shall be suitably de-rated for grouping and higher ambient temperature.

All cables shall be of 1100 Volts grade.

All accessories like cable glands, clamps, pipes, wire and terminal marks etc. shall also be provided.

Cable laying and terminations shall be such that the chances of cables getting damaged is remote.

Cable sizes shall be selected considering motor rated current.
In all passages and on trolley the cable shall be laid in trays and shall be covered by similar trays and properly clamped & fixed.

01 LT Power Cable

1.1 kV, heavy duty power cable, 4/3.5 core with stranded sector shaped (sm) or with compact circular stranded (rm/V) or circular stranded (rm) Copper conductors as applicable, PVC insulated suitable for 70°C operation as per IS:5831-1984, core stranded together provided with a common covering of PVC inner sheath, galvanized round steel wire armoured and PVC outer sheathed, multi core conforming to IS:1554 (Part-I – 1988) Type TWY.

02 Control Cables

1.1 kV, circular stranded (rm), annealed copper conductor, PVC insulated suitable for 70°C operation, as per IS:5831-1984, cores stranded together provided with a common covering of PVC inner sheath, galvanised round steel wire armoured and PVC outer sheathed, multi-core similar to IS:1554- (Part-I)-1988, Type YWY.

03 Flexible Trailing Cable


28. Earthing

A ring earthing system shall be provided on the crane. Each and every electrical equipment shall be connected to this earthing at least at two points. However the electronic circuit insulated earth wire shall run in panel and terminate at main earth connection only at one point. The earthing shall be connected to the fourth trolley line in DSL system through 2 nos of current collector. Additionally current collectors shall also be provided on crane rails for earthing on crane. All these collectors shall be connected to earthing ring.

An earth core shall be provided in trolley feed cable and the magnet. The cable reeling drum shall have a separate slipring for earthing purpose.

It shall conform to general specification for earthing.

Rubber mattings shall be provided in front of the protective and control panels.

All bonds between earth conductors and crane parts shall be welded if possible, or rivetted and soldered. Where screwed bonds are made, care shall be taken that there is satisfactory contact surface and nuts shall be locked to prevent their loosening. Earth connections to equipment shall be made by means of multi strand flexible conductor to adequate section.

The earth ring on the crane/ machine shall be connected to the plant earthing system through to gantry rails. Each end of each gantry rail shall be bonded to the plant earthing system.

In addition, intermediate earthing bond shall also be provided on the rails at every 60 m in case of longer tracks.
Flexible copper bonds shall be provided across any gap in the running gantry rail.

For mobile equipment with flexible cables, one separate copper conductor of adequate size shall be provided for earthing.

29. **Crane weighing system**:

Electronic weighing system including calibration equipments, cables, load cells and panel mounted associated electronics (microprocessor based) with communication capability with PLC on bus. Cranes & hoist (as per scope of supply) including their complete electrics & control (as given in relevant chapter) including power supply, power conductor lines (DSL), Load break isolators (to be located in bay) & cables.

Crane weighing system to be connected to ground station by Radio link module. Necessary hardware & software including cables for above as well as communication of ground station with main automation network of shop automation system to be considered.

Other details of crane weighing system:

1. The Weighing system shall be designed, manufactured, assembled & tested in accordance with relevant OIML / NTEP standards.
2. Load cell shall be of globally reputed make, confirming to OIML/NTEP Standard & preferably digital type. Load cell shall be easily replaceable type, provided with safely devices from impact load, vibration, heat & dust.
3. Weighing system shall be auto zero & auto calibration facilities.
4. Redundant electronics shall be provided.
5. Test weight for calibration shall be provided.
6. Two nos. large display unit shall be provided.
7. The requirement of the system are:
   i) The Weighing system will be sufficient to measure, display and telemeter the loading material weight, meet all operating requirement and necessary safety provision including alarms for abnormal conditions. Design should support better tolerances in the mechanical system.
   ii) The equipment selected for the purpose will be suitable for a continuous and reliable functioning in environment generally prevailing in steel plant area. Signal transmission will be through radio communication. The frequency used shall be in license free bands as per prevailing standards in India.
   iii) The designed will include all necessary precautions and provision for the safety of operating and maintenance personnel and equipment.
   iv) Accuracy of the system will not be less than ± 0.5% of FSD.
   v) The Crane Weigh unit will be able to tolerate sudden shock loads caused by the lifting and traveling of crane. Weigh unit will be suitable for continuous loading for long durations. Electronics will be resistant to vibration prevalent in cranes.
   vi) Weight signal shall not be affected by the height at which load is weighed.
   vii) The Weighing system shall have protection against strong magnetic field, electrical surge, RF interference and heat & dust.
   viii) Data updation on real time basis in the central computer.
8. The scope of work includes Supply, Erection, Testing and commissioning of Crane Weighing systems as per following:
   i) Crane Weighing units complete with top & bottom crane mounting accessories, weighing electronics, wireless communication interface, anti heat shielding for the equipment, protection against EMI, batteries and chargers, one standby battery for
each weigh unit, power supply unit etc. the Amp. Hour of the battery shall be adequate enough for minimum one month working.

ii) Hand held unit based on radio frequency signal with toggling facility for current and cumulative weight display complete and charger, long range antenna (as per site requirement), wireless communication interface, provision for entering product and customer details. This unit will have calibration facility with password protection.

iii) Wireless Transceiver at PC end (with IP65 enclosure), power cable, antenna (if required as per site condition)

iv) Commercial grade PCs.

v) The required tools and testing instruments for normal maintenance and operation of the equipment.

vi) The weighing system shall have real time connectivity to the plant MES / ERP through plant wide network.

vii) Supply of following tools and testing equipments:

a) Digital Multimeter 4 ½ digit- 2 nos. (make: Philips / HP / Fluke)

b) Portable Think pad based software programmer (make: HP / IBM / SONY) - 1 no.

c) Universal calibrator (make: HP / Fluke) - 1 no.

d) Professional tool kit (make: RS / Philips)

viii) Integration of subunits.

ix) Supply of complete data, design calculations, technical literature and documents, erection / maintenance and operation manuals, erection drawings, Quality Assurance Plan (QAP) and as built drawings.

x) Supply of special tools and tackles, commissioning spares.

xi) Component level training to maintenance staff of BSP at the tender’s works.

xii) Earthing.

xiii) Stamping and verification at the manufacturer’s works by the tender as required under Weights and Measures Act.

xiv) Suitable safety devices for the protection of the weighing and processing system against impact loading.

1.02.21 Erection Specification

1.02.21.01 Guidelines for design of system and engineering the layout of electrical equipment.

001 General

The tenderer shall prepare the layout drawings for civil assignment and civil drawings for construction of the substation buildings and civil buildings for other electrical premises taking into consideration the requirement listed below. In case of total turnkey contract the civil aspects mentioned in following specification shall be adhered to while planning / executing civil work.

002 Electrical premises

- All electrical premises shall have adequate space to accommodate the electrical equipment from the point of view of operation and maintenance, and conform to IE Rules & Regulations.
• The clearance between the ceiling of the electrical room and top of the tallest equipment shall not be less than 1m, 2m where the equipment are to be maintained from top and additional height of lifting tackle wherever required.
• Lifting/handling facilities shall be provided. Rolling shutters shall be provided to facilitate transportation of the equipment into and out of the electrical room, MCC rooms.
• Electrical room located on the top floors shall have erection openings and landings.
• All electrical rooms shall have cable basement/cable galleries/cable trenches as per equipment layout in the electrical rooms. The clear height of the basement/cable gallery walkways shall be minimum of 2.2 m for cable tunnels and 3 m for basement/galleries.
• The wall of the basement shall have water proofing and draining facilities below ground level.
• All electrical rooms shall be constructed with heatproof material at the roof if it is exposed to sunlight.
• Cable basement/galleries shall be provided with suitable lighting/ventilation facilities.
• 24V AC sockets fed from dry type L.V. transformers shall be provided for hand lamp connection throughout the premises including basement and cable tunnels.
• Airtight double door arrangement shall be provided for electrical rooms and basement. The stairs to the basement shall be from inside the electrical room.
• Welding power socket outlets shall be provided within basement at intervals of 60m with minimum of one, where basement is less than 60m long.
• Electrical room and cable galleries/basement shall be considered fire hazardous.
• Roofs of the electrical premises shall be fully watertight and moisture proof.
• Erection openings with removable cover plates shall be provided on the floor of the electrical rooms connecting the basement/cable gallery.

003 Control rooms/pulpits

• Location of control posts shall be decided taking care of clear visibility.
• All control rooms shall be air-conditioned and temperature shall be 24 deg. C.
• Air lock rooms shall be provided for all the control room / pulpits.
• Inner walls shall be sound proof.
• Granite flooring shall be provided.
• Window glass shall be toughened, heat resistant and of greenish tint, hinged glass to be opened from inside.
• Double glass panels, wherever required, shall be provided to make the control post heatproof.
• Suitable wire mesh shall be provided for the glass windows for protection against mechanical damage wherever required.
004 Cable tunnels

Standard cable tunnel size:

- Full tunnel: 2200 mm (W) x 2200 mm (clear height)
- Half tunnel: 1500 mm (W) x 2200 mm (clear height)
- Partition door between basement and the cable tunnel shall be air tight and of fire retardant material. Cable tunnel shall be provided with fire / smoke detectors as per norms.
- Gradient of the floor at transition from one elevation to another shall not exceed 15 deg. Gradient shall be in the form of ramp.
- Floor gradient towards the water collecting pit shall not be less than 0.3%.
- Plate inserts (200 x 100 x 6 mm) at an interval of 1500 mm shall be provided on the wall along the length of the tunnel. Three rows of inserts shall be provided at suitable intervals along the height.
- Plate inserts shall be provided at an interval of 1.5 m under the ceiling for lighting fixture.
- Entries to the cable tunnel shall be provided generally at 70 m interval along the length of the tunnel inside the shop or at least 2 entries in case of small tunnels.
- Tunnel walls shall be waterproof design.
- For interplant cable tunnels, long tunnel shall be split into compartment not exceeding 150 m with fire proof partition doors.
- All cable tunnels shall be properly ventilated.
- Atleast two evacuation exits should be provided in each of the cable gallery and cable tunnel. The distance between any point and exit should not be more than 35m. The distance from dead end of cable gallery/cable tunnel to the exit should not be more than 25m.
- All the cable tunnels and cable galleries shall be provided with sump pumps for pumping out seepage water. Sump pumps shall be provided with high level/low level switches for automatic operation.

005 Cable shafts

- Cable shafts shall be of either civil or structural design as per requirement.
- Landing platform shall be provided at every 5 m of height.
- Suitable cat ladders shall be provided in the cable shaft.
- Suitable ventilation/lighting facilities shall be provided for the cable shafts.

006 Clearances inside the electrical rooms

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Clearance</th>
<th>Min. Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Back clearance</td>
<td>Front to front clearance between drawout / semi-drawout panel boards</td>
</tr>
<tr>
<td>---</td>
<td>----------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>1.0</td>
<td>1250</td>
<td>2500</td>
</tr>
</tbody>
</table>

- Resistance boxes shall be floor mounted and shall be placed on the floor near the respective MCC.
- Disposition of control desk, mimic boards, instrumentation panels shall be properly located for visibility and operational convenience.
- Profile & dimension and painting of control desk / mimic panels shall be same as for control room for aesthetic design
- In any other case, the layout shall confirm to provide clearances as per Indian Elect. Rules.

**007 Transformer rooms**

All mineral oil filled transformers shall have oil soak pit around it. These soak pits in turn shall be connected to a common catch pit for collection of oil. The capacity of catch pit shall be equal to 1.2 times of the oil content of the biggest transformer.

In case oil filled transformers are located inside the shop, the catch pit shall be outside the shop connected to soak pits by pipes. Also the transformer room shall be enclosed on three sides. Access side may have steel framed gate with expanded metal jali doors with wicket door provision.

All mineral oil filled transformer shall be separated from switchgear/electrical rooms with partition wall. All transformers and heavy equipment shall have adequate transportation and lifting facilities.

There shall be minimum 1m clearance all around the transformer. The ceiling height of the rooms shall be 1.5 m above the conservator. The minimum dimension of transformer room shall be 6mx6mx5.0m(H).

**1.02.21.02 Guide-line for erection of Electrical equipment and accessories**

**001 General**

All the electrical equipment shall be installed with proper care and as per layout drawings. Minor modifications required at site shall be made by the contractor with
approval of purchaser representative/Consultant for installation of the equipment. Care shall be taken for proper handling of equipment and undue vibrations shall be avoided particularly in case of sensitive (instrument mounted on panels) equipment.

The contractor shall have valid electrical contractor's license valid for State Govt. and as well supervisory licence. He shall have in his employment sufficient number of electricians and supervisors holding valid licenses for HV and LV installations. It will be the responsibility of the Contractor to get the installation cleared and relevant drgs. Certified / approved by Electrical Inspectors, Factory inspectors, Insurance agencies and other statutory authorities. The Govt. fees and necessary commercial aspects will be taken care by the Contractor.

002 Rotating machines

The erection work of motors shall include checking of all motors before installation including thorough cleaning and checking of bearings, replacement / rectification of defective items, greasing of bearing, if required, making minor modifications in its mounting arrangement, wherever required, assembling and its mounting on the motor base plate or on mechanical equipment, as the case may be, including levelling and alignment, checking insulation resistance and improving the same, if necessary, checking of internal connections etc.

All work associated with revisioning of motor shall also be included such as uncoupling and removing of motor from mechanical equipment, disassembling, cleaning, checking of insulation resistance and improving the same, if necessary, regreasing and replacing defective items/bearings on foundation, wherever required, reassembling, placing, levelling, aligning and fixing of coupling of the revisioned motor with mechanical equipment.

The contractor shall check different parts and assemble the motor at site in correct sequence wherever the motors are delivered in a dismantled state i.e. base frame, bearing pedestals, armature, field frame etc. in separate packages. Erection, alignment and securing shall be done under expert technical supervision. Straight edges, feeler gauges, dial gauges etc shall be used for aligning purpose. The height of the shaft of the motors shall correspond to the machine to be driven, if discrepancies are encountered these shall be compensated by inserting machined metal sim plates under the supports of the motor. The motors mounted on the movable base frames / base plates shall be connected via intermediate terminal boxes with flexible cables. After the complete installation of the motors, all bolts and bolted joints of the mechanical and electrical equipment shall be checked to ensure that they are done up
tightly by torque wrench. A further check shall be made to ensure that the armature can be easily rotated.

The insulation resistances of the coils and connecting leads within the machine shall be checked against earth by a suitable megger. Insulation resistance if found less, the machine shall be dried to achieve the desired value.

Space heaters of main drive motor required to be installed in motor foundation pits shall be suitably and firmly mounted.

For handling the machine with the crane, the slings, lifting cables etc. shall not be secured around the shaft. However, the armature of disassembled machines may be lifted or supported by the shaft.

The machine shall be lifted or lowered without shocks or quick jerks to avoid any damage.

Handling facilities of the motors shall be provided at places where direct crane approach is not possible.

The system components delivered in separate packages like tank, gear pumps, filters, pressure switches, thermometer, flow regulators, centrifuge etc. shall be assembled at site and installed as per supplier's drawings. The supply and return pipelines along with their supporting structures from the lubrication system to the motor bearing shall be laid/erected by the contractor as per the relevant pipeline routing drawings. Meters and gauges shall be fixed and wired.

003 **Sheet metal enclosed panels, open control panels, control desks and boxes**

The base frames of all panels, desks, posts etc., shall be welded to structures or to the civil inserts provided on the floor/walls. Fabrication of supports(frames, wherever required, shall be done by the contractor.

The shipping section shall be placed in position before removing the protective covering to eliminate scratch/damage. The shipping section shall be moved by using rollers under the shipping skids wherever lifting cranes are not available. The contractor shall do the assembly at site as per manufacturer's general arrangement drawings and installation instruction. While assembling a complete board comprising several unit type cubicles, the board as a whole shall be aligned. The panels shall be properly leveled prior to grouting the holding down bolts or welding the panels to the inserts. All interconnection of busbars and wiring between the panels shall be done as per manufacturer's instructions and drawings. Welding work on the panels shall only be carried out after consultation with the purchaser. Damage to the paint due to welding shall be rectified by the contractor.

After mechanical installation of the board is completed, loose instruments shall be installed, wherever required, and wires shall be connected to the instrument. The
wiring of intermediate terminal strips between two panels, wherever disconnected for transport, shall also be connected.

Each post shall be mounted at the place of installation in such a way that the operator has both the plant and the post before him.

The installation of control posts / boxes on mechanical equipment must be approved by the purchaser.

In cases where the control posts / boxes are separately mounted near the equipment, the contractor shall manufacture a structural support for the same before mounting the control posts/box.

004 Static converters

The installation shall be carried out as per manufacturers' instructions & equipment layout drawings.

The preservative grease from the metallic parts shall be removed by petrol and with clean markin cloth. Grease from copper parts shall be removed with ethanol and wiped with clean dry markin cloth.

The base frame of panels shall be welded to the civil inserts.

The panels supplied in separate shipping units shall be assembled at site as per manufacturer's drawings / instructions. The unit installation shall be started with the main converter. All the cabinets shall be aligned in a perfectly straight row and each of them exactly leveled. All inter-connections shall be done as per manufacturer's drawings/instructions.

005 Transformers and reactors

The transformer and its accessories and mountings like radiators, conservator, thermometers, silicagel breathers, marshalling box, rollers etc., delivered at site in separate packages, shall be assembled at site after cleaning by the contractor in proper sequence as per manufacturer's drawings. The unit installation shall be started with the main converter. All the cabinets shall be aligned in a perfectly straight row and each of them exactly leveled. All inter-connections shall be done as per manufacturer's drawings/instructions.

Jacks shall never be placed under valves or cooling tubes.

Suitable stopper shall be provided both in front as well as rear of transformer to keep the transformer stationary in its position. For the front wheels such stoppers shall be screwed on the rails.

The oil conservator and the pipes shall be erected as shown in the manufacturer's drawings. All radiator tubes shall be cleaned before installation.

Before the transformer is filled/topped with oil, oil samples shall be checked by the contractor from each container. The oil shall possess the dielectric strength as per relevant IS/CEA. Oil shall be filled upto the mark shown.

The contractor shall also test the oil from each transformer to determine its suitability for use. If required, the contractor shall carry out drying and filtering operations as per
IS code of practice to ensure that moisture is completely removed and the oil is free from impurities. This may be carried out by using oil filtering equipment to be provided by the contractor having vacuum as well as heating arrangement. Only after the dielectric strength of oil and other parameters are checked and approved, the external connections shall be made to the transformers.  
The dial thermometers shall be screwed to the thermometer pockets after removal of the blind plugs.  

All necessary cabling shall be connected before charging of the transformer. This will include signaling cables upto marshalling box and from marshalling box to meters, if not already done, as well as inter cabling between surge suppressor cubicle and transformer secondary.  
Any modifications to HT and LT terminal box to accommodate the number of cables to be terminated shall be carried out by the contractor.  
Naked light and flame shall never be used near the transformer.  
Reactor shall be suitably shielded to avoid magnetic interference to electronic circuit.

006 Battery installation  
All batteries shall be installed in a separate room. It shall have a water tap and adequate ventilation facilities for acid/alkali fume extraction. Battery for UPS (SMF type) shall be panel mounted located by the side of UPS.  
Rooms having battery installation shall have acid resistant floors.  
Walls will have acid resistant tiles on the side walls upto 1.5m height.

007 Busbar  
Busbar installation shall be commenced from the middle section and the buses shall be fastened without tightening the bolts. The buses shall lie freely on the insulators without warping and if necessary, suitable packing shall be provided at the insulators.  
Final tightening of the bolts shall be done after the complete laying of buses. Approved means shall be used for tightening of the bolts.  
Bimetallic strips/ washers shall be used wherever aluminium busbars or aluminium cables are terminated on copper busbars.

008 Crane Trolley Lines  
While sectionalising, one middle safety section shall be arranged slightly in excess of the crane braking distance so that it can act as a buffer and prevent the danger of crane collector bridging the isolator gap and leading to accidents on other section under repair or maintenance.  
Boarding or access platform shall be arranged within the limits of each repair section for approach to the crane.
In the middle of the run between two expansion joints and at sectionalising gaps, the rails shall be rigidly fastened/supported.

**009**  
**Resistance boxes**

The resistance boxes shall be installed on frames to be welded to civil inserts already provided.

**010**  
**Cables Installations**

Interplant cabling shall be done in cable tunnel. Overhead cable bridges / concrete cable channels can be considered in case of lesser number of cables. Cables laid overhead using separate structural cable bridge with suitable walkway of minimum 800mm wide for laying of cables. Cables of small in numbers and cables for drives/field switches inside shop units shall be laid along the structures and columns of the shop / buildings. Cables may run partly in walkable cable tunnels or underground trenches and/or surface ducts in the shops and partly along the structures and columns of the buildings.

In case of space constraints/restrictions, cable shall be laid in walkable cable tunnels. Where the number of cables to be laid calls for walkable tunnels and cable shafts, same shall be provided. Underground walkable cable tunnels shall have hydro sealing to prevent water seepage.

For multi-layer installation, overhead cable bridge/walkable cable tunnels shall be used depending upon the number of cables to be laid.

Laying of cables directly in underground or in trenches shall be avoided. However, it may allowed in special case with permission from site in charge. In such case, cable shall be laid in one layer only, more than one layer is not permissible.

Cables in trenches shall be laid on 8 cm of riddled sand and covered with 8 cm of riddled sand. RCC slabs shall be provided for covering these trenches. The maximum trench depth shall normally be 1.5 m and thickness of top cover of 75 mm. If the trench is to cross railway tracks/roads or any load bearing area the cables shall be taken through suitable GI conduits/pipes/ducts.

For crossing the road / rail track, cables shall be laid in concrete cable ducts, heavy duty GI pipes . 25% spare conduits / pipes / duct openings shall be provided.

Installation of cables directly buried in ground shall generally conform to the requirements given in IS: 1255 –1983.

**011.1**  
**Laying in tunnels/surface ducts/on structures**

Cable racks for cable trays shall be fixed at a maximum interval of 1.5 m.

Cables leaving the ground/floor shall be protected upto 2-m height by conduits/metallic guards.
Ladder type cable racks and trays shall be provided to lay cables in tunnels/shafts/cable basements. Cables shall be laid in separate racks according to the voltage / application classification. Fireproof partitions such as asbestos sheets shall be provided between trays carrying LT & HT power cables, control and screened cables, communication cables, instrumentation cables & telecommunication cables. The cables shall be laid from top to bottom in order of HT on top rack followed by LT cables and other cables on lower racks.

All communication cables shall be laid through separate conduits to be installed in different routes with suitable separation from the other electrical cables. Conduits carrying special cables shall be painted, coded, marked as per plant norms.

All necessary frame works and fixings for the support of cables and accessories shall be supplied.

Cables shall be suitably protected against heat, and mechanical damages.

Cables at fire partition wall crossings shall be painted with heat resistant paint 2 m on either side of wall.

011.2 Structures for cable laying

Power cables shall be laid on ladder type cable trays. Ladder type cable trays shall be selected from sizes 300 mm, 450 mm & 600 mm and shall be fabricated from 50x50x6 mm MS angles for longitudinal members and 25x5 mm flats for cross members placed at an interval of 250 mm along the length of cable tray. Control cables shall be laid on perforated trays.

Supporting vertical racks and horizontal hooks shall be of 50x50x6 mm MS angles. Cable racks and hooks shall be of welded construction.

To avoid damage during cable laying, cable structures shall have no scales, abrasive or rough surfaces or cutting edges.

The over head cable bridge structure shall be designed considering future cable laying and shall have 30% spare space for installation of future cable trays.

Walkway of minimum 800mm wide shall be provided for laying of cables.

Two numbers additional cable trays and 20% extra space on each cable tray for future use shall be provided as far as possible.

Cable shall be fixed to racks or trays or cleats as required for proper support, accessibility and neatness of installation. Hanging of cables racks over panels shall not be permitted rather no cable shall be laid/pass over any electrical equipment e.g. transformer, switchboards etc. Cable tags shall be provided at a regular interval of 30M. For cable run shorter than 30M one cable tag shall be provided in the middle. These tags shall be in addition to end cable tags. The cable tags shall be marked with cable number, size and voltage grade. Middle tag shall be indicated with destination. The end tag shall be with second terminal point.
Cables shall be clamped rigidly at an interval of not more than 1000 mm in horizontal, and 500 mm in vertical & inclined run and at bends.

In the cable basement/cable galleries, cable structures shall be properly arranged giving sufficient clearance for movement of personnel from one part of the basement/gallery to the other. It shall also be possible to escape easily in case of fire. Cable passing through water/scale pit/acid fume etc. shall be laid in PVC pipe with PVC junction boxes and pull boxes etc. Where cable racks or trays cannot be erected or the number of cables on the route does not justify their use, cables shall be cleated direct to walls or structural steel work. Perforated trays shall only be used where necessary for the support of a number of small cables. Each tray shall be firmly supported at suitable intervals and shall carry the weight of its cables without sagging. Trays shall be painted and where the surfaces or edges are cut or otherwise impaired during erection, they shall be made good by coating with aluminium paint.

Small cables may be bunched together under one saddle provided that in any bunch all cables have sheaths of the same material. The number of cables shall not exceed four wide and two deep.

Not more than one cable shall be drawn into one conduit unless otherwise agreed. After the cable has been drawn in, the conduit shall be sealed by an approved means.

After complete installation of racks and trays etc. it shall be painted with a primer of red oxide(zinc chromate) and a top coat of finishing paint as approved.

Fire protection barrier as approved by purchaser shall be provided between HT cables on racks laid on top and LT cables on racks below the HT cable rack.

All cables shall be tested for proper insulation before start of laying work. Cables shall be laid in conduits, racks/trays, cable tunnels/trenches, along with structures or buildings, as per cable routing drawing and cable list.

Suitable adjustment shall be made in cable routes, if required at site, with a view to avoid any interference with any part of building, structures, equipment, utilities and services with the approval of the purchaser.

While laying cables, care shall be taken that kinks, twists or mechanical damage do not occur to the cable.

All bends in cables shall be made with due consideration to the minimum permissible bending radius of the cables.
Loops shall not be allowed to be formed during the laying of the cables. When being pulled, the cable shall not be allowed to drag drawing along the ground or over a second cable already laid. Special care shall be taken while pulling through an opening where other cables have already been laid. Only approved cable pulling devices shall be used.

No joints shall normally be made at any intermediate point in through run of cables unless the length of the run is more than the standard drum length. In such cases where jointing is unavoidable, the same shall be made inside proper bases having plastic moulds and shall have moulded epoxy resin construction. Provision shall be made for earthing continuity at the joint. Cable splicing and jointing shall be done in accordance with the relevant IS, code of practice and manufacturer's instructions. Insulation resistance of cables shall be checked before cable jointing.

Adequate length of cables shall be pulled inside the switch boards, control panels, control desks, etc. so as to permit neat termination.

All cables shall be neatly dressed without interlocking or cross overs. While laying the cable vertically, these shall be clamped at suitable intervals. Horizontal runs shall be rigidly secured to trays on racks/hangers in all the places where the direction of the route changes as well as at cable terminations or joints. The clamps shall not be done up so tight that the insulation is damaged or deformed.

Cable markers shall be provided on either side of road crossing at each turning and at 30 m intervals at straight runs for underground cables.

Where cables are required to cross roads, surface drains and water, oil, gas or other pipe lines, they shall be taken through reinforced spun concrete or steel pipes.

Entry of cables from underground to the buildings or trenches shall be through pipe sleeves. After laying of cables, the sleeves shall be sealed with bitumen or epoxy compound with sand matting and cement plaster to make them fully water tight. Special consideration shall be given for protection of cables against chemical and mechanical damage.

All cable entry openings in the equipment shall be sealed and made vermin proof. All cable openings in walls and floors shall be sealed after laying of cables by a weak mixture of asbestos and cement mortar.

All cables shall be provided with identification tags indicating the cable number in accordance with cable lists. Tags shall be fixed at both ends of the cable and at 15 m spacing for straight runs as well as on both sides wherever cables are crossing walls/floors. The tags shall be of aluminium/PVC with numbers punched/painted on them and securely attached to the cables by non-corrosive wires. The shape of tags
shall be round, triangular and rectangular for control, medium voltage and high voltage
cables respectively.
Glanding shall be done for direct entry of both power and control cables into the panels
by the contractor. Compression type brass or aluminium alloy cable glands shall be
used.
The cables shall be terminated in accordance with relevant connection diagram.
Termination and clamping shall be carried out in such a manner as to avoid strain on
the terminals.

All power cable terminations shall be by means of crimping type cable lugs. For
flexible conductors, soldered termination shall be adopted. In case of aluminium power
cables termination on copper bus bars, suitable aluminium copper bimetallic washers
shall be used. Corrosion inhibiting grease shall be used for aluminium cable
terminations. All 1.5 sq.mm screened cable/ 2.5 sq.mm control cable termination shall
be made by crimping using pin / fork type (as decided during engineering stage)
insulated copper lugs. The 1.5 / 2.5 sq.mm copper lugs shall be supplied by the
contractor.

Suitable numbered and coloured letter interlocking type ferrules shall be provided for
end termination of power and control cables. Cross ferruling shall be used for control
termination as far as possible

Control cable entering switch boards, control panels, control desks etc. shall be neatly
bunched and straddled with PVC perforated straps and suitably supported to keep in
position at the terminal blocks. All spare cores of each cable shall be segregated,
marked spare, neatly dressed and suitably tapped at both ends.
When the cores of two or more multicore cables take a common route in side
equipment, cores of each cable shall be separately bound and the separate bundles
neatly bound together.
Individual cores of control cables shall have plastic interlocked type coloured ferrules
with engraved numbers at both ends of the circuit for identification.

The contractor shall be responsible for correct phasing of motor power connections
and shall interchange connections at the motor terminals box, if necessary, during
each motor is test run.
The trays shall be earthed and rendered electrically continuous by welding the trays to
the grounding strip at not less than two places from both sides of the tray.

011.3 Cable Joint/termination accessories

The cable accessories shall include end termination kits, straight through joints and
also any special tool and tackles and accessories required for making the
joints/terminations.
The straight through joint/termination arrangement shall be complete with all fittings and consumables. The joint shall have electrical and mechanical withstand capability, same as that of the associated cable. For all cables, a minimum extra length of 2 metres will be left before jointing.

The termination kit shall be of heat shrinkable type only.

The termination kits/straight through joints shall have the following features:

- Electrical stress control to be provided at the cable insulation shield terminus.
- An external leakage insulation to be provided between the cable conductors and ground.
- Adequate protection to be provided at the end of the cables against the entrance of the moisture and, provision to maintain the constant pressure in the cable.

012 Exposed conduits

Exposed conduits shall be laid along walls, floors, ceilings, on steel supports etc. as per working drawings/site requirements in consultation with the supervisory personnel. The conduits shall be neatly run and evenly spaced.

Fixing of conduits to the supports on wall, column, structure shall not be done by welding. Exposed conduits shall be adequately supported by racks, clamps, straps etc.

Jointing of conduits shall be done only in straight portion and not in bend portion.

The contractor shall have available at site bending facilities for conduits as well as dies for threading conduits of diameters and threads corresponding to the standards. The threaded ends of conduits shall be painted with anticorrosive paint. The outer ends shall be smoothened free of burrs and sharp edges. Bushings shall be fitted at both ends of conduits.

Flexible metallic conduits shall be used for termination of connections to motors and other electrical equipment like pressure switches etc. which need to be disconnected at periodic intervals.

All conduits shall be effectively connected to the earth terminal of the equipment where it terminates.

Both ends of conduits shall be suitably earthed. Earthing continuity to be maintained by means of flexible wire wherever two conduits are joined with sockets.

Approved conduit bending machines to be arranged by the contractor shall be used for bending conduits at site. The radius of any conduit bend shall be as per standards for cabling. Bends shall be free from cracks, crimps or other damage to the pipe or its coating.

1.02.22 Earthing and lightning protection

01 Earthing

Entire system shall be earthed in accordance with the provisions of the relevant IEC recommendations/ IS code of practice IS 3043-1987 and Indian Electricity Rules, so that the values of the step and contact potentials in case of faults are kept within safe permissible limits.
Parts of all electrical equipment and machinery not intended to be alive shall have two separate and distinct earth connections each to conform to the stipulation of the Indian Electricity Rules and apparatus rated 240 V and below may have single earth connections.

All shops and buildings as well as the electrical sub-stations and electrical rooms shall be provided with a ring main earthing system each. Individual ring main earthing systems shall again be interconnected as a network.

The ring earthing system around each building shall be laid at a distance of approximately 1.5 m from the building and at a depth of approximately 0.8m. The ring shall be bonded at intervals to the building steel structures, reinforcement of building columns and also to pipes, wherever they are crossing. The earth ring shall further be connected at intervals to deep earthing electrodes to achieve a combined earth resistance of less than one ohm.

For the purpose of dimensioning the earthing lines/conductors, the duration of the earth fault current shall be taken as 0.3 seconds.

For different floors in a building, localized ground mats shall be formed and connected to the ground earthing ring through vertical risers. The earthing mat shall be common to both power and lighting installations.

For protective earthing separate conductor shall be used for flow of earth fault current as elaborated below.

The LV side neutrals of the Power distribution transformers shall each be connected to two separate earthing electrodes. They shall also be connected with the neutral bus of the corresponding switchgear and the switchgear neutral bus shall be connected to the earthing ring at two different and distinct points. The fourth core or armour of cables and all conduits for cables shall also be connected to the earthing mains. A continuous earth strip shall be run in each side of cable tunnel and in cable ducts and trenches.

The power supply cables (LT) from the sub-station and the distribution cables to individual motors shall have 4/3.5 cores.

LT power supply cables shall have four cores and the fourth core shall have cross-sectional area of 50% of the other cores generally. The fourth core of the main supply lines shall be connected to the solidly earthed neutral bar in the substation switchgear as well as at the earth bars in MCC/distribution boards.

Separate electronic earthing system shall be provided for all electronic equipment like PLC*s, weighing panel, computer etc.
Earthing scheme to be finalized before basic engineering, in consultation with the client and approval of OEM.

02 Conductor sizes for ground connections:

For equipment ground connections, the minimum conductor sizes used should be as follows:

02.1 High voltage systems :-

75 x 5 mm GI flat :

- Main earthing rings
- Main LT switch-boards
- Transformers
- Earthing leads to earth electrodes.

02.2 LT system where the voltage does not exceed 650V normally :

6 Sq.mm Stranded GI wire :

- Motors and starters upto and including 2.2kW, Light fitting, JBs, etc.
- Instruments and miscellaneous small items protected by fuses of ratings not exceeding 15A.

16 Sq. mm Stranded wire :

- Motors and starters above 3.7 kW and upto and including 15 kW.

25 x 3 mm GI flat :

- Motors and starters above 15 kW, and upto and including 45 kW
- Control desks, cabinets, LCB, Welding socket outlet, Isolators, LDBs.

50 x 6 mm GI flat :

- Motors and starters over 45 kW and HT motors
- MCC, PDB, MLDB.
- Main earthing ring for MCC room, in shop units/plant buildings
- Bonds to crane gantries
- Cable trays all around
- LT Switchboards and other equipment protected by circuit breakers.

03 Earthing electrodes:

The earthing electrodes shall be of GI pipes 50 mm dia and about 4 mm thickness in one piece provided with water holes and other filling devices. Earthing system for
computers and microprocessor based equipment/ PCs shall be distinct and separate from the power and lighting equipment earthing system.

**Earthing of electrical equipment on cranes and travelling machines:**
Every electrical equipment shall have double earthing.
A ring earthing system shall be provided within the crane/machine to which every electrical equipment shall be connected at least at two places.
The earth ring on the crane/machine shall be connected to the plant earthing system through the gantry rails. Two sets of earth collector brushes shall be provided on each side of crane/machine to connect its earth ring to the gantry rails.
Each end of each gantry rail shall be bonded to the plant earthing system.
In addition, intermediate earthing bond shall also be provided on the rails at every 60 m in case of longer tracks.
Flexible copper bonds shall be provided across any gap in the running gantry rails.
For mobile equipment with flexible cables, one separate copper conductor of adequate size shall be provided for earthing.

**04 Lightning protection**

All buildings and plant structures vulnerable to lightning strokes owing to their height or exposed situation shall be protected against atmospheric flash-overs and lightning strokes in such a manner as to eliminate any danger to the personnel employed therein. Stipulations of IS : 2309 - 1969 shall be followed.
A 'Faraday Cage' made of hot galvanised strip steel connected to all buried pipes and steel structures crossing this cage ring shall be laid around each main building or plant unit as earthing device. This shall be separate from the electrical equipment earthing ring main.
All lightning arrester earth leads of the buildings and plant units shall be connected to this cage ring.
Air termination network should cover all salient points of the structure. All metallic chimneys, ducts and the like above the roof of the structure shall be bonded to and form part of the air termination network. Vertical air termination points shall project at least 30 cm above the object on which it is fixed.
Down conductors shall follow the most direct path possible between air termination and earth termination avoiding sharp bends. Down conductor shall have a testing point adjacent to the earth electrode. Each conductor shall have an independent earth termination. All earth terminations shall be interconnected.
Earthing electrodes and grid for lightning protection will be distinct separate from the earthing system for earthing of electrical equipment and at no place will be connected to other earthing system.
Earthing connection to equipment subject to movement, vibration and shocks, shall be through flexible stranded conductors.
The termination of strips to the equipment shall be done by bolting and the wires shall be terminated by compression lugs. Jointing of strips shall be done by welding for proper continuity. All contact surfaces shall be thoroughly cleaned of dust and oil and after jointing, the joints shall be given bitumen paint.

Earthing conductors laid directly in ground, shall be coated with one coat of bituminised paints, be wrapped with one layer of bitumaetic tape laid on half lapped and shall have a final coat of bituminised paint to prevent corrosion. Earthing conductors run on walls/floors/cable and equipment structures etc. shall be supported at suitable intervals and painted with black oxide paint.

All joints in the branch connections except at earthing electrode shall be welded and painted black.

At road /rail crossings earthing strips shall be laid through conduits /concrete ducts. Special earthing shall be provided for all electronic equipment as per manufacturer's recommendations / practice.

1.02.23 Repair network

01 General

A repair network shall be laid to cover all the units/buildings of main technological plant for providing power to maintenance tools, tackles and telpers.

Welding switch socket outlets shall be provided at every 60m distance in conveyor galleries and atleast one at every working platform of junction houses. The number of welding socket outlets for main technological plant units shall be decided based on requirement, approach etc. Generally the socket outlets shall be provided in such a manner so that using 30m flexible cable with welding set, total plant area can be covered. Upto three switch socket outlets can be looped per feeder circuit. Sheet metal clad switch units shall be provided for feeding power to telpers.

02 Switch socket outlets

- 415V, 100 A, 3 pole load break switch
- 3 phase and one earth pin socket
- Switch socket interlocked so as to prevent insertion or withdrawal of plug when switch is “ON”.
- Facilities for terminating two cables of 3.5 x 70 sq. mm aluminium cables.
- All the switch socket outlet shall be fed from PDB directly.

03 Cables

- Outgoing feeders to switch sockets 3.5 x 70 sq. -mm for 100A sockets,
- Outgoing to telphers as per requirement.

1.02.24 Ventilation and Air-Conditioning of Electrical Premises/Control Rooms

01 General

The control rooms shall be provided with air conditioning system. For central control rooms of standby air conditioners shall also be provided.

Rooms for shift in-charge and office in-charges shall be provided with package AC units.

Separate room, as part of control room shall be provided to house AC units.

The ventilation and air-conditioning system supplied shall be complete with all necessary central air-conditioning plants (morden microcomputer based), packaged air-conditioners (micro-computer based), fresh air filters, fan units, supply and return air ducts, monitoring and regulating equipment and electrical power supply equipment to complete the job complete in all respects.

Necessary safety interlocks shall be provided to stop the fans/AC system in case of fire and to prevent spread of fire.

Window / package Air conditioners: Energy savers with temperature sensors / Time switches for switching ON/OFF of compressor motors.

The equipment shall meet the requirement listed in equipment specification under part-I.

02 Switchgear rooms, MCC rooms, Cable cellar

All HT/LT substations, switchgear rooms and MCC rooms, cable basement/cellars which do not house any electronic equipment but contain only electrical equipment, shall be pressurised with cooled washed air to maintain the room temperature within 45 deg.C irrespective of outer temperature. This shall match with the duty conditions of electrical equipment in the rooms. Where a large number of electrical equipment are involved, adiabatically cooled air washer system shall be provided to maintain room temperature at 40deg.C. Suitable capacity fan and pumps (1W+1S) shall be provided for each unit. Necessary ducts shall be supplied by tenderer.

03 Electrical rooms with electronic equipment

The electrical rooms housing electronic equipment, Remote I/Os, electronic weighing panels including telephone exchange equipment shall be air-conditioned with pressurisation to maintain the following conditions:
- Room temperature : 30 Deg.C
- Relative humidity : Not more than 50 %
- Pressurisation : 2-3 mm WC

04 Central Control rooms, Rooms for PLC, Servers, Computers and Level-1/2 automation system equipment.

These rooms shall be air-conditioned with pressurisation to maintain the following conditions:

- Room temperature : 21 to 24Deg. C
- Relative humidity : 50 to 60%
- Pressurisation : 2-3 mm WC
- Temperature gradient: 2 Deg. C/h

05 Small local Control Rooms/pulpits

The control rooms/pulpits shall be air-conditioned to maintain the following conditions:

- Room temperature : 24Deg. C
- Relative humidity : 50-60%
- Pressurisation : 2-3 mm WC

06 Cable tunnels and basements

These shall be ventilated with fresh filtered air to maintain temperature of air at exit so as not to exceed 45 deg.C and pressurised - ventilation of cable basements and tunnels shall not be combined with other premises.

Cable tunnel ventilation shall be sectionalised to maximum length of 150m.

Temperature rise shall be limited to 3-5 deg. C above atmospheric dry bulb temperature subject to a maximum of 45 deg.C at the exit of air from these premises.

Ventilation and air conditioning system shall be interlocked with fire detection system for safety.

1.02.25 Testing

Test of all equipment shall be conducted as per latest ISS/ IPSS applicable. Tests shall also confirm to International Standards IEC/VDE/DIN/BS (in case corresponding test are not mentioned in ISS/ IPSS).
All routine test shall be carried out at manufacturer’s works in the presence of purchaser or his representative.

The tenderer shall submit type test certificates for similar equipment supplied by him elsewhere. In case type test certificates for similar equipment are not available, the same shall be conducted in the presence of purchaser or his representative if purchaser so desires, without any financial implications to the purchaser.

All the equipment shall be tested at site to know its condition and to prove suitability for required performance. The site tests and acceptance tests to be performed by Contractor are detailed below.

The Contractor shall be responsible for satisfactory working of the complete system in an integrated manner and its guaranteed performance.

1.02.25.01 Type & Routine

.01 Transformers

A. Routine Tests

viii) Assembly inspection/ Painting check
ix) Measurement of winding resistance
x) Measurement of voltage ratio and check of voltage vector relationship
xi) Measurement of impedance voltage (Principal tapping), short circuit impedance and load loss.
xii) Measurement of no-load and current.
vi) Measurement of insulation resistance/ polarizatation index.
xiii) Dielectric test:
  a) Induced over voltage withstand test
  b) Applied voltage withstand test
     (H.V. power frequency test)
xiv) Certification for off-load tap changer
 xv) Final documentation check

B. Type Tests

i) Temperature rise test
ii) Measurement of acoustic sound level
iii) Lightning impulse withstand test (if test certificates are not available)
iv) Short circuit test
v) Measurement of commutating reactance and determination of inductive voltage drops (for thyristor converter transformer only).

.02 Busduct

A. Routine Tests

i) One min. power freq. withstand voltage
ii) Measurement of insulation resistance
iii) Measurement of resistance and reactance of busbars

B. Type Tests
   i) Heat run test
   ii) Short time rating test (thermal & dynamic)
   iii) Impulse withstand test
   iv) Tests for degree of protection for enclosures

.03 Power Control Centre and LT switchgear
A. Routine Tests
   i) Assembly inspection/Painting check
   ii) Measurement of insulation resistance
   iii) Dielectric test for assembled unit
   iv) Functional test including automatic bus transfer scheme
   v) Tests of ACBs including operation test, calibration of releases, measurements of contact resistances.
   vi) Polarity tests for CTs.
   vii) Final documentation check

B. Type Tests
   i) Temperature rise test for main and vertical bus-bars.
   ii) Short-circuit test for main and vertical bus-bars.
   iii) Enclosure class, degree of protection
   iv) Dielectric test including protective circuit.

.04 Load Break Isolator
A. Routine Tests
   i) Assembly inspection/surface treatment check
   ii) Power frequency voltage withstand dry test on the main circuit.
   iii) Voltage withstand test on auxiliary and control circuits.
   iv) Check of the main circuit
   v) Mechanical operating test
   vi) Insulation resistance measurement
   vii) Contact resistance
   viii) High voltage test
   ix) Final documentation check

B. Type Tests
   i) Type test for typical isolator and/or earthing switches
.05 **Current Transformer and voltage transformer**

**A. Routine Tests**

i) Assembly inspection  
ii) Power-frequency tests on primary windings  
iii) Power-frequency tests on secondary windings  
iv) Over-voltage inter-turn tests  
v) Dielectric test  
vi) Ratio & polarity test  
vii) Measurement of ratio error & phase angle error  
viii) VI characteristics  
ix) PT winding resistance  
x) Final documentation check

**B. Type Tests**

i) Short-time current test  
ii) Temperature rise test

.06 **Final Test of Materials of Grounding and lightning system**

i) Visual check  
ii) Dimensional check  
iii) Accessories fitting check  
iv) Mechanical and electrical test (where applicable)  
v) Final documentation check

07 **CABLES**

1. **Shop Tests**

a) The cables shall be subject to shop tests in accordance with relevant standards to prove the design and general qualities of the cables as below:-  

   b) Routine test on each drum of cables

2. **Acceptance tests on drum chosen at random for acceptance of the lot**

a) High Voltage withstand test for HT cable (Hi Pot test)  
b) Type tests certificates on each type of cable, inclusive of measurement of armour D.C. resistance of power cables will be furnished by Contractor

**B. PACKING**

1. Cables will suit barrel diameter and securely clamped/fixed. The barrels must be sufficiently strong to withstand mechanical shocks and shall effectively protect against transit.
2. Both ends of cable will be metal capped to prevent moisture ingression. Ends shall be kept inside the cable drum in a manner so that these are accessible for testing.

3. Cable drum identification/marking will be as follows:
   a) Makers name
   b) Consignee’s full address
   c) Type size and length of cables
   d) Net and gross weights
   e) Any other marking for shipping
   f) Drum Markings

C. Drum Lengths

1. LT Cables will be delivered at site preferably on standard drums each containing 500 m or 1000 m cables. Where total quantity of a particular cable is less than 500 m, the entire length will be supplied in one drum.

2. For 90% cable drum of each item of cable permissible tolerance is in length + 5% For 10% balance cable drums, Contractor shall ensure that each 500 m capacity drum contains at least 250m and each 1000m capacity drum contains at least 500m cable lengths. Overall tolerance for each item of cable is + 1% of total length.

08. Motors :-

A. Routine Tests
   The following are the routine tests carried out on each and every motor :
   1.0 Measurement of resistance.
   2.0 Insulation resistance test.
   3.0 Motors are tested at 1/3 times the rated voltage for checking the ability of the motor to run up to full speed, when switched in either direction.
   4.0 No load test.
   5.0 High voltage test.

B. Type Tests
   1 Measurement of rotor resistance.
   2 No load test
   3 Locked rotor test.
   4 Full load reading of voltage, current, power input and slip.
   5 Temperature rise test.
   6 Momentary overload test.
   7 Insulation resistance test.
   8 High voltage test.
   9 Polarisation index test (for HT motors)
09 SITE TESTS AND CHECKS

001 General
All the equipment will be tested at site to know their condition and to prove suitability for required performance.
The test indicated in following pages will be conducted after installation. All tools, accessories and required instruments will have to be arranged by contractor. Any other test that is considered necessary by the manufacturer of the equipment, Contractor or mentioned in commissioning manual has to be conducted at site.
In addition to tests on individual equipment some tests / checks are to be conducted / observed from overall system point of view. Such checks are highlighted under miscellaneous tests but these will not be limited to as indicated and will be finalised with consultation of client before charging of the system.
The Contractor will be responsible for satisfactory working of complete integrated system and guaranteed performance.
All checks and tests will be conducted in the presence of Client’s representative and test results will be submitted in six copies to Client and one copy to Electrical Inspector. Test results will be filled in proper proforma.
After clearance from Electrical Inspector, system / equipment will be charged in step by step method.
Based on the test results clear cut observation will be indicated by testing engineer with regard to suitability for charging of the equipment or reasons for not charging are to be brought by the Contractor.

002 Trial Run Test
After the successful test of each equipment as per standard test procedure, the entire control system will be put on trial run test on actual site conditions and operation of the system.

003 Acceptance Test
The acceptance test on the system will be carried out by the contractor as per mutually agreed test procedures to establish satisfactorily functioning of the system as a whole and each equipment as part of the system.

004 Site Tests
The tests to be carried out on the equipment at pre-commissioning stage will include following but not limited to the following:

Transformer

1. IR test on each winding to ground and between winding and check for polarization index.
2. Turns ratio test on each tap
3. Polarity and vector group test
5. Heating and drying and checking with heating and cooling curve.
Checking of earthing wrt transformer tank (flexible from top cover to tank) other parts, neutrals and tank to electrodes of LAs (for LAs located near transformer).

Testing of Buchholtz relay for alarm and trip conditions

For bushing CTs, tests applicable will be as for current transformers.

Calibration and setting of oil/winding temperature indicators, level gauge

Check insulators for cracks.

Checking for oil leakage and arresting of leakages (if required)

Checking of operation of all valves.

Checking of open operation of all valves (except drain and filter set)

Filtration of oil by using line filter and heater set

BDV test on Oil samples from top & bottom

Checking of Oil for acidity, water content and tan delta as per IS 335.

Measurement of magnetising current and no load loss.

Checking of silica gel breather.

Checking of noise level at no load and at full load.

Checking of air circulation conditions for indoor transformers.

Conducting magnetic balance test.

Checking of other points given in manufacturer’s commissioning manuals.

IR, wiring and operational tests on all control devices in control cabinet, oil level indicator winding and oil temp. indicators, oil pump, cooling fan etc.

**HT ISOLATOR**

1. IR test before & after HV test

2. HV test

3. Operational test

4. Checking of interlocking with earth switch

5. Checking of operation of earth switch

6. Checking of tightness of earth connection

7. Check for continuity of aux contacts
8. Check working of shunt trip (if applicable)

9. Checking of CTs, PTs (if applicable) as per the details given in HT board.

10. Contact resistance/ millivolt drop test

**LT SWITCHBOARD**

1. IR test
2. HV test with 2.5 kV megger
3. Functional test for all feeders
4. Testing and calibration of all meters
5. Checking and calibration of overload relays and protective relays by primary injection method.
6. Check operation of contactors from local and remote points.
7. Checking of interlocking between incomers/ bus couplers and other feeders
8. Test of prove interchangeability of similar parts.
9. Test to prove correct operation of breakers at minimum and maximum specified control voltages.
10. Checking operation of RC circuit (if there) for tripping of circuit breaker after disappearance of control voltage.
11. Checking of earthing connection for neutral-earth bus, cable armour, location of E/F CT etc. as per the scheme.
12. Checking of tests, service and drawout position of all the breakers and operations of mechanical flag indicator and electrical indication lamps.
13. Checking the functioning of various electrical schemes like auto change over, signaling etc.
14. Contact pressure test

**BUS DUCTS**

1. IR measurement before and after HV test.
2. HV test.
3. Checking tightness of bolts with torque wrench.
4. Checking for phase sequence marking.
5. Check for clearances between phase to phase and phase to earth.
6. Check for minor damages and cracks in supporting insulators and bushings after cleaning.
7. Checking of busbar cracks and rectification of same.
8. Checking for inspection openings and accessibility for replacement of insulator etc.
9. Check tightness of earthing connections on enclosure.
10. Checking of silicagel breather (if there).
11. Checking of working of space heater.
12. Hot air blowing to remove moisture if required.

Cables
1. Visual check
2. Checking of continuity and IR values for all the cables before and after HV test.
3. HV test and measurement of leakage current after termination of cable kits (for HT cables).
4. Checking of earth continuity for armour and fourth core (if applicable)
5. Check for mechanical protection of cables.
6. Check for identification (tag number system) distance placement of cable marker, cable joint etc. as per the cable layout drawing.
7. Check earthing of cable structures.
8. Check safe head room in tunnel and basement area.
9. Check clearance from ventilation duct and light fittings for cable structures.
10. Check proper fixing of cable structures.
11. Check for proper drainage and removal of water (if any).

Lightning Protection
1. Check continuity of all the earth strips / shield wire.
2. Check tightness of all connections.
3. Measure earth resistance of each electrode and combined system.

Earthing
1. Check tightness of all earth connections.
2. Check earthing of all metallic equipments, cable trays, busbar supporting structures, building column (if steel) all elect equipments, pipe lines etc. as per the drawing / specification
3. Measurement of earth resistance for each electrode.
Measurement of earth loop resistance for E/F path of biggest LT drive.

**Miscellaneous**

1. Checking of continuity of the system.
2. Checking of phase sequence from overhead line consumer end.
3. Checking safe accessibility of all operating points.
4. Check availability of emergency lighting.
5. Check availability of control aux. supply.
6. Ensure availability of first aid box, fire fighting equipments, earth discharge rods, rubber mats, rubber glove.
7. Check oil drainage system for transformer oil.
8. Check filling of gravels in transformer pits.
9. Check for safe movement of operators control room / switchgear etc., wrt proper illumination, escape light uncovered openings provision of hand railings in stairs etc.
10. Check proper covering of cable channels.
11. Placement of shock treatment chart, danger boards provision of boards indicating ‘Man on work’ Do not switch ON ‘Do not switch OFF’. ‘EARTHED’ etc.
12. Provision of route map at gallery entry points for indication of escape.
13. Check proper dressing of cables, mechanical protection of cables, placement of cable markers.
14. Check sealing of all cable openings including conduits opening with fire resistance material.
15. Check sealing of all openings at bottom of electrical panels.

**APPENDIX**

**TABLE - I**

**SELECTION OF POWER COMPONENTS & WIRING FOR CONTINUOUS DUTY CAGE MOTOR DRIVES**

Rating of MCCB / MPCB as required shall be selected based on type-2 protection.

<table>
<thead>
<tr>
<th>Motor rating at S1 duty (kW)</th>
<th>Minimum rating of MCCB in Amps (AC23)</th>
<th>Minimum rating of Power contactor Amps (AC3)</th>
<th>Minimum size of Cu wire / flat in sq. mm for internal power connection</th>
<th>Minimum size of Power cable (Al.) termination in sq.mm.</th>
</tr>
</thead>
</table>
1.02.27 ILLUMINATION

1.0 General

The lighting system inside and outside plant units are designed based on the desired illumination levels recommended by IS and the practices followed in industries, architectural arrangement, building dimensions including mounting height, environmental considerations, ease of maintenance and reliability of the lighting distribution network.

2.0 The illumination system shall be designed as per IS:3646-1992. The level of illumination, type of fittings, maintenance factor to be considered is as given below:

<table>
<thead>
<tr>
<th>Area</th>
<th>Type of Light Fittings</th>
<th>Lux level</th>
<th>MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control rooms</td>
<td>Louvered recessed type 2x40W &amp; 4x20W fluorescent fittings</td>
<td>300</td>
<td>0.75</td>
</tr>
<tr>
<td>Electrical rooms having PDB, MCC, VFD, panels, PLC</td>
<td>Industrial corrosion proof fluorescent lamp fittings for 2x36W fluorescent lamps Philips type TKC 22/236 or equivalent</td>
<td>200</td>
<td>0.7</td>
</tr>
<tr>
<td>Staircases of plant buildings - do -</td>
<td></td>
<td>70</td>
<td>0.6</td>
</tr>
<tr>
<td>Staircases (steel) of plant</td>
<td>Industrial well-glass integral type luminaire</td>
<td>70</td>
<td>0.6</td>
</tr>
</tbody>
</table>
complex and cable tunnels / cellars

<table>
<thead>
<tr>
<th></th>
<th>suitable for 70W HPSV lamps, similar to Philips type SDL-23/70 or equivalent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump house</td>
<td>- do -</td>
<td>200 0.6</td>
</tr>
<tr>
<td>Flood lighting</td>
<td>Weather proof flood light fittings for 1x400W HPSV lamps Philips type H/SVF12 or equivalent</td>
<td>70 0.5</td>
</tr>
<tr>
<td>Pipeline tunnel</td>
<td>Industrial fittings for 24V, 2x50W halogen lamps “Sigma” make deck lights or eqvt.</td>
<td></td>
</tr>
<tr>
<td>Casting Bay</td>
<td>High bay HPSV industrial incandescent (1000 W) equivalent to HDK /SDK of PHILLIPS make</td>
<td>200</td>
</tr>
<tr>
<td>Conveyor Houses / conveyor gantries / junction houses</td>
<td>Fluorescent / incandescent industrial type fitting equivalent to TPW / NXC of PHILLIPS make</td>
<td>70 to 100</td>
</tr>
<tr>
<td>Aviation obstruction</td>
<td>Aviation obstruction light fittings, flame retardant type consisting of multi ultra high intensity 60 mscp LED module, without flashing module, steady in red colour, having omni directional capability and shall be suitable to deliver maximum light output in the zone between 70° above and 10° below the horizontal with a maximum of condition at 20° above the module.</td>
<td></td>
</tr>
</tbody>
</table>

a) Standard wattage of lamps shall be

1. FTL
   36 W high luminous lamps.
2. HPMV
   250 and 400 W
3. HPSV
   70, 150, 250 and 400 W
4. Incandescent
   60, 100 W (Use of Incandescent lamps shall be avoided)

b) Compact fluorescent lamps are to be used for offices and corridors.

c) All switches and sockets used in office buildings shall be of flush type

d) For street lighting, necessary control gear shall be provided for reduced voltage running during off peak traffic for energy conservation.

Illumination: Electronic ballast having third harmonic distortion less than 6 % and total harmonic distortion less than 12 % with high luminous tube lights are to used. Time switches, reduced voltage controllers, group solar lighting sections for remote areas shall be provide wherever feasible. Lighting Fixtures and Accessories shall be energy efficient

3.0 Area Lighting :-

<table>
<thead>
<tr>
<th>Classification</th>
<th>Type of road</th>
<th>Av. Lux level</th>
<th>Type of illumination</th>
<th>MF</th>
</tr>
</thead>
</table>

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| Group - A1 | Important traffic road carrying fast traffic | 30 | Cut off / semi cut off | 0.6 |
| Group - A2 | Main road carrying mixed traffic | 15 | Cut off / semi cut off | 0.6 |
| Group - B1 | Secondary road with considerable traffic | 8 | Cut off / semi cut off or non cut off | 0.6 |
| Group - B2 | Secondary road with light traffic | 4 | Cut off / semi cut off or non cut off | 0.6 |

**MF :** Maintenance factor

The light fittings shall be complete with all accessories like electronic ballast, reflector etc. External area lighting including street/road lighting / tower lights shall be fed from MLDB through separate SLDB located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers. Flood light towers shall be fed through 415/240V, 3 phase, 4 wire circuit with individual fittings distributed at 240V, single phase, with control and protection located at bottom of each tower. Rewireable fuse in a sheet steel box shall be provided near each fitting to facilitate removal of lamp in off position. In high bays walkway shall be provided for maintaining light fittings. At other places suitable ladder/platform/approach shall be provided for maintaining/replacement of light fittings.

**B. Power distribution**

1.0 The distribution of lighting power supply for the individual areas shall be done at 415V, 3 phase, 4 wire bus system through Main Lighting Distribution Boards (MLDB) for the area. The MLDB shall be fed through a lighting transformer. The outgoing feeders of the MLDB shall feed the required numbers of Sub Lighting Distribution Boards (SLDB) for lighting. Each SLDB shall receive power at 415V AC, 3 phase, 4 wire and distribute it into 240V, 1 phase circuits for connection to the lighting fixtures and 240V receptacles. The SLDB shall be located in the rooms, bays etc. covering the respective zone. The SLDB shall be located in the electrical rooms in the respective area.

2.0 **Emergency lighting**

In case of indoor illumination, separate lighting circuit shall be provided as emergency lighting circuit. Emergency lighting circuit shall be through emergency MCC/PDBs so that in case of failure of power in lighting DBs circuit, these lights can continue to glow. 20% lights shall be connected to this circuit. Balance lights shall be connected through lighting circuit. Portable Emergency lighting including built-in battery, battery charger & lamps shall be provided in strategic areas like control rooms, staircases, entry of cable tunnels/basements, escape routes, etc. for safety.

3.0 **Maintenance lighting**

For maintenance lighting, power supply shall be fed from 240/26.5V small capacity step-down transformers to the 24V socket outlets.

4.0 **Outdoor lighting**
Flood lights for area lighting shall be mounted on towers/poles or building structures. Tower height shall be kept to an average of 22m.
Street/road lighting and boundary wall lighting shall be provided with HPSV/fluorescent lamp fittings mounted on poles of 9m to 11m height.
Neon aviation obstruction lights shall be provided on chimneys and other such tall installations as per regulation. M/S Binay or equivalent make aviation obstruction lights (LED type) shall be provided. For street lighting necessary control gear shall be provided for reduced voltage running during off peak traffic for energy conservation.

5.0 **Power factor improvement**

Power factor of all the light fittings shall be improved so that it is not less than 0.90. Power factor shall be improved by providing capacitor banks with discharge resistor in the light distribution or by providing capacitors with individual fittings.

C. **SPECIFICATIONS :-**

A. **EQUIPMENTS AND COMPONENTS**

1. **Lighting Transformer**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Type</td>
<td>Dry Type</td>
</tr>
<tr>
<td>2.0</td>
<td>Power Rating</td>
<td>As per load calculation</td>
</tr>
<tr>
<td>3.0</td>
<td>Primary Voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>4.0</td>
<td>Secondary Voltage</td>
<td>415 V</td>
</tr>
<tr>
<td>5.0</td>
<td>Connection</td>
<td>Star - Star</td>
</tr>
</tbody>
</table>

2. **Main Lighting Distribution Board (MLDB)**

A. **General**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td></td>
<td>- Metal clad .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Non drawout type.</td>
</tr>
<tr>
<td>2.0</td>
<td>Construction</td>
<td>- Modular construction .</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Fully compartmentalized with metal / insulating material partition.</td>
</tr>
<tr>
<td>3.0</td>
<td>Enclosure class</td>
<td>IP52</td>
</tr>
<tr>
<td>4.0</td>
<td>Type of execution</td>
<td>Single front.</td>
</tr>
<tr>
<td>5.0</td>
<td>Mounting</td>
<td>- Floor mounting.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Free standing with ISMC 75.</td>
</tr>
<tr>
<td>6.0</td>
<td>Installation</td>
<td>Indoor.</td>
</tr>
</tbody>
</table>

B. **Constructional Features :-**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Component</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Sheet steel</td>
<td>- 2 mm for load bearing members.</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>- 1.6 mm for non load bearing members.</td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>CRCA</td>
</tr>
<tr>
<td>2.0</td>
<td>Cable entry</td>
<td>- Incomer :- Bottom cable entry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Outgoing :- Bottom cable entry.</td>
</tr>
<tr>
<td>3.0</td>
<td>Design</td>
<td>- Separate bus alley and cable alley on opposite side of the outgoing modules.</td>
</tr>
</tbody>
</table>
### STEEL AUTHORITY OF INDIA LIMITED
### BHILAI STEEL PLANT
### GENERAL TECHNICAL SPECIFICATION

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
</table>
| 4.0 Interlocking & protection | - Module door interlocked with main power isolating devices.  
- Power circuit isolation device to have pad locking in the OFF position with door closed. | |
| 5.0 Operating height | - Minimum : 300mm  
- Maximum : 1800 mm. | |
| 6.0 Gland plate | Undrilled removable bottom gland plates (3 mm thick) | |
| 7.0 Miscellaneous | - Neoprene rubber gasket shall be provided for all the doors, removable covers & between adjacent covers.  
- Lifting hooks for the panel.  
- Doors shall have concealed hinges. | |
| 8.0 Labelling | Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of: - 25-50 mm for MLDB panel  
- 5 mm for components and module name plates.  
- Danger board on front and rear sides in English, Hindi and local language. | |
| 9.0 Earthing | - Two separate earthing terminals will be provided.  
- Bolted joints with tooth spring washers for good earth continuity.  
- Earth bus to run in all cable alley of the panel. | |
| 10.0 Shipping length | To be limited to 2.4 M. | |
| 11.0 Limiting dimensions | - Width of MLDB : 2400 mm  
- Depth of MLDB : 500 mm  
- Width of Cable alley : 300 mm  
- Width of Bus alley : 300 mm  
- Height of module : 400 mm (min) | |
| C. Busbars | (i) Main horizontal & vertical busbars | |
| 1.0 Arrangement | Three phase & neutral. | |
| 2.0 Material | High conductivity electrolytic aluminium alloy confirming to grade E91E as per IS-5082 –1981. | |
| 3.0 Phase Busbar Rating | - Shall be able to carry continuously the connected load (considering all derating factors) plus a 25% margin.  
- Max. current density shall be  
  - 1.0 A/sq.mm for Aluminium  
  - 1.5 A/sq.mm for Copper. | |
| 4.0 Neutral Busbar Rating | 50 % of phase busbar rating | |
| 5.0 Short circuit rating | 50 KA for 1 sec. | |
| 6.0 Busbar configuration | Red-yellow-blue from front to back or top to bottom or left to right as viewed from front. | |
| 7.0 Busbar insulation | Heat shrinkable PVC  
- R,Y,B coloured sleeves for phases  
- Black for neutral. | |
| 8.0 Busbar supporting insulators | - Non-hygroscopic  
- Flame retarded | |
| 9.0 | Max. temp. rise of bus | Not to exceed 35 deg. C. above ambient of 50 deg.C. |
| 10.0 | Air clearance for bare busbar | Phase to phase :- 25.4 mm (minimum)  
Phase to earth :- 19.0 mm (minimum) |
| 11.0 | Joints and tap off points | - Busbar joints and tap off points shall be shrouded and bolted (with cadmium coated bolts with plain and spring washers and locknuts).  
- Bimetallic connectors for connection between dissimilar metals.  
- Antioxide grease for all bus connections. |
| 12.0 | Neutral bus isolation | Through disconnecting link. |
| 13.0 | Vertical busbar | Rear side |

(ii) Earth bus

| 1.0 | Material | GI. |
| 2.0 | Size | Minimum 50 x 6 mm with extension at both ends. |

(iii) Control bus

| 1.0 | Material | Copper. |
| 2.0 | Size | Minimum 25 x 3 mm. |

D. Insulation level

| 1.0 | Rated insulation voltage | 1100 V |
| 2.0 | Impulse withstand voltage | 4 KV as per IS-13947 (Part I) 1993 |
| 3.0 | One minute power frequency withstand voltage | 2.5 KV for power circuit & 500 V for control circuit |

E. Pollution Degree

| 1.0 | Pollution Degree | Pollution Degree 3  
as per IS-13947 (Part-1) : 1993 ;  
unless otherwise stated |

F. Feeder arrangement

Incomers

| 1.0 | Isolating Equipment | 3 pole MCCB (for rating upto 630 A)  
(with E/F protection). |
| 2.0 | Quantity | Two incomer |
| 3.0 | Autochangeover | - Through contactor logic with suitable timer.  
- Normally only one Incomer shall be ON. |
| 4.0 | Indication Lamps | LED type indicating lamps for :-  
- MCCB ON/OFF/TRIP.  
- Power ON R / Y / B. |
| 5.0 | Meters and selector switches | - 144 sq.mm size voltmeter with 7 position selector switches  
- 144 sq.mm size ammeter with 4 position selector switches |
| 6.0 | Current transformer | 3 numbers for metering. |

Outgoing feeder arrangements

| 1.0 | Circuit breaker | Three pole MCCB |
| 2.0 | Indications | ON/OFF/TRIP indication lamp. |
| 3.0 | Protection | All the equipment inside the boards shall be covered in front with a 3 mm thick bakelite sheet. Only the operating knobs of the equipment shall be projected outside the bakelite sheet for safe operation. |
### G. Panel wiring

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Power / current transformer circuit</td>
<td>1.1Kv grade single core, black colour PVC insulated, stranded copper conductor of minimum size 2.5 sq.mm.</td>
</tr>
<tr>
<td>2.0</td>
<td>Ferrules</td>
<td>Numbered plastic/ceramic ferrules. Self locking type.</td>
</tr>
<tr>
<td>3.0</td>
<td>Marking</td>
<td>Wiring will be properly marked as per relevant IS.</td>
</tr>
<tr>
<td>4.0</td>
<td>Terminals</td>
<td>Power &amp; control terminals shall be segregated by insulating material like hylam / bakelite sheet. Power terminals will be stud type. Control terminals will be ELMEX type suitable for connecting two cores of 2.5 sq.mm wires. Minimum 20% spare terminals will be provided. The minimum rating of control terminal shall be 10 Amps.</td>
</tr>
<tr>
<td>5.0</td>
<td>Cable glands</td>
<td>Double compression cable glands for receiving external power and control cables</td>
</tr>
</tbody>
</table>

### 3.0 SUB LIGHTING DISTRIBUTION BOARD (SLDB)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Type</td>
<td>Metal clad. Shall be suitable for 415/240V, 3 phase and neutral.</td>
</tr>
<tr>
<td>2.0</td>
<td>Construction</td>
<td>Totally enclosed. Dust &amp; vermin proof. Welded back and sides.</td>
</tr>
<tr>
<td>3.0</td>
<td>Enclosure class</td>
<td>IP54. IP 55 (with canopy) for outdoor installation.</td>
</tr>
<tr>
<td>4.0</td>
<td>Type of execution</td>
<td>Single front.</td>
</tr>
<tr>
<td>5.0</td>
<td>Mounting</td>
<td>Wall mounting.</td>
</tr>
<tr>
<td>6.0</td>
<td>Installation</td>
<td>Indoor / Outdoor (with canopy).</td>
</tr>
</tbody>
</table>

### B. Constructional Features :-

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Sheet steel CRCA Thickness</td>
<td>2 mm.</td>
</tr>
<tr>
<td>2.0</td>
<td>Cable entry</td>
<td>One Incomer and outgoings. Incomer :- Bottom cable entry. Outgoing :- Top / Bottom cable entry.</td>
</tr>
<tr>
<td>3.0</td>
<td>Design</td>
<td>All the components shall be accessible from front. Access to the operating handle of the incoming isolating switch shall be from the front of the cubicle without opening the front door. Operating knobs of outgoing MCBs shall be accessible only after opening the front door of the cubicle. Protective insulated cover plate (3 mm thick bakelite sheet) shall be provided inside the cubicle to shroud all the live parts.</td>
</tr>
<tr>
<td>4.0</td>
<td>Gland plate</td>
<td>Undrilled detachable gland plates (3 mm thick) shall be provided at the top and bottom with suitable gaskets for cable entry.</td>
</tr>
<tr>
<td>5.0</td>
<td>Miscellaneous</td>
<td>Neoprene rubber gasket shall be provided for all the doors, removable covers &amp; between adjacent covers. Suitable locking devices.</td>
</tr>
<tr>
<td>Section</td>
<td>Requirement</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>Labelling</td>
<td></td>
</tr>
</tbody>
</table>
|         | Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of:  
|         | - 5 mm for components and module name plates.  
|         | - Danger board on front and rear sides in English, Hindi and local language. |
| 7.0     | Earthing    |
|         | Two separate earthing terminals will be provided. |
| 8.0     | Limiting dimensions |
|         | - Width of SLDB 800 mm  
|         | - Depth of SLDB 300 mm  
|         | - Height of SLDB 400 mm (min) |
| 9.0     | Paint shade |

### C. Busbars

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Arrangement</td>
</tr>
<tr>
<td>2.0</td>
<td>Material</td>
</tr>
<tr>
<td>3.0</td>
<td>Phase Busbar Rating</td>
</tr>
<tr>
<td>4.0</td>
<td>Neutral Busbar Rating</td>
</tr>
<tr>
<td>5.0</td>
<td>Short circuit rating</td>
</tr>
<tr>
<td>6.0</td>
<td>Busbar configuration</td>
</tr>
<tr>
<td>7.0</td>
<td>Busbar insulation</td>
</tr>
<tr>
<td>8.0</td>
<td>Busbar supporting insulators</td>
</tr>
<tr>
<td>9.0</td>
<td>Air clearance for bare busbar</td>
</tr>
</tbody>
</table>

### F. Feeder arrangement

#### Incomers

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Isolating Equipment</td>
</tr>
<tr>
<td>2.0</td>
<td>Quantity</td>
</tr>
<tr>
<td>3.0</td>
<td>Indication Lamps</td>
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#### Outgoing feeder arrangements

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Circuit breaker</td>
</tr>
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</table>

### G. Panel wiring

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Requirement</th>
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<tbody>
<tr>
<td>1.0</td>
<td>Power / current transformer circuit</td>
</tr>
<tr>
<td>2.0</td>
<td>Ferrules</td>
</tr>
<tr>
<td>3.0</td>
<td>Marking</td>
</tr>
</tbody>
</table>
### 4.0 Terminals
- Power & control terminals shall be segregated by insulating material like hylam / bakelite sheet.
- Terminals shall be ELMEX type suitable for connecting two cores of 2.5 sq.mm wires.
- Minimum 20% spare terminals will be provided.
- The minimum rating of control terminal shall be 10 Amps.

### 5.0 Cable glands
Double compression cable glands for receiving cables.

### 4.0 Control Room Switchboard

| 1.0 Location | Control room for controlling the lighting fixtures |
| 2.0 Type | Flush mounted type |
| 3.0 Construction | Fabricated from 14 SWG MS sheet with 6mm thick bakelite cover. Shall have conduct knockouts on the sides. |
| 4.0 Switch mechanism | Quick make and quick break mechanism |
| 5.0 Power source | The switchboards shall be fed from SLDB of respective area. |

### 5.0 Transformer for 24V AC Sockets

| 1.0 Type | Dry type |
| 2.0 Rating | Minimum 2500VA |
| 3.0 Primary / secondary voltage | 240V / 26.5 V AC, single-phase |
| 4.0 Construction | The transformer shall be enclosed in industrial wall mounting stainless steel (2 mm thick) box having separate chambers for the transformer, incoming and outgoing MCB's. |
| 5.0 Cable entry | Suitable knock-outs shall be provided at the top and bottom for cable entry through GI pipes. |
| 6.0 No. of winding | Two winding |
| 7.0 Protection | SPN MCB's on primary and secondary side incorporating overload and short circuit releases. |
| 8.0 Utility | Power supply to 24V repair network |
| 9.0 Location | On structural platforms |

### 6.0 24 V AC SWITCH SOCKET OUTLET

| 1.0 Type | 2 pole, 3 pin with third pin earthed industrial type receptacles |
| 2.0 Rating | 24 V AC, 5A |
| 3.0 Construction | Metal clad gasketted construction, weatherproof |
| 4.0 Cable entry | Suitable for cable entry through 20mm dia. conduit. |
| 5.0 Mounting | Wall / column mounting |

### 7.0 240V SWITCH SOCKET OUTLET

| 1.0 Type | 1 pole, 3 pin with third pin earthed industrial type receptacles. non-reversible, metal-clad, dust proof, industrial type suitable for horizontal insertion. |
| 2.0 Rating | 240 V AC, 15A |
| 3.0 Construction | Metal clad gasketted construction, weatherproof |
All socket outlets will be supplied with heavy-duty type plug and cap with chain.

4.0 Isolation Switch rotary type switch mounted flush in the socket outlet box. The isolating switches will be manually operated industrial type of category AC 22.

5.0 Protection Operating handle of the rotary switch will be fixed in such a manner that it will not be possible either to insert or withdraw the plug without switching off the supply.

6.0 Cable entry Suitable for cable entry through 20mm dia. conduit.

7.0 Mounting Wall / column mounting

8.0 Inscription Inscription plate will be provided indicating the voltage and current rating of the switch socket outlet.

9.0 Miscellaneous In hazardous area, flame proof switch socket outlet will be provided.

### Miniature Circuit Breakers

<table>
<thead>
<tr>
<th>1.0 Type</th>
<th>Heat resistant plastic moulded type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 Ref. Standard</td>
<td>IS: 8828 –1978</td>
</tr>
<tr>
<td>3.0 Protections</td>
<td>MCBs shall be provided with quick break trip-free mechanism and direct acting thermal overload and short circuit trip elements.</td>
</tr>
<tr>
<td>4.0 Short circuit capacity</td>
<td>Not less than 9000A at 0.8pf</td>
</tr>
<tr>
<td>5.0 Mounting</td>
<td>DIN Channel mounting. Single phase MCBs mounted adjacent to each other and connected to different phases will be provided with adequate insulated phase barriers.</td>
</tr>
<tr>
<td>6.0 Current Rating</td>
<td>The MCBs shall be selected from standard current ratings,(Asper SLD) MCB shall confirm to curve C. Motor duty MCBs will be provided, if specified.</td>
</tr>
</tbody>
</table>

### 240 V SINGLE/ DOUBLE POLE SWITCHES

<table>
<thead>
<tr>
<th>1.0 Application</th>
<th>The switches are intended for controlling lighting circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 Type</td>
<td>Weather and dustproof and industrial type</td>
</tr>
<tr>
<td>3.0 Design</td>
<td>The rotary or toggle switches provided will be of sturdy design</td>
</tr>
<tr>
<td>4.0 Standard</td>
<td>As per IS : 6875 (Part-3) - 1980</td>
</tr>
<tr>
<td>5.0 Housing</td>
<td>The unit will be housed in cast iron or cast aluminium box having gasketted, screwed front cover plate, fixing lugs and suitable provision for terminating conduit/cable at the top, bottom or sides as specified.</td>
</tr>
<tr>
<td>6.0 Mounting</td>
<td>DIN Channel mounting. Single phase MCBs mounted adjacent to each other and connected to different phases will be provided with adequate insulated phase barriers.</td>
</tr>
<tr>
<td>7.0 Terminal suitability</td>
<td>Terminals suitable for aluminium conductor cables.</td>
</tr>
</tbody>
</table>

### Cabling and Wiring

All wiring from SLDB to lighting fixtures and receptacles shall be carried out with 1100V / 650V grade PVC insulated and PVC sheathed unarmoured cable in MS / GI pipes. For each outgoing phase conductor from the MCB of SLDB, one no. neutral conductor shall be taken.
from the same SLDB and shall run along with the phase conductor throughout the length of the cable run upto the luminaires.

02 All lighting cables for the entire complex shall be PVC insulated with copper conductors.

C. Lighting Fixtures and Accessories

01 All the luminaires will be designed, manufactured and tested in accordance with the Indian Standards in so far as they are applicable. Lighting Fixtures and Accessories shall be energy efficient.

02 All the luminaires will be industrial type. Specification for the various types of sodium vapour and fluorescent fittings mentioned in the schedule of quantities will be followed. All the lighting fixtures will be complete with all parts along with lamps/tubes, control gears and accessories for installation and efficient performance whether specifically mentioned in the specification or in the schedule of items or not.

03 Individual light fittings will be provided with suitable gland arrangements for 3x2.5 sq.mm armoured copper cable entry unless otherwise specified. Terminals of all fittings will be suitable for taking 3x2.5 sq.mm, copper conductor PVC insulated and PVC sheathed cable.

04 All fittings will be supplied with all interconnections made and fully wired upto the terminal block.

05 All live parts will be provided with suitable sleeves to prevent accidental contacts. The earthing terminal in the fitting will effectively earth the body of the entire luminaire.

06 Dust and vapour tight fittings will have the enclosures suitably designed to withstand the heating effect.

07 The fixing arrangement of various components and lamps will be in such a way that the maintenance and replacement jobs can be easily carried out.

08 All flameproof equipment will be provided with flameproof plugs.

09 Flame proof fittings and control gearboxes will be provided as per relevant IS in hazardous area.

D. ILLUMINATION FITTINGS

1.0 OUTDOOR LIGHTING FITTINGS.

All road lighting fittings will be mounted on steel tubular poles with single/ double or triple outreach brackets having sodium vapour lamps. The fittings will be cut-off / semi cut-off distribution and integral type.

For lighting of open areas self-supporting steel towers shall be provided with flood light fittings and sodium vapour lamps.

2.0 FLUORESCENT FITTINGS

2.01 DECORATIVE FLUORESCENT LIGHT FITTING

Decorative type fluorescent tube light fitting complete with stove enamelled mounting rail, polyester filled ballast, spring loaded rotor lamp holders, starter holder and starter, power factor correction condenser to improve the power factor to 0.95 and acrylic diffuser. Provision will be made for mounting the fitting end to end in continuous row and/or for mounting individually using high impact black polystyrene end plate. All the fluorescent tube lights fixtures shall have electronic ballast having third harmonic distortion less than 6% and total harmonic distortion less than 12%.

2.02 INDUSTRIAL TYPE FLUORESCENT LIGHT FITTING
The fitting will have channel and reflector made of CRCA sheet steel with white cover plate. Channel and reflector will be finished with light Grey stove enamelled outside and white stove enamelled inside. The fitting will be complete with all electrical accessories like polyester filled ballast, starter, spring loaded rotor lamp holders, starter holder, power factor improvement capacitor to improve the power factor upto 0.95 etc. All the fluorescent tube lights fixtures shall have electronic ballast having third harmonic distortion less than 6% and total harmonic distortion less than 12 %.

All types of fluorescent fittings will be suitable for mounting on wall/ceiling/conduit suspension.

2.02.1 WELL GLASS FITTINGS
Well glass lighting fitting will be fitted with sodium vapour or mercury vapour lamps. These fittings will be suitable for hanging by means of hangers, brackets, hooks etc. as required. All fittings will be integral type.

2.02.2 FLOOD LIGHT FITTING
- Sodium vapour flood light fittings are required for area lighting as specified in schedule of quantities.
- The flood light fitting will be weatherproof and suitable for outdoor duty. The housing/enclosure will be of die cast Aluminium alloy and finished with hammertone Grey. The enclosure of the luminaries will be provided with a flat toughened glass in the front. Adequate gasketting will be provided with synthetic rubber for making the luminaries completely weatherproof. The fitting will be provided with facility to position the luminaries for effective lighting at the target area. The fitting will also be provided with graduated protractor to aid accurate aim and ensure a con-trolled light distribution.
- High quality polished Aluminium will be used in the reflector to ensure powerful light beams. The reflector will be anodised to enhance the longevity and contoured in multiple segments for optimum optical performance. The fitting will be provided with GES porcelain lamp holder. The control gear housing (separate control gear-non-integral type) will be housed with copper wound ballast, perfected improvement capacitor and terminal block. An electronic igniter will be provided in the luminaries.
- All the control gear components will be pre-wired in all respects and terminated to the terminal block for incoming cables. The fitting will be provided with earthing terminal and wiring will be done by multi-strand copper conductor. All the fasteners will be electroplated and passivated. The fitting will be suitable for twin/Single 400 watts HPSV lamps.

2.02.3 STREET LIGHT FITTING
- Street light fittings will be suitable for outdoor duty in weatherproof, single piece die cast Aluminium enclosure, finished with epoxy paint outside and stove enamelled inside. The fitting will be provided with GES porcelain lamp holder, and anodised Aluminium reflector with facility for obtaining cut off as well as semi-cut off light distribution. These will also be provided with high transparency clear acrylic cover with neoprene rubber gasket to make them absolutely dust and weather proof. Control gear compartment will be provided with detachable CRCA steel, pre-wired with ballast, capacitor, igniter and terminal blocks for incoming supply. Fittings will be provided with earthing terminals and wiring will be done with multi-strand copper conductor.
- All the fasteners will be electroplated/passivated and mounting arrangement will be suitable for direct mounting on poles having maximum 65 mm. OD with provision for holding the pipe in extended portion of control gear by means of clamps

2.02.4 FLAME PROOF FITTINGS
Flame proof type fittings will be well glass type luminaries suitable for use with HPLN 250W (High pressure Mercury Vapour) lamp with separate control gear complete with copper ballast, power factor improvement capacitor, terminal block enabling loop-in-loop out connection. Both fittings & control gear will be of cast Aluminium alloy LM6 or cast iron stove enamel, Grey hammertone finish outside and white inside.

The control gear box and enclosure for fittings will have certification from CMRS, Dhanbad and will be suitable for gas groups IIA & IIB as per IS 2148-1981. The fittings will be designed as per IS 2206 (Part-I) -1987. The material for cable gland will be brass/stainless steel/aluminium alloy LM6 and will be double compression type suitable for indoor/outdoor use. These are must for every flameproof fittings and accessories.

2.02.5 CONTROL GEAR, LAMP & ACCESSORIES

- Lamps

Sodium vapour lamps will be suitable for universal burning position. The characteristics of the lamps will be in line with the relevant Indian Standards. The outer bulbs will be elliptical hear resistant type, evacuated to minimise heat losses and coated with light diffusion film for pleasing colour discharge. The lamp will be provided with corrosion resistant, nickel-plated screw base.

- Ballast's

All ballast's will be of proven design and capable of delivering long trouble free service. The ballast's will be made up of low loss silicon with steel lamination and will be wound with polyester-based super enamelled copper wire. The ballast will be polyester filled and able to dissipate the heat efficiently so as to keep the temperature rise well within the limits specified in the IS.6616-1972. The ballast will be provided with tapping at 200,220 and 240 volts and will be suitable for HPSV lamps.

- Capacitors

Capacitors will have element wound from layers of high purity Aluminium foils laid over the two faces of capacitor paper. The Aluminium cylindrical case containing the elements will be dried under high vacuum and impregnated before being sealed. The solder type lug terminals will be mounted over porcelain insulators at the sealed end and the capacitor will conform to IS: 1569. The value of capacitance will be chosen as to raise the power factor of burning lamps to above 90%.

- Igniters and Starters.

Igniters for HPSV lamps will be of proven design and capable of delivering long trouble free operations. The igniter and starters will be suitable for tropical condition and conform to IS: 2215-1968.

- Lamp and Starter Holders

Lamp and starter holders will have good spring contacts and of well tried out design. The spring contact will be such as to prevent disconnection due to vibration during cleaning. They will also have facility for easy removal.

3.0 Street Lighting Poles

Lighting poles will be fabricated from GI of specified section with joints swaged together when hot and bevelled on outside edges. A weatherproof sheet steel junction box will be provided at the bottom of the pole and contain fuse, neutral link, bolted type terminals, grounding stud etc. The bolted type terminals will be suitable for receiving 4 x 16 mm2 AYFY cables with loop-in-loop out arrangement GI conduits will be embedded in the muff for incoming and outgoing cables.
The street light poles of 9M height will be conforming to: 410-SP-29
The street light poles of 7M height will be conforming to: 410-SP-3
All erection consumables like bricks, sand, cement stone chips etc. for foundation of poles will be supplied & erected

4.0 High Mast Lighting Tower

4.01 Mast Proper

The mast will be 30 meter’s high and designed in such a manner that it is capable of withstanding external forces exerted by wind pressure as per IS: 875 (Part 3)-1992 along with load of the lantern carriage assembly.

4.02 Mast Construction

The mast will be fabricated from special steel plates conforming to BS 4360 cut and folded to form number of polygonal sections, giving a continuous tapered profile for stability and aesthetics. Silicon content in steel should not exceed 03% for good quality galvanisation. Bottom section will be provided with plate welded to it for anchoring the mast to a reinforced concrete foundation block. To increase the strength, gussets will be provided.

The bottom section will be accommodate winch, electric drive etc. and for the safety of the same a vandal resistant and weather proof door will be provided with locking arrangement.

The fabricated and welded mast sections as detailed above will be hot dip galvanised with a minimum thickness of coating 90 microns conforming to IS 4759-1996, IS: 2629-1990 & IS: 2633-1992, both internally and externally.

After the delivery of the mast at site, these will be jointed by slip stressed fit method with necessary stressing equipment. No site welding or bolted joints will be accepted. Earthing terminal will be provided on the mast base and feeder pillar-box as per relevant ISS.

The mast will be provided with suitable aviation obstruction lamp.

4.03 Head Frame

The head frame designed to be a capping unit of the mast will be of welded steel construction, galvanized internally and externally after assembly.

The head frame assembly will accommodate specially designed LM 6 die-cast pulleys to accommodate the wire ropes and cable. Pulley construction will ensure that wire rope does not jump out of the grooves.

The suspension arrangement for lantern carriage will be with three ropes of stainless steel running on three on three pulleys for superior stability. There will be a separate pulley for running the electric supply cable.

The pulleys will run on stainless steel shaft/spindles and will be self lubricating type.

The whole head frame assembly will be covered and protected by steel canopy, hot dip galvanized internally and externally and secured to frame by stainless steel hardware.

4.04 Lantern Carriage

It will be of mild steel construction and hot dip galvanized internally and externally. The lantern carriage will be so designed and fabricated to hold designed number of flood light fittings and their control gearboxes, radically symmetrical. All junction boxes, Controlgear, fittings etc. mounted on the lantern carriage will be on non-corrodable material with class of protection IP 55.
At the top docking position, combined guides and stops will ensure concentricity between the lantern carriage and the masthead. The stops will also help to ensure proper levelling and positioning of the lantern carriage at its top position. All the lower docking position, the lantern carriage will rest firmly at a maintainable height from the ground level with the help of stoppers for ease of maintenance.

During lowering/raising operation the design will ensure that there is no damage caused to the mast surface and any other parts installed.

4.05 Winch Assembly
The winch will be self sustaining and self lubricating type specially designed without the need of breaks, springs or clutches, and will consist of two drums fabricated from steel with machined grooves and mounted inside the mast at a convenient height from the base.

The wire rope will be wound on the drum with one end attached to the lantern carriage while the other end is clamped to the winch drum. The design will ensure no inter winding of the fitting ropes.

At least four turns of rope will remain on the drums when the lantern carriage is fully lowered.

4.06 Support Ropes
The support ropes will be of stainless steel and will be capable of safely handling the lantern carriage load.

4.07 Supply cables.
Power supply cables will be class B insulated with required number of cores provided with multi-pin heavy duty locking type male/female connectors at the end. Pulley assembly will accommodate extra cable for emergency supply.

Test load will be of 5-meter length 5-core 2.5-mm² copper conductor cable with multi-pin heavy duty locking type male/female connectors at the ends. Under no circumstances the test lead will travel through the mast.

4.08 Foundation
The design and construction of foundation for high mast lighting tower will be included in the scope of the contractor. The contractor will consider the following indicative data as design parameter for high mast. However the actual data will be indicated during tender scrutiny.

a) Soil bearing capacity at 1-Metre depth :- As per data supplied by Purchaser (BSP)
b) Wind speed :- As per data supplied by Purchaser (BSP)
c) The Contractor will submit the design drawings for approval of MECON for high mast based on soil bearing capacity and wind speed. The Contractor will be responsible for safe & efficient erection of the mast.

4.09 Electric Drive & Fittings
The drive will be 3 phase, 415 volt, 50 Hz, class B insulated, flameproof type induction motor/geared motor with suitable torque limiter.

The motor will be mounted on MS hot dip galvanised plate inside the mast with a possibility of adjusting its position. The drive will be capable of taking the load of whole lantern carriage with luminaries, control gearboxes, aviation obstruction light mounted on it.

Manual handle will be supplied along with power tool for operating the winch manually in case of power failure. Reversible type starters for motor, contactors for lighting circuit, MCB isolator switch etc. will be provided in a flame proof & weatherproof enclosure.
4.10 Light Fittings

The light fittings will be of flood light type with twin 400-watt HPSV lamps. The quantity, mounting position/angle and optical characteristics will be decided on the basis of the following illumination requirement.

Minimum 30 lux illumination will be achieved at a horizontal distance of 30 meters from the bottom of the mast all around. Illumination level of 10 lux will be sufficient at plant boundary wall, parking area, Administrative Building, etc. Minimum of 3-5 lux is required to be achieved at a horizontal distance of 125 Metre from the bottom of the mast towards all area. Minimum 20 lux will be achieved in the areas adjoining at the perimeter of 40 meter (approx.) radius considering the mast base at the centre.

All lighting performances will be checked holding the lux meter in horizontal plane at ground level.
INSTRUCTIONS FOR FILLING UP:

1. GAP shall be submitted for each of the equipment separately with break-up of assembly/sub-assembly & part/component or for group of equipment having same specification.

2. Use numerical codes as indicated for extent of inspection & tests and submission of test certificates & documents. Additional codes & description for extent of inspection & tests may be added as applicable for the plant and equipment.

3. Separate identification number with quantity for equipment shall be indicated wherever equipment having same specification belonging to different facilities are grouped together.

4. Weight in tonnes (T) must be indicated under column 5 for each item. Estimated weights may be indicated wherever actual weights are not available.

ABBREVIATIONS USED:

CONTR: CONTRACTOR
MFG: MANUFACTURER

EQUIPMENT DETAILS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description (with equipment heading, place of use and brief specification)</th>
<th>Identification No.</th>
<th>Quantity</th>
<th>Manufacturer's Name and Address</th>
<th>Expected Schedule of Final Inspection Inspln</th>
<th>Raw Material and Inprocess Test Certificates</th>
<th>Test Certificates &amp; documents to be submitted to MECON</th>
<th>Acceptance Criteria Standards/BS/ASME/Norms and Documents</th>
<th>REMARKS/SAMPLING PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td></td>
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CODES FOR EXTENT OF INSPECTION, TESTS, TEST CERTIFICATES & DOCUMENTS:

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<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
<td>Dimensional</td>
</tr>
<tr>
<td>3</td>
<td>Fitment &amp; Alignment</td>
</tr>
<tr>
<td>4</td>
<td>Physical Test/Sample</td>
</tr>
<tr>
<td>5</td>
<td>Chemical Test (Sample)</td>
</tr>
<tr>
<td>6</td>
<td>Ultrasonic Test</td>
</tr>
<tr>
<td>7</td>
<td>Magnetic Particle Test(MPT)</td>
</tr>
<tr>
<td>8</td>
<td>Radiography test</td>
</tr>
<tr>
<td>9</td>
<td>Dye Penetration Test</td>
</tr>
<tr>
<td>10</td>
<td>Metallographic Exam.</td>
</tr>
<tr>
<td>11</td>
<td>Welder's Qualification &amp; Weld Procedure Test</td>
</tr>
<tr>
<td>12</td>
<td>Approval of Test and Repair Procedure</td>
</tr>
<tr>
<td>13</td>
<td>Heat Treatment</td>
</tr>
<tr>
<td>14</td>
<td>Pressure Test</td>
</tr>
<tr>
<td>15</td>
<td>Leak test</td>
</tr>
<tr>
<td>16</td>
<td>Balancing</td>
</tr>
<tr>
<td>17</td>
<td>Vibration Test</td>
</tr>
<tr>
<td>18</td>
<td>Amplitude test</td>
</tr>
<tr>
<td>19</td>
<td>Sponge test</td>
</tr>
<tr>
<td>20</td>
<td>Dust/Water Ingress test</td>
</tr>
<tr>
<td>21</td>
<td>Friction Factor Test</td>
</tr>
<tr>
<td>22</td>
<td>Adhesion Test</td>
</tr>
<tr>
<td>23</td>
<td>Performance Test'</td>
</tr>
<tr>
<td>24</td>
<td>No. Load/Free Running Test</td>
</tr>
<tr>
<td>25</td>
<td>Load/Overload Test</td>
</tr>
<tr>
<td>26</td>
<td>Measurement of speeds</td>
</tr>
<tr>
<td>27</td>
<td>Accoustical test</td>
</tr>
<tr>
<td>28</td>
<td>Geometrical Accuracy</td>
</tr>
<tr>
<td>29</td>
<td>Repeatability and Positioning Accuracy</td>
</tr>
<tr>
<td>30</td>
<td>Proving Test</td>
</tr>
<tr>
<td>31</td>
<td>Surface Preparation</td>
</tr>
<tr>
<td>32</td>
<td>Manufacturer's Test Certificates</td>
</tr>
<tr>
<td>33</td>
<td>BIR/Other statutory agencies' compliance certificate</td>
</tr>
<tr>
<td>34</td>
<td>Internal Inspection report by Contractor</td>
</tr>
<tr>
<td>35</td>
<td>Hardness test for manufacture</td>
</tr>
<tr>
<td>36</td>
<td>Spark test for Lining calibration</td>
</tr>
<tr>
<td>37</td>
<td>Safety device test identification</td>
</tr>
<tr>
<td>38</td>
<td>Case of Maintenance</td>
</tr>
<tr>
<td>39</td>
<td>Thickness measurement of Zinc coating</td>
</tr>
<tr>
<td>40</td>
<td>Line/Layout diagram</td>
</tr>
<tr>
<td>41</td>
<td>Bill of Material/Item no./specification and amendments</td>
</tr>
<tr>
<td>42</td>
<td>Calibration Certificate of all measuring instrument and gauges.</td>
</tr>
<tr>
<td>43</td>
<td>Calibration Certificate of all</td>
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INFORMATION & REFERENCES:

For CONTRACTOR / SUB-CONTRACTOR

(Stamp & Signature)

For MECON (Stamp & Signature)
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### QUALITY ASSURANCE PLAN

**FOR ELECTRICAL EQUIPMENT**

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<td>15</td>
<td>Partial Discharge Test.</td>
<td>D2</td>
<td>Approved single line / schematic diagram</td>
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<td>3</td>
<td>Filment &amp; Alignment</td>
<td>16</td>
<td>Heat run test/Temp. rise Test.</td>
<td>D3</td>
<td>Catalogues / Approved data sheet</td>
</tr>
<tr>
<td>4</td>
<td>Physical Test(Sample)</td>
<td>17</td>
<td>Enclosure protection Test.</td>
<td>D4</td>
<td>Approved Bill of Materials</td>
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<td>5</td>
<td>Chemical Test(Sample)</td>
<td>18</td>
<td>Calibration.</td>
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<td>6</td>
<td>Ultrasonic Test</td>
<td>19</td>
<td>Noise &amp; Vibration.</td>
<td>D6</td>
<td>Calibration Certificate of all measuring instrument and gauges</td>
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<td>7</td>
<td>Magnetic Particle Test(MPT)</td>
<td>20</td>
<td>Test Certificates for bought components.</td>
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<td>8</td>
<td>Radiography test</td>
<td>21</td>
<td>Tank pressure Test.</td>
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<tr>
<td>9</td>
<td>Dye Penetration Test</td>
<td>22</td>
<td>Paint shade verification.</td>
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<tr>
<td>10</td>
<td>Measurement of R Value : a) Before HV Test</td>
<td>23</td>
<td>Short time rating.</td>
<td></td>
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<td>11</td>
<td>High voltage test/Dielectric test.</td>
<td>24</td>
<td>Operation &amp; functional</td>
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<td>Overspeed Test.</td>
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<td>Type tests as per relevant IS/other standard.</td>
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<td>Flame proof Test</td>
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**DOCUMENTS:**

D1. Approved GA drawings
D2. Approved single line / schematic diagram
D3. Catalogues / Approved data sheet
D4. Approved Bill of Materials
D5. Unpriced P.O. copy
D6. Calibration Certificate of all measuring instrument and gauges

### ABBREVIATIONS USED:

- CONTR : CONTRACTOR
- MFG : MANUFACTURER

### EQUIMENT DETAILS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description (with equipment heading, place of use and brief specification)</th>
<th>Identification No.</th>
<th>Quantity</th>
<th>Manufacturer's Name and Address</th>
<th>Expected Schedule of FInal Inspection</th>
<th>Test Certificate &amp; documents to be submitted to MECON</th>
<th>Acceptance Criteria Standards/IS/BS</th>
<th>REMARKS/SAMPLING PLAN</th>
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1.0 SYSTEM SPECIFICATION OF AIR CONDITIONING SYSTEM (SS1)

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Air Conditioning System with all accessories required to be installed for HVAC application to achieve desired performance in all respect. Specific technical requirement of Air Conditioning System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Air Conditioning System is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. Description

This specification specifies general requirement of refrigeration and air-conditioning system for different application.

In general following types of air – conditioning units and accessories are required to be installed:

- AIR HANDLING UNIT – ES1
- CENTRIFUGAL FAN – ES4
- CENTRIFUGAL PUMP – ES5
- VAPOUR ABSORPTION M/C (VAM) – ES6
- CENTRALISED AIR CONDITIONING SYSTEM – ES7
- COOLING TOWER – ES9
- DAMPERS – ES11
- DUCTING NETWORK FOR HVAC SYSTEM – ES13
- FILTER DRY TYPE – ES15
- PACKAGE TYPE A/C SYSTEM – ES19
- PROPELLER FAN – ES20
- THERMAL & ACOUSTIC INSULATION FOR HVAC APPLICATION – ES17
- TUBE AXIAL FAN – ES23
- VALVES – ES24
- WINDOW & SPLIT TYPE A/C SYSTEM – ES25

Design Consideration:

For Design Ambient Temperature, internal heat load due to equipment, lighting, solar radiation, occupancy and inside design conditions refer job requirement of technical specification. The air-conditioning system will be designed to operate continuously round the clock twenty four (24) hours a day for all seasons of the year.

Following Indian Standards shall be followed for designing Air Conditioning System:

<table>
<thead>
<tr>
<th>IS-655-1963 (RA-1999)</th>
<th>HVAC System duct</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS-659-1964 (RA-1991)</td>
<td>Safety code for A/C system</td>
</tr>
<tr>
<td>IS-778-1984 (RA-1995)</td>
<td>Copper Alloy Gate, Globe, Check Valves</td>
</tr>
<tr>
<td>IS-1239-1990 (RA-1998 Part-1)</td>
<td>MS Tubes &amp; Pipes</td>
</tr>
<tr>
<td>IS-1391-1992 Part-1</td>
<td>Unitary (Window) A/C Unit</td>
</tr>
<tr>
<td>IS-1391–1992 Part-2</td>
<td>Split A/C Unit</td>
</tr>
</tbody>
</table>
The following design data shall be considered for selecting and sizing various equipment for chilled water plant, air conditioning and ventilation systems:

<table>
<thead>
<tr>
<th>SEASON</th>
<th>TEMPERATURE 0°C (DBT)</th>
<th>RELATIVE HUMIDITY (%)</th>
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<tr>
<td>SUMMER</td>
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<tr>
<td>Hot Zone side (20 m from hot metal/liquid steel handling)</td>
<td>60</td>
<td>26</td>
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<tr>
<td>Other zones</td>
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<td>45</td>
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<td>MONSOON</td>
<td></td>
<td>33</td>
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<tr>
<td>WINTER</td>
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</table>

In general the different air conditioned served electrical premises shall be maintained at 23±2 °C and 55±5 % RH.

All glasses in Air-conditioned served premises shall be double glass type with airtight double door entry provision.

For improved water quality in refrigeration system chemically treated water shall be considered as make-up for corrosion protection. Alternatively soft water plant shall be installed for make-up water supply to A/c system.
Chilled water pipe line shall be laid over ground.

For better distribution of chilled water in the network, ring main shall be considered. Alternatively reverse return line shall be considered for vertical chilled water distribution at different floor. At the end of main supply and return chilled water line provision shall be kept with isolation valve for hooking up with adjacent plant chilled water network. Interfacing of chilled water network form one plant to other shall be done by Purchaser separately depending upon requirement.

Preferable Exhaust fan rpm shall not exceed 900. All pumps (above 15m³/hr capacity) shall be horizontally split type with maximum RPM of 1,500. Monoblock pump can be used for capacity less than 15 m³/hr

Remote monitoring from central control room through main automation system for all critical areas under AC systems shall be provided. Provision for monitoring of chilled water flow quantity, temperature and served premises temperature shall be kept from central control room station.

Chilled water plant shall be selected such that it shall have 20 % more capacity rating than design calculation for future scope and interconnection with other adjacent plant.

The following velocities will be maintained in duct line for different air conditioning systems.

- i) Main header ducting 6 to 8 m/ sec.
- ii) Branch ducting 5 to 7 m/ sec.
- iii) Supply air grill 2 to 3 m/ sec.
- iv) Return header ducting 5 to 6 m/ sec.

Noise level generated in Central plant, Package AC plant, AHU and duct line shall not be transmitted to the served premises. Noise level in the served premises will not exceed 65 dB (A).

For control of temperature and dehumidification of the conditioned premises, thermostat and humidistat will be provided in the package A.C. plant room/ AHU Room.

High efficiency filter and strip heater will be installed in the supply air duct at the discharge end of blower and the strip heater will be interlocked with the blower to prevent independent control/switching of heaters. Pan humidifier shall be installed in the Air Handling Unit Plant Room if required for critical control of R.H. Level.

Make up air supply to AHU / package AC plant room shall be provided with filter and damper.

**Filter:** Efficiency of pre filter will be 90% down to 10 micron and fine filter will be 99% down to 5 micron. High efficiency filter will be installed in the supply air duct at the discharge end of blower in line with job specification requirement. For details refer ES16.

Local control of fan, pump, blower shall be provided near installation area for ON/OFF operation as required.

**Humidity Control:**

The strip heater will be installed in the supply air duct at the discharge end of blower for dehumidification purpose and the strip heater will be interlocked with the blower unit to prevent independent control/
switching of heaters. Safety thermostat shall be installed in the duct line near strip heater for safety precaution.

Pan type humidifier shall be installed in the air handling plant room for adding moisture if required for critical control of R.H. Level. Safety thermostat shall be installed in the pan humidifier chamber near immersion heater for safety precaution. In Pan humidifier chamber make–up water line, overflow, drain provision with gate and float valve arrangement shall be provided.

**Condenser cooling circuit.**

Centrifugal pump and cooling tower for condenser cooling shall be supplied in line with job specification requirement for water-cooled type condensing unit. For air cooled condenser unit selection maximum ambient temperature factor shall be considered for capacity selection. 

Rubber/Neoprene gaskets will be used on all bolted joints as a seal against water leakage.

Water pipe line will be of MS Heavy (C) Class and as per IS 1239 - 1990, (part I) (RA – 1998), upto a size of 150 NB, IS 3589-2001 for sizes beyond 150 NB MS, spirally welded, 6mm thick & conforming to IS:3589. Pipe fittings up to 150 NB will be as per IS 1239-1992 (Part II), Amendment 2000. Fabricated fittings manufactured from pipes may be provided for pipes of size 200 NB & above.

Velocity of water in pump suction line and delivery line will be within 1.25 and 2 m/sec respectively.

Pot /Duplex strainer will be provided in suction line of pump and ball valve/ butterfly valve will be provided in the delivery side of pump.

Butterfly valve/ ball valve will be provided in water pipeline at condenser inlet & outlet, AHU cooling coil inlet & outlet, pump inlet & outlet.

For better distribution of chilled water in the network in vertical line reverse-return line shall be provided for balancing of water flow at consumer points. However for multiple consumer points in horizontal line balancing valve shall be provided at chilled water return branch line.

Insulated drain piping network is to be included as required for steam condensate drain, with isolation valves at proper places.

Pipe supports will be steel, adjustable for weight and coated with rust preventive primer and finish coated with Aluminum paint. Where pipe and clamp are of dissimilar material a gasket will be provided in between.

All piping will be tested to hydrostatic test pressure of at least one and half times the maximum of operating pressure for period of not less than 2 hours.

**Thermal and acoustic insulation :**

For details refer ES22. Thermal and acoustic insulation for air conditioning systems shall be considered in line with job specification requirement. However, following minimum insulation work shall be considered.

- a) Inside surface of the packaged a/c blower/AHU Blower section.
- b) Supply air tail end duct to prevent condensation
- c) All supply air and return air duct line passing through non-air conditioned premises.
- d) Acoustic insulation of duct line at blower outlet up to 5 m length minimum.
- e) Steam condensate drain
f) Under deck insulation of sunlit exposed roof  
g) Chilled water pump, chilled water pipeline, valves, chiller, expansion tank as per job specification requirement.

**Fire safety**

No combustible material, lining like insulating material will be used anywhere in the entire air-conditioning system of shop. AC system blower, motorized fire dampers / Solenoid operated fire dampers in the duct shall be inter locked with fire detection system to stop air flow.

**Control & Instrumentation**

The following instrumentation and necessary interlock and controls to be provided for air conditioning system :

i) HP/LP cutout switch.  
ii) Cooling thermostat, heating thermostat, Operating and antifreeze thermostat & Humidistat.  
iii) Pressure gauge & temperature gauge (150-mm dial type)  
iv) Water flow switch/differential pressure switch with interlock and signal.  
v) Dry bulb & wet bulb thermometer for all air conditioned premises.  
vi) Thermostatic expansion valve, sight glass, refrigerant strainer,  
vii) Steam pressure and flow control of Vapor Absorption based system.  
viii) Chilled water flow and condenser cooling water flow rate

Any other instrumentation required for the system will be indicated & provided by the Tenderer.

**Guidelines to eliminate interference between ducts, lighting and false ceiling**

Minimum clearances for duct routing will be as follows :

A minimum clearance of 100 mm will be provided between beam bottom and top of duct to take care of duct fabrication, flanges, insulation and allowances for civil construction.

Minimum clearance of 200 mm will be provided between duct bottom and false ceiling to take care of collar fitting, variation in levels of false ceiling and floor levels, if any.

The successful Tenderer will study the false ceiling drawing. Additional grid work, if found necessary, based on diffuser sizes, shall be carried out. Size of the diffuser color will match with false ceiling grid. For served premises, return air recess may be provided at the periphery all around.

**Sequence of preparation of drawings**

i) Duct routing drawing will be prepared based on air conditioning requirement.  
ii) Duct routing and diffuser locations will be checked for interference if any with light fittings and false ceiling grid as per the Architectural/Electrical drawings. The diffusers and light fittings will be in different rows, as far as possible.  
iii) The finalised duct/diffuser layout drawing will be drawn on the false ceiling grid drawing before submission for approval.
Construction supervision

Interference during construction stage due to lack of supervision and co-ordination etc., will be corrected during erection by the AC system Successful Tenderer. The false ceiling Tenderer will draw the grid on the ceiling. The AC system Successful Tenderer will make the exact location of diffusers on the ceiling. Similarly, locations of light fittings on the ceiling shall be considered. AC system Successful Tenderer will co-ordinate in this regard with other Contractors to avoid any interference at a later stage. By using plumb, from locations of diffusers drawn on ceiling, the duct fabricator will erect the main and branch ducts. However, collars should be cut only after the false ceiling is properly leveled.

Suggested sequence of operation

i) Under deck insulation shall be completed.
ii) Main duct will be erected by the Successful Tenderer.
iii) Hangers for false ceiling & lighting etc., will be placed.
iv) Skeleton false ceiling with grid main runners will be erected.
v) Branch duct to be erected as per center lines of grid/main runner.
vi) False ceiling to be leveled and grid to be provided for lights and diffusers.
vii) Collars to be cut by the Tenderer to match the false ceiling grid and level.
viii) Fixing of diffusers on to the collars after leveling the false ceiling.
ix) The diffuser level and false ceiling level will be properly matched for good aesthetic appearance. The false ceiling panel opening will be done by the Tenderer for diffuser fixing.
x) The AC system Tenderer will plan the activities of duct erection in consultation with other Tenderers, (namely, Electrical and Civil) so as to avoid delays and extra work by all concerned.
x) Concerted efforts will be made by the AC system Tenderer together with other agencies for proper erection of ducting and diffusers avoiding any interference with electrical works and false ceiling grid.

DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offers.

1. Type of refrigeration / air conditioning system
2. Total capacity of air conditioning system
3. Make of equipment
4. Design cooling load
5. Indoor climatic condition shall be maintained
6. Total power requirement
7. Total water requirement
8. Any specific design consideration
9. Noise level at 1m distance from the AC equipment
10. Noise level at served premises
2.0 DUST EXTRACTION SYSTEM SPECIFICATION (SS2)

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Dust Extraction System with all accessories required to be installed to achieve desired performance in all respect. Specific technical requirement of Dust Extraction System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Dust Extraction System is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. Description Of The Dust Extraction Systems

Dust extraction systems shall comprise of suction fan, dust extractor, ducting network, dust disposal system, electrics, instruments & controls.

This specification specifies general requirement of Dust Extraction system for different application.

In general following equipment specification (ES) shall be referred

- BAG FILTERS – ES3
- CENTRIFUGAL FAN – ES4
- CENTRIFUGAL PUMP – ES5
- DUCTING NETWORK FOR DE SYSTEM – ES12
- CYCONES, MULTI-CLONES, PRE-COLLECTOR – ES10
- ELECTROSTATIC PRECIPITATORS – ES14
- SCRUBBER – ES21
- THERMAL INSULATION FOR HOT APPLICATION – ES18
- VALVES – ES24

DESIGN CRITERIA

1. All the rotating parts shall be statically and dynamically balanced. Monitoring ports in ducting and stack with platforms, approach ladders/stairs and other requirements shall be strictly as per the latest emission standards published by Central Pollution Control Board.

2. The efficiency of the dust cleaning equipment shall be such that the emission from stack should not be more than 50 mg/Nm$^3$ unless other wise specified in the job specification. The average inlet air dust concentration may be taken as 10~15 gm/Nm$^3$ unless otherwise specified in the job specification.

3. The dust extraction systems shall be such that the work zone dust concentration Respirable Particulate Matter (RPM) less than 10 micron should be limited to 1mg/Nm$^3$ over back ground level unless otherwise specified in the job specification.

4. The capacities of the dust extraction systems shall be selected considering at least 10% for safety over the calculated values.

5. Following Indian Standard may please be followed as design guidelines:
i) IS-638-1979 : Rubber Gasket sheet jointing
ii) IS-800-1984 (RA 1998) : Use of structural steel
iii) IS-822-1970 (RA 1997) : Inspection of welds
iv) IS-875-1987 (RA 1997) : Structural design
v) IS-1239-1990 (RA 1998) : Pipe & pipe fittings
Part I & Part II amendment 2000
Part I to Part 15
vi) IS-2062-1999 Amendment 2001 : Steel for general structure
vii) IS-2309-1989 (RA 1995) : Lighting code practice
viii) IS-2712-1998 : CAF gaskets
ix) IS-4894-1957 (RA 1994) : Centrifugal fan
x) IS-6392-1971 (RA 1998) : Design of Steel Chimney
Part I & Part II
xi) IS-8183-1993 (Amendment 1997) : Mineral wool insulation
xii) IS-14164-1994 (Amendment 2000) : Thermal insulation for 80°C to 750°C
xiii) IS-11304-1985 (RA 1993) : Air Pollution Control in steel plants

6. The duct lines shall be designed self balanced. Successful tenderer has to furnish pressure drop calculation and system capacity selection calculation before carrying out detail engineering of DE system.

7. The dust extraction system shall be designed based on norms specified in the Hand Book of American Conference of Governmental Industrial Hygienists (ACGIH) with fines factor and to meet the required fugitive emission standard based on the party’s experience.

The Successful Tenderer should calculate and decide the systems capacities of their own using the standard norms. However, in no case, the systems capacities should be less than as specified in job specification.

7. The dust extraction equipment shall be located near to the building. Approach, handling and hoisting facilities shall be provided for the equipment. Monitoring port holes of 100mm diameter with plug, platforms, approach ladders/ stairs, power socket of single phase, 50 Hz, 230 V, 15 A and monitoring equipment lifting facilities shall be provided as per the emission standards published by Central Pollution Control Board.

8. All stacks for discharge of clean air from dust extraction systems shall have a minimum height of 30m or 3m above top of roof of the tallest adjacent building / structure whichever is higher or as specified in the job specification. The efflux velocity from the stacks for dust extraction systems shall be maintained 15m/ sec.(approx.). For rain protection concentric duct to be provided on the top of stack shall be designed such that it restricts rain water entry into stack but allows the gases to move vertically upward with the above mentioned efflux velocity.

9. Generally the following air velocities shall be considered for the dust extraction systems.

   At hood inlet 1.5 m/sec (max)
   Ducting 18-25m/sec
10. Suction hood for the dust extraction systems shall not be less than 5 mm thick MS sheet. The ducting shall be of circular cross section.

11. Duct lines shall have cleaning hatches of size 100mm x 75mm with air tight seals for easy cleaning of accumulated dust near bends & inter connections.

12. Horizontal duct shall be avoided as far as possible. Vertical/ inclined ducting shall be provided.

The Successful Tenderer shall include duct supports in their scope as follows:-

a) In-house ducting shall be suitably supported at approx. 3m intervals.

Ducting inside the building shall be supported on the floor or from the column/ civil beam/building structure/technological structure etc. as applicable. The location and type of supporting arrangement shall be decided by the Successful Tenderer in consultation with purchaser/or purchaser’s consultant.

b) Trestle supports shall be provided on ground for the ducting outside the building.

13. The dust extraction system shall be interlocked with the technological equipment/ conveyors. The sequence of operation shall be such that the dust extraction system shall start 5 minutes before start of the technological equipment and shall stop 5 minutes after stoppage of the technological equipment.

14. **Dust Disposal System**

Dust disposal system including chain / screw conveyors, double cone valve/rotary air lock valve, Dust moistener, dust storage hopper / Rotary feeder etc.

a) **Chain Conveyors and Double Cone Valves**

b) Chain /screw conveyors and double cone valves will be provided below the dust extraction equipment hoppers for disposal of dust. Chain / screw conveyors will have bearings with outside greasing terminal, protected from dust by packing around the glands. All the vulnerable parts requiring frequent attention will be readily accessible. If two flights of a screw coupled then, overlapping of each flight at center point shall be made for smooth flow of material.

c) Double cone valves will be made of cast iron with the carrying side hard faced. The double cone valve will be complete with shaft of EN8, cast iron housing, geared drive, geared box/geared motor etc.

d) Chain conveyor of following specification will be supplied.

- **Forge link chain material = 16 Mn Cr5**
- **Strength of link (Breaking load) = 20 t.**
- **Length to suit design requirement**
- **Hardness of chain link - 55-60 HRC.**
- **Flight thickness - 10 mm.**
- **Bottom Plate - IS-2062-A-1999 - 8 mm thick with 10 mm SAIL HARD Liner.**
- **Side Plate - IS 2062-A-1999 - 6mm thick with 10mm SAIL HARD Liner.**
- **Top cover - IS 2062-A -1999 - 3.15 mm thick.**
e) Zero speed switches will be provided for all dust disposal system drives.

e) Compensator between rotary feeder and the chain conveyors, between two conveyors and between dust moistener and rotary feeder will be provided to facilitate maintenance. Slide gates will be provided before all the double cone dust valves/rotary feeder. For calculation and design of structural members, accidental fill up of dust up to top of hoppers in worst case will be considered by Successful Tenderer.

g) Dust hopper/ Holding hopper

A dust storage hopper for each dust collector cell shall be provided. A pyramidal hopper with 65° valley angles shall be installed to collect the settled dust. The hopper shall have a 2 days dust storage capacity. Rack and pinion sliding gate (motorised) arrangement shall be provided at the hopper discharge. Dust conditioner of double screw type / disc palletizer with controlled moisture addition shall be provided at storage hopper outlet as defined in the Project specific TS. Vibrator if required in the hopper is to be provided. Disposal of dust to the closed truck / pneumatic system shall be done through telescopic chute as defined.

h) Rotary Air Lock Valve

Rotary air lock valve shall be made of cast iron with the carrying side hard faced. The rotary air lock valve shall be complete with shaft of EN8, cast iron housing, geared drive, geared box/geared motor.

15. Instrumentation

a) High level/ Intermediate level switch in hopper.
b) Hopper heating units as required.
c) Temperature and pressure transmitter as required,
d) Pressure gauge at inlet and outlet of dust extractor.
e) Differential pressure switch across dust extraction equipment.
f) Master controller and solenoid valve for each module as required.
g) Sequential Timer for bag filter application as required.
h) Compressed air pressure gauge and pressure regulator as required.
i) U – Tube manometer across dust extraction equipment.
j) Continuous pollutants (Particulate matter, \(\text{SO}_x\), \(\text{NO}_x\) level monitoring as required.
k) Dry running protection of wet system.

16. Platforms and access stair case

The minimum platform width shall be 1.2 meters. The platforms shall be located at the top of hoppers, level, at the top of the gas cleaning equipment, and at the different levels required for maintenance and operation of the equipment and dampers. A safe guard rail should be provided on the platform. Safe and easy access to the platform shall be provided by providing stairways and railing. Intermediate platforms shall be provided for the bag filters. Following minimum structural member shall be considered.

Hand rail : 25 NB, IS:1239-1990
Operating Criteria

1. As the technological equipment starts dust generation starts at material handling / transfer points.

2. Duct isolation dampers to activate duct routes as per active technological equipment.

3. Adjust the manual butterfly balancing damper connected to the suction hoods for adequate suction of dusty air from all the hoods as per design requirement so as to control the escaping of dusts at the dust generation points.

4. Electrical Interlocking for starting of dust extraction system:

   Interlocking to be considered in the MCC to make sure the following sequential starting before the start of technological equipment:

   a) Rotary Airlock Valve/double cone valve.
   b) Activate dust extraction system
   c) Start Fan Motor.
   d) Open Fan Inlet Damper after appropriate time delay of fan motor starting.
   e) Activate duct line Isolation Damper in ducting network to minimise idle suction from non-operating points as per system requirement.

5. In normal condition, switching off operation of DE system should be followed as per following sequence:

   a) Stopping of Technological Equipment
   b) Fan Motor.
   c) Fan inlet damper.
   d) Rotary Air Lock / Double cone valve after appropriate time delay.
   e) Deactivate Dust Extraction Equipment

Note: In case the RAL/Double Cone Valve trips the fan motor should also trip to avoid uncontrolled accumulation of collected dust in Dust Extraction Equipment hopper which otherwise may result into choking/clogging of Dust Disposal System.

The Successful Tenderer will examine the above logic and operating principle of the DE system and changes, if any, necessary for trouble free operation of the system being offered by the party shall be indicated.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offers.

11. Type of dust extraction system
12. Total capacity of dust extraction system
13. Make of equipment
14. Design suction quantity
15. Outlet emission quantity
16. Work zone dust concentration
17. Total power requirement
18. Total water requirement
19. Any specific design consideration
20. Noise level at 1m distance from the dust extraction equipment
21. Space requirement (L x B x H)
22. Support / Structure / Weathering shed DE system

13. Dust Disposal Arrangement
   Conveyor, Type, nos. capacity tph
   - Rotary air lock valve capacity tph & nos.
   - Slide gate (Manual)
   - Expansion joint at outlet of RAL
   - Rotary feeder
   - Dust moistener
   - Water requirement m3/h at kg/cm2
   - Dust bin
   - Storage Hopper
      a) Volume in m3
      b) Type
      c) Size (L x B x H)
      d) Motor rating KW & Pole of rack and pinion type discharge gate.
      e) Material / thickness of hopper
   - Zero speed switch of drives

14. Instrumentation
   Bearing & winding temperature monitor of fan & motor
   Pressure transmitter
   Temperature transmitter
   Level switch
   Thermostat for heaters

15. Weight of Dust Extraction Equipment & structure
   - Structures
   - Dust Extraction Equipment - casing, hopper, internals, Insulation & cladding as applicable, storage hopper, expansion joints & dust disposal equipment
   - Fan with drive & accessories
   - Duct, suction hood & duct line damper
   - Steel stack
   - Auxiliary equipment as per job specification requirement
3.0 DUST SUPPRESSION SYSTEM (SS3)

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Dust Suppression System with all accessories required to be installed to achieve desired performance in all respect. Specific technical requirement of Dust Suppression System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Dust Supression System is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. Description Of The Dust Suppression System

There are essentially three types of dust suppression system applied to control pollution in bulk material handling. They are spraying of only water at material transfer points, spraying a solution of water & chemical compound at material transfer points, a dual fluid water and compressed air supplied through nozzle for production of ultra fine water particles, i.e. fog at material transfer points.

02.1 Plain water type dust suppression system

In plain water dust suppression system in general plain water at high pressure is sprayed over stockpile area. This type of system is envisaged for the stockpile area to suppress the generated dust due to stacking / reclamation. Spray water header will be provided along the stockpiles. Dust suppression system is to be designed to prevent lift of dust from stockpiles. Water spray over the stockpile area is produced by sufficient number of sprinklers suitably installed in a header to cover the entire stockpile area. Plain water may be sprayed at transfer station as per job specification requirement.

The sprinklers should be of swiveling type. Each sprinkler operation cycle is to be controlled by a sequential timer to have optimum consumption of water. Water will be stored in a feed water tank. In the supply waterline to feed water tank float valve shall be provided. One additional quick fill line to water storage tank shall be provided. Water from feed water tank shall be supplied to different spray header by a high-pressure pump. Sprinkler post of approx. required height should be installed on the spray header along one/ both side of ores/ coal stock pile area. Before each sprinkler globe valve & solenoid valve shall be provided for manual control and automatic control respectively. The water pump is interlocked with low level switch of feed water tank to prevent the pump from dry running. A pressure switch at the pump discharge line shall be provided to by pass water to storage tank. A solenoid valve in by pass line shall be energized by high-pressure signal from pressure switch.

02.2 Chemically treated water type dust suppression system

Chemically treated dust suppression system work on the principle of agglomeration. Dust particles released from material handling become air borne, are made to pass through a blanket of extremely fine water droplets. The dust particle and the droplets collide and adhere to each other, thus increasing their mass. After a series of such collision the dust particles mass become heavy. The system implies spraying of chemical compound wetting agent and water mixture in certain ratio at each material transfer points. Chemical solution at the pressure of 4 Kg/cm² supplied at the atomising nozzles. The wetting agent (chemical compound) from drum is transferred to solution tank with the help of metering pump (one working and one reserve). Chemical compounds is added in measured quantity in the feed water line to solution tank. The tank is provided with high, low and very low level switch.
There are two-solution pumps (one working and one reserve). Any one of the solution pump can be started if the tank is filled above the low level switch of solution tank and any one of the solenoid valve at spray point is energised. Feed water pump will start when solution level in solution tank reaches low level. Metering pump operation is interlocked with feed water pump. Feed water pump will stop when water level in solution tank reaches high level. In case of very low level in solution tank solution pump will stop. In case of low level in water storage tank feed water pump will stop. A pressure switch at the solution pump discharge line shall be provided to by pass water to solution tank. Solenoid valve in by pass line shall be energised by high-pressure signal from pressure switch. Solenoid valve shall be installed in pipeline in a box at each junction house point to cater solution spray at belt discharge point and belt receiving point. Solenoid valve operation should be interlocked with conveyor motor and load sensor unit. Conveyor motor running under load will draw high current compare to conveyor running under no load. A current transformer located in the power cable circuit will monitor conveyor motor current and shall be interlocked with the operation of solenoid valve.

Chemically treated dust suppression system should be provided for the material transfer points in junction houses.

### 02.3 Dry Fog Dust Suppression System

The Dry Fog dust Suppression (“DFDS”- water atomization with compressed air) system works on the principle of agglomeration. Water and compressed air are mixed in atomizing nozzles which produces an ultra fine droplets size fog when sprayed and achieve dust suppression though agglomeration. Dust particles released from a material handling or processing plant which becomes air borne, are made to pass through a blanket of extremely fine fog. The dust particles and the micronic sized fog droplets collide and adhere to each other, thus increasing their mass. After a series of such collisions, the mass becomes heavy enough to cause settlement of the agglomerates on to the larger mass of the material being handled.

The System uses an air Driven Acoustic Oscillator Nozzle which is capable of producing supper fine atomization of water droplets that greatly increase the dust particle to water droplet contact resulting in settlement of dust. The fine droplets evaporate before wetting anything but the dust. The approximate water addition is 0.1% of the weight of material being handled.

### Description of Scheme

The DFDS system comprising main equipment installed at the application points and auxiliary equipment installed at central water and compressed air supply point. Brief components of both type of equipment are mentioned below:

- **Main Equipment**

  The Main Equipment will include Spray Bar Assemblies fitted with Dual-fluid air Driven Acoustic Oscillator Atomizing Nozzles, Pressure Regulating Units and Flow Activation Stations for ON-OFF Control of the System and Instrumentation for Auto Operation.

- **Auxiliary Equipment**

  The Auxiliary Equipment will include Water Storage and Pumping Unit with duplex Water Filter Compressors with air receivers and Associated Electrical Works, Air and Water Piping, Enclosures etc.
02.4 Elements of dust suppression system

In general following elements specification shall be considered as described in respective equipment specification.

- CENTRIFUGAL PUMP – ES5
- VALVES – ES24

Spray nozzles

Spray nozzles for dust suppression systems shall be of fog-jet type and shall have a solid cone spray pattern with a round impact area and minimum spray angle of 60°.

The nozzles should produce spray distribution of fine sized droplets at the given flow rate and pressure and should provide complete coverage of the spraying area or zone.

The nozzle housing shall be made of cast aluminium alloy and the tip shall be of stainless steel conforming to AISI-410 or SS-304 with SS strainer

The nozzles should be of self cleaning type with in-built filters made of brass.

Sprinklers

Circular swiveling type sprinklers shall be provided for dust suppression system of stockpiles to spray water and prevent fugitive dust emission.

The brief specification of the sprinklers is as follows.

<table>
<thead>
<tr>
<th>Size of inlet connection</th>
<th>To suit stand-post pipe size and fittings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinkler type</td>
<td>Circular swiveling type</td>
</tr>
<tr>
<td>Material</td>
<td>Cast Iron swiveling arm</td>
</tr>
<tr>
<td></td>
<td>Cast aluminum alloy body</td>
</tr>
<tr>
<td></td>
<td>SS nozzle</td>
</tr>
</tbody>
</table>

This specification specifies general requirement of dust suppression system for different application.

02.5 DESIGN CRITERIA

1. The dust extraction systems shall be such that the work zone dust concentration Respirable Particulate Matter (RPM) less than 10 micron should be limited to 1mg/Nm³ over ambient unless otherwise specified in the job specification.

   i. The capacities of the dust suppression systems shall be selected considering at least 10% for safety over the calculated values.

   ii. Following Indian Standard may please be followed as design guidelines:

a. IS-638-1979 : Rubber Gasket sheet jointing
b. IS-800-1984 (RA 1998) : Use of structural steel
c. IS-822-1970 (RA 1997) : Inspection of welds

d. IS-875-1987 (RA 1997) : Structural design

e. IS-1239-1990 (RA 1998) : Pipe & pipe fittings
   Part I &
   Part II amendment 2000

   Part I to Part 15

g. IS-2062-1999 Amendment 2001 : Steel for general structure

h. IS-2712-1998 : CAF gaskets

i. IS-11304-1985 (RA 1993) : Air Pollution Control in steel plants

j. IS-10221 – 1982 (RA 1997) : Wrapping and coating of underground MS Pipe

iii. The pipelines shall be self balanced without use of valves.

   The Successful Tenderer should calculate and decide the system capacities on their own using the standard norms. However, in no case, the system capacities should be less than as specified in job specification.

iv. The dust suppression equipment shall be located near to the application area. Approach, handling and hoisting facilities shall be provided for the equipment.

v. Generally the water line velocity shall be considered for the dust suppression system 0.75 to 1.5m/sec.

vi. Pipeline shall be of heavy class construction.

   The Successful Tenderer shall include pipe supports in their scope as follows-

   a) In-house piping shall be suitably supported at approx. 2.5m intervals. piping inside the building shall be supported on the floor or from the column/ civil beam/building structure/technological structure etc. as applicable. The location and type of supporting arrangement shall be decided by the Successful Tenderer in consultation with purchaser/or purchaser’s consultant.

   b) Outdoor piping may be required to be led through underground trench work with wrapping coating arrangement

vii. Instrumentation

   a) High level/ Intermediate level switch in water tanks.
   b) Pressure gauge at pump outlet of dust suppression system
   c) Pressure/ flow switch at pump outlet
   d) Sequence timer for sprinkler operation control as required.
   e) Load monitoring switch for noting conveyor running on load
   f) Flow meter at pump discharge line for large DS system or as specified in the job specification.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offers.

23. Type of dust suppression system
24. Total capacity of dust suppression system
25. Make of equipment
26. Design water flow quantity
27. Work zone dust concentration
28. Total power requirement
29. Total water requirement
30. Any specific design consideration
31. Noise level at 1m distance from the dust suppression equipment
32. Space requirement (L x B x H)
33. Support / Structure / Weathering shed DS system
34. List of drive
35. Spray nozzle make rating, quantity
36. Spray nozzle material of construction
37. Sprinkler make, rating, quantity
38. Sprinkler material of construction
39. Load monitoring switch type, quantity and rating
40. Sequence timer type, quantity and rating
41. Solenoid valve type, quantity and rating
4.0 SYSTEM SPECIFICATION OF VENTILATION SYSTEM (SS4)

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Ventilation System with all accessories required to be installed for HVAC application to achieve desired performance in all respect. Specific technical requirement of Ventilation System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Ventilation System is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. Description

Ventilation system shall be provided to maintain proper working conditions environment compatible with human hygienic requirements and to maintain conditions necessary for proper storage of materials and working of plant and equipment. The ventilation system generally include one or more items of equipment and accessories such as fans, air filters, duct work, pumps, air washer, air supply grills, dampers, insulation, instrumentation and controls, electrics, etc.

Ventilation system will be designed considering the climatic conditions prevailing in the region and the plants will generally be installed in separate plant rooms independent of the served premises. The plant rooms will be provided integral with and adjacent to the served premises at proper locations on considerations of convenience of routing of ducts/pipes, availability of fresh uncontaminated air and creating least disturbance to the adjacent premises in terms of vibration and noise.

Ventilation system will be provided with adequate measures for safety and fire fighting for fire hazardous areas and shall be of flame proof/explosion proof construction.

Detail item specification of following accessories for HVAC System is mentioned in the respective Equipment Specification.

- Centrifugal Fan – Reference ES4
- Tube Axial Fan – Reference ES23
- Propeller Fan – Reference ES20
- Ducting network for HVAC system – Reference ES13
- Air Washer - Reference ES2
- Thermal insulation for HVAC Application – Reference ES17.
- Damper – Reference ES10.
- Filter Dry Type – Reference ES15.
- Filter Viscous Oil Type – Reference ES16.

Ventilation facilities

Buildings and shops will generally be provided natural ventilation. Mechanical ventilation will be provided for premises where adequate ventilation cannot be provided by natural means alone. Depending upon the specific requirement, the shops/buildings will be provided with either exhaust ventilation or plenum ventilation. The system design will take into account the requirements of air change as well as excess heat removal. Filters will be provided with plenum systems. By plenum ventilation, the served premises will be pressurised to 2-3 mmWC to avoid ingress of dusty air. Hot
### General Technical Specification

**Location/Shop** | **Facilities**
---|---
Electrical premises, Switch gear rooms, Cable basements of Electrical sub stations | Pressurised ventilation with or without air washer as per job specification requirement
Compressed air stations | Exhaust ventilation
Battery rooms | Exhaust ventilation
Pump houses | Air cooled type ventilation
Toilets/Stores rooms | Exhaust ventilation
Hot working spots | Portable ventilation

Work areas will be provided with portable man-coolers for spot cooling. Man-coolers will be provided also in a few other areas where the premises are manned and have high heat radiation. General details and types of system to be considered is mentioned below. However, specific requirement of ventilation system shall be provided in line with job specification requirement.

The temperature of the Electrical premises and other sub-stations shall be maintained at in the range of 35 - 37 deg C right through the year by the provision of suitable air-cooling system. Air changes for air-cooling system shall be considered minimum 15 and for dry ventilation minimum system 20. Water eliminator in air washer shall be made of PVC.

The temperature of the areas being exhaust ventilated shall not exceed 3 deg C above the ambient at any part of the year.

Following Indian Standard may please be followed as design guidelines:

1. IS-638-1979 : Rubber Gasket sheet jointing
2. IS-800-1984 (RA 1998) : Use of structural steel
   - Part I & Part II amendment 2000
   - Part I to Part 15
6. IS-2062-1999 Amendment 2001 : Steel for general structure
7. IS-2712-1998 : CAF gaskets
8. IS-4894-1957 (RA 1994) : Centrifugal fan
   - Part I & Part II
10. IS-8183-1993 (Amendment 1997) : Mineral wool insulation
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offers.

42. Type of ventilation system
43. Total capacity of ventilation system
44. Make of equipment
45. Design cooling load
46. Indoor climatic condition shall be maintained
47. Total power requirement
48. Air change/hr
49. Total water requirement
50. Any specific design consideration
51. Noise level at 1m distance from the ventilation equipment
52. Noise level at served premises
5.0 **ES1 - AIR HANDLING UNIT/FAN COIL UNIT**

01 **General**

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Air Handling Unit (AHU)/Fan Coil Unit (FCU) with all accessories to make operation of Air Handling Unit (AHU)/Fan Coil Unit (FCU) complete in all respect. Specific technical requirement of Axial Flow Fan if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Air Handling Unit (AHU)/Fan Coil Unit (FCU) is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

Job specification of the project shall be referred for any specific requirement.

02 **Description**

**Air handling units / fan coil units (FCUs)**

The Air handling unit / FCU shall be of Fabricated construction, comprising of the following sections:

The air handling unit comprising of fan section, cooling coil section and pre-filter section. The AHU shall be of double skin panel construction. Double skin sandwich panels shall be fabricated from 22 gauge GI sheet. Minimum zinc deposition shall conform to Grade 275 of IS 277,1992. AHU casing shall be thermally insulated with 25 mm thick PUF board in between the outer and inner skin. The unit sections are mounted on galvanized sheet steel channel & aluminium die cast legs. Panels shall be fitted to Al frame work with neoprene gaskets & screws. The framework of AHU casing shall be assembled by means of reinforced nylon corners. The fan section of the casing shall be provided with access door. Aluminium die cast hinges & handles shall be used in access door. Fan impeller shall be of backward curved blade centrifugal type. Impeller shall be of double width double inlet. Impeller blades shall be fabricated from heavy gauge galvanized sheet steel or MS with spray galvanized. Fan rpm shall not be more than 750 rpm. Flexible connection & volume control damper (opposed blade type) shall be provided at fan outlet.

Blower fan shall be statically and dynamically balanced as per ISO1940 Gr 2.5. The first critical speed of the rotating assembly shall be at least 25% above the operating speed. The motor & blower assembly shall be isolated from the main frame by means of spring. Motor & fan assembly shall be mounted on base frame made of aluminium profiles and fixed on antivibration rubber mounts. Motor shall be mounted on a slide rail to adjust the belt tension. Fan shall be coupled to motor by V belts. V belts shall be provided with guards that do not impede the air flow to the fan inlet. Make of AHU fan
will be Nicorta/ Kruger/ Comferi. Fan static pressure shall be 65 mmwc or more (as required based on pressure drop calculation).

Chilled water cooling coils shall be constructed with copper tubes with fins of aluminium. Thickness of Cu tubes shall be minimum 0.75 mm thick and fins spacing shall be minimum 10 fins per inch. Cooling coil header shall be of GI. Chilled water coils shall be provide with suitable vent and drain connections. Drain pan shall be fabricated from minimum 22 G stainless steel sheet and stainless steel nipple for drain connection. The entire assembly shall be mounted on PUF insulated bottom panel. Condensate drain pipe of required length with sealing loop shall be provided and be insulated. The drain from drain pan shall be connected to floor drain. Air velocity through cooling coil shall not exceed 2.5 m/sec. Water pressure drop through cooling coil shall be limited to 5 mwc. Rows of cooling coil of AHUs shall be 6, however for 100% fresh air application Rows of cooling coil of AHUs shall be 8.

Chilled water flow through AHU will be controlled by 3 way mixing valve. A bypass line around 3 way valves shall be provided. Make of 3 ways valve shall be Honeywell/ Johnson/ Siemens/ Sauter.

Temperature switch and transmitter for monitoring of chilled water and served premises temperature shall be provided.

Fan coil units (FCUs) shall be wall mounted or ceiling suspended type and shall be installed inside the served premises for small isolated cabins / rooms.

03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer for Air handling unit/fan coil unit.

A. General
   a) Make & Model No.
   b) Type of unit (Horizontal/vertical)
   c) Overall dimensions (mm)
   d) Weight (kg)
   e) Noise level at 1 meter distance in dB(A)
   f) Vibration level
   g) Vibration isolations details

B. Fan Section
   a) Air quantity (m$^3$/hr)
   b) Total/static pressure (mmWC)
   c) Fan speed (RPM)
   d) Fan dia (mm) & number
e) Balancing (Static and dynamic)
f) Fan motor (KW)
g) Type of fan/size/make
h) BHP
i) Type of starter

C. Cooling coil

a) Coil fin materials
b) Tube dia (mm) and thickness
c) Fin size (mm)
d) No. of fins per inch
e) Outside coil surface (m²)
f) Face area (m²)
g) Row deep
h) ADP (deg C)
i) Bypass factor
j) Selected air velocity across coil (m/sec)
k) Make of cooling coil
l) Water through coil in m³/hr.
m) Water velocity through coil in m/sec.

D. Filter section Pre filter

a) Type & make
b) Gross filter area (m²)
c) Velocity through filter (m/sec)
d) Pressure drop through filter when dirty & when clean (mmWC)
e) Efficiency
f) Filter box construction details
g) Overall dimensions & No. of filters
h) Fixing frame details
i) Recommended methods of cleaning
6.0 (ES2) AIR WASHER UNIT

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Air Washer Unit with all accessories required to be installed for HVAC application to achieve desired performance in all respect. Specific technical requirement of Air Washer Unit if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Air Washer Unit is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02 Description of air washer unit

Air washer unit comprises of intermediate chambers at inlet and outlet, air washing chamber with water tank. The water tank. Adapter section shall be provided for connecting air washer unit with other equipment. Description of these items are given below:

Air washing chamber with water tank

The air washer is used for evaporative cooling of air. The air washer shall be complete with headers, spraying brass nozzles, air distributors, water droplet eliminators, make up water connection with float valve, strainer, overflow connection, quick filling connection, drain connection and other standard accessories. The number of nozzles, size, headers and their disposition shall be suitable for the saturation efficiency of not less than 90% for air washer. The door with viewing port shall be provided for servicing the chamber. The lower portion of the air washer shall serve as tank.

Water of the air washer tank shall be recirculated through pump ( 1 W + 1 S ) & piping network consisting of suction pipes, pot strainers, valves, delivery pipes with branches and spray nozzles etc. The air distributor (perforated plate) shall be provided at the inlet of spray chamber for proper distribution of air to the spray chamber. The PVC droplet eliminator shall be provided at the outlet of spray chamber to arrest/ prevent the water droplets from the air going out of the spray chamber. Water loss in the air washing unit shall be filled by the make up water. Make up water from separate source shall be taken to the air washer tank through necessary make up water pipe line with float and globe valves. Another quick fill water pipe line also shall be provided with gate valve for the air washer tank filling. Temperature gauges, pressure gauges, water proof lights, manometer shall be provided at the air washer chambers. Dry running protection of re-circulating pump with water flow switch / tank level switch shall be provided. Drain connections with valves shall be provided for all the three chambers of air washer equipment. The over flow pipe shall also be provided for air washer tank which shall be connected to its drain pipe after/ below the valve of the drain pipe.

The casing and tank shall be made of mild steel plate with black bituminous protective paints. The distributor and eliminators shall be made of galvanised sheet steel.

The sheet thickness for air washer tank shall be 6mm and for the body of the air washer shall be 4 mm unless otherwise specified in the TS.
The water proof lights shall be provided inside the chambers of the air washer with lead wiring and switches. Low level switch at air washer tank & interlocked with the re-circulating pump shall be provided.

Air washing chamber shall be provided with drilled flanges at both ends to connect with intermediate chambers on both sides. Rubber gaskets shall be provided at the connection point of intermediate chambers and at inspection window to prevent water leakage.

Water Eliminator shall be PVC baffle arranged such that no water droplets are carried away with the air stream.

The water pipelines shall be of galvanised iron pipes. The nozzles shall be made of brass or gun metal unless otherwise mentioned in the TS.

The face velocity shall not be more than 2.5 m/sec.

Resistance to air flow in washing chamber shall not exceed 15 kgf/m².

The air washer with the tank shall be mounted on a foundation made on the floor of the ventilation room.

**Masonry construction air washer chamber may be required to be installed as per job specification requirement.**

**Intermediate chamber**

Intermediate chamber shall be fabricated out of heavy gauge steel sheet (not less than 4mm thick) with drilled flanges at both ends. Water proof light with lead wiring and switches, air-tight door, coupling for installing check instruments, drain connection etc. shall be provided with the intermediate chambers.

**Adapter section**

Connecting box/transition piece/reducer shall connect the intermediate chamber with fan inlet through flexible connection. It shall be fabricated out of heavy gauge steel sheet with drilled flanges at both ends of minimum thickness 3.15 mm.

**Supports for intermediate chamber**

Triangular leg type (Δ shaped) supports shall be provided on the floor for supporting the intermediate chambers.

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01.02 **DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER**

The following data air washer unit shall be furnished by the tenderer along with the offer.

a) **Air washing chamber with water tank**

   1. Make & Model No.
   2. Type of unit (Horizontal/vertical)
3. Overall dimensions (mm)
4. Weight (kg) with and without water
5. Air flow capacity in m$^3$/h.
6. Air flow velocity
7. Total Pressure drop, kgf/m$^2$
8. Material of construction, diameter and numbers of spray header pipes
9. Material of construction, diameter and number of nozzles
10. Make up water requirement
11. Details of make up, over flow, drainage, supply and return water pipe lines
12. Saturation efficiency
13. Amount of water and its pressure at the nozzle
14. Material of construction and thickness of casing, tank, air distributor plate
15. Water tank capacity
16. Mounting supports
17. Details of mist/droplet eliminator: material of construction, material thickness and depth.

b) Intermediate chamber

1. Size
2. Material of construction
3. Thickness of material

c) Adaptor section

1. Size
2. Material of construction
3. Thickness of material

d) Re-circulating water system

1. Pump capacity & head, motor KW
2. Re-circulating piping & fitting;
3. Strainer & valve
4. Instruments – pressure gauge, temperature gauge, water flow switch, manometer
7.0 ES3 - BAG FILTER

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Bag Filter with all accessories required to be installed for Dedusting System application to achieve desired performance in all respect. Specific technical requirement of Bag Filter System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Bag Filter System is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. Description of bag filter system

Constructional Features

The bag filter assembly shall generally consist of the following:

- Module shell.
- Hopper for each module with RAVS/Screw conveyor with RAVS.
- Storage hopper with rack & pinion gate valves
- Housing and roof panels.
- Tube plate.
- Compressed air distribution system.
- Access doors.
- Filter bags and cages.
- Inlet and outlet manifolds.

The bag filter shall have a plenum chamber, which distributes the incoming gas onto an array of fabric filter bags. Dust particles shall be entrapped on the filter fabric, cake lining the bag surface by straining, impingement, interception and electrostatic attraction. Rotary air lock valves shall be provided at the bottom of bag filter hopper for dust removal and air sealing.

Normally bag filter casing thickness shall be 5 mm with sufficient stiffener to withstand design static pressure inside Bag filter chamber.

The inlet air plenum for the fabric filter should feature a tapered feed duct in order to ensure uniform gas flow distribution to all cells.

Air entry to the cells should be directed uniformly by angles deflection louvers to ensure complete bag usage within the cell. Cross horizontal flows shall not impinge on the bags in any area.

The bag fixing arrangement shall be such so as to enable easy and quick changing of bags.

Bags shall be hung as near as practicable to vertical so that the bags are not touching anywhere along their length. The Bag filter shall have antistatic Bags and spark proof design for the coke/coal application.

Particular attention shall be paid to the layout of the bags. A minimum distance of 75 mm between the bags and the closest fabric surface such as walls or columns of the casing shall be provided. The spacing between the bags shall be 50 mm (minimum).
Required Air/cloth ratio

The contractor should design the pulse-jet fabric filter dust collector to operate under design flow conditions with a gas/air to cloth ratio as 1.4 m$^3$/min/m$^2$ unless otherwise specified in the project specification. However, the same can vary from 1.0 to 1.8 depending on fabric and dust material to be handled.

Bag Cleaning

The bag filters shall be of on line / off line cleaning pulse-jet type as specified in the job specification. Material of construction of bags shall be selected based on operating temperature, dust quality, quantity and composition and air quality. The cleaning of bags shall be carried out in a predetermined cycle by high-pressure pulse of compressed air by automatic operation of solenoid valve with timer.

A differential pressure measurement system shall be provided across the bag house. As the dust collects over the bags, the pressure drop shall be sensed by this system. As this drop exceeds a preset value the differential pressure measurement system shall send a pulse to start the bag cleaning operation.

Compressed air shall be the cleaning medium and this shall enter the bags in short surges thus inflating the bags. The dust shall collect in the hoppers provided and shall be transferred by conveyor/ RAVS to holding hopper. In general centralized Compressed air network with air drier shall be provided to ensure supply of dirt and moisture free compressed air for bag cleaning as per job specification requirement.

The successful tenderer shall supply compressor along with drive and accessories safety valve, pressure gauge, air filter cum moisture separator unless otherwise specified in the job specification.

Dust hopper/ Holding hopper

A dust storage hopper for each fabric filter module shall be provided. A inverted pyramidal hopper with 65° valley angles shall be installed to collect the settled dust. Vibrator if required in the hopper is to be provided. For hot gas cleaning system hopper heater with thermal insulation shall be provided to reduce chance of condensation in hopper. Normally storage hopper thickness shall be 8mm unless defined in the TS.

Platforms and access stair case

The minimum platform width shall be 1.2 meters. The platforms shall be located at the top of hoppers, level, at the top of the gas cleaning equipment, and at the different levels required for maintenance and operation of the equipment and dampers. A safe guard rail should be provided on the platform. Providing stairways and railing shall provide safe and easy access to the platform. Intermediate platforms shall be provided for the bag filters. Following minimum structural member shall be considered.

<table>
<thead>
<tr>
<th>Member</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand rail</td>
<td>25 NB, IS:1239-1990</td>
</tr>
<tr>
<td>Post</td>
<td>32 NB, IS:1239-1990</td>
</tr>
<tr>
<td>Access grating</td>
<td>40 depth, 6 thick,</td>
</tr>
<tr>
<td>Stair</td>
<td>40 C/C, 38° slope</td>
</tr>
</tbody>
</table>
Electrics For Bag Filter System of Each DE System

The Electrics for bag filters of D.E. system will consist of pressure switches cum indicator in the compressed air line, differential pressure switches, solenoid valves, control panel and all other associated equipment. The brief specification of the major components will be as given below:

Control panel for Bag filter

The control panel will be free standing, floor mounting, fabricated from 2.0 mm thick CRCA sheet steel on a base channel of size 77 mm x 40 mm (ISMC - 75) provided with cable gland plates, having synthetic rubber gasketting, provided with double door & canopy and enclosure conforming to IPW-55. The control panel will be factory assembled, wired with 1.1 kV grade PVC flexible wire of copper conductor (minimum size 2.5 sq.mm), factory painted. The control panel will be provided with following major equipment:

a) Incoming switch (minimum 32A, AC23 duty) with operating handle interlocked with the door, HRC fuses, contactors, MCBs in the various circuits.

b) Control transformer of required VA rating having +/-5 percent and +/- 2.5 percent tappings in the primary side of the control transformer with Isolating switches/MCBs in the primary & secondary sides.

c) 24V DC full wave power pack complete with filter and protective elements and also isolation cum short circuit protection both at AC and DC sides for power supply to solenoid valves.

d) Auxiliary contactor for control power supply monitoring, interlocking, and controls etc.

e) Auto-manual selector switches, push button switches, indication lamps, various monitoring devices, terminals (with 20 percent spare terminals) and other circuit elements required for control and monitoring.

f) Solid state Bag filter timer.

The Bag filter timer will provide timed sequential energisation of 24V DC operated solenoid valves of bag filters. LEDs for each solenoid energisation, power ON in PCB, feed back relay will be provided with potential free contacts which will close under following conditions:

i) Fault in the PCB.

ii) Open contact in the output side connected to individual solenoid valves. The contact will not close in the event of power failure to the controller.

iii) The sequential control (i.e. process) will start when the Differential Pressure (DP) switch is actuated at the first set point for normal operation. The process will continue till the pressure differential drops below the set value. When again the DP
switch is actuated the process will continue from the previous position (i.e. next solenoid valve). However, when the power supply to sequential controller trips, the process will stop and sequential controller is reset to first load position enabling the process to start from the beginning.

iv) Sufficient space will be provided for installation of bag filter panel with required front clearances for operation and maintenance including side and back clearances as required.

**Differential Pressure Switch**

i) The differential pressure switch will have two sets of independent micro-switches. The first set will be used for normal sequential cleaning operation of the bag filters as per lower set value of differential pressure. This set point will be independently adjustable.

ii) The second set of N.O. contact will close at upper set value of differential pressure representing clogged condition of bag filter and will be used for signaling and monitoring. This set point will also be independently adjustable. The contacts will be rated for 5 Amp, 240V AC.

iii) The DP switch will be suitable for outdoor installation. The DP switch casing will be made of pressure die cast Aluminum with enclosure conforming to IP-66.

iv) One number differential pressure switch with two set points will be provided for each module of the Bag filter. Alternatively, two numbers of DP switches may be provided for each module one for initiation of bag cleaning operation and other for signaling and monitoring of clogged condition.

v) Manometer across filter.

**Solenoids**

i) The solenoid coil will have encapsulated coil (class F’ insulated with a water proof (IP-65) plug-on connector. The coil will be suitable for 24V DC having + 10 % to -15 % voltage variations. The coil will be made of copper conductor.

**Air Pressure Switch cum indicator**

i) One number compressed air pressure switch cum indicator will be provided for each bag filter system in the incoming compressed air pipeline of the bag filter. The pressure range will match with the operating pressure. The switches will be snap action type with 1 NO + 1 NC contacts of 5A, 240 V AC. These contacts will be wired up to terminals in the bag filter control panel. The enclosure of the air pressure switch will be pressure die cast aluminum conforming to IP-65.

**GENERAL ELECTRICAL LOGIC AND OPERATING PRINCIPLE OF THE BAG FILTER SYSTEM**

A. Mainly the differential pressure will govern the Dedusting Bag Filter system across the Dedusting Modules.

The total electrical logic will be controlled by the Devices like Differential Pressure Switch (DPS), solid-state sequential multi channel timer, solid-state master card, solenoid operated Diaphragm valves, inlet compressed air line pressure switch (P.S.) etc. DPS will be connected across the clean and dirty Air Chamber of the Bag Filter Module to measure the Pressure.
Differential. As the Filtration process commences, there is a gradual build up of dust on the Filter Bags which generates Differential Pressure. When this Differential Pressure attains a Pre-set value based on inlet dust concentration, type of dust and its particle size distribution, the differential pressure switch will get energized and send signal to the master card located in the control panel.

The master card will actuate the timer whose channels are connected with solenoid valves mounted on the compressed air header-Air Manifold Tank. Through the timer, the solenoid coil gets magnetized and makes an opening for the compressed air to flow from air manifold tank to pulse header pipe.

The pulse duration time will be adjustable. During this time the solenoid coil will remain energised allowing pulse air to flow. Energisation of other solenoid will take place in sequence one after the other. The time gap between the two-solenoid energisation will also be adjustable.

The process continues till the pressure differential drops below the set value. The D.P. Switch then gets de-energised which in turn cuts off the timer resulting in de-energisation of solenoid valves. The process will repeat again from the next solenoid valve based on the pressure differential switch and signal from the master card.

A pressure switch mounted on the compressed air line will sense the available pressure and dedusting system/centrifugal fan will switched off in case the available pressure falls below the specified pressure in compressed air line.

B. Following sequential steps of operation will be followed before actually switching on the main technological equipment to be dedusted:

1) Screw conveyor drives along with rotary air lock drive will be started first.

2) a) Setting differential pressure in differential pressure switch at the initial time of commissioning and for re-commissioning after long gap with clean Filter bags.

   b) Power to timer to be switched ON

3) Fan motor to be started in the inlet Damper closed condition. After appropriate time delay fan inlet damper to be opened.

DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER:-

The tenderer along with the offer shall furnish the following data:

Bag filter

1. Make, type and quantity
2. Model No.
3. Type of bag filter
4. Capacity in m$^3$/hr
5. Filtering area in m$^2$
6. Fabric type
7. No. of bags
8. Diameter & length of bags in mm
9. Filtering velocity m/sec.
10. Pressure drop in mm WC
11. Weight of bag filter in kg (without dust)
12. Weight of bag filter in kg (with dust)
13. Efficiency of bag filter Vs particle size
14. Material / thickness of bag filter casing in mm.
15. Material / thickness of bag filter hopper in mm.
16. Compressed air requirement m$^{3}$/hr.
17. Compressed air pressure
18. Compressed air quality
19. Velocity of air at inlet / outlet in m/sec.
20. Fixing arrangement of filter bags
21. Space requirement (L x B x H)
22. Rotary Air Lock Valve details
   a) Quantity
   b) Capacity in m$^{3}$/hr (at 50% filling)
   c) Speed in rpm
   d) Motor rating kW & Pole.
23. Storage Hopper
   f) Volume in m$^{3}$
   g) Type
   h) Size (L x B x H)
   i) Motor rating kW & Pole of rack & pinion type discharge gate.
   j) Material / thickness of hopper
24. Support / Structure / Weathering shed for bag filter
8.0 ES4 - CENTRIFUGAL FAN

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of different type of Centrifugal Fan required to be installed for HVAC, Dust Extraction, Combustion System process application with all accessories to achieve desired performance. Specific technical requirement of Centrifugal Fan if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of different type of Centrifugal Fan is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02 Description of Centrifugal Fan

Generally the fans shall be of limit load design. Centrifugal Fan design shall conform to IS 4894 – 1987 (Reaffirmed 1991).

The fan shall be of rugged steel construction, industrial duty type and suitable for the proposed project/plant. Fan housing shall be of welded construction and provided with flanges at inlet and outlet sides for duct connections.

The fan unit shall be free from undue noise and vibration during operation; normally the fan speed shall not be more than 1500 RPM, preferably less than 1000 RPM.

The fan shall be both statically and dynamically balanced as per ISO:1940. In general HVAC system application balancing grade shall be of 6.3 and for process application balancing grade shall be of 2.5.

The fan impeller may be backward curved / backward inclined/forward curve/radial job specification as per requirement.

Drain connection shall be provided at the lowest point of scroll.

Fan bearing shall be of self aligning, heavy duty type. Bearing shall be selected with ample safety factor for longer life.

Sufficient number of suitable vibration isolators of approved make shall be provided to ensure isolation of vibration from the equipment to foundation as per requirement.

Fabricated steel bracket of M.S. angles, channels and chequered plates shall be provided to take static and dynamic load of the fan and motor assembly.

Electrically operated / manually operated inlet vane damper shall be provided as a regulating device for control of fan flow volume as per TS requirement. The air stream shall be caused to rotate through alteration of the pitch of guide vanes.
Manually/electrically operated fan outlet damper shall be provided as per TS requirement.

Fan inlet and outlet flexible connections shall be provided as per TS requirement. Guide plate shall be provided to prevent direct contact of flexible fabric with air flow.

Anchor bolts, nuts, foundation plates etc. as required shall be supplied with the equipment. The equipment shall be designed to permit ease of access during inspection, maintenance and repair.

The first critical speed of the rotating assembly shall be at least 25% above the operating speed.

The housing shall be provided with lifting eye for ease of handling and bolted type access door.

The noise level of fan shall not exceed 85dB(A) at a distance of 1 m when running at full load. Material of construction, capacity and static pressure of fan shall be as per TS requirement.

The fan shall have following minimum thickness of materials for different parts unless otherwise specified in TS for HVAC application:

a) Capacity below 20,000 m³/hr:

- Casing: 3.15 mm
- Back plate: 4 mm
- Impeller: 2.5 mm

b) Capacity above 20,000 m³/hr and below 50,000 m³/hr

- Casing: 4 mm
- Back plate: 6 mm
- Impeller: 3.15 mm

c) Capacity above 50,000 m³/hr upto 1,00,000 m³/h

- Casing: 6 mm
- Back plate: 8 mm
- Impeller: 6 mm

However for different process application depending upon specific requirement material of construction shall be defined in TS.

The fan shall be provided with drive motor, drive coupling/V-belt, belt pulley, belt guard, fan inlet and outlet flexible connections, variable inlet vane, fan outlet damper, slide rails, foundation plates, gaskets, base frame, vibration isolators, foundation bolts and nuts, fan inlet protection screen and other standard accessories unless otherwise specified in the TS. All these items/materials and accessories shall be supplied with the fan.
DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER:-

The following data shall be furnished by the tenderer along with the offer.

a) CENTRIFUGAL FAN

1. Make & Model No.
2. Quantity, no.
3. Type of blade
4. Capacity, m³/h
5. Static pressure and total pressure, mm WC
6. Operating speed, rpm
7. Critical speed, rpm
8. Shaft power, kW
9. Total Efficiency, %
10. Motor rating, kW/ pole
11. Fan Characteristic Curves
12. Impeller Diameter in mm
13. Impeller weight in kg.
14. GD² value
15. Velocity at inlet & outlet of fan, m/sec
16. Static weight & dynamic weight of fan and motor, kg
17. Coupling details/V-belt details
18. Vibration level
19. Vibration isolator type & quantity.
20. Outlet damper size
21. Material of construction & thickness of scroll, blade, shroud, back plate, shaft diameter in mm
22. Noise level at 1m distance in dB(A)
23. Bearing details
24. Acoustic lagging / silencer, if included :
   i) Material of construction
   ii) Insertion loss
25. Overall size
26. Drive Motor rating suggested
27. Special constructional feature, if any

a) FAN DRIVE MOTOR DETAILS

1. Type & make
2. Voltage, phase & frequency
3. Rated power, kW
4. Speed, RPM
5. Starting/ pull out torque
6. Starter details
7. Line current
8. Starting current
9. Overall efficiency
10. Class of insulation
11. Type of enclosure
12. Any other information
b) **VIV Damper**

1. Make, model and type
2. Diameter of VIV
3. Type of actuator, if applicable
4. Motor kW/pole
5. Material of construction and thickness
9.0 ES5 - CENTRIFUGAL PUMP

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, testing and supply/fabrication of Pumps with all accessories required to be installed to achieve desired performance in all respect. Specific technical requirement of Pumps if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Pumps is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned under clause No. 03.

02 Pumps

The pumps shall be designed, manufactured and tested as per IS:1520-1980 (R.A. 1993), IS:5120.1977 (R.A.1997) Amendment 2000, IS:9137-1978 (R.A. 1993), IS6595-1993 (Part II) or as per other international standards acceptable to the Purchaser and shall be suitable for the duty conditions and capacities as indicated in this specification.

The centrifugal pumps along with their auxiliary equipment shall be suitable for the required duty conditions and shall be designed and manufactured for continuous duty at full load.

All the pumps shall be capable of developing the required total head at rated capacity for continuous operation. The pumps shall operate satisfactorily at any point on the H-Q characteristic curve over a range of 50% to 130% capacity or capacity corresponding to 75% of the total head whichever is lower.

Capacity vs discharge pressure curve for each pump shall preferably be continuously drooping from the shut-off point to the rated operation point and be suitable for parallel operation. The pumps shall be designed to avoid cavitation at any of the operating points.

The required duty range for a pump shall be on stable portion of its head-capacity curve close to the best efficiency point. The head developed at the best efficiency point shall be close to the required differential pressure so that throttling is not required at pump discharge.

The equipment and auxiliaries shall be designed for quick and economical maintenance. The equipment shall be easily dismantlable without disturbing the suction and delivery pipe connections.

The equipment design shall incorporate provisions for reduction in noise level.

The rotating elements of the pumps shall be checked for critical speed in bending as well as torsion. The critical speeds shall be at least 30% away from the normal speeds for units with flexible shafts and at least 20% away from the maximum operating speed in case of stiff shafts.

All passages inside the pump casing and impellers, which may be inaccessible to machining, shall be ground to a smooth finish as far as practicable.

All pumps preferably shall be horizontally split type with maximum RPM of 1,500. However, very small pump of capacity less than 15 m³/h for air
washer application mono-block type pump may be provided.

Material of construction

- Casing: C.I
- Impeller: Bronze
- Bearing Bracket: C.I
- Shaft protection sleeve: Bronze
- Wearing ring: Bronze
- Shaft: C-45
- Common base frame for pump & motor: M.S

The direction of rotation shall be clearly marked either by incorporating it on the casing or by an arrow on a separate metal plate securely fitted to the casing.

A stainless steel name plate of 2 mm thickness shall be provided and securely attached by stainless steel pins at an easily accessible point on the pump. The plate shall be stamped with the following minimum information:

- DESIGN CAPACITY
- TOTAL HEAD
- SPEED
- MOTOR RATING
- MODEL NUMBER
- MANUFACTURER’S SERIAL NUMBER
- WEIGHT OF EQUIPMENT
- TAG NUMBER

The total head-capacity curve shall preferably be continuously rising towards the shut-off. The shut-off head shall be at least 110% of the total head.

The required NPSH at duty point shall be at least 1.0 m lesser than the available NPSH.

The velocity of vibration shall be within 4.5 mm/sec.

The power rating of the pump motor shall be larger of the following

- 110% of the power required at the duty point.
- For parallel operation, motor rating should be sufficient enough for running of single pump also.

The common base frame for pump and motor shall be in one piece with suitable holes for grouting. Adequate space shall be provided between pump drain connections and base plate for installation of minimum 15mm drain piping. Pumps shall be supplied with suitable drain pans or drain rim type base plates with valved drain connections.

Coupling guard, made of expanded metal and bolted to the base plate shall be supplied for all pumps.

Pumps will be supplied with flexible coupling. Back-pull out type pump shall be provided with
spacer type coupling.

Standard hydrostatic test shall be conducted on the pump casing with water at 1.5 times the maximum discharge head or twice the rated discharge head whichever is higher. The hydrostatic tests on the casing shall be conducted for a minimum duration of 30 minutes.

Casing

The casing shall be of cast iron and shall be designed for a pressure not less than the shut-off pressure at the highest operating speed plus the maximum pressure that may be encountered at the pump inlet. In addition, CI casing shall have corrosion allowance of not lower than 3 mm.

Impellers

Impeller shall be of bronze. Impellers and balancing drums (if provided) shall be statically and dynamically balanced. Dynamic balancing shall be at the operating speed of the pump. For multi stage pumps, all the impellers shall be assembled together for balancing. Provision shall be made for adjusting the clearance between the impeller and the casing to compensate for wear.

The impeller shall be keyed or screwed on to the shaft in such a way that it does not come-out due to reverse rotation of the pump.

Shaft

The shaft shall be of EN-8 or C-40 or equivalent and shall be designed for critical speed. The ratio of critical speed to speed of shaft shall be not less than 1.3 for solid shafts.

The deflection in line shaft shall not exceed 1 mm per meter of length. All shafts above 150 mm diameter shall be ultrasonically tested. Shafts shall be checked for endurance and strength. Change of sections in shafts if considered shall be made with due allowance for stress concentration. Shafts shall be machined to close tolerance for mounting on impeller bearings, shaft seal, shaft sleeve, shaft coupling etc. The magnitude of shaft deflection at the face of the shaft seal shall not exceed 50 microns.

Coupling and coupling guard

Horizontal pump sets shall be provided with flexible couplings of pin and bush type and shall be constructed of metallic materials except for bush which shall be of rubber materials. Coupling shall be properly keyed in place and the cylindrical fit shall allow simple removal of the coupling in the field.

Removable coupling guards shall be supplied and mounted. Guards shall be sufficiently heavy and rigid to provide adequate personnel safety.

Shaft sealing

Shaft seals shall be provided to prevent leakage out of, or into, a pump over the range of specified operating conditions. The seals shall be suitable for variations in inlet conditions that may prevail during start-up and shut down. They shall be accessible for inspection and replacement without disturbing any part of the installation.
Bearing

Two bearing assemblies shall be provided, one within the frame to carry radial load only and the other to carry both radial and axial thrust. Bearings shall be of manufacturer standard design, antifriction type, oil / grease lubricated. Suitable thrust bearings shall be provided in the pump to take total thrust of the pump including hydraulic thrust. Thrust bearings shall be of oil lubricated type with suitable cooling arrangement. Motor thrust bearing shall be designed without water cooling arrangement. Suitable tapped holes shall be provided for refilling of oil in the bearing housing.

All the vertical pumps shall be provided with separate thrust bearings with proper lubrication and cooling facilities as required so that the thrust and other vertical loads due to the moving parts are not transferred to the prime mover.

Base plate

All horizontal pumps shall be supplied with sturdy base plates of manufacturer’s standard, common to pump and drive. Base plates and pump supports shall be constructed so rigidly and the unit so mounted as to minimize misalignment due to piping strain, internal differential thermal expansion, etc. Base plates shall be fabricated from MS channels.

Companion flanges, bolts, nuts & gaskets

Plate flanges having raised face shall be provided at suction and delivery side of pumps and they shall be of mild steel and conform to table 17 of IS: 6392-1971 (R.A.1988). Slip on raised face flanges to 150 Lbs. class conforming to ANSI B16.5 shall also be acceptable.

Black bolts and nuts conforming to IS 1362-1992 shall be provided for the companion flanges.

CAF gaskets of 1.5 mm thickness conforming to IS: 2712-1979 (R.A. 1994) shall be provided for the companion flanges.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER :-

The following data shall be furnished by the tenderer along with the offer.

1. Make and model no.
2. Type of pump
3. Capacity in m3/hr.
4. Total head in m WC
5. Quantity
6. Material of Construction of
   • Shaft
   • Impeller
   • Casing
7. Pump speed (rpm)
8. Shaft power
9. Drive details
   • Motor make
   • Motor kW
   • Class of insulation
   • Frame size
10. Bearing type & make
11. Type of coupling
12. Vibration level
13. Noise level at 1 m distance
14. Duty
15. Weight of pump & motor separately
16. Characteristic curves for pumps
17. Type of liquid to be handled
10.0 **ES6 – VAPOUR ABSORPTION M/C (VAM)**

The VAM based chilled water plant shall include:

- Vapour absorption machine(s) with accessories
- Hot well pumps (1w +1s)
- Cold well pumps (1w +1s)
- Condenser water pumps (1w+1s)
- Induced draft counter flow FRP cooling tower with RCC basin & PVC fills. Cooling tower basin shall be at higher elevation than the condenser water pump.
- Steam piping (from battery limit onwards) along with all necessary valves (shut off valve, flow control valve etc.), instruments & safety devices. IBR approval are in the scope of tenderer.
- Steam pressure & temperature control system.
- Steam condensate disposal arrangement. Steam condensate line shall be of SS
- Chilled water/ condenser water piping.
- Valves/ strainers etc in pipe lines
- Thermal insulation of chilled water pipes and steam pipelines.
- RCC hot well tank & cold well tank. Insulation of tanks. Tanks shall be located at the top most location of the entire chilled water piping network.
- MCC, starter panel, electrics, instrumentation etc.

VAM shall be completely factory assembled and wired in a single package complete with evaporator, absorber, two stage generator, condenser, heat exchangers, solution pump, refrigerant pump, vacuum pump for purging, starter panel (starting control), micro processor control panel (safety & operating controls) , all necessary sensors/ instruments, internal cabling and piping work.

VAM shall be supplied with full operating charge of refrigerant (water) & lithium bromide solution (with non toxic inhibitor) and shall be factory tested under operating conditions.

Automatic control of chilled water outlet temperature by controlling steam flow rate.
VAM shall have connectivity for communication, data logging, history charts, mimics to PC at remote location.

M.O.C of all the heat exchangers tubes shall be of Cu (70%) - Ni (30%) & seamless.

Solution & refrigerant pump impeller shall be of SS & drive shall be hermetically sealed.

Insulation of VAM unit.

Fouling factor for condenser & evaporator shall be considered 0.001 & 0.0005 hr-ft²·°F/Btu respectively

Purchaser will make available steam at 8 Kg/cm² (g) pressure.

Vapour absorption m/c shall be chosen not only to meet the full load design, but also to perform efficiently at lower loads and at lower condenser water inlet temperature (particularly during winter season). If needed condenser water temperature control shall be provided. Tenderer shall furnish the inlet condenser water temperature range of their machine.

Evaporator heat exchanger design shall meet the chilled water inlet & outlet temperature required for process cooling.
11.0 ES7 - CENTRALISED HVAC SYSTEM VAPOUR COMPRESSION BASED

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of different type of Direct Expansion (DX) type / Chilled Water generator equipment with all accessories required to be installed for HVAC and process cooling purpose to achieve desired performance. Specific technical requirement of Direct Expansion (DX) type / Chilled water generator type equipment if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of different type of Direct Expansion (DX) / Chilled Water generator Type Equipment is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02 Description

1. Base Frame:

Water chilling package base frame structure will hold the following:

A. Reciprocating / centrifugal / screw refrigeration compressor
B. Condenser
C. DX water chiller
D. Associated refrigerant piping, fittings and controls.

Normally Water chilling package shall be of floor mounted two tier type.

Direct Expansion (DX) type frame structure will hold the following:

A. Reciprocating / centrifugal / screw refrigeration compressor
B. Condenser
C. Associated refrigerant piping, fittings and controls.

Resistoflex neoprene pads shall be used as vibration isolator between common base frame and floor and spring cup type vibration dampers shall be used between compressor and common base frame.

2. Refrigeration compressor

Refrigeration compressor shall be of multi cylinder reciprocating / centrifugal / screw type. The compressor shall be driven by TEFC motor through V-belt drive/flexible coupling direct drive. Compressor design shall conform the required safety measures as per IS-11461-1985 guide lines and testing of compressor shall confirm to IS-5111-1993.

The chiller shall be supplied with full operating charge of refrigerant R-22/ R-134a & lubricating oil. Chiller performance shall be ARI certified as per ARI standard 550-92. Cooler (evaporator) shall be dry expansion type.

Compressor housing cylinder head shall be of fine grained cast iron. Valve plates shall be of cast iron or stainless (ring plate type). The piston shall be made from light metal
alloys preferably Aluminum with one oil groove and two compressor rings. The connecting rod shall be of forged steel of Aluminum alloys with integral bearing surfaces on crank and piston pin ends. Crank shaft shall be of forged steel with drill for oil distribution. Crank shaft shall be statically and dynamically balanced to eliminate vibration. In case of shaft seal, the same shall be positive acting to prevent the leakage of refrigerant and infiltration of air during compressor operation and idle periods.

The main bearing shall be of self-alignment, horizontally split and lined with anti-friction bearing metal.

Compressor shall be lubricated by forced feed lubrication system comprising of reversible, positive displacement gear type oil pump, interconnecting pipes, filter cartridge, oil strainer, sight glass, oil drain valve. If required, oil coolers shall be provided. Oil safety switch shall be provided to stop the compressor in case of excessive or lower oil pressure.

The refrigerant compressor shall be equipped with built-in automatic unloaded starting arrangement.

Electrically operated crankcase heaters suitable for specified power supply system shall be provided. Heaters shall be automatically actuated when compressor is stopped.

The compressor shall have automatic capacity control in addition to manual capacity regulation. Capacity regulation shall permit the operation of the compressor at part load with reduced power consumption.

The following accessories and instrumentation shall be considered for the refrigerant compressor:

A. Large suction strainer, muffler.
B. Service stop valves for suction and discharge sides.
C. Pressure and temperature gauges for suction, discharge and lubricating oil.
D. Common base frame for compressor and motor including Coupling.
E. Flexible coupling/V-belt drive.
F. Coupling belt guard.
G. Crank case heater.
H. Oil chargers and oil check valves.
I. Electric motor, drive set.

The following controls and safety devices shall be provided for the compressor:

A. Oil safety switch.
B. High and Low pressure cut outs
C. Relief by pass valves.
D. Spring loaded, built-in safety valves for each cylinder.
E. Indicating lamps and alarms.
F. Timer to set time interval between starting and loading the compressor.

3. Condenser
The condenser shall be of horizontal, shell and tube type construction with water flowing inside the tubes and the refrigerant gas condensing outside the tubes. Alternatively as per job specification requirement air cooled type condenser may be provided. Condenser design shall confirm to IS-11327-1985 guide lines.

The condenser shall be equipped with integral finned type, solid drawn, seamless copper tubes.

Multi-pass construction condenser shall be provided. It shall be designed for proper number of passes to give optimum water velocity, efficient heat transfer and allowable pressure drop.

The condenser tubes shall be rolled into the grooves of tube sheets at either end to ensure a perfect water and air tight joint.

Adequate baffling arrangement shall be used in the condenser for improved heat transfer.

Condenser tubes shall be adequately supported to prevent sagging and vibration failure.

The joints of water boxes and tube sheets shall be water tight while those of tube sheets and shell are air tight to prevent leakage of refrigerant and infiltration of moisture into the system.

The condenser shall be equipped with following accessories/safety devices:

A. Purge valve
B. Charging valve
C. Relief valve/fusible plug
D. Hot gas inlet/liquid outlet connections or the shell with flanges.
E. Water inlet/outlet connections with flanges.
F. Hand shut-off valve for water inlet and outlet to condenser and chiller.
G. Pressure and temperature gauges for water inlet and outlet/refrigerant gas inlet and outlet.
H. Vent valves etc.
I. Charging valve.

Chemically treated water shall be considered as make-up for condenser cooling system. Necessary water treatment/softening plant shall be considered by the successful tendered contractor.

4. Chiller

The chiller will be of direct expansion, horizontal, shell and tube type construction with the refrigerant flowing inside the tubes and the water outside the tubes.

Chiller shall have MS fabricated shell, copper tubes with internal turbulators and MS tube sheet and MS fabricated or cast iron shell end boxes. The shell shall be designed for approximately 10 kg/cm2.

The copper tubes shall be rolled into grooves on tube sheets for a water and airtight joint. Joints between the tube/sheets and the shell should be watertight while those
between the shell and the boxes should be airtight. Adequate sealing gaskets should be used to prevent leakage of refrigerant and the infiltration of moisture and air into the system.

The chiller shell shall have flanged water inlet and outlet connections welded as an integral part of it.

The chiller assembly will be thermally insulated with polyurethane or equivalent material of adequate thickness and finished as described under ‘Insulation’.

Chiller shall be equipped with the following controls/accessories/safety devices:

A. Refrigerant liquid inlet and gas outlet connections with flanges and liquid line, shut-off valve,
B. Liquid distributor with proper circulating arrangement,
C. Thermostatic expansion valve,
D. Solenoid valve on liquid inlet line,
E. Cooling and anti-freeze thermostats,
F. Water inlet/outlet connections with flanges and shut-off valves, along with counter flanges.
G. Vent connections with valves,
H. Pressure and temperature gauges at the water inlet/outlet.
I. Relief valve, purge valve, drain valve, shut-off valve,
J. DP switch across the chiller.

5. Interconnecting refrigerant piping, fittings and valves

Refrigerant piping is required to interconnect the compressor, condenser and the chiller into a closed network.

Expansion valves shall be pilot operated type. Solenoid valve shall be provided for ‘Pump down’ operation of the unit.

Moisture indicators, filter/drier unit shall also be provided in the liquid line with isolating valves.

Strainers shall be of brass, complete with bronze screen and permanent magnet strainers shall be installed up-stream of refrigerant solenoid valves, as per requirements. Strainers shall be provided with isolating valves and valves bypass.

Heavy duty seamless steel pipes shall be used for the piping network; while seamless solid drawn copper tubes shall be used for the refrigerant liquid line.

The piping network shall incorporate loops in the circuit to efficiently separate oil and liquid refrigerant from the gas and suction vapour respectively.

All horizontal lines shall be pitched to 12 m for every 3 meters in the direction of refrigerant flow. All necessary loops and bends shall be provided to ensure proper return of oil to the Compressor. All the piping shall be adequately supported and isolated by means of suitable vibration isolators.

Suction line shall be thermally insulated with polyurethane or equivalent material of adequate thickness.
The following accessories/controls shall be provided for the refrigerant piping:

A. Liquid line strainer/drier,
B. Liquid to suction heat exchanger,
C. Hand shut-off valves,
D. Sight glass etc.

All the piping network shall be pressure tested, leak tested, dried, evacuated and charged with the refrigerant after erection.

6. Controls & Instruments

- **Pressure gauges**

  Pressure gauge shall not be less than 150 mm diameter dial with appropriate working range and be complete with shut off gauge cocks etc., duly calibrated before installation. Pressure gauges shall be provided at the following location.

  A. Supply and return of Chillers and Condensers.
  B. Discharge of pumps.
  C. Inlet and outlet of heat exchangers.
  D. Supply and return chilled water line of A.H.U.

  In refrigerant line suction side gauges shall be compound gauges of the range 0-75 mm (0.3”) mercury vacuum and 4 kg/sq. cm positive pressure. Discharge side gauge 0-6 kg/sq cm pressure. Gauge shall be connected to pipe by 6 mm dia copper tubing through 6 mm dia shut off cocks.

- **Thermometers**

  Thermometers shall be 150 mm dial type with capillary tube and protective sheets, duly calibrated before installation.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER:-

The following data shall be furnished by the tenderer along with the offer.

1. **Refrigerant Compressor**
   a) Manufacturer
   b) Model No.
   c) Refrigerant
   d) Capacity at operating conditions
   e) Maximum speed/operating speed
   f) BHP at operating conditions
   g) BHP/TR at operating conditions
   h) BHP consumption
      - 100% load
      - 75% load
      - 50% load
   i) Types of controls offered and make
   j) Motor
      - Make :
      - Type :
      - Rating (KW) and rpm :
   k) Starter : Make & Type
   l) Capacity control
   m) Lubrication
   n) Total weight
   o) Noise level at 1 meter distance in dB(A)
   p) Vibration level
   q) Vibration isolators details

2. **Condenser**
   a) Manufacturer
   b) Shell diameter and length (mm)
   c) Tube material
   d) Fouling factor
   e) No. of tubes
   f) Tube diameter (mm) and thickness
   g) Tube length (mm)
   h) Tube surface area inside (m²)
   i) Tube surface area outside (m²)
   j) No. of passes
   k) Water flow (m³/hr)
   l) Water velocity (m/sec)
   m) Water temperature entering (Deg.C)/leaving (Deg.C)
   n) Fin material and No. of fins/inch.
   o) Operating charge
   p) Pressure drop
   q) Refrigerant temp (Deg. C)
   r) Maximum cooling capacity (K.Cal/hr.)
3. **Chiller**

   a) Manufacturer
   b) Shell diameter and length (mm)
   c) Tube material
   d) Fouling factor
   e) No. of tubes
   f) Tube diameter (mm) and thickness
   g) Tube length (mm)
   h) Tube surface area inside ($m^2$)
   i) Tube surface area outside ($m^2$)
   j) Water flow ($M^3$/hr)
   k) Water velocity (m/sec)
   m) Water temperature entering (Deg.C)/leaving (Deg.C)
   n) Fin material and No. of fins/inch.
   o) Pressure drop
   q) Refrigerant temperature inlet /outlet (Deg. C)
   r) Maximum cooling capacity (K.Cal/hr.)
   s) Operating weight (kg)
12.0  ES8 - CHAIN PULLEY BLOCK

01  General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Chain Pulley Block with all accessories complete in all respect. Specific technical requirement of Chain Pulley Block if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Chain Pulley Block is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

02  Description

Chain pulley block shall be considered conforming to IS:3832 – 1986.

Indian Standard

Hand-operated chain pulley blocks are used extensively for material handling during construction, erection and maintenance of industrial plants.

The minimum requirements of load chains shall be graded to Grade 40. Further a design test to prove the design of the block to a factor of safety of 4 has been included.

This standard lays down the general requirements and testing of the hand-operated chain pulley blocks, worm or spur gear type.

Hand-Operated Chain Pulley Blocks - A block riveted with a load chain and operated by a hand chain so as to give a mechanical advantage.

DESIGN - The blocks shall be so designed that all components shall withstand without failure, an application to the block of a load equal to at least four times the working load limit.

RATING - The hand-operated chain pulley blocks shall be rated according to the working load limit which in case of a block with four or fewer falls shall be determined from the safe working load of the load chain. Where the falls exceed four, or angles are introduced into the chain run, a chain stronger than that for the corresponding four-fold block is required to provide for the additional load caused by friction.

Each chain pulley block shall be subjected by the manufacturer to a proof load of 1.5 times the working load limit through a length of lift which will ensure that every part of the block will sustain the load test.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer.

1. Make & Model
2. Capacity handling in ton
3. Quantity
4. Class of duty as per IS:3832-1988
5. Head room, mm
6. Lift room, mm
7. Minimum radius of curvature of the track beam with which this hoist can be negotiate
8. Weight
9. Specification of each chain
10. Tools & tackles included in the offer
11. Commissioning spares & 2 years operating spares included in offer.
12. Effort
13. Velocity ratio
13.0 ES9 - COOLING TOWER

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Cooling Tower with all accessories to make operation of Cooling Tower complete in all respect. Specific technical requirement of Cooling Tower if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Cooling Tower is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

Job specification of the project shall be referred for any specific requirement.

02 Description

Cooling tower shall be power driven or natural draft type shall be selected as per job specification requirement.

In General FRP type cooling tower shall be provided for the cooling of condenser recirculating water for HVAC application.

The capacity of the cooling tower shall be adequate to take care of the entire cooling water required for the air-conditioning plant. Only make up water will be made available from the plant network.

The cooling tower shall be mounted on masonry pillars on the floor.

Normally natural draft cooling tower shall have RCC basin construction. Alternatively the party may offer for wooden basin as per job specification requirement. Cooling tower capacity shall be adequate to cool water basin temperature up to maximum 32°C as per prevailing ambient condition.

Cooling Tower

Type : Induced draft counter flow
Casing/ Basin : RCC (for chilled water plant), FRP (for air conditioning systems)
Frame Work : MS hot dip galvanized (for air conditioning systems)
Fills : PVC
Nozzles : Brass
Bolts, nuts, miscellaneous hardware : MS electro galvanized
Fan hub & blades : Cast Aluminium
Fan type : Axial flow, direct drive
Fan speed : 720 rpm
Degree of protection of motor : IP 55 (temperature rise limited to class B)
Ladder : Galvanized steel ladder with safety cage & hand railing up to the top of tower. Inclined to 30° to the vertical
Eliminators : No. of deflector to be arranged to reduce drift loss < 0.2% of water circulation.

Cooling Tower Accessories:
(i) Level switch at cooling tower basin (to be interlocked with pump)
(ii) Make up connection with float valve (float made of copper), back up ball valve
(iii) Quick fill connection with ball valve
(iv) Overflow connection
(v) Drain connection with ball valve
(vi) GI wire mesh 18 gauge strainer
(vii) Equalizing line of cooling towers with isolation valves
(viii) Cooling tower basin (for chilled water plant) shall have minimum 5 minute water holding capacity (of circulation water volume)
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer for cooling tower.

1. Make & Model
2. Type
3. Quantity
4. Overall size of cooling tower
5. Capacity of cooling in TR.
6. Water flow m³/h
7. Air flow
8. Design water inlet temperature, outlet temperature
9. Material of construction and its thickness
10. Speed in rpm.
11. Drive details.
12. Shaft Power consumption.
13. Wheel diameter.
15. Size of fan
16. Static & Dynamic weight of fan & motor assembly
17. Bare weight and operating weight of cooling tower
18. Noise level at 1m distance in dB(A)
19. Fixing details.
20. Vibration level.
21. Water spray nozzle type
14.0 **ES10 - CYCLONES, MULTI-CLONE & PRE-COLLECTOR**

01 **General**

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Cyclone / Multi-clone/Pre-collector System with all accessories required to be installed for dust extraction / process application to achieve desired performance in all respect. Specific technical requirement of Cyclone /Multi-clone/Pre-collector System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Cyclone /Multi-clone/Pre-collector is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. **Description**

02.1 **Single cyclone/group of cyclones**

This consists of a vertical cylindrical body, in which dust-laden gas is introduced at the top through horizontal tangential inlet. The cylinder has a truncated cone as the lower section. As the gas moves down the cyclone body, it forms a peripheral vortex. This gives rise to centrifugal force, which throws the dust particles in the gas stream towards the walls which then separate from the gas stream and fall down and are taken out through a dust pipe. As the gas reaches the conical portion, the gas stream reverses direction and moves upwards towards the exhaust pipe forming an inner vortex. Cyclones shall be constructed of suitably stiffened mild steel casing of not less than 6 mm thickness. For variable flow application compartmentalized cyclone chamber shall be constructed to maintain required minimum velocity to achieve desired performance.

02.2 **Multi-clone**

This shall consist of a number of small diameter cyclones operating in parallel. Multi-cell cyclones shall be enclosed in suitably stiffened mild steel casing of not less than 6 mm thickness. The cyclone elements shall in general have diameters of 150 mm and below and shall have smooth finished surfaces.

Each unit shall include, but not be limited to the following: gas inlet chamber, cyclone elements with casing, clean gas exhaust chamber, bottom hopper for dust collection, rotary valve for each hopper, a differential pressure gauge to measure pressure drop across the unit and leak proof access openings. For variable flow application compartmentalized cyclone chamber shall be constructed to maintain required minimum velocity to achieve desired performance.

02.3 **Pre-Collector**

The collector shall be used as a preliminary dust catcher and a common header for different incoming ducts from various suction hoods. The collector shall comprise cylindrical casing with service doors of quickly clamped type, incoming and exhaust manifold connected to collector, rotary air lock / double flap valve at the bottom. The dust accumulated at the bottom of collector shall be disposed off through rotary air lock / double flap valve to the conveyor. The velocity of air inside the collector shall be around 4-5 m/s. The Tenderer shall compute the diameter of the collectors to achieve this velocity. The length of the collector shall depend on the convenience of connecting various ducts to it. Duct connections should not be bunched in a particular area and shall be evenly distributed on the cylindrical surface.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The tenderer along with the offer shall furnish the following data.

a) Pre-collector

1. Make & Model.
2. Capacity in m$^3$/h.
3. Pressure drop in mmWC.
4. Overall size of pre-collector
5. Velocity through collector body in m/sec.
6. Material of construction
7. Cleaning efficiency Vs particle size
8. Methods of dust disposal.
10. Total weight of pre-collector

b) Cyclone

1. Make & Model.
2. Capacity in m$^3$/h.
3. Pressure drop in mmWC.
4. Overall size of cyclone
5. Velocity through cyclone body in m/sec.
6. Material of construction
7. Cleaning efficiency Vs particle size
8. Methods of dust disposal.
10. Total weight of cyclone

c) Multi-clone

1. Make & Model.
2. Capacity in m$^3$/h.
3. Pressure drop in mmWC.
4. Overall size of multi-clone
5. Smaller cyclone diameter of multi-clone
6. Velocity through multi-clone body in m/sec.
7. Material of construction
8. Cleaning efficiency Vs particle size
10. Supporting frame details.
11. Total weight of multi-clone
15.0 ES11 - DAMPERS FOR AIR FLOW CONTROL

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of different type of air dampers required to be installed in the Air Flow Path with all accessories for HVAC system. Specific technical requirement of air dampers if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of dry air dampers is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. Descriptions of the dampers

02.01 Wall mounted dampers

a) Self acting damper (Gravity damper)

Self acting dampers are provided to maintain pressurisation inside the premises. The damper shall be multiblade type made of Aluminium flaps of not less than 24G thickness and MS frame. These shall be designed to operate when the positive pressure inside the premises exceeds 2-3 mm WC. It can operate in fully open or partial open positions.

b) Fusible link fire damper

Fusible link fire dampers are provided to stop the flow of air through the exhaust opening when fire breaks out in the premises. This damper shall be provided at the inside face of wall opening to be provided for outlet/exhaust of air from the premises. This damper shall essentially consist of multi-leaf blades. MS frame, fusible link with spring/gravity arrangement of auto closing of the damper. The fusible link shall be made of low melting alloy which can fuse at a temperature of about 70/80°C. The damper shall be normally in open position; it shall close on melting of the fusible link caused by temperature rise due to fire etc. in the premises.

02.02 Duct line dampers

a) Hand operated damper (Geared hand wheel)

The hand operated damper shall be multileaf opposite acting aerofoil blade type damper with external operating links provided at the outlet of the fan for controlling air flow. The damper shall be made of GI sheet with MS frame unless otherwise specified in the TS. The fully close/ open/ partial closing position shall be marked on the damper casing.

b) Electrically operated/pneumatic damper

The electrically operated damper shall be provided as a regulating device for control of air flow through duct as per TS requirement. Provisions shall be kept for interlocking the damper with fire protection system. The fully closed / open / partial closing position shall be marked on the damper casing.
c) Solenoid operated fire proof damper

This damper shall be provided in supply air duct. It shall be operated by solenoid which is to be interlocked with the fire detection system of the served premises. In case of fire in the premises the fire detection system shall activate the solenoid and the solenoid in turn shall close the damper to stop air flow in the duct line. The fully close/open position of the damper shall be marked on damper casing.

03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer.

03.01 Wall Mounted Dampers

a) General data applicable for all types of dampers
   1. Size
   2. Quantity offered
   3. Material of construction and its thickness
      i) Frame
      ii) Blade
      iii) Flange
   4. Provision of horizontal & vertical direction control
   5. Weight
   6. Velocity of air

b) Self acting damper

   1. Operate on differential pressure requirement mm WG –

b) Fusible link fire damper

   1. Material of fuse link
   2. Melting temperature of the fuse link

03.02 Duct line Dampers

a) Hand operated damper (Geared hand wheel)
   1. Operating device

b) Electrically operated damper
   1. Type of actuator
   2. Motor kW /Pole (in case of electrically operated damper)
   3. Pneumatic piston (for pneumatic operated damper): make, type and weight
   4. Compressed air requirement with pressure for pneumatic operated damper

b) Solenoid operated fire proof damper

   1. Type of actuator
   2. Supply voltage and solenoid power supply rating
16.0 ES12 - DUCTING NETWORK OF DUST EXTRACTION SYSTEM

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Ducting Network with all accessories required to be installed for Dedusting System application to achieve desired performance in all respect. Specific technical requirement of Ducting Network of Dust Extraction System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Ducting Network of Dedusting System is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. DUCTING NETWORK

Ducting Network shall comprise of suction hood, ducting, duct support, measuring hatch, cleaning hatch and duct line dampers as required.

Details of collecting enclosure and suction hoods

The suction hoods and enclosures shall be constructed of 5 mm MS plate unless otherwise specified in the job specification with necessary external stiffeners, flanges, counter flanges, fasteners, gaskets and other accessories for fixing with technological equipment and duct line.

Dust collection hoods and enclosures shall be fitted with conveniently placed hinged access doors (top hinged type) to enable internal access to the equipment for maintenance as required. The air velocity at hood inlet shall be 1.5m/Sec (max).

Duct work details shall have following minimum features:

1) Construction

The duct sizing shall be so selected to maintain proper conveying velocity throughout the system. Man holes/hand holes and dust outlets shall be provided at intervals to facilitate cleaning of dusts and for disposal of dust. The successful tenderer shall design the dedusting system ductwork connecting the dust collection hoods, to the dust collector, fans and stack. The ducting shall be fabricated from M.S. (IS: 2062-1999) having thickness as follows unless otherwise specified in the job specification:
At all duct bends (carrying abrasive dust such as sinter dust etc.) above 900 mm diameter shall have abrasion resistant liners with caster wood / rock basalt/FRP in line with job specification requirement.

For special application corrosion / abrasion resistant duct liner material of construction of FRP / Linear material may be required to be installed in line with job specification requirement.

2) Conveying velocity
A conveying velocity of 18-25 m/Sec shall be maintained at all points in the ductwork between dust collection hood and dust collection plant to ensure flow of air without settling of dust.

3) Provision for Slide Gates/ Dampers
All extraction points shall have slide gates (single leaf inclined plate type) / dampers provisions for flow balancing during commissioning if required. These gates/dampers shall be bolted by the successful tenderer in position after commissioning to prevent inadvertent operation and consequent un-balancing of flow of the dedusting system.

4) Provision of Flow Testing Points
All extraction branch ducts shall have two 50mm diameter capped sockets installed at 90° to one another at least 6D away from flow disturbance (bends, hood inlets) for insertion of pitot tubes for flow measurement and system balancing during commissioning. Test points are to be located in a readily accessible position in the duct. However in any suction hood if flow appears to be on the lower then necessary flow measurement and correcting device shall be made by the successful tenderer to suit site.

5) Straight Duct Runs
Interconnecting duct work shall be circular in cross section. The duct work shall be fabricated from mild steel plate, IS:2062-1999 or be seam welded spiral wound duct work as per job specification requirement.

6) Branches
Branch connections should be oriented to the top or side of the main with no two branches entering at opposite sides.

7) Joints
Matching flanges are to be bolted together with asbestos rope gasket or rubber gaskets. All bolts and gaskets for jointing shall be included in the successful tenderer scope of work. All duct joints are to be air tight to minimise air leakage.

8) **Duct Cleanout Doors**
Clean-out doors will be provided on horizontal runs, before elbows and junctions. The spacing between cleanout doors should not exceed 6 meters. Clean out doors will be constructed to have a length of 600 mm or the duct diameter which ever is less for ducts upto 1 meter diameter. Larger diameter ducts will have clean out doors sized 600 mm high by 600 mm wide.

9) **Duct system hangers and support**
The ductwork support spacing and hangers will be designed for the weight of settled dust plus a 25% design margin. Following dust load will be considered for designing duct and duct support and duct stiffeners.

<table>
<thead>
<tr>
<th>Duct dia</th>
<th>% Cross section of duct filled up with dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 500 mm</td>
<td>35%</td>
</tr>
<tr>
<td>500 mm to 1400 mm</td>
<td>30%</td>
</tr>
<tr>
<td>1400 mm and more</td>
<td>25%</td>
</tr>
</tbody>
</table>

Bulk density of dust will be considered 1.7 t/m$^3$ unless otherwise specified in job specification.

All inside building duct and duct along main structural building will be supported from plant building structure. Duct supporting member's length height section will be decided during detail engineering. To suit site condition supporting members may have to be modified by the successful tenderer without any commercial implication to the purchaser. All outside ducting network shall have independent duct supporting trestles.

10) **Ductwork Layout**
Ductwork will not interfere with fixed or mobile crane access to the plant. Horizontal run of the ducting will be avoided to prevent settling of dust.

Minimum horizontal clearance from road center line is 5 meters. It is the successful tenderers responsibility to effect the dedusting system ductwork arrangement in accordance with the design requirements set down in the specification and to the satisfaction of the purchaser/consultant.

11) **Ductwork integrity**
The successful tenderer’s ductwork design must ensure that the ductwork will not collapse at any point, should it be subject to the maximum suction capacity of the fan system. The design will accommodate any variation in ambient temperature.

12) It is the responsibility of the Successful tenderer to size all ductwork in detail as per duct balancing calculation. Duct balancing calculation will be furnished by the successful tenderer for approval of the purchaser. It is the Successful tenderer’s responsibility to
establish routes both inside and outside building. This is to be done in conjunction with and to satisfy the Purchaser.

13) The duct work will be pressure balance type. However, during testing and commissioning if any throttle piece is required for adjustment of flow in any duct branch same will be carried out by the successful tenderer without any commercial implication.

14) Flexible connection at inlet & outlet of fan and in the ducting network will be provided by the successful tenderer as required.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer.

A. Ducting

1. M² of duct work
2. Weight of duct work
3. Weight of supports and flanges
4. Material and thickness of duct work

B. Suction Hood

1. Material of construction
2. Measuring hatch provided or not
3. Capturing velocity
4. Hoods sizes

C. Duct line Damper – Manual / Elec. Operated

1. Make & Model & Type
2. Size of amp.
3. Material of construction and its thickness
4. Total weight
5. Fixing arrangement
6. Any other information
17.0 ES13 - DUCTING NETWORK FOR HVAC SYSTEM

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of GI/MS Ducting Network with all accessories required to be installed for HVAC application to achieve desired performance in all respect. Specific technical requirement of Ducting Network if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Ducting Network is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. Description of ducting network

The ducting network comprises of ducting work, duct line dampers, down comer & supply air diffuser with volume control damper (for HVAC system only), supply air grill/adjustable louver grill duct supporting arrangement, flexible connections etc.


These items are briefly described below:-

a) Ducting work

Ducting work consists of main duct, branch ducts, bends, reducers, joints, access doors etc. Duct work shall be complete with flanges, gaskets, stiffeners, fasteners (nuts, bolts & washers), hangers, etc. as required. Minor modification of ducting network may be required to suit site condition. GI Ducts shall be fabricated at site to match with site condition. Alternatively ventilation duct work may be fabricated with MS sheet in line with job specification requirement.

All ducting work shall be properly reinforced to prevent sagging, buckling or vibration.

GI Ducting shall be provided with joints at 2.5-3m interval conforming to IS: 655-1963 (RA 1999) as and where required. In case of flanged joints, the flanges shall be of angle iron type riveted with GI sheet on duct perimeter. Flange joints should be made air tight with use of felt gaskets.

Duct supports shall be provided to keep the ducting in position in aligned condition.

Measuring hatch for measurement of flow / pressure shall be provided in ducting network at convenient locations.

For proper distribution of air in the premises supply air grills (adjustable louver grills) with volume control dampers shall be provided in the ducting work for ventilation system and supply air diffusers with volume control damper shall be provided in the ducting work for air conditioning system.
Sizing of the duct shall be done for pressure balancing as well as to maintain the air velocities in the ducting work as given below:

<table>
<thead>
<tr>
<th>Description</th>
<th>Air Velocity for Ventilation System</th>
<th>Air velocity for Air conditioning system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main duct</td>
<td>8 – 10 m/sec.</td>
<td>6 – 7 m/sec.</td>
</tr>
<tr>
<td>Branch ducts</td>
<td>6 – 8 m/sec.</td>
<td>4 – 5 m/sec.</td>
</tr>
<tr>
<td>Supply air grills</td>
<td>4 – 6 m/sec.</td>
<td>-</td>
</tr>
<tr>
<td>Branch risers</td>
<td>-</td>
<td>4 – 5 m/sec.</td>
</tr>
<tr>
<td>Supply air diffuser</td>
<td>-</td>
<td>3 – 4 m/sec.</td>
</tr>
</tbody>
</table>

The following accessories may be fitted in the duct line depending upon the job specification requirement.

i) High efficiency filter  
ii) Strip heater for dehumidification purpose  
iii) Pan humidifier for humidification purpose

**Joints :**

In line with IS 655-1963 guide lines the type of transverse joints shall be follows unless otherwise specified in job specification:

Sealing:

All construction joints and duct seams shall be reasonably sealed with bitumastic cold emulsion or equivalent vapour seal.

**Bends :**

The interior of all ducts shall be smooth for free flow of air. The radius to bend shall be not less than 1.5 D. Turning guide vane shall be provided in all large duct bends and bends with radius less than 1.5 D for proper air flow.

**Access door :**

All main ductwork shall be accessible throughout using tight fitted hinged access doors, provided with sponge rubber gaskets. Angle joints shall be provided with felt or rubber gaskets for leak-tightness of the joints.

Access doors/panels are to be provided at following places:

- Near each fire damper  
- Near each Reheat coil  
- Near high efficiency filter/absolute filter

Any other place if envisaged by the owner about its essentiality during drawing approval or construction period.

In case access doors are to be installed in the insulated ducts, the access door panel should be insulated too with overlapping, such that it can be operated without damaging the duct insulation and there should be no condensation either on the access doors or on the duct when the plant is in running condition.
b) **Duct line dampers**:

Refer equipment specification no. ES-10.

c) **Adjustable louvers grill (Supply air grill) with volume control damper for ventilation system**

1.25mm MS sheet shall be used for the manufacture of grill. All grills shall be true to shape and shall be checked with a level gauge before being secured in position. No distortion or warping is permitted.

All duct mounted grill shall be complete with rubber gaskets and flanged holding frames of suitable design for the intended installation. They shall be mounted on collar extending from the duct. No part of grilles shall project into the main duct. The adjustable louver grill shall be provided with volume control damper as well as double deflection flap/grill for direction control.

d) **Supply air diffuser with volume control damper for AC System only**

Thickness of Grills, Diffuser, Damper shall be as follows:

- (a) Frame 16 gauge
- (b) Louvers 18 gauge

Supply air diffusers shall be circular/rectangular in shape as per detailed engineering requirement. The throat of a diffuser shall be connected with collar piece provided at the duct bottom for holding the diffuser as well as for supply of air. Each diffuser shall be provided with volume control damper. Each diffuser shall comprise of fixed plate, damper blade, damper blade operating knob, spindle, connecting rod etc. The diffuser should flush with the false ceiling. False ceiling shall not bear the load of any diffuser. The load of diffuser shall be borne by the duct and collar. Each diffuser shall be painted with appropriate colour to match with the colour of the false ceiling. Diffuser shall be placed considering light fittings position and false ceiling runner position. Diffusers/grills shall be of extruded aluminum powder coated/Anodized aluminum.

e) **Return air grill**

In general the return air opening shall be provided above false ceiling in the wall between served premises (control room) and A.C. plant room. The return air grill of suitable size shall be provided at the A.C. plant room side face of the said opening for smooth flow of return air. The air supplied in the served premises (control room) shall come/return above false ceiling through the return air slit of 50~100 mm all around false ceiling along the walls of the served premises. From there it shall pass into the A.C. plant room through the return air passage. The return grill shall comprise of horizontal fixed louvers made of 2 mm thick MS sheet, 50x6 thick MS
f) **Insulation**

Sheet metal duct shall be acoustically and thermally insulated as per requirement. For details of insulation refer respective equipment specification.

g) **Flexible connections**

Flexible material shall be used for fabrication of flexible connections of at least 100 mm length shall be provided at each connection between duct work and fan units and any other places as asked in the job specification. Flexible connection material shall be selected considering temperature, pressure application of the job specification requirement.

h) **Hangers & supports for ducting**

All duct work shall be provided with adequate supports as required to ensure rigid support and to prevent vibration.

The fixing and supports interval shall not exceed 3 meters. Hanger rods having U-bend at one end and threading at other end shall be hanged from angle clit to be anchor fastened from. Hanger rod shall be attached to the ceiling by anchor/ expansion bolts. Duct angle supports from brick wall/RCC wall/ structural wall shall be grouted / welded to suite site.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offers.

a) Ducting

1. m² of duct work
2. Weight of duct work
3. Weight of support and flanges
4. Material and thickness of duct work
5. Duct support type and material
6. Velocity of air.

b) Supply Air Grills (Adjustable louver grills) /Diffuser with volume control facility

1. Size
2. Quantity offered
3. Material of construction & thickness
4. Provision of horizontal & vertical direction control
5. Weight
6. Velocity of air
7. Methods of volume control

e) Return air grills/intake air louvers

1. Size
2. Quantity offered
3. Material of construction
4. Weight
5. Velocity of air
18.0 ES14 - ELECTROSTATIC PRECIPITATOR

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Electrostatic Precipitator (ESP) System with all accessories required to be installed dust extraction / process application to achieve desired performance in all respect. Specific technical requirement of Electrostatic Precipitator (ESP) System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Electrostatic Precipitator (ESP) System is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02 Description

1. Electro Static Precipitator and Accessories will include:
   - Housing assembly of fabricated plate work.
   - Gas distributor plate at inlet and outlet of ESP.
   - Dust hopper assembly of fabricated plate work.
   - Discharge electrodes.
   - Dust collecting electrodes.
   - Rapping units for both discharge, collecting electrodes and gas distributors.
   - ESP supporting structure complete with service platforms and walkways, stairs, hoisting facilities etc.
   - In general Minimum no. of 4 electric field shall be considered unless defined in the TS to achieve required stack emission standard
   - Two nos. rapping system (for collecting electrodes) at the 3rd & 4th field to control puffing dust.
   - Specific collection area shall be considered based on party experience on past project. However required specific collection area shall not be less than minimum as defined in the TS.

2. Electrics
   - High voltage power supply package.
   - Power supply to all drives with interlocks and controls.
   - TR controller with feedback control optimisation of current voltage from on line continuous stack monitoring instruments.
   - For details refer job specification requirement.
   - Temperature and pressure transmitter, CO gas analyser as required.

DESCRIPTION OF ESP SYSTEM

ESP system will comprise of multiple fields, unit/multiple cells Electrostatic Precipitator (ESP) and its accessories such as Dust disposal system, Electrics and control, Instrumentation, interlocks, Supports etc.
Design requirement

1. The Electrostatic Precipitator (ESP) will be in general dry, horizontal flow type. It should be a completely self-supporting unit, ready to be assembled on the foundation.

2. Configuration

The Electrostatic Precipitator will feature one gas pass design, with Compensator at inlet & outlet of ESP.

3. Electrostatic Precipitator casing

   a) The precipitator steel casing will be gas tight and of welded construction throughout. Casing plate thickness will be 6 mm minimum unless otherwise specified in job specification.

   b) The precipitator must cope with the fan running at full output and the fan inlet damper shut without suffering structural or mechanical damage. For gas cleaning system, working pressure will be maintained as per system requirement. The normal working pressure of suction and temperature will be considered as specified in job specification.

   c) The precipitator will have access openings ladders, will stairs, platform etc. necessary for inspection, cleaning and maintenance. All equipment and the openings will be made accessible to the maintenance personnel by installation of access ways, ladders, platforms etc.

   d) Sealing of glands, inspection doors, etc. must be such that air is prevented from leaking into the electrostatic precipitator to prevent in filtration of ambient air. The precipitator will be of weatherproof construction.

4. Electrodes

   a) The discharge electrodes will be of rigid ribbon type so that they can withstand efficient rapping and temperature changes.

   b) Collecting electrodes will have a spacing of approximate 400 mm. The collecting plates should be 1.5 mm thick CR sheets to ensure an adequate service life.

   c) Discharge electrodes and collecting plates will be automatically and sequentially rapped with heavy duty tumbling hammer type mechanical rappers.

5. Rapping

The electrode rapping system will be capable of maintaining clean electrodes. The supplied rapping mechanism will feature a microprocessor based adjustable rapping frequency for each field.

6. Insulator housing

Special attention will be given to the support rapping shaft insulators. These will be electrically heated to avoid condensation and will have efficient seals to avoid dust deposits.
7. Safety

The Electrostatic Precipitator will be provided with a key interlocking system for preventing access to high voltage internals of the precipitator until the associated high voltage system is de-energised and grounded. All the access opening will be provided with earthing rods. The earthing strips will be of GI and it will be firmly bolted to the precipitator casing.

8. Hoppers

Each field of the Electrostatic Precipitator will be fitted with a dust hopper. The hopper will be constructed of 8 mm plate unless otherwise specified in TS. The hoppers will have a pyramidal / conical configuration with 65\(^\circ\) valley angle minimum.

Inspection doors, poke holes and electric heaters will be provided in the hoppers. Motorised double cone valves will be provided at the hopper discharge. High and intermediate level switches will be installed in each ESP hopper. With the help of intermediate level switch dust in hopper can be discharged into the chain conveyor by double cone valve. High level switch in ESP hopper will be provided for safety interlocks. Stainless steel liner of 1.6 mm thick up to a height of 1.2 m from the bottom flange of ESP hoppers and storage hopper will be provided for smooth flow of dust.

Separate dust-dumping outlets with flange provision, necessary chutes, gates etc. will be provided by Successful Tenderer with each ESP hopper and dust storage hopper for dumping of dust in case of increase in alkali content to prevent recycling of dust under emergency situations as per requirement. Therefore, Truck / dumper entry provision below each ESP hopper will be provided by Successful Tenderer for dust disposal.

9. Insulation

ESP walls, roof panels, and hoppers will be provided with thermal insulation of resin bonded mineral wool of density 100 kg/m\(^3\) as per IS 8183-1993 having 50 mm thickness for hot gas application. The thermal insulation will be covered with 0.8 mm CGI sheet cladding.

10. Platforms and access ladders

The minimum platform width will always be 1.00 meters. The platforms will be located at the top of hoppers level and at the top of the gas cleaning equipment. Safe guard rails will be provided around all the platforms. Angular rather than round rails members will be used, if possible. Safe and easy access to the platforms will be provided by providing stairways to chain conveyor platform level, ESP chamber access door level, ESP top and transformer house etc. Maintenance platforms all over ESP area, at dust disposal conveyor level will be provided. Access door to ESP chamber will be provided from both side. Access doors to distributor grid will also be provided. Maintenance platforms at access door level all around ESP will be provided. Ladder approach with platform will be provided for hopper level switches, access doors, hopper heater and for any other equipment or access above man height.
Brief specification of material of construction is mentioned below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item</th>
<th>Material</th>
<th>Thickness (minimum)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Collecting Electrodes</td>
<td>IS-513 CR sheet</td>
<td>1.5 mm</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Discharge Electrodes</td>
<td>IS-513 spiral SS coil / rigid member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>ESP casing</td>
<td>IS-2062-1999 Gr. A</td>
<td>6.0 mm thick</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>G.D. screen</td>
<td>IS-2062-1999 Gr. A</td>
<td>3.15 mm</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Hopper wall</td>
<td>IS-2062-1999 Gr. A</td>
<td>8.0 mm thick</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Pert house roof(insulator chamber)</td>
<td>IS-2062-1999 Gr. A</td>
<td>5.0 mm thick</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Side wall of insulator chamber</td>
<td>IS-2062-1999 Gr. A</td>
<td>3.15 thick</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>ESP inlet and outlet connection piece</td>
<td>IS-2062-1999 Gr. A</td>
<td>8.0 mm</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Access grating, stair trades</td>
<td>IS-2062-1999</td>
<td>45 depth – 6 mm thick, 40 centre to centre</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Insulation or ESP casing (for hot gas application)</td>
<td>Resin bonded mineral wool IS-8183-1993 density 100 kg/m3</td>
<td>50 mm thick with 0.8 mm CGI sheet cladding</td>
<td>Density of wool 100 kg/m3</td>
</tr>
<tr>
<td>13.</td>
<td>Insulation of hopper (for hot gas application)</td>
<td>Resin bonded mineral wool IS-8183-1993 density</td>
<td>50 mm thick with 0.8 mm CGI sheet cladding</td>
<td>Density of wool 100 kg/m3</td>
</tr>
</tbody>
</table>

Keeping in view the properties of the dust, the Successful Tenderer will make selection of material and thickness of plates and supporting structure. However, minimum material of construction specification shall be as mentioned above.

11 Air tightness of ESP housing

The construction of the ESP housing and design of dust disposal gates, insulator boxes and discharge electrodes will be such that air infiltration inside ESP housing is negligible to prevent corrosion problem.

**DESIGN CRITERIA**

1. Following technical input parameters will be considered as a general guide line only for designing the ESP cleaning system since the actual gas & dust composition and condition of gases changes based on operation / process condition of technological plant. Based on the job specification data as well as the past experience of successful tenderer and their collaborator on design of ESP for technological process, successful tenderer will demonstrate and establish performance guarantee parameters under varying process parameters.

   i) Type : cells, fields, dry/wet horizontal/vertical
   ii) Gas handled : Dusty gas from process application
   iii) Design flow : m³/hr (avg.). at operating temp.
iv) Temperature : °C Normal °C maximum
v) Bulk density of dust : t/m3.
vi) Dust content at ESP inlet : gm /Nm3.
vii) Dust content at ESP outlet : mg /Nm3.
viii) Gas velocity through ESP : m/sec
ix) ESP duty condition : 24 hrs continuous operation
x) Chemical composition of air(% vol.)
   - Oxygen -
   - Carbon dioxide -
   - Carbon monoxide -
   - Nitrogen -
   - Sulphur dioxide-
   - Moisture-
   - Other constituents-
xi) Chemical composition of dust (% weight)
   - CaO -
   - SiO₂ -
   - Fe₂O₃ -
   - Fe -
   - FeO -
   - Al₂O₃ -
   - MgO -
   - MnO -
   - P -
   - S -
   - C -
   - Na₂O & K₂O -
   - Other constituents-
xii) Particle size of dust (% distribution):
   < 5micron :
   5-10 micron :
   10-20 micron :
   20-30 micron :
   30-40 micron :
   > 40 micron :
xiii) Expected cleaning efficiency under normal design condition:
   (moisture content -v/v, Temperature : Deg C ,
   Inlet dust content - gm/Nm3, Gas flow volume - m3/hr)
xiv) Basicity Ratio –
xv) Migration velocity – cm/sec
xvi) Permissible noise level - 85 dB (A)

2. Guaranteed Emission value

The efficiency of the ESP will be such that the guaranteed emission of dust from stack will
not be more than 50 mg/Nm² or as per job specification requirement.

Correction curves for calculating revised efficiency will be applicable for change in following
input parameters:
a) Temperature  : Design temperature will be considered as defined in the TS.

b) Moisture content : Correction factor will be not be applicable

c) Dust load : Correction factor will be applicable provided dust emission not exceeding 50 mg/ Nm3.

d) Gas flow : Positive factor or negative correction factor will be applicable for decrease or increase in gas flow respectively.

e) Dust composition  :
   gas composition and particle size analysis : No correction factor will be applicable for change in said parameters. Successful tenderer will select the ESP which will be suitable for dust generated by the specific process.

3. The Successful Tenderer will adopt the following criteria while designing dust disposal system.
   i) Easy maintenance of dust disposal equipment.
   ii) Minimisation of outside infiltration to the ESP casing.
   iii) Moisture regulation facilities to control dry dust disposal nuisance as well as too much wet dust handling problem.

4. The equipment will be suitable to operate satisfactorily under such variations of load, pressure and climatic conditions as may occur during working.

5. Working parts of all equipment will be suitably located for convenient operation and will allow access to facilitate easy replacement, connecting up, inspection, lubrication, maintenance and repair, without dismantling other equipment/ components/ structures.

6. The Successful Tenderer will do physical model testing for gas flow distribution study inside ESP at a minimum scale of 1:15 for this project at manufacturer’s works for designing and selection of GD screen. Necessary inside model elements of ESP like GD screen, discharge electrodes, collecting electrodes etc. will be fitted with the model as per scale. Purchaser and purchaser’s representative will witness the above testing at manufacturer’s works. The date of witnessing of the test will be informed by the Successful Tenderer during design engineering.

7. Design calculation of ESP main supports, weather enclosure, structures, platform will be based on IS-875-1987 Part-I, II & III and IS-800-1984. Service load of 4KN/sqm and 2 KN/sqm will be considered for maintenance platform and walk ways respectively.

8. Compensator between rotary feeder and the chain conveyors, between two conveyors and between dust moistener and rotary feeder will be provided to facilitate maintenance. Slide gates will be provided before all the double cone dust valves/rotary feeder. For calculation and design of structural members, accidental fill up of dust up to top of ESP hoppers in worst case will be considered by Contractor.

9. To ensure safe and reliable operation of ESP, the Successful Tenderer will provide the following minimum safety measures.
i) Prevention of condensation inside ESP chamber.
ii) Prevention of rapping system from damage.
iii) Prevention of insulator creeping and damage.
iv) Prevention of air leakage and corrosion.
v) Provision of heat expansion accommodation.
vi) Prevention of personal inquiry.
vii) Lighting resistance and grounding
viii) Explosion protection arrangement.
03. DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER:

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Item Description</th>
<th>Technical Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. ESP design data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Model No.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Treatment velocity</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Treatment time sec/Treatment length m</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Aspect ratio</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Press, drop mm WC</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Migration velocity cm/sec</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Guaranteed outlet emission at design conditions</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>WI of ESP with dust, ton</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Overall size, Approx. WxLxH m</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Cross sectional Area m²</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Collaborator</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Casing Design condition</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>TR set rating</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>SCA m²/m³/sec.</td>
<td></td>
</tr>
<tr>
<td><strong>B. Collecting Electrode</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Material</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Height m</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Spacing mm</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Area m²</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Rapper type</td>
<td></td>
</tr>
<tr>
<td><strong>C. Discharge Electrode</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Material</td>
<td></td>
</tr>
<tr>
<td><strong>D. ESP – Proper</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Gas distributor</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Insulator heating</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Bearing</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>ESP, inlet and outlet cones</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Whether enclosure sheeting and fixing hardware for TR set</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Monorail with electrical operated trolley and hoist for lifting TR sets</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Insulation of casing and hopper</td>
<td></td>
</tr>
<tr>
<td><strong>E. ESP Hopper</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Quantity</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Hopper volume each</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Valley Angle in deg.</td>
<td></td>
</tr>
<tr>
<td><strong>F. TR Rating and Drive Rating in KW</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>TR sets for different fields with quantity</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Rappers :</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas distributor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C. Electrode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D. Electrode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hopper heater</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>RAL Valve</td>
<td></td>
</tr>
<tr>
<td><strong>G. Safety Interlock System</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Mechanical Key interlock safety system for each access door</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Lightning arrester and grounding</td>
<td></td>
</tr>
</tbody>
</table>
19.0 ES15 - FILTER DRY TYPE

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of different type of dry air filters required to be installed in the Air Flow Path with all accessories for HVAC system to achieve desired efficiency of cleaning. Specific technical requirement of air filter if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of dry air filter is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02 Description of the dry air filters

Dry panel type air filter shall be of high efficiency cleanable type, constructed out of HDPE (6 ply) supported by layers of GI wire gauge. It shall be corrugated to the depth of filter casing in order to increase the ratio of filtration area to frontal area. It shall be covered by strong GI/MS frame and have space to ensure uniform distribution of air. Filtering panel shall be of standard size which can be mounted on angle frame in multiple number as per capacity of the fan. Face velocity of air shall not exceed 1.5 m/sec. The resistance of air filter shall not exceed 10 mm WC when dirty. Efficiency of the normal air filter shall not be less than 90% down to 10 microns unless otherwise specified in the TS. Cleaning efficiency of the high efficiency air filter shall not be less than 99% down to 5 microns unless otherwise specified in the TS. Absolute filter as required shall be considered in line with job specification requirement. The whole filter and frame assembly shall be mounted at the wall / at the inlet of tube axial flow fan/ metallic box as required Panel type air Filters testing shall conform to IS-7613 –1975 ( Reaffirmed – 1996)
DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The tenderer along with the offer shall furnish the following data.

a) **Dry Panel type filter**
   1. Make & Model.
   2. Capacity in m$^3$/h.
   3. Pressure drop in mmWC.
      i) When clean
      ii) When dirty
   4. Effective cross sectional free and face area in m$^2$
   5. Velocity through filter free and face area in m/sec.
   7. Cleaning efficiency Vs particle size
   8. Methods of surface regeneration.
   10. Overall dimensions & no. of filters.
   11. Fixing frame details.
   12. Total weight. free and face area
<table>
<thead>
<tr>
<th>20.0</th>
<th>ES16 – FILTER VISCOUS OIL TYPE :</th>
<th>VOID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>01 t</td>
<td></td>
</tr>
</tbody>
</table>
21.0  **ES17 – THERMAL & ACOUSTIC INSULATION FOR HAVAC (INSULATION FOR COLD APPLICATION)**

**01. General**

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Insulation with all accessories for HVAC application. Specific technical requirement of Insulation if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Insulation is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

**02. Description of Insulation requirement:**

The insulation of water piping, air-handling units, ducting, chillers etc. shall be carried out as per following specifications (a) to maintain proper temperature of fluid/vapour in the conduits (b) to prevent surface condensation on cold surfaces.

1. **Insulation Materials**

The materials to be used for insulation shall be as follows, unless some other material is specifically mentioned elsewhere.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Surface Material</th>
<th>Insulation material</th>
<th>Insulation</th>
<th>Thickness (mm)</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Refrigerant piping</td>
<td>Closed cell foamed plastic</td>
<td>--</td>
<td>30</td>
<td>Al cladding</td>
</tr>
<tr>
<td>2.</td>
<td>AHU drain pipe</td>
<td>Closed cell foamed plastic</td>
<td>Pipe section</td>
<td>30</td>
<td>Al cladding</td>
</tr>
<tr>
<td>3.</td>
<td>AHU casing and condensate pan</td>
<td>PUF</td>
<td>Slabs</td>
<td>25</td>
<td>--</td>
</tr>
<tr>
<td>4.</td>
<td>Chilled water piping (100 NB &amp; less)</td>
<td>PUF</td>
<td>Pipe section</td>
<td>30</td>
<td>Al cladding</td>
</tr>
<tr>
<td>5.</td>
<td>Chilled water pipe insulation (125 NB &amp; above)</td>
<td>PUF</td>
<td>Pipe section</td>
<td>50</td>
<td>Al cladding</td>
</tr>
<tr>
<td>6.</td>
<td>Cooler</td>
<td>Closed cell foamed plastic</td>
<td>--</td>
<td>50</td>
<td>Al cladding</td>
</tr>
<tr>
<td>7.</td>
<td>Chilled water pumps, valves, flanges etc.</td>
<td>Resin bonded glass wool</td>
<td>--</td>
<td>--</td>
<td>Al cladding</td>
</tr>
<tr>
<td>8.</td>
<td>Expansion tank</td>
<td>PUF</td>
<td>Slab</td>
<td>50</td>
<td>Sand cement plaster</td>
</tr>
</tbody>
</table>
9. **Acoustic insulation**

10. **Under deck thermal insulation**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acoustic insulation</td>
<td>Resin bonded glass wool</td>
<td>Fiber glass tissue &amp; perforated Al sheet</td>
</tr>
<tr>
<td></td>
<td>Under deck thermal insulation</td>
<td>PUF</td>
<td>Slab</td>
</tr>
<tr>
<td></td>
<td>Slab</td>
<td>50</td>
<td>Al cladding</td>
</tr>
</tbody>
</table>

### 3.0 **Ducting**

The air handling ducts shall be insulated with resin bonded glass/mineral wool with density not below 24/48 Kg/M3 with polythene back bessian on outer side. Duct insulation thickness shall be as follows:

- AC Duct in conditioned space: 25 mm thickness
- AC Duct in unconditioned space: 50 mm thickness
- AC Duct with treated fresh air: 50 mm thickness

#### 5.1 **Application Procedure**

- Clean the surface with wire brush to make it free from rust etc.
- Apply two coats of hot bitumen 85/25 to the surface at a ratio of 1.0 Kg/M2 for first coat & in patches for second coat wrap the duct with insulation blankets of the specified thickness. Apply PBH layer on the outside and reinforce it by tying GI wire of 0.5 mm at interval of 450 mm.

Duct in outdoor areas exposed to weather shall be covered with 24 SWG Aluminium sheet bent true to shape and secured with self-tapping screws and over lapped joints sealed with Loidseal – 94.

### 4.0 **Acoustic Lining**

The first 4.5 meter length of duct starting from each fan outlet shall be provided with insulation for acoustic purposes. The insulation material already specified in clause 2.2.2. Then it shall be covered 0.56 mm perforated Aluminium sheets.

#### 4.1 **Application Procedure**

- The duct surface shall first be cleaned from inside. The insulation boards shall be wrapped in Glass Cloth of 7 mil thick. With ends stitched. The boards shall be fixed inside the duct. The insulation shall then be covered with 0.56 (24 SWG) perforated Aluminum sheets.

The sheet and the insulation, shall be secured to the duct by means of cadmium plated bolts, nuts and washers and the ends should be completely sealed off so that no insulation material is exposed.

### 5.0 **Walls and Ceiling – Acoustic Treatments of equipment rooms**

Insulation material shall be resin bonded glass wool/mineral wool of density 32/48 Kg/M3 of 50 mm thickness.

#### 5.1 **Application Procedure**

- Fix 40 mm x 50 mm Deodar/Kail wood battens at 500 mm intervals longitudinally. Then fix cross battens at 1.0 meter C – C using suitable gutties and brass/SS Screws.
Fill each rectangle with 50 mm resin bonded glass/mineral wool wrapped in glass cloth. Then tie with 24 SWG GI wires at 300 mm intervals. Then cover with 24 SWG (0.56 mm) perforated Aluminum sheet having 3 mm perforations at 6 mm C – C. Overlap all the joints and provide beady of 25 mm by 1.5 mm MS flat.

**Extent of Acoustic Treatment :**

- **Walls :** Two of the walls enclosing the room starting from 1 ft. above the floor up to the ceiling.
- **Ceiling :** The entire ceiling covering the room.

6.0 **Measurement :**

The measurement of insulation of vessels, piping and ducts shall be made over the insulated surface area as per IS : 7240 – 1981.

**03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER FOR INSULATION OF HVAC APPLICATION**

The following data shall be furnished by the tenderer along with the offer.

22. Make & Type
23. Quantity
24. Density in kg/m3
25. Thermal conductivity
26. Sound absorption co-efficient
27. Material of construction and its thickness
29. Vapour barrier material
30. Firel resistance property
31. Cladding material
22.0 ES18 - INSULATION FOR HOT APPLICATION

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Insulation with all accessories for hot surface application. Specific technical requirement of Insulation if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Insulation is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

02. Description of Insulation requirement:

02.1 General Requirements:

Thermal insulation shall be provided for all vessels, equipment, pipe fittings, heat exchangers etc. containing fluid or vapour for which it is necessary to (a) Conserve heat (b) Maintain temperature for process control (c) provide for personnel protection.

Thermal insulation system shall be selected so as not to result in a residual heat loss exceeding 150 Watts/M2 under plant operating conditions measured over insulated surfaces. For design, the following data are specified:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient air temp.</td>
<td>45°C (Max.)</td>
</tr>
<tr>
<td>Wind velocity</td>
<td>1 m/sec.</td>
</tr>
<tr>
<td>Surface temp.</td>
<td>Not to exceed 15°C above ambient</td>
</tr>
</tbody>
</table>

Design should include de-rating factors of direct conduction paths e.g. spacer rings and stitching wires normally associated with blanket type insulation material.

02.2 Reference Standards:

- IS : 9842 - Specification for pre-formed Fibrous Pipe Insulation, Group– III
- IS : 737 - Wrought Aluminum and Aluminum Alloys, sheets & strips
- IS : 7413 - Code of practice for the application & Finishing of thermal insulation materials at temperatures between 40°C and 700°C (latest revision)

02.3 Application procedure: Piping:

- For surface preparation wire brush shall be used to remove rust, dust or oil etc. thoroughly.

- Fix the pre-formed pipe-section insulation of required thickness against each diameter of pipe as per the Thickness requirement for Temperature glass and pipe diameter. Construction (upto 75mm thick – 1 layer thereafter 2 or 3 multi layer) joints should be staggered so that complete breaks are minimum on single layer insulation and no through joints occur in multi layout work. The insulation must be held in position by strapping with 20mm x 24 SWG Aluminium Straps.

- When lightly bonded rock wool mattress are used, they shall be wrapped around the pipes without any under layer. On top of each layer, the wire netting already on top of mattresses should be tightly butted against each other so that the fibers interlock both along the longitudinal
and circumferential joints. The pipe joints shall be stitched with 22 SWG soft GI lacing wire for pipes upto 400mm O.D. For pipes over 400mm O.D., the mattresses should be further secured by strapping with 20 mm x 24 SWG Al. straps at 500mm intervals.

- All uninsulated flanges, pipeline insulation shall be stopped off at a suitable distance from the flange for facilitating withdrawal of bolts without disturbing insulation.

- In regard to supporting of insulation to vertical pipelines it is essential that all the pipe insulation (above 200 NB pipe) should be supported at minimum of 3.0 meters distance by applying insulation support spider clamps. These clamps are fitted around the pipeline bare surface with projecting legs whose length should not be more than 70% of insulation thickness.

- **Flanges and Valves**

Removable covers shall be provided over all flanges and valves whenever they are insulated with preformed materials. These covers over valves and flanges shall have provision for quick – release clips.

- **Sheet Metal Cladding**

All pipes shall be covered with Aluminum sheet (Aluminum sheet of 24 SWG/0.56mm upto 325mm O.D. inclusive of insulation thickness and Aluminum sheet of 22 SWG/0.71mm beyond 325mm O.D.) conforming to IS:737, to the outside of the insulation with minimum 25mm circumferential and longitudinal over laps. The over lapping should be grooved so as to prevent ingress of water into the insulation. In horizontal piping, joints shall be arranged at an angle of 30 to 40° from the horizontal so as to shed rain water.

When lightly bonded rock wool mattresses have been used as the insulation material, spacer rings shall be required screwing the Aluminum sheet. The sheet metal shall be secured to themselves by self-tapping screws at a pitch not exceeding 150mm.

After securing the Aluminum sheet, the overlapped joints of the sheet metal shall be sealed with metal sealant to make joints perfectly waterproof.

**02.4 Application Procedure – Vessels & Equipment:**

- The surface to be insulated shall be thoroughly cleaned by wire brushing to remove dirt, loose scales, dust etc.

- Where welding is permissible, weld 10 SWG GI spokes at 300 – 400mm diamond pitch.

- ‘L’ shaped lugs to be fixed to the spacer rings made of 25mm x 3mm MS flats at 450mm C – C with 25mm x 25mm x 3mm asbestos mill board washers and 4mm MS rivets.

- The spacer rings shall be fixed around the tank at 900mm C – C by welding ‘L’ shaped lugs to tank body.

- Impale Rock wool lightly bonded machine stitched mattresses with one side wire netting of required density (upto 400° – 100 Kgh/M3, above 400° – 120 Kgh/M3) and thickness with the ends of mattresses butted closely together with lacing wire of 22 SWG. In addition, mattresses shall be secured with tightly tensioned circumferential Aluminium bands at approx. 450mm pitch.
• The ends of GI spokes to be bent on the insulation.
• The Aluminium metal cladding (22 SWG/0.71mm) is to be fixed on the spacer rings with self-tapping screws at 150mm C – C.
• All over lapped joints of Aluminum sheet metal shall be sealed with loidseal-94 to make joints waterproof.

02.5 Expansion Joints:

Expansion joints shall be provided in the insulation to allow for movement and expansion of the pipe or vessel without producing random crack. At the expansion joints, there shall be complete cut and the cutout portion shall be 25mm wide and dry filled with loose insulation material the density of which shall be equal to that of the basic insulation. The expansion joints wherever necessary shall be installed by overlapping the cladding material.

<table>
<thead>
<tr>
<th>Pipe temp. °C</th>
<th>Spacing of Expn. Joints in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 200°C</td>
<td>No Expn. Joint.</td>
</tr>
<tr>
<td>201 to 300°C</td>
<td>3.5</td>
</tr>
<tr>
<td>301 to 400°C</td>
<td>3.0</td>
</tr>
<tr>
<td>Above 400°C</td>
<td>2.0</td>
</tr>
</tbody>
</table>

02.6 Design Criteria

- Ambient air temperature : 35°C or 45°C
- Design surface temperature : Not to exceed 15°C above ambient air temperature
- Wind velocity : 1 meter/second
- Cladding over insulation : Aluminium (Emissivity : 0.2)
- Insulation material : Rock wool density 144 Kg/M3 upto 350 mm NB, 100 Kg/M3 above 350°C and 150 Kg./M3 above 400°C

General Guidelines for insulation thickness

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>100°C</th>
<th>200°C</th>
<th>300°C</th>
<th>400°C</th>
<th>500°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe NB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>25</td>
<td>40</td>
<td>70</td>
<td>100</td>
<td>140</td>
</tr>
<tr>
<td>200</td>
<td>25</td>
<td>45</td>
<td>80</td>
<td>115</td>
<td>160</td>
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<tr>
<td>300</td>
<td>25</td>
<td>45</td>
<td>85</td>
<td>125</td>
<td>170</td>
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<tr>
<td>400</td>
<td>25</td>
<td>55</td>
<td>95</td>
<td>145</td>
<td>190</td>
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<tr>
<td>500</td>
<td>25</td>
<td>55</td>
<td>95</td>
<td>150</td>
<td>195</td>
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<tr>
<td>600</td>
<td>25</td>
<td>55</td>
<td>100</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>Flat</td>
<td>25</td>
<td>60</td>
<td>115</td>
<td>140</td>
<td>255</td>
</tr>
</tbody>
</table>

Note: For piping upto 325 mm OD (including insulation thickness) aluminum sheet thickness – 24 SWG (0.56mm) and beyond 325 mm OD (including insulation thickness) aluminum sheet thickness – 22 SWG (0.71mm).
03. DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER FOR INSULATION OF HOT SURFACE APPLICATION

The following data shall be furnished by the tenderer along with the offer.

32. Make & Type
33. Quantity
34. Density in kg/m3
35. Thermal conductivity
36. Material of construction and its thickness
38. Vapour barrier material
39. Fire resistance property
40. Cladding material
23.0  **ES19- PACKAGE AIR CONDITIONER**

01  **General**

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Package Air Conditioner with all accessories to make operation of Package Air Conditioner complete in all respect. Specific technical requirement of Package Air Conditioner if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Package Air Conditioner is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

02  **Description**

The water/air cooled packaged air-conditioner will be designed for continuous duty.

The equipment shall be designed, manufactured and tested as per IS:8148-1976 (RA 1995).

The packaged unit shall comprise compressor, cooling coil, refrigerant circuit, fan, air filters, electric drives and controls, instruments and other necessary standard accessories assembled in packaged form in a steel cabinet.

All electrical connections shall be built in, Purchaser will provide the power supply load.

Each package air-conditioner will essentially comprise of compressor, cooling coil, refrigerant circuit, condenser, blowers, air filter, electric drives, instruments and controls and other standard accessories assembled in steel cabinet.

The compressor will be semi-hermetically/ hermetically sealed, mounted on anti-vibration pads & dynamically balanced.

The condenser will be water cooled, shell and tube type with effective surface area for heat transfer taking into consideration the scale factor for water side and optimum number of passes to achieve desired duty conditions water cooled package AC unit. Provision will be made in the steel cabinet for tube side cleaning during maintenance. The condenser will also serve as refrigerant receiver of refrigerant circuit with fusible relief plug. Alternatively as per job specification requirement condenser may be air cooled with fins and tube type with effective heat transfer area taking into consideration high ambient temperature of site selected. A refrigerant receiver shall be provided in the refrigerant circuit. Air cooled condenser along with the fan shall be installed in the free area for movement of outside air through condenser tube for effective cooling of refrigerant.

Cooling coil will be direct expansion type with integrally finned copper tubes and fitted with equalising distributors to ensure equal amount of refrigerant in each circuit. Condensate drip pan will be provided below the cooling coil for collecting the condensate.

The refrigerant circuit will be completely piped at factory and charged with required amount of refrigerant. The circuit will comprise of thermostatic expansion valve, distributor, liquid strainer, liquid line shut off valve, dehydrator etc. The circuit will be protected with safety devices such as high and low pressure cutouts, fusible plug, water flow/differential pressure switch, oil safety switch, time delay relay etc. to protect the unit from damage due to sudden and serious
fluctuations in operating conditions. The refrigerant will be R22 / ANY OTHER OZONE FRIENDLY REFRIGERANT.

For control of temperature and dehumidification of the conditioned premises, thermostat and humidistat will be provided in the package A.C. plant room as per job specification requirement.

The centrifugal blower will be designed for distribution of the conditioned air through the network of duct and supply air diffusers. The impeller will be of forward curved, dynamically balanced for low noise and vibration free operation. The fan will be coupled with motor by V-belt and mounted on anti vibration mounting.

**Control & Instruments:**

The necessary control and instruments include thermostatic expansion valve, sight glass, strainer, cooling thermostat, heating thermostat, humidistat, strip heater, shut off purge valve and drain valve, dial type pressure and temperature gauges etc. Cooling thermostat and humidistat will be provided in the return air circuit (in A.C. plant room) as per job specification requirement.

The dial type 150mm dia pressure gauge will be provided with isolating cocks/ valves. Flow switch will be installed in condenser water inlet line to stop the compressor while water supply stops. High efficiency filter & strip heater will be installed in the supply air duct at the discharge end of packaged unit and the strip heater will be interlocked with the blower of the packaged unit to prevent independent control/ switching of heaters as per job specification requirement.

The blower and the evaporative coil sections of the packaged unit will be thermally insulated to minimise thermal leakage. The unit will be supplied with rubber pad for installation on PCC pedestals.

Circulating condenser water cooling pipeline will be provided with strainer and by pass line.

Minimum efficiency of pre filter unit in package AC will be 90% down to 10 micron.
03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer for Package Air Conditioner Unit.

41. Make & Model
42. Quantity
43. Capacity in TR
44. Overall dimension of Package AC Unit
45. Air flow capacity of blower m3/h
46. Total Pressure, mm WC
47. Fan Motor kW
48. Fan RPM
49. Compressor type, model
50. Compressor motor kW
51. Refrigerant type
52. Condenser type
53. Condenser material of construction
54. Overall size of condenser
55. Material of construction and its thickness of casing
56. Insulating material of casing
57. Total Power consumption.
58. Noise level at 1m distance in dB(A)
59. Vibration isolation pad
60. Performance curve.
61. Fixing details.
62. Refrigerant drier and strainer
24.0 **ES20 - PROPELLER FAN**

**01 General**

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Propeller Fan with all accessories to make operation of Propeller Fan complete in all respect. Specific technical requirement of Propeller Fan if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Propeller Fan is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

**02 Description of Equipment**

Propeller type axial flow fan

This type of fan is used for general air exchange of the premises. The fan shall be heavy duty and wall mounted type propeller fan design shall conform to IS:2312 – 1967 (Reaffirmed 1994). Fan impeller blade shall be of aerofoil section and mounted directly at the motor shaft. The RPM of the fan preferably shall be restricted to 900 RPM. Noise level should not exceed 85 dB(A) at 1 m distance. Air entry shall be from motor side. Louver shutter/non-return damper shall be provided at the outlet side of fan to prevent back draft. The fan shall be provided with fixing frame, supporting lugs and other standard accessories.

**03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER**

The following data shall be furnished by the tenderer along with the offer.

14. Make & Model
15. Capacity in m3/hr
16. Quantity
17. Material of construction
18. Total pressure in kgf/m²
19. Characteristic curve
20. Speed in rpm
21. Size of fan
22. RPM
23. Drive details (kW & power supply)
24. Efficiency
25. Fixing details
26. Weight of fan & motor
27. Performance curve
28. Details of non-return damper/louver shutter
29. Fixing frame
25.0  SCRUBBER (ES21 for DE System Application)

01. General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Centrifugal / Venturi Scrubber System with all accessories required to be installed for dust extraction / process application to achieve desired performance in all respect. Specific technical requirement of Centrifugal / Venturi Scrubber System if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Centrifugal / Venturi Scrubber is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. Description

02.1 Centrifugal scrubber

Centrifugal scrubber is essentially a vertical steel cylinder with conical bottom. Casing and bottom are made of heavy gauge sheet steel. The top of the casing is connected to exhaust fan and conical portion of the casing is provided with a hydraulic seal. The rectangular inlet of the scrubber is welded to the casing tangentially with respect to its inside surface and with a slant of 10° toward casing. Dust deposited on the walls of the inlet duct is washed by water sprayers.

The inside surface of the casing is continuously sprayed by sprayers. The water jet emerges from sprayers in the same direction as the swirling air, and at the same time, tangentially to the inside surface of the casing and thus washes it without producing any droplets. The operation of nozzles is checked through inspection holes located just above them.

Dust laden air enters the bottom cylindrical part of the scrubber casing through inlet duct at an approximate velocity of 20 m/sec. As it enters the scrubber, a portion of the stream is directed upwards along a helical line, following closely the inside surface of the casing and thus washes it without producing any droplets. The remaining stream revolves and descends, rebounds from the scrubber bottom and rises along a helical line but closer to cyclone axis. Both streams merge at the outlet.

A centrifugal force arising on rotation of the air stream ejects dust particles towards the sprayed surface of the scrubber. The majority of the particles reaches the film of water and are captured by it.

Water containing captured dust particles trickles down the casing wall and is removed via the hydraulic seal. The protective baffle provided above the sprayers is intended to minimize entertainment of droplets. The mean air velocity for the full cross section of the cylindrical portion of the scrubber is taken to be 5.5 m/sec.

The efficiency of the scrubber should be sufficiently high so that the dust concentration in the exhaust ducting shall not exceed 50 mg/Nm3.
02.2 Venturi scrubber

The venturi scrubber consists of high speed atomizer and centrifugal separator. High speed atomizer consists of converging cone, throat and diverging cone. Air stream is accelerated in converging cone and the velocity of the stream rises. Water is introduced at the throat, where it is atomised due to high pressure.

Dust laden air and water enter the throat, where they are mixed at high energy and extreme turbulence. The throat with its length provides an extended period of thorough mixing. The scrubbed air and entrained droplets (with contaminants entrapped) then enters the diverging cone where further collisions and agglomeration takes place creating larger droplets. The air stream then proceeds to centrifugal separator where liquid droplets due to their coarse size are easily removed from the air stream. The working of the centrifugal separator is similar to that of centrifugal scrubber except that the water sprayers are not required.

The efficiency of the venturi scrubber shall be sufficiently high so that the dust concentration in the chimney does not exceed 50 mg/Nm$^3$ or as per job specification requirement.

03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The tenderer along with the offer shall furnish the following data.

d) Centrifugal Scrubber

11. Make & Model.
12. Capacity in m$^3$/h.
13. Pressure drop in mmWC.
14. Overall size of centrifugal scrubber
15. Air velocity through scrubber body in m/sec.
16. Water quantity and pressure required for scrubbing
17. Spray nozzle quantity, diameter and material of construction
18. Material of construction of scrubber body
19. Cleaning efficiency Vs particle size
20. Water sealing arrangement at bottom of scrubber
22. Supporting frame details.
23. Total weight of pre-collector

e) Venturi Scrubber

1. Make & Model & capacity in m$^3$/h.
2. Pressure drop in mmWC.
3. Overall size of venturi scrubber and centrifugal collector
4. Air velocity at inlet, throat & outlet of scrubber in m/sec.
5. Water quantity and pressure required for scrubbing at throat & slurry disposal at centrifugal collector
6. Spray nozzle quantity, diameter and material of construction
7. Material of construction of scrubber body
8. Material construction of throat
9. Cleaning efficiency Vs particle size
10. Water sealing arrangement at bottom of centrifugal collector
11. Methods of slurry disposal.
12. Supporting frame details.
13. Total weight of pre-collector
26.0 ES22 - STACK

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Stack with all accessories required to be installed for exhaust of air to achieve desired performance in all respect. Specific technical requirement of Stack if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Stack is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02 STACK

1. Construction

Self-supported stack made of M.S. Plates (IS:2062-1999) shall be provided to discharge the cleaned air from each of the system to atmosphere.

The height of the stack shall be as per CPCB norms i.e. 2-3m above the nearest highest building or minimum 30m. Stack shall be fabricated as per IS – 6533-1989 (RA 1995) Part – I & Part – II or as specified in TS.

2. Lightning Protection

Protection against lightning shall be made in accordance with IS:2309-1989 (RA 1995).

Lightning Protection shall be provided by creating a path of minimum electrical impedance from the stack top to an earthing strip on the ground. At about 1500 mm from the stack top, a circumferential conductor (coronal band) shall be provided which is lead-covered, stranded and of tinned copper. This is connected to air-terminal rods (which shall project about 750 mm above the top of the earthing strip. During construction temporary lightning protection shall be provided and this should be in the form of a single conductor connected to a temporary air-terminal at the top of the earthing system on the ground.

Vertical reinforcing bars near the stack base shall be electrically connected to a down conductor. Similarly all steel parts and footing reinforcement should be connected to a down conductor. At the top of the stack the lightning conductors shall be adequately protected from chemical corrosion by applying a lead coating or by other suitable means.

3. Aviation Warning Lights

Aviation warning lights shall be provided even during construction once the stack reaches a height of about 45m above ground. Both temporary as well as permanent provisions shall be of
neon type. These lights shall have sufficient intensity (about 100 lux) so that they are conspicuous considering the background illumination level against which they are viewed.

Day marking shall be provided by painting the stack in contrast colour bands for at least the top one-third of its height. Such bands shall range from 0.75 to 3 m in width with the outer bands in darker colour. The paint used for the bands shall be acid-resistant and shall safely withstand the temperature expected at the top of the stack.

4. **Staircase**

   The stack shall be provided with staircase, landing / resting platform at every 10 m, handrails, painter's trolley, structures etc. Ring platform around stack shall be provided at location of aviation lamps.

5. **Clean-out and Access Door**

   A suitable access door shall be provided at the bottom of the stack.

6. **Sampling Ports**

   The sampling ports shall be provided as per Emission Regulation Part-III or its latest amendments.

7. **Work Platform**

   a) **Construction**

      Size and extent of platform: If two ports are required at 90 degrees the work platform should serve that half of the stack circumference between the ports and extend at least 1.2 meters beyond each port. If four ports are required at 90 degrees, the work platform should serve the entire circumference of the stack. The minimum platform width shall always be 1.2 meters regardless of diameter of stack and number of sampling ports.

   b) **Platform Access**

      Safe and easy access to the platform shall be provided via stairway or other suitable means.

      Guardrails and Stairwells: A safe guard rail should be provided on the platform. Angular rather than round rails members should be used, if possible. No stairwell or any other opening shall be located within 1 meter of any port.

   c) **Platform Loading**

      The work platform should be able to support at least three men (average 80 kg each) and 91 kg of test equipment (stack monitoring kit etc.). If the stack exists through a
building roof, the roof may suffice as the work platform, provided the minimum test site conditions are still met.

d) **Clearance Zone**
A three dimensional, obstruction free clearance zone should be provided around each port. The zone should extend 0.6 m above, below, to either side of the port. The zone should extend outward from the exterior wall of the stack to a distance of at least 3 meters.

03. **DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER:**

The tenderer along with the offer shall furnish the following data:

Stack / exhaust dust

a) Diameter in mm  
b) Material & thickness  
c) Height in m  
d) Level of sampling port holes  
e) Level of platforms  
f) Support & structure with stairs  
g) Weather Cowl / telescopic duct connection
27.0 **ES23 - TUBE AXIAL FLOW FAN**

**01 General**

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Tube Axial Flow Fan with all accessories to make operation of Tube Axial Flow Fan complete in all respects. Specific technical requirement of Axial Flow Fan if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Tube Axial Flow Fan is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

Job specification of the project shall be referred.

**02 Description of Equipment**

These fans shall be of heavy duty type and of four kinds, as per service requirement, as follows: a) Roof exhauster, b) Roof mounted supply air fan, c) Wall exhauster, d) wall mounted supply air fan.

Axial fan design shall confirm to IS:3588–1987(Reaffirmed 1994).

The roof exhauster / roof mounted supply air fan shall have multi-bladed impeller with short duct casing while the wall exhauster/ wall mounted supply air fan shall have cone inlet suitable for free discharge of air. The fans shall be capable of withstanding the stresses which may be experienced during normal operation under the condition which it is required for and during over speed test. The noise level shall not exceed 85dB(A) at 1m distance.

The first critical speed of the rotating assembly shall be at least 25% above the operating speed. The speed of the fan shall preferably be limited to 1500RPM for fan with diameter 600mm or less and 960RPM for fans with diameter more than 600mm to limit the noise generation.

**Impeller:**

The impeller shall be of cast aluminium alloy construction of high efficiency aerofoil section blades. The fan impellers shall be cast in one piece, finished all over and carefully balanced both statically and dynamically as per ISO - 1940. Finally the assembled rotor shall be dynamically balanced.

**Casing:**

Axial flow fan casings for wall mounted/roof mounted fans and their components shall be suitable for outdoor installation. The casing shall be minimum 2 mm thick. The casings shall be provided with flanges at inlet and outlet. All nuts & bolts associated with it shall be of zinc or cadmium plated. Easily removable inspection cover having galvanised fly nut shall be provided. The covers shall be located such that the grease nipple for all bearings, and also motor terminals are easily accessible through the cover.

**Hood and Cowl**

a) Roof exhauster/supply air fans shall be provided with hood for protection against
rain and other contingencies. It must ensure no dripping of rain water under any circumstances and will have low pressure drop of air. The hoods shall be provided with a heavy gauge expanded metal bird screen.

b) Rain protection cowls shall be designed to suit wall exhausters for protecting fans from rain. The cowls shall be provided with bird screen of heavy gauge expanded metal netting. The rain protection hood & cowl shall be fabricated from minimum 14G thick MS sheet (Hot dip galvanised).

Coned Inlet

Wall exhausters shall be provided with coned inlet made of MS 2 mm thick or 16G, GI sheet.

Inlet Screen

Inlet screen shall be manufactured with minimum 14 SWG galvanised wire knitted in 25 mm square mesh. Suitable flanges to protect the edges of the screen shall be provided.

Fans for Special Application

These fans & motor when used in explosive / inflammable fume extraction system shall be of spark proof construction. Fan impeller and inside surface of the casing shall be epoxy painted. In case of exposure to acid fumes, the fan along with drive motor, accessories & supports etc. shall have acid proof painting.

Fan Drive

All direct drive axial flow fan impellers shall be directly mounted on extended motor shafts special constructional features shall be applicable as for fan. Alternatively as per job specification requirement bifurcated type V-belt drive may be considered.

Materials of Construction

The following materials shall be used for the construction of various parts:

a) Impeller : Cast Aluminium Alloy
b) Shaft : EN-8 as per BS-900 or its equivalent
c) Fan Scroll : Heavy gauge M.S.
d) Fan Supports, Frames : M.S. of adequate thickness and Structures
e) Coned inlet for wall Exhausters/supply fans : M.S. 2mm thick
f) Dampers : M.S. of heavy gauge
g) Connection pieces : Galvanised/M.S. unless otherwise specified
h) Bolts and Nuts : Galvanised/M.S. unless otherwise specified
i) Rain protection cowls, hoods and casing for wall & roof exhausters : GI/MS sheet

03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer.
63. Make & Model
64. Quantity
65. Capacity in m³/h.
66. Total Pressure, mm WC
67. Material of construction and its thickness
68. Speed in rpm.
69. Drive details like make, kW rating, type, insulation & protection class etc.
70. Shaft Power consumption.
71. Wheel diameter.
72. Efficiency.
73. Size of fan
74. Static & Dynamic weight of fan & motor assembly
75. Critical speed of fan
76. Noise level at 1m distance in dB(A)
77. Performance curve.
78. Air flow direction.
79. Fixing details.
80. Vibration level.
28.0 **ES24 – WATER LINE VALVES**

01 **General**

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply/fabrication of Valves with all accessories required to be installed for exhaust of air to achieve desired performance in all respect. Specific technical requirement of Valves if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of Valves is given below under clause No. 02. The point wise list of data to be furnished by the tenderer along with the offer is mentioned below under clause No. 03.

02. **Valves**

Gate valves will be provided at pump outlets & inlets & at tank outlets.

Non return valves shall be provided at pump outlets

Pressure relief valves shall be provided at pump outlet to divert water back to the tank in case downstream usage of water is reduced.

Butterfly valves shall be provided in branch headers to operate a particular group of sprinklers

Globe valves shall be provided on sprinkler headers to control the flow through each sprinkler.

All valves shall conform to the relevant IS code.

**Valves**

Butterfly Valves shall be provided in water line of size 65 NB and above and ball valve be provided for pipe size below 65 NB

**Butterfly valve**

Type : Wafer design, flange less
Body : SG iron with nitrile rubber/ EPDM lining
Disc : SG Iron with teflon (PTFE) coating
Stem : High tensile stainless steel

The valves shall be provided with integrally moulded & bonded body liner to provide perfect seating and complete isolation of body material from fluid. The body liner shall provide the seating to valve disc, primary seal to the stem & gasket joint with mating pipe flanges. Valves shall be provided with self locking lever operation from open to fully closed position with intermediate positions marked on the indicator plate mounted on the top flange. The valves shall conform to BS : 5155 / IS : 13095. Extended valve
shaft shall be provided so that the lever can be operated without any obstruction on the insulated pipes. Gear operated valves shall be provided for sizes more than 250 NB.

Ball Valve

Body : Cast steel
Body liner : Nitrile rubber/EPDM
Ball : ASTM A351 Gr CF8
3 piece design
Socket welded type

Ball valves shall be with 200 mm length welded joint pipes from manufacturer works.

Check valve

Type : Dual plate check valve with two springs hinged on a central hinge rod
Body : SG iron
Body liner : Nitrile rubber/EPDM
Disc : ASTM A351 Gr CF8
Wafer design

03 DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer.

81. Make & Model -
82. Type -
83. Quantity -
84. Size -
85. Pressure rating -
86. Material of construction -
87. Operating system -
88. Drive details.
89. Gland packing -
90. End connections -
91. Service -
92. Test pressure -
29.0 ES25 - WINDOW TYPE AIR CONDITIONER/SPLIT TYPE AIR CONDITIONER

01 General

This specification outlines the minimum requirement for design, engineering, selection, manufacture, test and supply of Window Type Air Conditioner / Split Type Air Conditioner with all accessories to make operation of Window Type Air Conditioner / Split Type Air Conditioner complete in all respect. Specific technical requirement of Window Type Air Conditioner / Split Type Air Conditioner if any shall be mentioned in the job specification/data sheet as furnished along with the Technical Specification.

Brief description of the Tube Axial Flow Fan is given below under clause No. 02. The equipment-wise list of data to be furnished by the tenderer along with the offer is shown below under clause No. 03.

Job specification of the project shall be referred for any specific requirement.

02. Description

1. Window Type Air Conditioners

Window air conditioners shall comprises of hermetically sealed compressors, air cooled condenser, refrigerant piping, blower, instruments and controls, supply air grill with direction deflector etc. enclosed in a insulated steel cabinet. 3 meter long power cable along with plug and socket unit shall be provided for each air conditioner. Necessary installation fittings like condensate drain pan and fixing attachment shall be provided by the successful tenderer. Any additional services required shall be included in line with job specification requirement. Window air conditioner unit shall conform to IS:1391-1992 Part I.

2. Split Type Air Conditioner

Split air conditioning unit mainly comprises of two section, Indoor and Outdoor section. Indoor section comprises of cooling coil, fan, supply air grill, filter. Outdoor section comprises of air cooled condenser, blower, hermetically sealed compressor. Sealed refrigerant piping inter connect indoor and outdoor section. Outdoor unit shall be installed in open space for easy heat dissipation from condenser. Indoor section shall be ceiling surpended or wall mounted type as per job specification requirement. Duct lines may be connected at the outlet of fan in indoor section with strip heater as per job specification requirement. Remote control unit, thermostat and other standard accessories for successful installation of split type air conditioner shall be included in the scope of successful tenderer. Any additional services required shall be included in line with job specification requirement. Split air conditioner unit shall conform to IS:1391-1992 Part II.
DATA TO BE FURNISHED BY THE TENDERER ALONG WITH THE OFFER

The following data shall be furnished by the tenderer along with the offer.

93. Make & Model
94. Quantity
95. Capacity in TR
96. Air Flow m3/h
97. Flow direction and volume control grill
98. Material of construction
99. Compressor type
100. Drive details and total power consumption
101. Overall dimensions
102. Refrigerant type
103. Filter efficiency
104. Weight of unit
105. Noise level at 1m distance in dB(A)
106. Fixing details.
107. Vibration level.
16. Accessories included
30.0 **Solid Waste Management System.**

Integrated Iron and steel plant generates various type of waste during manufacturing of saleable products. In addition to the main line of production of iron and steel the allied and associated activities give rise to many waste which differ in composition, characteristics as well as physical state.

Solid waste generated in steel plant can be classified in major two groups. One group will be solid waste, which can be recycled/reused in the iron & steel making process in the plant itself and other groups contain solid wastes which cannot be used in technological process and has to be disposed. Wherever it becomes unavoidable, the wastes shall be disposed under controlled conditions. Disposal of waste shall be done in such a way that the pressure on land and subsequent land contamination shall be progressively brought to minimum.

All efforts shall be made to minimize the generation of waste and maximize the effective utilization of waste in the plant.

All waste from the pollution control system and treatment shall be used or recycled to the extent possible.

Solid waste generated to be managed as per charter of corporate responsibility for Environment Protection (CREP) for Iron and steel Industries published by Central Pollution control Board (CPCB).

As per Minutes of twentieth meeting of the Peer & core expert committee on Developments of Effluent and Emission standards of Iron & steel plants held on Feb 19,2007 , CPCB circulated the following guidelines:

- Total BF slag, BF flue dust utilization shall be 100% by year 2008
- BF gas cleaning plant(GCP) sludge utilization shall be 50 % by 2012, New units shall plan to meet the target of 50 % utilization from Inception stage itself
- Total BOF slag utilization shall be 100% by year 2008
- BOF dust/ sludge utilization shall be 50 % by 2012, New units shall plan to meet the target of 50 % utilization from Inception stage itself

Accordingly waste generated in these two plants may be managed.

Hazardous waste generated in the plant shall be handled as per “The hazardous waste (Management and handling) rules 1989 and subsequent amendment”.

Fly ash and Bottom ash generated shall be managed/handled as per latest notification on Ash management by Ministry of environment and forest, Govt of India.

Lead Acid batteries shall be handled and disposed as per Batteries (Management and Handling) Rules 2001.
01 GENERAL

01.01 This specification covers the materials, tools, facilities and quality requirement for surface preparation and painting of steel structures, equipment, piping, ducts, chutes, wood work etc.

01.02 This is only a general guideline of the painting scheme to be followed by the Tenderer. However, in case a specific painting procedure is stipulated in any tendering specification, then this general guideline shall be superceded. Any special case which may arise from time to time shall be dealt with individually on the merit of each case.

01.03 The term “painting” referred herein covers rust preventive, fungus/insects preventive and decorative coating along with surface protection of the following area but not limited to the areas indicated below.

i) Structural steel works
ii) Mechanical equipment
iii) Electrical equipment
iv) Instrumentation and control equipment.
v) Pipe work
vi) Oxygen plant, etc.

01.04 Surfaces made of asbestos, aluminum, brass, bronze, galvanized steel, stainless steel, cast iron and other corrosion resistant alloys and rubber/synthetic polymer/fiber reinforcement plastic and buried pipe work are not required to be painted unless specified except for aesthetic purposes or for identification bands, wherever relevant.

01.05 The complete paint system for any item includes the following basic activities:

i) Proper surface preparation
ii) Application of primer coats
iii) Application of intermediate coats
iv) Application of finished coats

All the above coats shall be of quality paint products and of approved make. The scope of work shall also include supply of all paint materials as per specification described herein.

01.06 If the contractor desires to adopt alternative paint system for any specific item for an improvement or equivalent to the system specified here-in or as per recommendations of paint manufacturer, may do so subject to purchaser’s approval in advance.

02 SURFACE PREPARATION

02.01 Surface preparation required for paint application, shall be such as to clean the surface thoroughly of any material which will be conducive to premature failure of the paint substrates.
02.02 All surfaces shall be cleaned of loose substances, and foreign materials, such as dirt, rust, scale, oil, grease, welding flux, etc. in order that the prime coat is rigidly anchored to the virgin metal surface. The surface preparation shall confirm to pictorial representation of surface quality grade of Swedish Standards Institution SIS – 055900 or equivalent standards such as SSPC – VIS – 1.67 or DIN 55928(Part 4) or BS 4232 or IS 1477 – 1971 (Part I).

02.03 The acceptable surface preparation quality / grade are described under each paint system. The procedures include solvent cleaning, hand tool cleaning, power tool cleaning, blast cleaning, wood surface cleaning, flame cleaning and pickling. This will ensure surface quality as required by the specific primer paint. For ready reference surface preparation quality grade to be adopted in respect of SIS 055900 and DIN 55928 (part-4) is given in Annexure-01.

02.03.01 **Solvent Cleaning**

The surface shall be cleaned by wiping, immersion, spraying or vapour contacting of a suitable solvent or washing with an emulsion or alkaline solution to remove oil, grease, dirt, old paint, etc. Solvent cleaning shall not remove rust, scales, mill scales or weld flux. Therefore, before application of paint, solvent cleaning shall be followed by other cleaning procedures as stated in subsequent clauses.

02.03.02 **Hand Tool Cleaning**

The surface shall be cleaned manually by vigorous wire brushing as per grade St-2 quality of Swedish Standard Institution SIS 055900 and DIN 555928. This method effectively removes loosely adherent materials, but would not affect residues of rust or mill scales that are intact are firmly adherent. Finally the surface is to be cleaned with a vacuum cleaner or with clean compressed air or with clean brush. After preparation the surface shall have a faint metallic shine. The appearance shall correspond to the prints designated St – 2.

02.03.03 **Power Tool Cleaning**

The surface shall be cleaned by electric or pneumatic tools, such as brushes, sanding machines, disc abrasive grinder, rotary disc scaler etc. to St – 3 quality. The tools shall be used carefully to prevent excessive roughening of surface and formation of ridges and burrs. This method will remove loosely adherent materials but would not affect residues of rust or mill scales that are firmly adherent and intact.

02.03.04 **Blast Cleaning**

The surface shall be cleaned by impingement of abrasive materials, such as graded sand at high velocity created by clean and dry compressed air blast as per the grade according to Swedish Standard Institution SIS 055900. This method will remove loosely adherent materials as well as adherent scales and mill scales. Prior to application of blast, heavy deposit of oil and grease are removed by solvent cleaning excessive
surface scales are removed by hand tools or power tool cleaning. The extent of removal of adherent scales is varied, depending on the application and are defined by the surface quality grades Sa1, Sa2, Sa2.5 and Sa3 in the order of increasing cleanliness. The blast cleaning is not recommended for sheet metal work.

02.03.05 **Flame Cleaning**

The surface is cleaned by rapid heating by means of oxyacetylene flame to loosen the adherent scales, followed immediately by wire brushing. This method will remove loosely adherent materials as well as most of the adherent scales and mill scales. In order to minimize or prevent distortion flame cutting shall not be used on members having thickness of 6 mm and lower.

02.03.06 **Pickling**

In this method the surface is cleaned of mill scales, rust or rust scales by chemical reaction or electrolysis or both.

03. **PAINT APPLICATION**

03.01 **Paints**

03.01.01 Paint shall be applied in accordance with paint manufacturer’s recommendations. The work shall generally follow IS 1477 – 1971 (Part II) for jobs carried out in India and SSPC-PA-1 or DIN 55928 or equivalent for jobs carried out outside India.

03.01.02 General compatibility between primer and finishing paints shall be established by the paint manufacturer supplying the paints.

03.01.03 In the event of conflict between this general procedure on painting and the paint manufacturer’s specification, the same shall be immediately brought to the notice of the Purchaser. Generally in cases of such conflicts, manufacturer’s specifications/recommendations shall prevail.

03.01.04 Before buying the paint in bulk, it is recommended to obtain sample of paint and establish “Control Area of Painting”. On Control Area, surface preparation and painting shall be carried out.

03.01.05 If required, samples of paint shall be tested in laboratories to establish quality of paint with respect to:

(i) Viscosity
(ii) Adhesion/Bond of paint in steel surfaces
(iii) Adhesion/Simulated salt spray test.
(iv) Chemical analysis (percentage of solids by weight)
(v) Normal wear resistance as encountered during handling & erection.
(vi) Resistance against exposure to acid fumes, etc.

03.01.06 Whole quantity of paint for a particular system of paint shall be obtained from the same manufacturer.
03.01.07 The main Contractor shall be responsible for supply of paints and this responsibility shall not be passed on to the sub-contractor.

03.01.08 The painting material as delivered to the Contractor, must be in the manufacturer’s original container bearing thereon manufacturer’s name brand and description. Paint/Painting material in containers without labels or with illegible labels shall be rejected, removed from the area and shall not be used.

03.01.09 Thinners wherever used shall be those recommended by the paint manufacturers and shall be obtained in containers with manufacturer’s name and brand name of thinner legibly printed, failing which the thinner is liable to be rejected and shall not be used.

03.01.10 All paint containers shall be clearly labeled to show the paint identification, date of manufacture, batch number, special instruction, shelf life etc. The container shall be opened only at the time of use.

03.01.11 All paints shall be stored in accordance with the requirements of laid down procedure by the paint manufacturer.

03.01.12 All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments before use and during application to maintain homogeneity.

03.01.13 The proposed make, quality and shade of the paint shall have the approval of the client.

03.01.14 The colour code of the finishing paint to be followed shall be intimated to the successful Tenderer after finalisation of order. The undercoat shall have different tint to distinguish the same from the finishing coat.

03.01.15 The Contractor shall furnish paint manufacturer’s test report or technical data sheet pertaining to the paint selected. The data sheet shall indicate among other things the relevant standards, if any, composition in weight percent of pigments, vehicles, additives, drying time, viscosity, spreading rate, flash point, method of application, quality of surface preparation required, corrosion resistance properties and colour shades available.

03.01.16 For details of paint materials refer Annexure - 02

03.02 General

03.02.01 Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots.

03.02.02 Each coat of paint shall be sufficiently dry before application of next coat.

03.02.03 Paint shall be applied at manufacturer’s recommended rates. The number of coats shall be such that the minimum dry film thickness specified is achieved. The dry film thickness of painted surfaces shall be checked with ELCOMETER of measuring gauges to ensure application of specified DFT.
03.02.04 Zinc rich primer paints which have been exposed several months before finishing coat is applied shall be washed down thoroughly to remove soluble zinc salt deposits.

03.02.05 The machine finished surfaces shall be coated with white lead and tallow before shipment or before being put out into the open air.

03.02.06 Areas which become inaccessible after assemble shall be painted before assembly (after obtaining painting clearance from the inspecting authority) after requisite surface cleaning as specified.

03.02.07 Paint shall not be applied when the ambient temperature is 5 deg C and below or 45 deg C and above. Also paint shall not be applied in rain, wind, fog or at relative humidity of 80 % and above unless the manufacturer’s recommendations permit. Applications of paint shall be only be spraying or brushing as per IS 486 – 1983 and IS 487 – 1985.

03.02.08 Primer paint shall be applied not later than 2 – 3 hours after preparation of surface, unless specified otherwise.

03.02.09 Edges, corners, crevices, depressions, joints and welds shall receive special attention to ensure that they receive painting coats of the required thickness.

03.02.10 Surfaces which cannot be painted but require protection shall be given a coat of rust inhibitive grease according to IS 958 – 1975 or solvent deposited compound according to IS 1153 – 1975 or IS 1674 – 1960.

03.02.11 Surfaces in contact during shop assembly shall not be painted. Surfaces which will be inaccessible after assembly shall receive minimum two coats of specified primer.

03.02.12 Surfaces to be in contact with wood, brick or other masonry shall be given one shop-coat of the specified primer.

03.03 Site/Field Painting

03.03.01 Wherever shop primer painting is scratched, abraded or damaged, the surface shall be thoroughly cleaned using emery paper and power driven wire brush wherever warranted, and touched up with corresponding primer. Touching up paint shall be matched and blended to eliminate conspicuous marks.

03.03.02 If more than 50% of the painted surface of an item requires repair, the entire item shall be mechanically cleaned and new primer coats shall be applied followed by intermediate and finishing coats as per painting specification.

03.03.03 All field welded areas on shop painted items shall be mechanically cleaned (including the weld area proper, adjacent areas contaminated by weld spatter or fumes and areas where existing primer paint is burnt).
Subsequently, new primer and finishing coats of paint shall be applied as per painting specification.

03.03.04 The first coat of finish paint at site shall be applied preferable within three months of the shop paint.

03.04 **Structural**

03.04.01 All fabricated steel structure, fabricated steel pipes, etc. shall have a minimum of two coats of primer paint before dispatch to site.

03.04.02 Parts of steel structures embedded in concrete shall be given a protective coat of Portland cement slurry immediately after fabrication and after surfaces of this part is thoroughly cleaned from grease, rust, mill scales, etc. No paint shall be applied on this part.

03.04.03 All structures shall receive appropriate number of primer and finishing coats in order to achieve overall DFT as per design drawings/specification.

03.05 **Hot Surfaces**

03.05.01 Total DFT for heat resistant paints should not exceed 100 – 120 microns, otherwise flaking occurs (as per paint manufacturer’s recommendations).

03.05.02 Heat resistant paints should be applied by brush.

03.05.03 Primer coat should not be applied on the surfaces having temperature condition more that 120 deg C.

04 **PAINTING SCHEMES**

For a complete painting scheme of any item being printed, all types of paints are to be procured from the same manufacturer as approved by the purchaser.

04.01 **Legend**

- **SP** - Surface preparation quality as per SIS standard  
- **2P1** - Two (2) coats of Primer paint type P1  
- **I1** - One (1) coats of Intermediate paint type I1  
- **2F1** - Two (2) coats of Finish paint type F1  
- **DFT** - Dry Film Thickness in microns developed  
- **CRT** - Clean and Retouch

Type of paint products like P1 to P9, I1 to I4 and F1 to F10 have been specified under Annexure-02.

04.02 The painting scheme to be followed for various structure/equipment exposed to different condition is briefly given in Annexure-03 for guidance to the tenderer.
04.03 The colour code for different applications are indicated in Annexure-04. Wherever colour codes are not specified, the same is to be mutually agreed between the Purchaser and Contractor.

05. **GUARANTEE**

05.01 The Contractor shall guarantee that the physical and chemical properties of the paint materials conform with the specification of paint products.

05.02 The Contractor shall submit internal test reports from paint manufacturers regarding the quality of paint whenever asked by the Purchaser/Consultant.

05.03 Guarantee period shall commence from the date of completion of finishing coat of paint. The guarantee period will be indicated depending on the type of surface preparation and system of painting. To fulfill this obligations the Contractor may obtain from the painting manufacturer, guarantee for the performance of paint/painted surfaces.
## Surface Preparation Grade

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Surface Preparation</th>
<th>Swedish Std SIS 055900</th>
<th>DIN Std. Din 55928 (Part 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blast cleaning to white metal</td>
<td>Sa 3</td>
<td>Sa 3</td>
</tr>
<tr>
<td></td>
<td>Removal of all visible rusts, mill-scales, paint and foreign matters.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Blast cleaning to near white metal</td>
<td>Sa 2.5</td>
<td>Sa 2.5</td>
</tr>
<tr>
<td></td>
<td>95% of any section of surface area is free from all rusts, mill-scales and visible residues.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Blast cleaning to commercial quality</td>
<td>Sa 2</td>
<td>Sa 2</td>
</tr>
<tr>
<td></td>
<td>At least 2/3 of any section of the surface area is free from all rusts, mill-scales and visible residues.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Brush-off blast cleaning:</td>
<td>Sa 1</td>
<td>Sa 1</td>
</tr>
<tr>
<td></td>
<td>Removal of all loose mill-scales, rust and foreign matters etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Power tool cleaning:</td>
<td>St 3</td>
<td>St 3</td>
</tr>
<tr>
<td></td>
<td>Very thorough scrapping and wire brushing to remove loose mill-scale, rust and foreign matters to have pronounced metallic shine.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Hand tool cleaning:</td>
<td>St 2</td>
<td>St 2</td>
</tr>
<tr>
<td></td>
<td>Removal by hand brushing of loose mill-scale, loose rust and foreign matters.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PAINT MATERIALS

01. PRIMER PAINTS (P)

Primer paint products shall be applied only on dry and clean surfaces.

01.01 Primer Paint – P1 (Phenolic – Alkyd Based)

A single pack air drying phenolic modified alkyd composition with zinc phosphate as a primer paint conforming generally to IS : 2074.

- Air drying time
  - About 60 minutes (touch dry)
  - Overnight (hard dry)

- Dry film thickness (DFT)/Coat
  - 40 microns (min)

- Temperature resistance
  - Upto 100°C dry heat

01.02 Primer Paint – P2 (Chlororubber Based)

A single pack air drying high build chlorinated rubber based zinc phosphate primer.

- Percent chlororubber
  - 20 to 22 (% Chlorine above 65% in chlororubber)

- Air drying time
  - About 15 minutes (touch dry)
  - Overnight (hard dry)

- DFT/Coat
  - 50 microns (min)

- Temperature resistance
  - Up to 65°C dry heat

01.03 Primer Paint – P3 (PVC Copolymer Alkyd Based)

Polyvinyl chloride (PVC)
- Alkyd zinc phosphate – redoxide based primer

Ratio
- PVC copolymer + alkyd resin (1:1)

Pigments
- Zinc phosphate & Fillers

Air drying time
- 24 hours

DFT/Coat
- 80 microns

Temperature resistance
- Upto 80°C dry heat
01.04 **Primer Paint – P4 (Epoxy Based)**

A two pack air drying Epoxy polyamide resin based red oxide-zinc phosphate primer.

- Epoxy content (% wt.) - 15 to 18
- Air drying time - About 30 minutes (touch dry) overnight (hard dry)
- DFT/Coat - 30 microns (min)
- Temperature resistance - Upto 120°C dry heat

01.05 **Primer Paint – P5 (Epoxy Based)**

A two pack air drying Epoxy polyamide with zinc dust of at least 92% zinc dust on the dry film

- Epoxy content (% wt.) - 8 to 10
- Air drying time - Less than 10 minutes (touch dry) Less than 2 hours (hard dry)
- DFT/Coat - 40 microns (min)
- Temperature resistance - Upto 300°C dry heat

01.06 **Primer Paint – P6 (Poly – Vinyl Butyral Resin Based)**

A two pack air drying polyvinyl butyral resin based wash primer with rust inhibitive pigments.

- Air drying time - 5 to 7 minutes (touch dry) 2 hours (hard dry)
- DFT/Coat - 8 microns
- Temperature resistance - Upto 65°C dry heat
- Application for - Galvanised iron, aluminium, light alloys etc. on which the adhesion of conventional paints are poor.

01.07 **Primer Paint – P7 (Ethyl Zinc Silicate, EZS Based).**

A two pack heavy duty zinc dust rich silicate primer which protects the surface with just a single coat.

- Total solids (3 wt) - 84 +/- 2
- Density (g/cc) - 3.07 +/- 0.05
General Technical Specification

Air drying time - To top coat 16 hours
DFT / coat - 60 microns
Temperature resistance - Upto 450 deg C dry heat

01.08 **Primer Paint – P8 (High Build Coal Tar Epoxy)**

A two pack cold cured H.B. epoxy coal tar coating – no primer is required.

Mixing ratio - Base: Hardener (4:1 by vol.)
Air drying time - 48 hours (hard dry)
DFT / Coat - 100 microns

01.09 **Wood Varnish-P9**

Treated oil based primer pigmented with suitable pigments:

Air drying time - 16 hours for application of top coat.
Coverage - 10 to 14 sq. m/litre

02. **INTERMEDIATE PAINTS (I)**

These paints shall be applied over primer coats as an intermediate layer to provide weather proof seal of primer coats.

02.01 **Intermediate Paint-II (Phenolic alkyd based)**

A single pack high build phenolic based paint with micaceous iron oxide (M10).

Air Drying Time - 4 to 6 hours (touch dry) - 2 days (hard dry)
DFT / Coat - 75 microns (min)
Temperature resistance - Upto 100 deg C dry heat
Compatible with - Primer P1

02.02 **Intermediate Paint-I2 (Chlororubber based)**

A single pack air drying high build chloro based paint with MIO.

Air Drying Time - 15 minutes (touch dry) - 24 hours (hard dry)
DFT / Coat - 70 microns (min)
Temperature resistance - Upto 65 deg C dry heat
Compatible with - Primer P2, P3 & P4

02.03 **Intermediate Paint-I3 (PVC – Alkyd Based)**

PVC Coploymer - Resin 1 : 1
Pigments - Micaceous iron oxide (MIO)
DFT / Coat - 80 microns (min)
General Technical Specification

Temperature resistance - Upto 80 deg C dry heat
Compatible with - Primer P2 & P3

02.04 **Intermediate paint-I4**

A two pack air drying high build epoxy resin based paint with MIO.

Air drying time - 6 to 8 hours (touch dry)
- 7 days (full cure)

DFT / coat - 100 microns

Temperature resistance - Up to 180°C dry heat
Compatible with - Primer P4 & P5

03. **FINISH PAINTS (F)**

Finish paint costs shall be applied over primer coats and intermediate coats after proper cleaning and touch up of primed surface.

03.01 **Finish Paint – F1**

A single pack air drying high gloss phenolic alkyd modified synthetic enamel paint suitably pigmented.

Air drying time - 3 to 4 hours (touch dry)
- 24 hours (hard dry)

DFT/Coat - 25 microns (min)

Temperature resistance - Upto 100°C dry heat
Compatible with - Primer P1
- Intermediate I1

Colour - Generally all shades

03.02 **Finish Paint – F2**

A single pack air drying polyurethane enamel of high gloss and hard finish suitably pigmented.

Air drying time - 2 to 2 ½ hours (touch dry)
- 6 hours (hard dry)

DFT/Coat - 30 microns (min)

Temperature resistance - Upto 100°C dry heat
Compatible with - Primer P1 & P8 and Intermediate I1

Colour - Generally all shades
03.03 **Finish Paint – F3**

A two pack air drying bituminous aluminum paint.

- **Air drying time**
  - 1 to 2 hours (touch dry)
  - 21 hours (hard dry)

- **DFT/Coat**
  - 25 microns (min)

- **Temperature resistance**
  - Upto 100°C dry heat

- **Compatible with**
  - Primer P1 and Intermediate I1

- **Colour**
  - Bright metallic

03.04 **Finish Paint – F4**

A ready mixed oil-alkyd based synthetic enamel paint of high gloss and hard wearing properties.

- **Air drying time**
  - 6 to 8 hours

- **Coverage**
  - 14 to 16 Sq. m /litre

- **Temperature resistance**
  - Upto 60°C dry heat

- **Compatible with**
  - P8

- **Colour**
  - Generally all shades

03.05 **Finish Paint – F5**

A single pack air drying plasticized chlororubber paint suitably pigmented.

- **Air drying time**
  - 30 minutes (touch dry)
  - 24 hours (hard dry)

- **DFT/Coat**
  - 35 microns (min)

- **Temperature resistance**
  - Upto 65°C dry heat

- **Compatible with**
  - Primer P2 & P3,
    Intermediate I2 & I3

- **Colour**
  - Nearly all shades except few.
03.06 **Finish Paint – F6**
A PVC – Copolymer alkyd based enamel.

- Density  
  - 1.17 ± 0.05
- Total solids (1 wt)  
  - 55 ± 2
- DFT/Coat  
  - 40 microns
- Compatible with  
  - P2 and P3

03.07 **Finish Paint – F7**
A two pack air drying epoxy polyamide enamel suitably pigmented.

- Air drying time  
  - 2 to 3 hours (touch dry)
  - 7 days (full cure)
- DFT/Coat  
  - 40 microns (min)
- Temperature resistance  
  - Up to 130°C dry heat
- Compatible with  
  - Primer P4 & P5,
  Intermediate I4
- Colour  
  - Generally all shades.

03.08 **Finish Paint – F8**
A single pack synthetic rubber based aluminium paint.

- Air drying time  
  - 2 hours (touch dry)
  - 24 hours (hard dry)
- DFT/Coat  
  - 25 microns (min)
- Temperature resistance  
  - Upto 200°C dry heat
- Compatible with  
  - No Primer paint except primer P6 is applicable in case of non-ferrous substrate.
- Colour  
  - Smooth aluminium.
## PAINTING SCHEME

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At Shop</td>
<td>At Site</td>
</tr>
<tr>
<td><strong>1.0</strong></td>
<td><strong>Steel Structures (Temp. not exceeding 80°C)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Technological steel structures for plant and equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indoor</td>
<td>SP – Sa 2.5</td>
<td>CRT 2F1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>SP – Sa 2.5</td>
<td>CRT 2F1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P1  1I1</td>
<td></td>
</tr>
<tr>
<td><strong>1.2</strong></td>
<td>Fabricated steel structures at site for rung ladders, cat-ladders, gates, rolling shutters, etc. (Springs/rubbing surfaces excluded)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Indoor / Outdoor</td>
<td>SP – St-2 and/ or St-3</td>
<td>CRT 2F1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P1</td>
<td></td>
</tr>
<tr>
<td><strong>1.3</strong></td>
<td>Walkways, stairs, platforms etc. which are of wearing surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Indoor</td>
<td>SP – St-2 and/ or St-3</td>
<td>CRT 2F1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Outdoor</td>
<td>SP- St2 and/ or St-3</td>
<td>CRT 2F1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P1  1I1</td>
<td></td>
</tr>
<tr>
<td><strong>1.4</strong></td>
<td>Steel doors and windows</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Indoor / outdoor</td>
<td>SP–St-2 and / or St-3</td>
<td>CRT 2F2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P1  1I1</td>
<td></td>
</tr>
</tbody>
</table>

### MECHANICAL EQUIPMENT

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At Shop</td>
<td>At Site</td>
</tr>
<tr>
<td><strong>2.0</strong></td>
<td><strong>MECHANICAL EQUIPMENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2.1</strong></td>
<td>Mechanical equipment (Temp. not exceeding 80°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2.1.1</strong></td>
<td>Static equipment like storage tanks, vessels, bins, bunkers, heat exchangers, coolers,</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Painting Scheme

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Painting Scheme</th>
<th>Total DFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At Shop</td>
<td>At Site</td>
</tr>
<tr>
<td></td>
<td>cyclones, scrubbers, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Indoor</td>
<td>SP – Sa 2.5</td>
<td>CRT 2F5/2F6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P2/2P3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Outdoor</td>
<td>SP – Sa 2.5</td>
<td>CRT 2F5/2F6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P2/2P3+1I2/1I3</td>
<td></td>
</tr>
<tr>
<td>2.1.2</td>
<td>Rotary/moving equipment and machineries</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>like crushers, mills, vibratory screens, bin activators, blowers, fan, air/gas compressors, pumps, gear boxes, machine housings etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Indoor</td>
<td>SP – Sa 2.5</td>
<td>CRT 2F6/2F7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P3/2P4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Outdoor</td>
<td>SP-Sa 2.5</td>
<td>CRT 2F6/2F7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P3 + 1I3/1I4</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Pipe / Duct work (Overground)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Non – insulated (temperature up to 80°C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Indoor</td>
<td>SP – St2 and</td>
<td>CRT 2F1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or St3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Outdoor</td>
<td>SP – St2 and</td>
<td>CRT 2F1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or St3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2P1 + 1I1</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Insulated (hot)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Indoor/Outdoor</td>
<td>SP- St2 and/ or St3</td>
<td>Remove paint and insulate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1P1</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td>Oxygen Plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>Outdoor steel structures</td>
<td>SP – St2 and /</td>
<td>CRT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or St3</td>
<td></td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Description</td>
<td>Painting Scheme</td>
<td>At Shop</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------------------------------</td>
<td>------------------</td>
<td>---------</td>
</tr>
<tr>
<td>4.2</td>
<td>Rotary equipment like air compressors</td>
<td></td>
<td>2P1 + 1I1</td>
</tr>
<tr>
<td>5.0</td>
<td>Others</td>
<td></td>
<td>2P4</td>
</tr>
<tr>
<td>5.1</td>
<td>Standard mobile equipment like chasis of trucks, dumpers, crawler cranes bulldozers, railway rakes, chasis of slag cars, ladle cars, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Laboratory equipment like ovens, screens, magnetic stirrers, samplers, etc.</td>
<td></td>
<td>Stove enamelling</td>
</tr>
<tr>
<td>5.3</td>
<td>Steel structures partly immersed in water</td>
<td></td>
<td>SP – Sa 2.5</td>
</tr>
</tbody>
</table>

**Notes:**

1. Painting scheme of all fabricated steel structures, fabricated pipe work, building structure, conveyor galleries, pipe trestles etc. is indicated in the Technical Specification of steel structures.

2. Primer Paint

   Primer coat shall be suitable for intended temperature applications as per manufacturer’s recommendation. The primer selection shall be generally in line with the specification laid down in Annexure-02.

3. Finish Paint

   In case of Aluminium cladding final painting will not be required.
# Colour Code

The colour codes are mentioned for all the items including pipe work. Shades of finish coat of paint applied over respective item indicated below are tentative and subject to alteration as per Purchaser’s request or due to compatible paint system adopted. The service for which colour code/bands are not specified are to be mutually agreed for by the Purchaser & the Contractor.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Items Painted</th>
<th>Colour</th>
<th>Colour No. of IS:5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Building frames including bracings, side girts, louvers etc.</td>
<td>Aircraft grey</td>
<td>693</td>
</tr>
<tr>
<td></td>
<td>Crane girders</td>
<td>Azure blue</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td>Crane stops</td>
<td>Post office red</td>
<td>538</td>
</tr>
<tr>
<td></td>
<td>Gutters</td>
<td>Black bituminous aluminium</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Fire escape platforms ladders, etc.</td>
<td>Signal red</td>
<td>537</td>
</tr>
<tr>
<td></td>
<td>General hand railing, top runners</td>
<td>Lemon yellow</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>Rung ladders</td>
<td>Lemon yellow</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>All members blocking passages for movement</td>
<td>Lemon yellow</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>Trestles, towers and pipe bridges</td>
<td>Dark admiralty grey</td>
<td>632</td>
</tr>
<tr>
<td></td>
<td>Conveyor gallery structures</td>
<td>Aircraft grey</td>
<td>693</td>
</tr>
<tr>
<td></td>
<td>Steel chimneys</td>
<td>Aluminium</td>
<td>-</td>
</tr>
<tr>
<td>2.</td>
<td>Equipment and Machinery</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General indoor equipment</td>
<td>Light grey</td>
<td>631</td>
</tr>
<tr>
<td></td>
<td>General outdoor equipment</td>
<td>Dark admiralty</td>
<td>632</td>
</tr>
<tr>
<td></td>
<td>Crane bridges, trolleys, hooks etc. and other mobile equipment</td>
<td>Base: Lemon yellow, Stripes: Black (100 mm wide)</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td>Furnaces</td>
<td>Aluminium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tanks</td>
<td>Base: Same as for general equipment, Strips: Same shade as for piping around the tank at half the tank height</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fire-fighting equipment</td>
<td>Signal red</td>
<td>537</td>
</tr>
</tbody>
</table>

### 3. Pipe work

Colours shall be as given below. The base colour shall be applied throughout entire length except on surfaces of materials such as asbestos, aluminium, brass, bronze, galvanized steel, stainless steel and other corrosion resistant alloys and rubber / synthetic polymers. In such cases identification colour bands of at least 500mm width shall be provided near each branch, valve and at distances not exceeding 10m either as local colour coatings or coloured adhesive type of suitable material or label attached to the pipe work. Additional identification bands superimposed over the base colour shall be provided near each branch, valve and at distance not exceeding 10m. The bands shall be at least 25mm wide except in case of double bands where the first band shall be about 100mm wide. Direction of flow shall be clearly marked on the pipelines at intervals not exceeding 10m and all branches and change of directions.
<table>
<thead>
<tr>
<th>Service</th>
<th>Colour</th>
<th>Colour No. of IS:5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea or river water (untreated)</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band - White</td>
<td>-</td>
</tr>
<tr>
<td>Cooling water</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band - White</td>
<td>166</td>
</tr>
<tr>
<td>Boiler feed water</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td>Condensate</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band – Light brown</td>
<td>410</td>
</tr>
<tr>
<td>Drinking water</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>First band - French blue</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>Second band – Signal red</td>
<td>537</td>
</tr>
<tr>
<td>Industrial water</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band – Light orange</td>
<td>557</td>
</tr>
<tr>
<td>Compressed air</td>
<td>Base – Sky blue</td>
<td>101</td>
</tr>
<tr>
<td>Instrument air</td>
<td>Base – Sky blue</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Band – Light brown</td>
<td>410</td>
</tr>
<tr>
<td>Drainage</td>
<td>Base – Black</td>
<td>-</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>Base – Light brown</td>
<td>410</td>
</tr>
<tr>
<td></td>
<td>Band – Signal red</td>
<td>537</td>
</tr>
<tr>
<td>Coke oven/BF gas/other fuel gases</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – Signal red</td>
<td>537</td>
</tr>
<tr>
<td>Argon</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – French blue</td>
<td>166</td>
</tr>
<tr>
<td>Acetylene</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – Dark violet</td>
<td>796</td>
</tr>
<tr>
<td>LP Gas (LPG)</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>First band – Signal red</td>
<td>537</td>
</tr>
<tr>
<td></td>
<td>Second band – Traffic green</td>
<td>267</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – Black</td>
<td>-</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Base – Canary yellow</td>
<td>309</td>
</tr>
<tr>
<td></td>
<td>Band – White</td>
<td>-</td>
</tr>
<tr>
<td>Non-acidic slurries</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band – White</td>
<td>-</td>
</tr>
<tr>
<td>Fire-fighting system</td>
<td>Base – Signal red</td>
<td>537</td>
</tr>
<tr>
<td>Rain water down pipes</td>
<td>Base – Sea green</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Band – Sky blue</td>
<td>101</td>
</tr>
<tr>
<td>Duct work</td>
<td>Base – Aluminium</td>
<td>-</td>
</tr>
</tbody>
</table>

**Note**: For these services, hazard marking as per fig. 4C of IS:2379 shall also be provided.
01. GENERAL

01.01 This specification broadly covers the basic features & requirements comprising design, engineering, selection criteria, supply, installation guidelines & practices to be followed for all field & control room mounted instrumentation and control devices & systems required for various shop units of the plant. Adequate and latest state-of-art technology based Instrumentation and control system shall be provided for all the shops/units of the plant, with a view to achieve safe, reliable, efficient and trouble-free operation of the plant, as well as safety of the plant equipment and operating personnel.

01.02 Instrumentation & control equipment shall conform to the Bureau of Indian Standards (BIS) / Inter Plant Standardisation in Steel industry (IPSS) / International Electro-Technical Commission (IEC) / Instrument Society of America (ISA)/ DIN / BS / JIS and other reputed internationally accepted standards as applicable, unless otherwise specified in the Technical Specification for Tender.

01.03 This specification, together with all other norms and standards, referred to herein or considered applicable as per good engineering practices, shall cover the principles of design, engineering and implementation of instrumentation & control systems for various shop units of the plants. This specification will be the main guiding and deciding document and can be over ridden only by a Client standards in very specific cases or particular requirements, indicated if any in the main technical specification of the tender document.

01.04 Instrumentation & control equipment shall comply with the Indian Electricity Rules, 1956 along with their latest amendments regarding safety, grounding and other required stipulations specified therein for installation and operation of electrical systems in the plants.

01.05 All the Instrumentation & control equipment shall conform to the safety requirements stipulated in relevant BIS eg, IS: 9858-1981 on Safety requirements of electronic measuring apparatus, IS 516-1981 on Safety requirements of mains operated electronic apparatus, IS 3945-1978 on Specification of electrical instruments for hazardous atmospheres, etc. All the equipment shall be suitably protected from voltage surges, Electro Magnetic Interferences, Radio Frequency Interferences and also from Lightning, in specific cases. Wherever Indian standards are not available, IEEE, ISA, NEMA standards shall be applicable.

01.06 All equipment to be supplied and all work to be performed including system design and engineering, shall comply with the statutory requirements of Government of India and the State Government.
02. **ENVIRONMENTAL SPECIFICATION**

All instrumentation & control equipment and their accessories, including those to be used in air-conditioned control rooms, shall be rugged, industrial grade and suitable to withstand the operating conditions in the plant and atmospheric conditions.

These equipment shall be suitable for operating continuously under the environmental conditions indicated below:

<table>
<thead>
<tr>
<th>Field instruments</th>
<th>Control room instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature :</td>
<td>0 – 60°C</td>
</tr>
<tr>
<td>Relative humidity:</td>
<td>0 – 95%</td>
</tr>
<tr>
<td></td>
<td>0 – 50°C (minimum)</td>
</tr>
<tr>
<td></td>
<td>0 – 80% (non-condensing).</td>
</tr>
</tbody>
</table>

The enclosure protection class for various instrumentation & control equipment shall comply with the guidelines indicated in IEC/EN 60529./IS: 13947, Part-1, 1993. Generally, the following protection classes for panels, consoles, desks etc. shall be followed as a minimum:

i) Air-conditioned control rooms: IP 22
ii) Indoor non-air-conditioned areas:
   a) Ventilated areas: IP 42
   b) Non-ventilated areas: IP 54.
iii) Outdoor areas: IP 65

All field devices shall be rated for minimum IP 65 protection class.

03 **BASIC DESIGN CONSIDERATIONS:**

03.01 General

The instrumentation & control system equipment shall be adequately designed to monitor and control all significant variables in accordance with the process & operating requirements along with process/ safety interlocks & alarms for abnormal conditions. The system shall be designed to ensure that the accuracy of instruments and the overall system accuracy meet the process requirements.

Design & selection of instrumentation & control system shall take care of the following features as a minimum:

1. Latest state-of art and proven technology
2. High accuracy, reliable performance, easy expandability, modular design.
3. Standardisation of items & makes for maximizing interchangeability and minimizing inventories.
5. Easy maintainability and diagnostic features.
6. Fail safe features.
7. User friendly testing & calibrating facilities in both local & remote mode.
8. Flexibility for carrying out maintenance work with the process on.
9. Generally Foundation field bus based field instruments shall be considered. Wherever, not applicable, two-wire, true Smart type transmitters, generally
operating on 4-20 mA DC having HART signal super imposed with 24 V DC power supply or field bus based as applicable.

10. For all instrumentation signals, open architecture based Automation system with facility for Foundation field bus/ Profibus interface shall be considered, which shall be interfaced to Level-1 automation network at HMI level.

11. Fail safe features.

12. Safety to plant equipment and operating personnel.

13. Sustained availability of spares & consumables for at least 10 years.


15. Provision for future expansion in design & selection, e.g. sizing of final control elements, flow sensors, space inside the control room, space on the panels/cabinets/desks etc.


17. Final control elements with electric, pneumatic, hydraulic or hybrid actuators depending on application requirement. Final control elements with local valve position indicators and valve position transmission to control room.

18. Steam, nitrogen, water or compressed air lines for purging and cleaning purposes, wherever necessary.

19. Dual redundant devices for measurement & control of critical parameters.

20. Uninterruptible Power Supply (UPS) system.

21. Calibration/ configuration of both HART based & Field bus based transmitters from DCS/PLC & through hand held calibrator.

22. Hand held calibrators shall be provided with adequate memory capacity & device description of all HART certified devices loaded therein. The calibrators shall be supplied with precision 250 ohm resistances.

23. All recorders shall be 12-channel high speed chart-less type with SVGA/TFT screen and multiple display formats. It shall be possible to download into DCS/PLC from these recorders. Recorder shall be provided with Ethernet connectivity. For this purpose, necessary software shall be provided by the recorder manufacturer. Recorder shall also have USB port for transporting data by pen drive.

24. All instruments shall have standard ranges. Ranges for indicators shall be selected so that normal value shall be indicated in the middle third of the scale.

25. In hazardous area applications, electronic/electrical instrumentation equipment shall be suitable for hazardous area classification as per IEC. These equipment shall be intrinsically safe conforming to CENELEC standard and certified by appropriate statutory bodies (FM, BASEFA etc.). Intrinsically safe systems shall be designed using zener/ IS barriers. Where intrinsically safe design is not feasible, ex-proof equipment/enclosure, certified by statutory bodies like CMRI Dhanbad/ CCOE Nagpur shall be supplied. Other acceptable safety procedures (e.g. increased safety procedure, pressurisation etc.) shall be used, wherever
applicable. Required documentation/certificates shall be submitted in conformance with all such features.

26. All transmitters shall have built-in digital output indicators calibrated in engineering unit of flow, pressure, level, temperature, differential pressure etc.

27. Flow switches shall be electronic type.

28. Isolator cards shall be provided for isolation of instrument signals, wherever necessary.

29. Transmitters in the field shall be housed inside transmitter cabinets.

30. All field-mounted instruments shall be of suitable weatherproof construction, as per details indicated for respective items.

31. Temperature sensors shall be with SS head, covers & SS chain.

32. Wetted parts of the instrumentation equipment shall be selected so as to withstand physical and chemical properties of the service fluid coming in direct contact with the instrument.

33. Colour codes for pipelines, cables, lamps, and panels shall be followed for the plant as per industry/ plant standard.

34. All the manufactured/fabricated items / impulse pipes & fittings shall be properly painted as per requirement & standard practice, depending upon nature of environment in which these are to be installed. Selection of primer and finish paint shall be done as per relevant IS standard or equivalent international / industry standards.

35. All impulse lines shall be SS pipes/tubes of appropriate ratings as per ASTM A269 standards. Tubes valves, manifolds & fittings shall be of Swagelok/ Parker make.

36. All fittings & accessories shall be new & rust protected. All flanged type instruments shall be supplied with companion flanges, nuts, bolts & gaskets.

37. Instruments used on oxygen lines must be oil and grease free and shall be marked ‘for oxygen use’ and colour coded blue.

38. Whenever corrosive atmosphere is present, all instruments and associated equipment exposed to such a medium shall be designed & protected to withstand the adverse effects.

39. Wherever instrumentation equipment is installed underground, suitable approach, sufficient space for maintenance, drainage, ventilation and illumination shall be provided.

40. All instrument ranges shall be standardized over the whole plant for local and remote instruments by the expression \((1, 2, 4, 6, 8, 10, 12, 15, 50) \times 10^n\), where \(n = 1, 2, 3, \text{ etc.}\)

41. Necessary certificates from appropriate authorities shall be submitted for all applicable items regarding their suitability & installation.

42. Continued availability & supply of Instrumentation & control equipment including their spares parts & consumables shall be guaranteed for a minimum period of 10 years.
43. In case, Instrumentation & control equipment are supplied from foreign sources / manufacturers, care shall be taken to select only those vendors who have competent associates/partners/representatives in India with ability to provide required technical support & after sales service.

03.02 **Temperature Measurements**

1. The following types of primary sensing elements shall be used, depending on temperature of process fluid & application requirements:

   i. Pt-Rh 13% / Pt (ISA Type “R”)
   ii. Pt-Rh 10% / Pt (ISA Type “S”)
   iii. Pt-Rh 30% / Pt-Rh 6% (ISA Type “B”)
   iv. Chromel – Alumel (ISA Type “K”)
   v. Chromel – Constantan (ISA Type “E”)
   vi. Copper – Constantan (ISA Type “T”)
   vii. Iron – Constantan (ISA Type “J”)
   viii. RTD (Pt 100)
   ix. Radiation Pyrometers

2. RTD shall generally be used for measurement in the temperature range of -200°C to 300°C and thermocouples for higher temperatures.

3. For control application or wherever duplication of temperature signals are required, microprocessor based temperature transmitters shall be used.

4. RTDs shall usually be three-wire type. Four-wire type RTDs shall be used, whenever specifically required.

5. For differential temperature measurement by RTDs, Pt-1000 elements shall be used.

6. Temperature transmitters or secondary instruments used with thermocouples, shall have automatic cold junction compensation. All temperature transmitters shall be SMART type. HART/Field bus compatible, as applicable. Enclosure class of temperature transmitter shall be IP 67 for field mounted transmitters.

7. Resistance thermometers (RTD) shall be used for cryogenics and low temperature applications, in general.

8. Thermocouples shall normally be mineral insulated (i.e., extruded MgO) type. However, for applications exceeding 1100°C, lead type ceramic insulation shall be provided. Ceramic insulation shall be of recrystallised alumina (Al₂O₃·99.7%) as per DIN VDE 0335.

9. Thermocouple assembly shall be spring-loaded to ensure positive contact with thermowell.

10. Measuring junction of thermocouples shall be grounded or insulated depending on the type of electric system or safety protection requirement.

11. Separate conduits or cable entries shall be provided where duplex thermocouples are used.

12. Thermocouple calibration shall be in accordance with IS, DIN, IPTS or equivalent standard:
13. For Pt-Rh / Pt thermocouples, Linearisation shall be done in temperature transmitter or in DCS/PLC, as applicable.

14. Thermowells fabricated out of bar stock having sufficient mechanical strength shall be provided to enable maintenance work of thermocouple / RTD without affecting production.

15. AISI 316 shall be used as thermowell material, unless other special material is required due to process fluid and conditions. For temperature range between 800°C – 1100°C, Inconel 600 shall be used as thermowell material. For temperature more than 1100°C, ceramic thermowell shall be used. Ceramic material shall be selected based on the process environment.

16. Any pipe of less than 4” nominal diameter, shall be expanded to 4” size to install thermowell.

17. Thermocouples shall be complete with compensating leads, installation fittings. The indicators, controllers shall have broken sensor protection.

18. Interconnections to / from thermocouples to temperature transmitter shall be made via compensating cables of thermoelectric characteristics matched with thermocouple.

19. Bimetallc type thermometers having minimum dial size Φ150mm shall be used for local indication of temperature. Temperature gauges with smaller dial sizes may be used for machine mounted applications.

20. For bimetal type thermometers, external dial reset facility shall be provided for zero adjustment.

21. Capillary tubes, wherever used, shall be of stainless steel material with flame-proof PVC, neoprene or steel armour, as suitable for the application.

22. In case, compensating leads are to be laid on the top of the furnace / hot surface, these shall be asbestos covered with mesh shielding or other suitable insulating materials. Mineral insulated cables shall also be used for such applications.

23. Compensating cables connected to transmitters shall not be through terminal blocks but shall be directly connected.

24. Junction boxes for connecting compensating cables shall have terminal blocks suitable for type of thermocouples to be connected.

25. A protection tube consisting of a gas-tight ceramic sheath, preferably reinforced with stainless steel, shall be provided with Pt-Rh/Pt thermocouples, unless some other special construction is specified.

26. Radiation pyrometers shall be used when:

1. Measured temperature is beyond the practical operating range of thermocouples.

2. Environment will contaminate or seriously limit the life of the thermocouples.

3. Target is not easily accessible.

4. Average temperature of a large area is to be measured.
27. Normally, the radiation pyrometer shall respond to 98% of the target temperature.

28. Radiation pyrometers shall be provided with scavenging air or nitrogen to keep their lens clean and shall be water-cooled or air-jacketed when the surrounding temperature exceeds 50°C.

29. Pyrometer for critical application shall be with water cooled facility with sensing of low flow condition by flow switches as well as automatic shut-off of pyrometer in case of failure of cooling water.

30. Isolation valve shall be provided before radiation pyrometer for on-line maintenance of radiation pyrometer.

03.03 Molten Steel Temperature Measurement

1. For molten steel temperature measurement, disposable type immersion thermocouples having response time of less than 3 seconds shall be used. The corresponding temperature measurement system shall be complete with lance assembly, adapter, disposable thermocouple cartridge and two-way connector for the lance.

2. For immersion type hot metal / steel temperature measurement, shielded flame proof and heat resistant compensating cables shall be provided.

3. Temperature measurement system shall be microprocessor based.

4. Linearisation shall be provided for B, R & S type thermocouple shall be done in microprocessor based temperature measurement system.

5. 4–20 mA analog output for the measured temperature shall be provided for hooking up to DCS/PLC.

6. 4-½ digit type digital indication shall be provided in the temperature measurement system panel. This digital indicator shall retain the last value until the next measurement cycle is initiated by inserting the thermocouple probe in the lance.

7. One printer shall be provided in the temperature measurement panel for printing the measured temperature along with the heat no. Heat no. will be down loaded to the measurement system from DCS/PLC through RS 232C/ RS 422/ RS 485 link.

8. Ready, measurement and measurement complete/ probe open signals shall be displayed in the measurement system panel with green, yellow and red LED indication.

9. In the field, one local control box, 200 mm jumbo display for temperature indication and red, yellow and green lights for measurement complete/ probe open signal, measurement and ready status display shall be provided. Measurement complete/ probe open shall also be indicated by blowing horn.

10. Power isolation switch at local control box end shall be provided.

11. 24 V DC signals and 230 V AC signals shall be segregated in the local control box and microprocessor based temperature measurement system panel.

03.04 Flow measurement

03.04.01 For Fluids:
1. Normally orifice plates, magnetic flow meters or vortex flow meters shall be used for flow measurement of industrial service fluids, depending on the merit of the application. Positive displacement, turbine and Coriolis flow meters shall be used in custody transfer measurements and in processes, where high measurement accuracy is required. However, other types of flow meters may also be used when necessitated by particular technical requirements.

2. Vortex flow meters shall be generally be used for steam/gas service, upto 8” line size.

3. Magnetic flow meters shall be generally used for water & fluids having conductivity greater than 5 μS/cm.

4. Coriolis type mass flow meter shall be used for all viscous materials (tar pitch etc.) and for inert gas (argon, nitrogen etc.) applications of line sizes upto 2’.

5. Vortex Flowmeters shall be used for inert gas flow metering for line sizes > 2”

**Differential pressure type devices**

1. Normally, concentric square-edge type orifice plates shall be used.

2. For better accuracy, the Beta (β) ratio of concentric type orifice plates shall not preferably exceed 0.6. However, in no case, β shall exceed 0.7.

3. Minimum thickness of concentric square-edge type orifice plate shall be as follows:-

   - 2 to 12” (i.e., 50 to 300 mm)  
     - 3.18 mm
   - 14” to 36”  
     - 6.35 mm
   - Above 36”  
     - 10.0 mm
   - For temperature >316°C
     - 2 to 8” (50 to 200 mm)  
       - 3.18 mm
     - 10” & above  
       - 6.35 mm

4. Quarter-circle and conical entrance type orifice plates shall be used for viscous fluids.

5. Eccentric or segmental type orifice plates shall be used with dirty fluids.

6. Flow nozzle, venturi or averaging pitot tube may be used in high flow applications or where the allowable pressure-drop is low.

7. All orifice plates shall normally be made of AISI 316 material, unless otherwise called for by process requirement.

8. Generally flange tappings shall be used. However, corner or D & D/2 type tappings can be used as per requirement.

9. For line sizes between 1” to 2”, carrier-ring type orifice plate with corner tapping shall be used.

10. For line sizes less than 1”, integral orifice plate shall be used.

11. For line sizes greater than 2”, orifice plate with flange tapping shall be used.
12. In dirty/contaminated process lines or process lines where line pressure is low (in mm WC range) & line size is large, D & D/2 tappings shall be used.

13. All orifice plates shall be fabricated with a collar, which shall extend outside the mounting flange.

14. Tag no., orifice plate bore diameter, upstream (+) and downstream (-) side marking, and plate material shall be engraved on the handle of the orifice plate.

15. Flanges shall be in accordance with ANSI B16.36 and of minimum Class 300 rating upto line size of 24". For line sizes above 24", flanges in accordance with IS 6392, and of suitable rating shall be used.

16. Tag no., flange size, flange rating and flange material shall be engraved on all flanges.

17. Gasket material for orifice plates shall be suitable to withstand physical and chemical properties of process fluid and shall be matched with the pipeline standard, as required.

18. Supply of orifice plate assembly shall include the orifice plate, flanges, stud-bolts, nuts, jackscrews, gaskets, pressure tapping nozzles and plugs.

19. Drain / vent hole correction shall be as per ISA RP 3.2.

20. Orifice plate or flow nozzle shall be installed as per standard, but not less than with straight pipe lengths of 10 times pipe internal dia. (10 D) on the up stream and 5 D on the downstream, free from bends, tees, branch pipes and control valves, etc. Upstream and downstream straight pipe lengths shall be as per section 1.1 of BS 1042. 1981 and also on the guidelines of ISO: 5167, 1997.

21. Control valves shall be installed after the orifice plates in the direction of flow.

22. All flow meters shall have drainage valves except for oxygen service.

23. Corrosive media shall be separated from transmitters by separating chambers with valves for isolation.

24. For steam flow and flow of liquid at temperature greater than 120°C condensation chambers of identical dimensions shall be used. Condensation chambers shall be installed as near to flow sensor as possible.

25. Depending on specific requirements/applications, averaging pitot tubes with multi-holes (eg. Annubar type) placed in the direction of fluid stream may also be used. The calculations and design shall be as per manufacturer’s standard.

26. IBR certification shall be provided for steam and vapour applications, as per IBR standard.

27. All flow meters on inter plant pipes for gas balance system shall have an accuracy of 0.5% f.s.d. or better.

28. In contaminated water lines / gas / orifice plates shall be installed in bypass line with isolation valves. So that on-line maintenance shall be possible.
29. Generally, metal tube type rotameters shall be used. Glass-tube enclosed type rotameters may be used up to 3 kg/cm² process pressure, if the process fluid is air, inert gas or water.

30. For line size greater than 2”, bypass type rotameters shall be used, instead of on-line mounted type rotameters.

03.04.04 **For solids:**

1. Generally, flow measurement of solids in powdered, amorphous or granular form shall be done using ultrasonic type or load-cell based weigh-hopper type or nucleonic type sensors, depending on the merit of the application.

2. For measurement of mass flow of suspended solids in liquids or slurries, nucleonic type instruments shall be used.

03.04.05 **Vortex flowmeters:**

For selection of vortex flow meters, following to be taken into account:

1. Reynold’s no. shall be at least 20000 and minimum flow velocity shall be as specified by manufacturer.

2. Vortex flow meters shall not be considered in wet gas application.

3. Vortex flow meters shall not be considered for viscous, waxy or erosive services.

4. For gas application, the bluff body shall be in horizontal position to avoid condensate and for liquids in vertical lines the flow shall be upwards to keep the line full.

5. A location with minimum pipe vibration shall be selected. The pipe shall be supported at both ends, as necessary.

6. If pressure and temperature compensation are required for gas flow application, the pressure tapping shall be placed as close as possible to upstream of flow meter. The temperature tapping point shall be located at least 5D on the downstream of flow meter.

7. Straight length requirement shall be as specified by manufacturer. If meter size is smaller than the line size, concentric pipe reducers shall be used. Eccentric reducers shall not be used as they disturb the flow profile.

8. All vortex flowmeter shall be SMART type with HART protocol. Local display of vortex flowmeters shall be calibrated in engineering unit.

9. Accuracy of the vortex flow meter shall be ± 1% or better.

10. Sensing technique of the vortex flow meter shall not be thermistor based.

11. Necessary calibration unit for checking the electronic unit of vortex flow meter shall be provided.

12. Enclosure class of vortex flow meter shall be IP 67.

03.04.05 **Electro - magnetic flow meters:**

1. Selection of Electromagnetic flow meters, shall be decided based on the following:

   All electro-magnetic flow meters shall be SMART type. Electro-magnetic flow meters, which are to be installed in the control, alarm & interlocking circuits, shall have 4-20 mA DC output with HART signal superimposed on it. Electro-magnetic flow meters, which are to be installed in the furnace cooling water monitoring circuits (not in control, alarm or interlocking circuits), shall be Field bus compatible.

   Liner material shall be selected based on service. Generally, for liner material PTFE shall be used.

   If gases are entrained in the liquid, meter shall be installed in vertical process line.
While installation it shall be ensured that flow tube is always completely filled with liquid.

Straight length requirement of minimum 5 D in the upstream and 3 D in the downstream shall be provided for water services. However, for other services it shall be designed as per manufacturer’s recommendation.

Installation of electromagnetic flow meters shall be avoided near large conducting surface e.g. metal surfaces. (Large surface may interfere with magnetic field of instrument thus affecting accuracy).

Pulsed DC excitation shall be provided for field excitation of Electro-magnetic flowmeter. Power & signal circuits of electro-magnetic flowmeter shall be completely isolated from each other.

Minimum one no. of grounding ring for metallic pipelines and minimum two nos. of grounding rings for non-metallic pipelines shall be used for installing the electro-magnetic flow meter.

Selection and sizing of electro-magnetic flow meters flow characteristics published by the manufacturers shall be followed. Allowable flow velocity shall be considered based on the specific merit of the service, allowable pressure drop, cost effectiveness and as per manufacturers recommendation. However, 2 to 3 meter/sec flow velocity shall be considered for optimum results.

In case tube sizes are lower than the process pipelines reducers and expanders constructed preferably from the same as pipeline material shall be used. Such reducers and expanders shall be designed with 8(eight) degree downward and 5(five) degree upward angle respectively.

Accuracy of electro-magnetic flowmeter shall be ± 0.3% or better. Local display shall be calibrated in engineering unit.

In contaminated water lines, electro-magnetic flowmeter shall be installed in bypass line with isolation valve.

Sensor & transmitter of the electro-magnetic flowmeters shall separated in all cases.

Electro-magnetic flowmeter shall be provided with built-in auto zero facility for ensuring stable zero point.

Separate earthing pit shall be provided exclusively for earthing of electro-magnetic flowmeters. Preparation of such earth pits shall be governed by the general methodology as described in IS: 3043, 1987 or relevant international standards.

Necessary calibration unit for checking the electronic unit of electro-magnetic flowmeter shall be provided.

Enclosure class of electro-magnetic flowmeters shall be IP 67.

03.04.06 Coriolis mass flow meters:

For selection and sizing of coriolis type flow meters, following shall be taken into account:

1. If required flow rate cannot be handled by one meter, two or more meters can be used in parallel.
2. Selection of wetted part materials shall be carefully chosen to suit process fluid.
3. SS shall not be used for liquids containing Halogen. Hastelloy tubes shall be used for all application containing Halogen.
4. Coriolis mass flow meters shall not be used in two-phase fluid application.
5. Pressure drop across flow meter shall be selected, ensuring no cavitation occur under any process condition.
6. Flow meter support shall be as per manufacturer’s recommendation.
03.04.07 Ultrasonic flow meters:

For selection of Ultrasonic flow meters, following to be taken into account:

1. Ultrasonic flow meters shall be used in clean liquids and gases.
2. Ultrasonic flow meters shall be used where pressure drop is not allowed.
3. On critical services Ultrasonic flow meters with insertion probes shall have retraction mechanisms to allow on stream maintenance.
4. Clamp on type shall only be used for liquid metering.

03.04.08 Turbine flow meters:

1. Turbine meters for custody transfer shall have two pick-up coils for use with an electronic pulse integrity input circuit in read out system.
2. Turbine type meters shall have flanged connections
3. Strainers shall be provided immediately upstream of turbine meters
4. In liquid service, adequate filtering and degassing shall be provided.

03.04.09 PD meters:

1. Positive displacement type meters shall have flanged connections.
2. PD meters shall not be selected for use in non-lubricating liquids e.g. LPG.
3. Strainers shall be provided immediately upstream of PD meters.
4. In liquid service, adequate filtering and degassing shall be provided.

03.05 Pressure measurement:

1. Either bourdon tube (spiral or helical), bellows or diaphragm type sensing element shall be used in pressure gauges/ switches, depending on the process service.
2. The pressure gauges shall be designed in accordance with IS: 3624, 1987.
3. Pressure gauge accuracy shall be ±1.0% of span or better. Accuracy shall include the combined effect of linearity, hysteresis and repeatability.
4. The element and other wetted part materials of pressure gauges/ switches shall be of AISI 316, unless process media necessitates use of other materials.
5. Movement material of gauges shall be of AISI 304. Outer casing and bezel material shall be either made of die cast aluminium with epoxy coating.
6. Pressure gauges shall have external zero adjustment facility and minimum IP55 housing.
7. The sensing element of pressure gauges/ switches shall withstand the specified over-pressure (i.e., at least 125% of span) for at least 30 minutes, without affecting their elastic characteristics.
8. Pressure gauges shall have dial size of 150 mm diameter. Gauges of smaller dial size may be used for machine mounted applications.
9. Pressure gauges/ switches used in pulsating pressure applications (e.g. delivery side of pumps, compressors, etc.) shall be provided with externally adjustable pulsation dampener or snubber.
10. Wherever the process temperature exceeds 70°C, pressure gauges/ switches shall be equipped with pigtail syphon of the same material and schedule as the process pipeline.

11. Wherever the process pressure exceeds 50 kg/cm², solid front type pressure gauges shall be used (i.e., a metal partition shall be provided between dial and element).

12. Window material of the pressure gauge shall be of shatterproof glass.

13. For pressure measurement in slurries, viscous and corrosive fluids, diaphragm seals of suitable material shall be provided along with pressure sensing devices. Diaphragm seals shall be integral with the gauges /switches, unless otherwise specified.

14. The sealing liquid for diaphragm seal shall be an inert liquid compatible with process fluid and its temperature.

15. Depending on process application, suitable chemical seal along with capillary of required length shall be provided.

16. Diaphragm seal type pressure gauges / switches used in applications where the temperature exceeds 100°C, shall have báordon / bellows type element. The bourdon / bellows shall be selected to withstand temperature upto 200°C.

17. However, in vacuum service, if the temperature exceeds 200°C, diaphragm seal shall not be used.

18. The working range of pressure switches shall be selected in such a way that the set pressure is between 35% and 65% of the range.

19. The switch enclosure shall be weatherproof to IP 65. Additionally, in hazardous areas, switch enclosure shall be explosion-proof conforming to IS: 2148: 2004 /IEC 60079-1 : 2001 and suiting to the area-classification of the hazardous area.

20. Dry contact type micro switches with minimum rating of 240V AC, 5A / 110VDC, 0.4A shall be used for pressure switches in non-hazardous area applications.

21. In hazardous areas, hermetically sealed micro switches with minimum rating of 240 VAC, 5A / 110VDC, 0.25A shall be used.

22. Pressure switches shall have an accuracy of at least ±2% of span and repeatability of at least ±1% of span.

23. Accuracy of DP gauges shall be ± 1.5% of span. Accuracy shall include the combined effect of linearity, hysteresis and repeatability.

24. Pressure gauges shall be supplied with three-way gauge cock. DP gauges shall be supplied with 3-valve manifolds of AISI 316 material of suitable pressure and temperature rating. The above items shall be in addition to the process isolation valves/ root valves at the process tapping point.

03.05.01 Transmitters

1. Pressure, flow, differential pressure and level transmitters shall be rugged, industrial, microprocessor based ‘Smart’ type. Transmitters shall work on 24 V DC
power supply having 2-wire, 4-20 mA DC output & ‘HART’ protocol based digital communication.

2. Accuracy of all transmitters shall typically be 0.1% or better, of calibrated span for turn-down ratio of minimum 10:1 and rangeability of 100:1. Accuracy shall include the combined effects of linearity, hysteresis and repeatability. In any application, the worst case error (WCE) consisting of static pressure effect, temperature effect, humidity effect and stability (1 year) shall not be greater than 0.75%, unless specified otherwise. Zero and span adjustments shall be non-interacting to each other.

3. Transmitters shall be suitably compensated against any thermal effects in the process medium.

4. Transmitters shall be able to withstand a minimum over pressure of 150 % of the rated pressure.

5. All the transmitters shall be weather-proof to IP-67.

6. Zero suppression & elevation features, built in surge protection and provision for selection of different damping levels shall be provided in each transmitter. Absolute pressure transmitters shall have provision for compensation of barometric pressure.

7. All transmitters shall have integral local linear digital indicators calibrated in engineering unit. DP transmitters for flow applications shall have built-in square root extractors. Local indications shall be adjusted / calibrated through hand held calibrator.

8. Power supply effect on transmitters shall be less than ± 0.05 % of calibrated span/10 V.

9. Pressure transmitters shall be supplied with 2-valve manifolds of AISI 316 material. Flow; DP and level transmitters shall be supplied with 3-valve manifolds of AISI 316 material having suitable pressure and temperature rating. Standard zero suppression / elevation facilities and output reversal facility shall be available for all transmitters. All the required accessories for mounting shall also be supplied with the transmitters.

10. All transmitters shall be provided with traditional mounting arrangement along with manifolds

11. One hand-held calibrator with required software, rechargeable battery and battery-charger shall be supplied for calibration checks of the transmitters.

03.06 Level Measurement

03.06.01 General

Selection of primary elements shall be based on the service conditions. A general guideline is given below. However, selection of particular type of sensor shall be decided on the basis of application requirement.

1. For Liquid Service
   1. Pressure / differential pressure type level transmitter with/without diaphragm seals
   2. Float or Displacer type level transmitters
   3. Ultrasonic type
4. Radar type  
5. Vibrating fork type  
6. Gauge glasses  
7. Magnetic level gauges  
8. Capacitance type  
9. Conductivity type  
10. RF Type  
11. Time domain reflectometry type

2. For Solid Service
   1. Ultrasonic  
   2. Nucleonic  
   3. Load Cell (weighing) system  
   4. Electromechanical servo gauges  
   5. Tilt switches  
   6. Capacitance switches  
   7. Vibration rod  
   8. RF Type  
   9. Time domain reflectometry type

3. For sumps
   1. Conductivity switches  
   2. Capacitance switches  
   3. Bubbler Tube System

4. Tank gauging
   1. Servo gauges  
   2. Radar

5. Level instruments shall have weatherproof, dust and corrosion resistant enclosures of minimum IP-65 grade. 
6. Additionally, explosion-proof enclosures shall be provided for hazardous area applications. 
7. In Tank Gauging applications, communication port shall be provided in level instruments, for connectivity to a computer.

03.06.02 Gauge Glasses

1. All gauge glasses shall normally be steel armoured reflex or transparent type. Magnetic level gauges may also be used when liquid temperature permits and liquid specific gravity is greater than 0.9.

2. Reflex gauges shall be used on clean, clear, non-corrosive liquids.

3. Transparent gauges shall be used for the following applications:
   1. interface service  
   2. when the process is dirty or viscous  
   4. For corrosive medium, (such as caustic, hydrofluoric acid and steam applications above 250 PSIG), transparent gauge glasses shall be used with internal mica or plastic shield to prevent chemical attack or discoloration of the glass.
5. If the process is a solvent that can dissolve the internal coating of the chamber of the reflex gauge, thereby reducing the effectiveness of the prisms, reflex gauges shall not be used.

6. Reflex gauge glasses shall not be shielded

7. Transparent level gauges, in general, shall be equipped with minimum 40 W illumination and switch (ex-proof for hazardous area).

8. For high temperature applications, level gauges with flexible end tube coupling or expansion loops (top/bottom) shall be used to take care of high temperature expansion.

9. Large chamber type gauge glasses shall be used for boiling / evaporating and heavy viscous liquids.

10. Gauge glass material shall be toughened borosilicate glass having adequate resistance to thermal and mechanical shock.

11. Gauge glass body and cover shall be made of carbon steel with rustproof finish, unless otherwise specified.

12. Gauges shall be provided with safety ball check offset type gauge cocks, vent and drain connection (with 1/2” vent & drain valves), nipples, caps etc.

13. Gauge glasses shall be provided with top and bottom or side connections. Where side connections are specified, the gauge glasses shall have two connections at each end, 180° apart, with one connection at each end plugged.

14. Unless otherwise specified, gauge cocks shall be of the quick-closing type with bolted bonnet, outside screw and renewable seats.

03.06.03 Displacer & Differential Pressure type

1. External displacer type instruments with ratable head shall usually be used for level measurement upto 1200 mm (48”), wherever process permits.

2. Displacers shall be made of AISI 316 with Inconel torque tube, unless otherwise specified or unless the process calls for any special material.

3. Side-side flange connection shall normally be used. Heat insulator / finned extension shall be used for temperatures above 230°C.

4. All such instruments shall have drain valves and vent plugs.

5. Stilling wells shall be provided for internal displacer type level instruments.

6. Differential pressure transmitter shall be used for level measurement in boiler drums and in other cases, where displacer type instruments are not suitable (e.g. level measurement beyond 1200 mm, applications requiring purge or where liquid might boil in external portion).

03.06.04 Vibration fork type

Vibration fork type level switches shall generally be used instead of float type level switches. Further, external cage type construction shall generally be used. Process connection to the cage shall be 1” socket weld type, unless otherwise specified.
03.06.05 Ultrasonic type

1. Ultrasonic type level transmitters shall be microprocessor based and shall use digital signal processing technique for signal conditioning. Possible to calibrate through universal HART calibrator. Ultrasonic transmitters shall be located in the control room. Only sensors shall be located in the field.

2. Suitable protection box for mounting ultrasonic type level transmitters shall be provided for mechanical protection & dust. Swiveling arrangement shall be provided for proper aiming/ focusing of ultrasonic type level transmitters.

3. The transmitter shall have facilities for storing the echo profile, manipulation of the echo profile to remove noise, multiple profile-averaging etc.

4. The transmitter shall have the capability to use statistical filtering techniques, wherever required, to compensate for rotating agitator blades or to suppress false signal due to heavy dust or fill-stream interference.

5. In very dusty applications or in silo / bunker, etc. filling applications, high power and long range (i.e., low frequency) transducer shall be used to overcome the detrimental effect of the dust. This type of instrument shall not be used for level measurement in process medium consisting of particles of sizes (~ 6 mm diameter).

6. The sensor shall have inbuilt temperature sensor for ambient temperature compensation.

7. Chemical compatibility of the sensor material with the process material shall be ensured, to avoid corrosion.

8. In applications, where material build-up on the sensor is expected, the transducer shall have suitable build-up compensation (i.e. repetitive, pulsating displacement at its face shall be used to remove the material build-up).

9. Ultrasonic transmitters shall be supplied along with necessary calibration & noise suppression software, HART to RS 232C modem, plug connector, cable, etc. for connection to a desktop PC/ Laptop.

10. Provision for the nitrogen purging facility in the ultrasonic level sensor shall be provided for cleaning the build up of the material.

03.06.06 Nucleonic type

1. Nucleonic sources shall have adequate shielding to limit radiation level at any point on the surface to below 6 milli-Roentgen per hour. At the same time, nucleonic type measurement systems shall not be excessively bulky or heavy.

2. Nucleonic sources shall have facilities for complete shielding during shipping, storage and transportation (in the form of rotary shutter, etc.).

3. The supplier shall furnish necessary certification of nucleonic type instruments from statutory bodies, as applicable.

03.06.07 Capacitance & conductivity type

1. Capacitance / conductivity type probes shall be as follows:

   1. Rod type : for lengths up to 2000 mm.
2. Rope type with gravity weight: for length exceeding 2000 mm.

2. For level measurement in non-conducting tanks or sumps or when the tank profile is non-linear, capacitance type instruments shall be provided with a reference electrode / ground probe.

3. Capacitance type level probes may be used for both switching as well as for continuous level measurement in liquids.

4. Capacitance type level probe shall not be used for level measurement in solids when there is likelihood of material build-up on the probe. Capacitance type level probe shall not be used in liquid service where there is a chance of dielectric value change (due to oil spillage etc.).

03.06.08 Radar Type

1. Radar type level instrument shall be used when the physical properties of the medium between the sensor and the measured interface may vary.

2. The Radar type level instrument shall be microprocessor based with HART protocol and shall use digital signal processing techniques for signal conditioning. Possible to calibrate through universal HART calibrator.

3. Suitable antennae shall be considered for the intended application.

4. Radar type level transmitter shall have facilities for storing echo profile, manipulation of the echo profile to remove noise, multiple profile-averaging etc.

5. The transmitter shall have the capability to use statistical filtering techniques, wherever required, to compensate for rotating agitator blades or to suppress false signal due to heavy dust or fill-stream interference.

6. The sensor shall have inbuilt temperature sensor for ambient temperature compensation.

7. Chemical compatibility of the sensor material with the process material shall be ensured, to avoid corrosion.

8. In applications, where material build-up on the sensor is expected, the transducer shall have suitable build-up compensation (i.e. repetitive, pulsating displacement at its face shall be used to remove the material build-up).

9. Necessary software, cables, connectors, HART to 232C converters etc. For calibration, noise suppression, etc. of Radar type level transmitters through windows based desktop PC / Laptop shall be supplied.

10. Suitable protection box for mounting radar type level transmitters shall be provided for mechanical protection & dust. Swiveling arrangement shall be provided for proper aiming / focussing of radar type level transmitters.

11. Provision for the nitrogen purging facility in the ultrasonic level sensor shall be provided for cleaning the build up of the material.

03.06.09 Time domain reflectometry type (TDR)

1. TDR type level measuring system shall be mainly used.
a) For level measurement of Liquids, interface in immiscible fluids, granules & fine powders
b) For medium having dielectric within 1.8 to 100.

2. Co-axial type, twin rods, twin cables, single cable / rod type probes shall be selected depending on tank height, properties of medium/media & application.

3. For interface level measurement top layer shall be of lower dielectric and minimum difference of dielectric between top & bottom layer shall be as per manufacturer’s recommendation

4. For adhesive/sticky in nature materials, coated probes as per manufacturer’s recommendation shall be used.

03.06.10 Radio frequency (RF) type

1. Radio frequency (RF) continuous/ point level measuring system, based on capacitance or admittance shall be used for level measurement of liquids, slurries, granulars, and liquid-liquid interface.

2. RF transmitter shall be
   a) Smart type
   b) Self-calibrating type i.e. as the level rises in the vessel, the span is set automatically and electronically by the smart transmitter.

3. For high temperature application, remote mounted transmitters shall be used.

4. RF type shall also be used for detection of absence or presence of liquids, slurries, interfaces and granules.

5. One hand-held calibrator with rechargeable battery and battery-charger shall be used.

6. It shall be possible to calibrate RF transmitters using calculated or known levels of capacitance directly entered by the hand held calibrator.

03.06.11 Others

Tilt Type, paddle type, bubbler type, electromechanical type, etc. level instruments may also be used, depending on application specific requirement.

04. GAS ANALYSIS SYSTEM

The gas analysis system shall be complete with the following units:

1. Gas sampling probe, complete with filters, isolation valves, ring heaters, insulator jackets etc, as required. Dual probes shall be used, wherever required as per process criticality.

2. Swagelock/ Parker fittings shall be used for sample handling system of gas analysers.

3. Gas preparation & conditioning system including sample conditioning, pumping, cooling, cleaning, drying etc. as applicable along with filter panels, scavenging panels complete with valves, tubing, fittings, accessories etc, as required.
4. Gas analyzer panel with analyzer instruments, monitoring devices viz., flow, pressure, temperature etc., tubing, fittings, accessories, as required.

5. UPS & non-UPS type electrical power supply for the complete gas analysis system, complete with isolation transformer, Circuit breakers, MCBs, relays, 24 V DC regulated power supply units, earthing system etc, as required for efficient performance of the analyzer system.

6. Calibration equipment with calibration gas cylinders. Facility for both automatic & manual mode of calibration shall be provided. Cross sensitivity correction shall be provided wherever applicable.

7. Suitable display unit with key-board/ switches shall be provided on the analyzer panel front for monitoring & display of different parameters, status of analyser & sample conditioning equipment etc.

8. Condensation monitors, complete sampling system shall be designed & supplied by the analyser manufacturers only. All components & fittings of the analyser & sample conditioning system shall be of reputed make, preferably imported.

9. Before the filter unit, SS isolation valves shall be provided for each probe to facilitate online changing of the filter unit. Sample gas coolers shall be provided with redundant sample gas path & peristaltic pumps.

10. Sampling of dusty, hot, dry, cold or wet gases shall be done using dual probes with automatic switchover and with intermittent purging facility.

11. Analyser shall be microprocessor-based and the analyser PLC shall do all related sequencing & logic functions. Analyser PLC shall preferably have the same series & model no. as envisaged for the main unit / plant to ensure reliable & trouble-free communication.

12. System & application software for configuring and diagnostics of the analyser. PLC shall be provided.

13. Response time of the Analyser system shall be designed to comply with process requirements.

14. Unless otherwise specified, accuracy of analyzers shall be within ±1% of span. Repeatability of analyzers shall be within ±1%.

15. Where there is a possibility of choking of analyser inlet filters, automatic inert gas purging facility initiated by the analyser PLC shall be provided.

16. All solenoid valves used in gas analysis system shall have manual override.

17. Separate analyser room shall be provided in the vicinity of gas sampling points. However, storage of calibration gas cylinders shall be arranged outside the analyser room. Ambient CO monitoring unit shall be provided in the analyser rooms.

18. Analyzers in explosion hazardous area shall be installed in ex-proof shelters.

19. Exhaust tubing shall be provided for the sample gas after analysis and will be either vented into atmosphere at safe elevation/ distance, or fed back into the process stream. Gases containing hydrogen shall have separate outlets.
20. Analysis system of Hydrogen & other explosive gases shall bear the approval of statutory body.

21. Wherever analysis of harmful gases has to be done, unmanned gas analyser room with proper air conditioning facility shall be planned. At least one inert gas and / or steam purging point with flexible hose connection and isolation valve shall be provided at the entry point of this room.

22. In analysis of explosive gases (or gases forming an explosive mixture), approval of design and installation of analyser system shall be obtained from competent authority.

23. Poisonous and explosive gas detection systems shall have safety-limit alarm annunciation. Safety limits of different gases shall be as per OSHA norms.

24. Normally, the following types of gas detectors / sensors shall be used. However, type of sensor shall be selected, depending on the application:
   1. Electro-chemical cell
   2. Semiconductor/solid state cells
   3. Thermal conductivity
   4. Paramagnetic
   5. Catalytic poison resistant
   6. Non-dispersive Infra-red radiation type

05. LIQUID ANALYSIS SYSTEM:

1. Analysis of pH or Oxidation—Reduction Potential (ORP) of industrial liquids shall be done using a measuring electrode and reference calomel electrode sensing system. The type of electrodes shall be selected based on the electrochemical and physical properties of the liquid.

2. Material of construction of conductivity analysis cell shall be based on the chemical corrosion activity and physical properties of the process medium. The type of electrodes shall be selected based on the electrochemical and physical properties of the liquid.

3. Buffer solution shall be provided along with the analyser for calibration purpose.

06. CONTROL VALVES

1. Control valves shall be provided with by-pass valves, except where the valves are used in split-range service.

2. Control valve characteristics shall be chosen in accordance with process requirement.

3. Control valves shall be sized in accordance with ISA-S75-01.

4. Valve sizing software, wherever used, shall be submitted along with sizing calculation.

5. Control valves shall be sized so that at minimum and maximum flow, the valve lift is always between 10% to 90% for equal% and 20% to 80% for linear characteristics.

6. All control valves shall be provided with hand wheel.
7. Wherever required (such as, in high temperature applications) or wherever specified, hard-faced or stellified valve trims shall be provided.

8. In extreme temperature applications, seal-welding of threaded seat-rings, etc. shall be done.

9. In very low temperature applications, valve trim materials shall be chosen to have adequate cold impact strength.

10. ‘Trim’ of a control valve shall include those parts of body assembly (excluding body, bonnet and bottom flange), which are exposed to and in contact with, the process medium. These parts shall consist of but not be limited to the seat ring, valve plug, plug stem, plug guide bushing and cage.

11. Valve guide bushing shall be of sufficiently hard material to resist side-thrust on the valve plug.

12. For temperature applications below 200°C, ‘Teflon’ valve packing shall be used.

13. For temperature applications exceeding 200°C, ‘grafoil’ packing shall be used.

14. Steam / electrical tracing shall be provided to control valves, wherever process demands.

15. Control valves in steam service shall be provided with IBR certification.

16. Valve body size shall be minimum 25mm. However, reduced trim may be provided with 25mm valve body, if the process demands.

17. Globe type control valves shall be, in general, used in throttling applications for valve applications up to 500 mm line size, when the line pressure is not very low & fluid is non-viscous.

18. Single seated globe valves with top guided plugs shall be generally used for low & medium flow applications & for clean fluid applications as well as fluid with suspended particle applications. Cascaded trim shall be used for cavitating services.

19. Globe valves with cage guided plugs are pressure balanced & shall be used for high flow applications where the fluid is clean or if there is a chance of flushing/cavitation. Generally, single seated globe valves with cage-guided plug shall be used from the viewpoint of maintenance & for better leakage class. However, double seated cage guided valves shall be used for better pressure balance, based on the process application.

20. Top & bottom guided double port double seated straight through type globe valves shall be used for very high flow applications & where wide rangeability is required. Wide rangeability is possible, as the valve operation is quite steady through out the stroke due to relatively low unbalanced force & because of the guiding at top & bottom. Another advantage of this type of valve is that valve action can be reversed without change of actuator.

21. Extension-bonnets shall be provided in control valves for services above 200°C or below (-) 30°C, or as recommended by the manufacturer.

22. Other types of valves (e.g. butterfly, angle, eccentric-disk, ball, V-notch ball type, etc.) shall be used only when operating conditions do not allow globe type valves.
23. For high viscous liquids, V-notch ball valves shall be used.

24. Angle valves shall be used wherever piping layout so desires. It is devoid of dead pockets & possible to achieve fine control through it. It can be used in slurry application also. In case of high-pressure drop application, multistage single seated cage guided angle valves shall be used. In very high-pressure drop applications, the multi stage pressure reduction trim prevents the liquid pressure falling below the saturation pressure at vena contracta, thereby eliminating the chance of cavitation. Due to its geometry, the chance of erosion & noise level is comparatively less than similarly constructed conventional globe type valves.

25. Three-way valve shall be used in mixing & diverting services.

26. Concentric disc type/ eccentric disc type butterfly valves shall be used in large line sizes & mainly in low-pressure applications or where allowable pressure loss across the valve is very low. Concentric disc type butterfly valves shall be designed for maximum opening angle of 60°. The maximum permissible opening for eccentric disk type butterfly valves shall be 90°. Applications where wide rangeability is required, eccentric disc type butterfly valve shall be used instead of concentric disc type butterfly valves.

27. Noise generated from operation of control valves shall be limited to OSHA specified levels.

28. Large size piston-operated and diaphragm-actuated type control valves or dampers shall be provided with positioners. Such valves or dampers shall have signal bypass facilities for manual local operation.

29. However, the maximum allowable noise is 85 dBA SPL. In case, the predicted noise level during calculation exceeds 85 dBA, the control valve shall be treated for noise. Only source treatment of noise shall be resorted to.

30. Control valve leakage class (in accordance with ANSI FC 70.2 / API) shall be selected as per process requirement.

31. Valve stem-position indicator shall be provided for all the control valves.

32. All diaphragm-type control valves shall have hysteresis (without positioner) less than 2% of spring range.

33. Fire-safe valves, wherever required, shall be as per API 607 and design shall be as per API-6D

34. Control valve accessories, such as solenoid valves, positioners, limit-switches, air-filter regulators etc., shall be firmly mounted on the valve body or yoke and shall be properly tubed using PVC-jacketed copper tube.

35. Valve position feedback & end limit switches shall be provided for all the control valves.

36. Solenoid valves installed in the control air supply line shall be of Universal type having minimum class ‘F’ insulation and shall be continuously rated direct-acting type. Solenoid valves shall be full-bore type with minimum bore size 3 mm.

**06.01 Actuators**

1. Actuators shall be sized for shut-off differential pressure.
2. Actuators shall be pneumatically operated, unless otherwise specified.

A) Pneumatic actuators:

1. For spring-opposed diaphragm type actuators, the spring shall be corrosion-resistant and cadmium or nickel-plated.

2. Actuator operating range shall be 0.2 to 1.0 kg/cm².

3. Valve positioners or boosters may be considered for actuators for the following applications:

   a) To split the controller output to more than one valve.
   b) To amplify the controller output beyond the standard signal range (i.e., 0.2-1 kg/cm²), in case of actuators with greater thrust or stiffness.
   c) To achieve minimum overshoot and fast recovery in control action, as in the case when long control air lines have to be used.
   d) In all the above applications, whether or not a positioner or booster is to be used, shall depend on the speed of response of the system.
   e) Wherever required, boosters shall be used for systems with a fast response (e.g. pressure and flow control loops etc.) and positioners shall be used for relatively slower control loops (e.g., temperature and level loops etc.).
   f) Actuator casing and diaphragm shall be designed to withstand at least twice the maximum pneumatic operating pressure of the control valve.

B) Electrical actuators:

1. The actuator shall have electric motor and gear box assembly for having low speed and high torque output.

2. The motor of electrical valve actuator shall be intermittent duty, high torque and high slip motor.

3. Gear mechanism shall be self-locking type.

4. The standard fitment of electrical actuator shall include as minimum:
   1. Torque and end limit switches (2 NO + 2 NC for each limit switch.)
   2. Intermediate limit switches as specified. (2 NO + 2 NC for each limit switch.)
   3. Continuous remote position transmitter.
   4. End travel indicator.
   5. Overload protector by a thermostat embedded in the motor winding

5. Power supply to actuator shall be through fast acting fuse – switch unit or fast acting circuit breaker.

6. Local control box with open/close, emergency stop pushbutton, local/remote selector switch and open close indication shall be provided.

7. Power supply shall be 240 V, 50 Hz, single phase or 415 V, 50 Hz, 3 phase, 4 wire.
8. Insulation class of motor shall be selected as per NEMA standard depending on ambient operating temperature.

9. Separate cable entry & gland shall be provided for power supply, control signals and position transmitter.

10. In explosion hazardous area use of electrical actuator shall be avoided. However, in case, electrical actuator has to be selected, shall be ex-proof type.

11. Regulating duty motors shall be generally selected as per following guidelines:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Ambient temp. in °C</th>
<th>Duty cycle of motor, in %</th>
<th>Starts per hour</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-30 to 40</td>
<td>100</td>
<td>1200</td>
<td>For example, if 100 % duty cycle motor is selected for 1200 start/hour use between ambient temp. range of (-) 30 to 40 °C, then the same motor can be used for 630 starts/hr only, if ambient temperature range is increased to 40 - 60 °C.</td>
</tr>
<tr>
<td>2</td>
<td>40 to 60</td>
<td>100</td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>60 to 70</td>
<td>100</td>
<td>516</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-30 to 40</td>
<td>50</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>40 to 60</td>
<td>50</td>
<td>315</td>
<td>Similarly, if 50 % duty cycle motor is selected then the start / hr of 1200 will be reduced to 600</td>
</tr>
<tr>
<td>6</td>
<td>60 to 70</td>
<td>50</td>
<td>258</td>
<td></td>
</tr>
</tbody>
</table>

**Positioners**

Valve positioners, wherever required, shall be side-mounted on the control valves and shall be direct-acting type, unless otherwise indicated.

Wherever the operating range of the actuator is the same as that of the control signal, the positioner shall be provided with an integral bypass switch.

All valve positioners shall have integral pressure gauges to indicate input supply, control signal and positioner output pressures.

All pneumatic connection points shall be of ¼” NPT(F), in accordance with ANSI B 20.1. In case they are different, suitable adapters shall be provided.

Positioners shall have corrosion-resistant linkages and rugged brackets.

Control valves positioners shall have repeatability within 0.5% of stroke, for a given input signal.

Valve positioners shall be SMART type with HART protocol.

All control valves shall be provided with position transmitters. Position transmitter shall be capacitive/ inductive type.

2 nos. of air filter regulator shall be provided with each control valve. One regulator for I/P converter and the other for positioner.

**Limit switches**
1. Limit switches, wherever specified, shall be suitable for mounting on the valve and shall be supplied along with all mounting accessories.
2. Limit switch enclosures shall be weatherproof to NEMA 4, or suitable for the specified hazardous area classification.
3. Limit switches shall be SPDT type, silver-alloy-plated, hermetically sealed and rated for minimum 240 VAC, 2A.
4. Flying leads are not acceptable. Terminal blocks of limit switches shall be located inside the switch housing.

07. CALORIFIC VALUE ANALYSER

The Calorific value analyser system shall be complete with required accessories from the following units, as applicable:

1. Tar separator
2. Sampling gas pump.
3. Silica gel container
4. Gas preparation (cleaning, cooling, drying etc.) unit consisting of: Water pot with drain valves, Ball valves, Water separator with automatic drain facility, Chemical Filter, Mechanical Filter, Aerosol Filter, Pressure reducer etc.
5. Steam purging facility
6. Analyser calibration equipment with calibration gas cylinders.
7. Automatic calibration and correction unit (wherever necessary)
8. Cooling air fan, Ceramic Burner, Safety pilots for burner, Thermopile, Pressure governor.
9. Mimic panel with LED indication (if required).
10. All necessary internal monitoring devices (for flow, pressure, temperature etc.)
11. The sampling system shall be suitably designed considering gas composition and its impurities
12. Analyser shall be microprocessor based.
13. Manufacturer’s software for configuring and diagnostics of the analyser shall be provided and loaded in the system for ease of maintenance.
14. Analyser system shall be designed to have dead time less than 15 seconds for the entire system and maximum possible accuracy.
15. Unless otherwise specified, accuracy of analysers shall be within ± 1% of span. Repeatability of the analysers shall be within ± 1%.
16. Purging facility, inlet filters, etc., shall be provided, wherever there is a possibility of choking of analyser.
17. All solenoid valves, used in analysis system, shall have manual override.
18. Separate analyser room shall be provided in the vicinity of the gas sampling points. However, storage of calibration gas cylinders shall be arranged outside the analyser room. Exhaust facility shall be provided in the analyser room. Tenderer shall indicate whether air conditioning facility is required for Cv analyser.
19. Analysers in explosion hazardous area shall be installed in ex-proof enclosures.
20. Suitable exhaust tubing shall be provided for the fluid under analysis, taking care of all safety means.
21. In analyses of explosive gases (or gases forming an explosive mixture), approval of design and pipe routing of the sampling system shall be obtained from the competent authority (viz, the Chief Controllers of Explosives, Nagpur).
22. Zero & span gas cylinders shall be provided as per the requirement.
23. Analyser panel shall have suitable digital display facilities in engineering units.
08. FLAME DETECTOR

1. UV type flame failure detector, suitable for the intended application shall be offered. Swiveling arrangement shall be provided for proper focussing of the flame detector.
2. The detector shall have self diagnostic facility.
3. For alarm output, potential-free contact (1 NO + 1 NC) shall be provided.
4. Suitable panel for housing the complete electronic system at field shall be supplied.

09. CONTROL PANELS/CABINETS

1. Panels shall be totally enclosed; flush-front, freestanding upright floor mounted type with welded construction. Panels shall be mounted on box-type base-frame.
2. Panels shall be made of cold rolled cold annealed (CRCA) sheet steel with thickness as follows:-
   - Front face, gland plate, equipment mounting plate : 3mm
   - other load-bearing sections
   - Door, top, bottom and side faces : 2mm
3. Sizes of panels and cabinets, as approved by purchaser / consultant, shall only be supplied.
4. Height and colour of new panels, to be installed in any existing room, shall match with existing panels. Otherwise, panel height shall be 2250 mm. with an additional 100x50x6 mm base channel and 15 mm thick anti-vibration pad on top. The panel / cabinet shall have minimum depth of 600 mm.
5. If the width of a panel exceeds 800 mm, double-door type construction shall be provided. Otherwise, panels will have a single door.
6. Panel doors shall have flush-type and lockable door-handles.
7. Panel doors shall have mesh-covered louvers at top & bottom, for air circulation. Additionally, wherever necessary, push-pull type circulating fans shall be provided for cooling of equipment inside.
8. In general, mounting height of instruments in the panel shall be as follows:
   1. Miniature instruments (bottom levels matched):
      - Bottom row - 1000 mm
      - Middle row - 1350 mm
      - Top row - 1600 mm.
   2. Annunciator : 1900 to 1950 mm (bottom levels matched):
   3. Push buttons : 800 mm center line(excluding base channel)
   4. Hooter (for alarm) : Outside cabinet - preferably at panel top.

Panel-mounted instruments conforming to DIN size and mounted in the same row shall have their bottom levels matching.

9. All equipment inside the panel shall be located in such a manner that their terminals and adjustments are readily accessible. Panels shall be dust and vermin proof. Panels installed in control rooms shall be weatherproof having minimum IP42 degree of protection. Suitable gaskets shall be provided, for this purpose.
10. Panel / cabinets located in the field shall have minimum IP-54 degree of protection. Pressurised local cabinets shall be installed in dusty areas. Pressurisation shall be achieved inside the cabinet by introducing clean (i.e., dust-free) air.

11. A space of at least 1.5m shall be provided in front and behind panels / cabinets for ease of operation and maintenance.

12. If the length of a panel exceeds 5m, approach from both sides shall be provided.

13. No process fluid other than air shall be piped to the panel / cabinet.

14. Panels / cabinets / desks etc. shall be supplied in finish-painted, completely wired and tested condition.

15. Panels shall first be chemically de-greased, de-rusted and phosphated. Then, 2 coats of red-oxide shall be applied. Finally, 2 coats of synthetic enamelled paint or epoxy-based paint shall be applied to have a non-glossy high class finish with aesthetically pleasing appearance and long life.

16. Colour shade of panels shall conform to RAL 7032. Outside shade of panels shall generally be RAL 7032, unless otherwise specified. The inside of panels shall be of brilliant-white. Panel base channel shall be painted black.

17. However, the supplier shall ensure uniformity of colour and height of all the panels as per customer’s choice, wherever instrument panels are installed along with electrical or other panels in the same room, or also as per existing plant standard, wherever applicable.

18. Panels shall have lifting hooks or eyebolts on the top at the four corners, for ease of transportation.

19. Instrument power supply shall be through a 1:1 isolation transformer to be installed in the instrument panel.

20. The inside of panels / cabinets / local panels shall be illuminated, preferably using incandescent type lamp. The illumination lamp shall be switched on/off using either a door switch or a toggle switch.

21. An inscription plate (with white letters on a black background) containing the tag no. etc. shall be provided for each instrument / device mounted on the panel. Separate nameplates shall be provided for rear-panel mounted instruments.

22. Anti-vibration mounting or shock absorber shall be provided for panel-mounted instruments in vibration-prone areas.

23. ISA symbols shall be used in Mimic panels. Graphic design, colours, materials, etc. used in mimics shall be in accordance with existing plant standard or as per Purchaser’s choice.

24. For panel wiring, following guidelines shall be followed:

**Signal wiring:** 1.0mm² PVC insulated, stranded Cu-wire: gray colour

**Power supply wiring:**
- For 240/110V, 50 Hz 1.5mm² PVC insulated stranded Cu-wire, colour code:
  - Live : red
  - Neutral : black / blue
- For 24V, DC
  1.5 mm² PVC Insulated stranded Cu-Wire, Colour Code:
  - Earth: green
  - Positive: brown
  - Negative: black / blue

- Earth
  4.0 mm² PVC Insulated stranded Cu-conductor, colour code: green-yellow spiral

25. Screen wires of screened signal cables from the field shall be earthed at the electronic earth-pit of the control system, which shall be separate and independent with respect to the power supply earth grid.

26. The following points shall be taken care of while deciding the internal layout of instrument panels or cabinets:

1. Electrical voltage higher than 240 V AC/DC shall not be brought inside the instrument panel / cabinet.

2. All internal wiring shall be housed in covered, non-flammable plastic raceways.

3. Separate wiring raceways shall be used for power supply wiring, signal wiring and intrinsically safe circuits' wiring.

4. Distance between the continuous edges of two adjacent terminal strips shall be minimum 100 mm.

5. Separate terminal strips shall be provided for 24 V DC, 240/110 V AC and intrinsically safe terminals.

6. Distance between cable gland plates & bottom of terminal strips shall be minimum 300 mm.

7. Terminal blocks shall be screw less clip-on type.

8. For signal wiring, 2.5mm² size terminals shall be used.

9. For power wiring, 4.0 mm² terminals shall be used.

10. A minimum of 20% spare terminals shall be provided, for power, signal and intrinsically safe circuits’ wiring.

11. Power supply terminals (e.g. 240VAC or 110VAC or 24VDC) shall be labeled.

12. In case a bus bar is used for power supply distribution, the bus-bar shall be shrouded with a transparent Bakelite plate.

27. Panels or cabinets shall be provided with the following items:

1. Power socket (of 240V AC, 15W rating) for soldering, etc.

2. Pair of earthing bolts on either side of the panel (at the bottom) for power earthing.

3. Copper bus-bar (of size 25x3mm.) mounted on an insulated base inside the panel with holes and nut-bolts - for instrument signal earthing (i.e., electronic earthing).
10. ELECTRICAL SYSTEM

The instrumentation and control system including all field instruments and the process computer shall be provided with a power supply system with provision of continuous availability of power even in case of fault or failure of the local power supply source.

Instrument power supply shall be single phase 110/240 V A.C. All instrumentation equipment shall be suitable for power-supply fluctuation within 240V AC, +10%, -15% and 50Hz +3%, - 6%. OR 110V AC ± 10%, 50 Hz ± 3%.

Wherever, power supply through UPS is specified, shall be supplied through parallel redundant UPS with 30 minutes of battery back up.

415 V, three phase power may be used to derive instrument power. However, the same shall not be brought inside the instrument panel.

A 1:1 isolation transformer shall be installed in the instrument panel or cabinet for isolation of input power supply. A master circuit breaker (with short-circuit protection and overload release facility) shall be installed in the instrument power supply line.

Terminals of 110V and above shall be labeled and isolated from terminals of lesser voltages.

All electrical systems and installations shall meet the statutory requirements of the Indian Electricity Act and rules & regulations of Central & State Government.

No instrument contact shall be used directly for alarm annunciation or interlocking. Contacts after multiplication through relays shall be used for alarms and interlocks.

Instrument power supply shall be through circuit breaker (with adjustable short circuit and overload release facility) and isolating transformer. Circuit breakers shall also be provided on the secondary side of the isolating transformer. All 4–wire instruments shall be provided with individual circuit breakers. All DCS/PLC loop powered instruments shall be provided with individual fuse in the terminal blocks of DCS.

Derivation of necessary voltage grade from the available power supply, as may be required for the offered system & distribution of power shall be carried out by the Tenderer.

Power supply equipment for instruments as may be required shall be installed inside the instrument panel.

All signal, control, compensating cables & power cables for instrumentation use shall be of armored type. The conductor shall be electrolytic grade tinned copper as per IS 8130 : 1984.

All cables shall be PVC insulated and PVC sheathed. Insulation material shall be PVC type C and sheath material shall be PVC type ST2 as per IS 5831 : 1984. Additionally, asbestos, silicone or sintered Teflon sheath shall be provided in high-temperature-prone locations.

Instrument power supply and control cables shall be made of multistrand copper conductor of 1.5 mm² of 1.1 KV grade and other details as per IS 1554, Part 1.

500 V grade cables with multi-stranded, twisted pair copper conductor of minimum cross-sectional area of 1.0 mm² shall be used for signal cables. Cable pairs shall be individually and overall shielded.
Shield in screened cables shall have 25% overlap and 100% coverage. Shield shall be kept open at the instrument end and to be connected to the electronic earth pit at the control room end.

For shielded compensating cable the shield shall be earthed near the point of the circuit ground. For grounded junction thermocouples, this means at the thermocouple head. For ungrounded junction thermocouples this means at the control room end.

Compensating/Thermocouple extension cables to be used in high temperature zone or are to be laid on the top of the furnace/hot surface, shall be sintered Teflon insulated, sinter Teflon sheathed overall SS braided cables. Additional Glass fibre insulation shall be used for temperature zone > 250 Deg C. Mineral insulated extension cables can also be used for such application.

The individual cores in multicore cables shall be PVC insulated & numbered and/ or identified by a definite colour code.

All cables, from field JBs to panels/ marshalling rack in the control room shall have at least 10% (minimum 1 no.) spare cores

11. PNEUMATIC SYSTEM

1. Air supply to pneumatic instruments shall be dry and free from oil, dust and moisture as specified below. Air shall be supplied from oil free compressors. The air shall be filtered & dried in a drier and stored in storage vessel of suitable capacity to ensure at least 30 minutes of continuous operation. On the supply line to each shop, pressure gauge shall be provided before and after the pressure reducer. On air supply failure, audiovisual alarm shall be initiated.

2. Instrument quality air shall have following parameters:
   - Dust particles size : Not more than 5 micron
   - Oil not to exceed : 5 to 10 ppm
   - Pressure Dew point : 10°C below the minimum temperature attained in any time of the year at site. However, pressure dew point shall not exceed 4°C.

3. Nitrogen, if used as pneumatic power supply, standby facility complete with air drier, filter and regulator shall be provided.

4. Supply airline to individual instruments shall have air pressure reducers, filters and isolating valves separately for the instrument. These shall be installed as near to the instrument as possible.

5. Compressed air at a pressure of 6 to 8 kg/cm² shall be processed in the air drying and filtration plant to achieve the specified quality of instrument air which could then be supplied to individual or group of pneumatic instruments at a pressure of 5 kg / sq. cm after passing through air filter and regulator.

6. In case, centralized air drying and filtration plant is not provided, specially for small shop units, suitable air drier & filter regulator units with accessories shall be provided at each consumer point for achieving instrument quality air from compressed air.
7. Transmission of pneumatic signals shall be done by 6 mm or 8 mm (for longer distance) by seamless steel tube or properly protected copper tube or armored tube bundles.

8. Distribution of instrument air shall be through air main (bulkhead) with separate supply to each instrument through a valve.

12. CONTROL ROOM DESIGN

1. Control rooms shall be aesthetically and ergonomically designed as per modern features with adequate safety features.

2. Doors shall be provided with automatic door closer and double doors shall be provided in dusty atmosphere. Doors shall preferably open outside. Doors shall be made of glass in aluminum frame.

3. Windows shall be made of aluminum frames and the glass panes shall be long, preferably on sheet for each frame. Small glass panes shall not be used. Glass windows shall be about 1,000 mm in height and at 750 mm from floor level.

4. Control room shall have false ceiling, false floor and double wall. Fresh air entering the control room shall pass through chemical filters.

5. The control room shall be air-conditioned with the following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>23± 2 °C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>50 to 60%</td>
</tr>
<tr>
<td>Dust content</td>
<td>0.1 mg / m³</td>
</tr>
<tr>
<td>No. of air changes</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Positive pressure</td>
<td>about 2 mm of WC</td>
</tr>
</tbody>
</table>

6. Walls shall be paneled with aluminum strips and painted with dust free, wear and fire resistant paints.

7. Floors shall be of linoleum / hard rubber fire-inhibited asbestos filled vinyl floor with antistatic properties.

8. Ample room shall be provided around the instrument panel / boards (minimum 1.5 to 2 m).

9. Control room illumination level shall be adjustable in the range of 250-550 lux and generally maintained at 500 lux. Illumination shall be done with shadow less and glare free concealed fittings.

10. Mounting frames/ inserts for panel mounting shall be provided.

11. Cable troughs or openings in the floor shall be provided to bring the cables to the panels. The opening shall be sealed after completion of erection.

12. Normally gas impulse lines shall not be permitted in the control room. If however, gas lines do enter the control room, proper ventilation shall be provided with more air changes to ensure safety.
13. **CABLE LAYING**

1. All cables shall be supplied & laid in accordance with the cable schedules and cable layout drawings. Before laying, cables shall be meggered and tested.

2. All armoured cables shall be laid on trays. Un-armoured cables shall be laid in suitable conduits.

3. All cables routes/lengths shall be carefully measured as per site conditions and cut to the required lengths to prevent undue wastage. While deciding cable lengths, adequate extra length of each cable shall be kept at the termination points at both ends.

4. Cable shall have complete uncut lengths from one termination to the other. Joints are not acceptable.

5. Power and signal cables shall be laid in separate trays. A gap of minimum 300 mm shall be maintained between power and signal cables wherever they are laid in parallel in the tray/duct/trench.

6. Crossing between signal cables and power cables shall be done perpendicularly.

7. Cables shall be terminated using cable glands. Cable glands and other openings in the junction boxes shall be properly sealed by means of sealing compound to make them thoroughly dust and moisture proof.

8. At junction box and sensor end, metallic (Aluminum) cable tags with cable no., J.B. no. and sensor tag no. shall be used. At control room end, metallic cable tag with cable no. and J.B. no. shall be used.

9. All cables shall be properly terminated using lugs, sleeves, ferrules, etc. for connection to terminal blocks.

10. All cores of electrical cables shall be identified by their wire numbers by means of the PVC ferrules following finalised philosophy. Ends of all PVC insulated

11. Unused cores shall be taped with PVC or rubber insulating tape. Use of cloth or other fabric type is not permitted.

12. Each underground cable (either in concrete trenches or buried) shall be provided with identifying tags made of Aluminium, securely fastened every 30m of its underground length with at least one tag at each end before the cable leaves/enters the ground.

13. Directly buried cables shall be laid underground in excavated cable trench wherever specified in layout drawings. Trenches shall have sufficient depth and width to accommodate all cables correctly spaced. Before cables are placed, the trench bottom shall be filled with 100mm layer of sand and leveled. Each layer of cables shall be covered with 100mm of sand on top and sand shall be lightly pressed. A protective covering of 75mm thick second-class red bricks shall be placed flat on the final layer of sand and cable. The remaining portion of the trench shall be then back filled with soil compacted and leveled. On completion of every group of cable laying, insulation test shall be carried out for every cables. Any cable found to be defective shall be replaced before the next group of cables is laid. Flags/ signboard shall be provided, indicating number of cables, depth and direction, along the cable route, on crossovers/turnings etc. to mark the cable route.
14. At each road crossings and other places, where cables enter pipe sleeves, adequate bed of sand shall be given so that the cables do not get damaged by pipe ends after pack filling. After laying, the pipe sleeves shall be sealed using sealing compounds. Wherever the cable is going into/ coming out of ground duct/ conduits shall be extended in the ground.

15. After laying of all the cables, the cable entry to control room shall be suitably filled and sealed so as to achieve a positive seal against the entry of gas/ water.

16. When laid inside conduits, following guidelines shall generally be followed for selecting the conduit dia:

<table>
<thead>
<tr>
<th>No. of cables</th>
<th>Conduit diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.7 D</td>
</tr>
<tr>
<td>2</td>
<td>3.0 D</td>
</tr>
<tr>
<td>3</td>
<td>3.2 D</td>
</tr>
<tr>
<td>4</td>
<td>3.6 D</td>
</tr>
<tr>
<td>5</td>
<td>4.0 D</td>
</tr>
<tr>
<td>7</td>
<td>5.6 D</td>
</tr>
</tbody>
</table>

D = Outer diameter of cable.

17. For cable sheaths and cores, internationally accepted colour coding shall be followed.

18. Cable trays shall be made up of hot dip galvanized steel plates of minimum thickness of 2 mm.

19. Separate cable trays shall be used for low and high voltage.

20. Each tray shall be provided with 20% spare space.

21. Cables shall be clamped at every 1.5 m distance in horizontal runs and at every 2 m distance in vertical runs, in trays.

22. Cables, which are not laid in the cable trays, shall be laid through protective conduits.

23. Sharp bends in cables shall be avoided. Wherever necessary, junction and pull boxes shall be used.

24. Conduits, junction boxes and pull boxes shall be properly grounded.

25. In hazardous locations, detachable steel plate covers on the tray shall protect the cable.

26. All the cores of the cables shall be marked with ferrules. Metal tags shall be provided at both the ends of the cable for identification.

27. Cables in hot areas shall have asbestos sheaths / covering or other heat protection. After completion of cable laying work, all cable bushings on panels, desks and cabinets shall be filled with sealing compound against the floor.

28. After erection, cables shall be tested for insulation. At least two cables in each sub unit shall be tested.

29. Cables will be identified by corrosion resistant tags.

30. Shield grounding shall be realised at one end of the cable only.
14. IMPULSE PIPE LAYING

Impulse lines shall be kept as short as possible consistent with good practice and accessibility and shall follow installation/hook up drawings.

All welding shall be carried out as per welding procedures and codes with electrodes approved by client. Only qualified welders shall carry out welding.

For installation of impulse tubes with compression fittings, proper care shall be taken for handling, bending of the tubes and tightening of the fittings. Standard instruction of the manufacturer shall be followed strictly for the above cases.

Pipes/tubes shall be bent using pipe/tube benders only. Hot bending of impulse pipes/tubes is prohibited. Impulse line bending shall be circular and smooth. Flat bending shall be rejected. Pipes/tubes shall be cut using pipe cutting device. Hot cutting will not be allowed.

All threaded joints shall be joined with Teflon tape and no other joining component shall be used except on high temperature service, where graphite sealing components shall be used. Pipe threading shall be made using suitable threading machine.

Impulse lines shall be properly supported and shall be clamped with the support. Impulse lines shall never be welded with the support, metal constructions and structure of building. Supports shall not generally be taken from process pipes, handrails etc. unless otherwise required.

Proper slope in impulse line (minimum 1:10) shall be maintained.

Impulse lines for explosive gases and air/inert gases shall not be laid together.

Impulse lines shall not be brought inside the control room.

Drainage pipes shall be connected to the plant drainage.

Impulse pipe sizes, type of fittings, flanges and number of pipes in multi-tubular bundle shall be standardized before engineering and shall be mutually agreed to.

Protection shall be provided where damage is likely to occur.

At the lowest points of air or gas impulse lines provision for drainage is to be provided.

In pipelines for liquids vent is to be provided at the highest points.

Horizontally laid steel pipes may be fixed at every 1.5 m and vertically laid ones at every 2.0 m.

Impulse pipelines and instruments used for oxygen service are to be degreased and cleaned with carbon tetrachloride.

The impulse lines for oxygen shall be clearly marked with colour code.
15. EARTHING

1. All junction boxes, local cabinets, field mounted instruments (having 110 V AC & above power supply) shall be connected to the nearby earth bus bar through 6 mm² (min.) stranded copper conductor with green sleeve.

2. Earthing network shall be realized with earth electrodes and/or buried bare conductors.

3. Two types of earthing system shall be generally provided –
   I. Main earthing system (ME).
   II. Electronic earthing system (EE).
   III. The electronic earth system shall be separate and independent from main earthing system. Main earthing system will be arranged by client.
   IV. The earth electrode(s) for EE shall be of the same type as those for the ME, but, in addition shall be placed in a galvanized steel pipe for a depth of minimum 4m to shield the electrode from surface earth stray currents, which may cause unwanted interference.

4. In general, the earth conductor between EE busbar of cabinets/ marshalling rack up to the earth pit shall be 16 mm2 insulated copper conductor.

5. The following shall be applicable for earthing:
   ♦ The metallic housing of electronic equipment/junction box /panel shall be connected to the main earthing system.
   ♦ The active electronic parts of electronic equipment shall be connected to the electronic earth (EE).
   ♦ The shield of the shielded cable shall be earthed to electronic earth at one end only i.e. at control room end.

6. For shielded compensating cable the shield shall be earthed near the point of the circuit ground. For grounded junction thermocouples, this means at the thermocouple head. For ungrounded junction thermocouples this means at the control room end.

16. GUIDELINES FOR SELECTION OF ERECTION MATERIALS:

01. Instrument Fittings:

   Carbon steel Fittings
   1. Fittings shall be as per ANSI B16.11.
   2. Fittings shall be socket-weld type forged pipe fittings of material cadmium plated ASTM A105. The minimum rating shall be class 3000.

   SS tube Compression Fittings
   1. Fittings shall be as per ISA RP 42.1.
   2. Fittings shall be flare less compression type and of three piece construction with ferrule, nut and body suitable for use on SS tube conforming to ASTM A269 TP316, hardness not exceeding RB 80.
   3. Hardness of ferrules shall be in the range of RB 85-90 so as to ensure minimum hardness difference of 5 to 10 between tube & fittings for better sealing.
   4. Threaded ends of fittings shall be NPT as per ANSI B1.20.1.
02 Instrument valves

1. The impulse line isolation and drain valves shall be forged gate/ ball/ globe valves with inside screwed bonnets. CS/ SS valve material shall be used depending on requirement and as indicated in the enclosed installation diagrams.
2. For SS valves, body and trim material shall be ASTM A182 Gr. F316. For CS valves body material shall be ASTM A105 Gr.II and trim material shall be ASTM A182 Gr. F316.
3. For screwed valves packing material shall be teflon only. However, for socket-weld valves packing material shall be grafoil only.
4. Valve hand-wheel material shall be cadmium or nickel plated steel.
5. Minimum valve rating shall be 800 class.

03 Impulse pipes & tubes

1. Impulse pipe shall be fully annealed, seamless and cold drawn 316SS tube as per ASTM A269 with compression fittings as per guidelines indicated in typical Installation drawings enclosed with this specification.
2. Tube wall thickness shall be 0.065” unless otherwise specified.

04 Cable trays and conduits

1. Perforated cable trays with sheet thickness of min. 2 mm shall be used for laying of cables.
2. The width of cable trays shall be so selected that 20% of tray space is available for future use of the complete installation.
3. Conduits used for cable laying shall be as per IS-1239 class medium & galvanized.

05 Transmitter cabinets/ enclosures/ canopies

1. Transmitter cabinets/ enclosures/ canopies shall be made of 2 mm thick MS sheet.
2. All cabinets shall be provided with external earthing lugs.
3. Sizes of cabinets/ enclosures/ canopies, as approved by purchaser / consultant, shall only be supplied and outside colour of panel shall be as per RAL 7032 and inside white.
4. Enclosure/ canopies shall be suitable to protect the instrument from direct exposure to sun, rain water & dust.
5. Cabinets shall be provided with lockable door-handles.
6. All equipment inside the cabinet shall be located in such a manner that their terminals and adjustments are readily accessible.
7. Cabinets shall be dust and vermin proof. Suitable gaskets shall be provided.
8. Pressurised local cabinets shall be installed in dusty areas. Pressurisation shall be achieved inside the cabinet by introducing clean (i.e., dust-free) air.
9. Cabinets shall be supplied in finish-painted, as per standard practice, completely wired and tested condition.
10. Cabinets shall have lifting hooks on the top at the four corners, for ease of transportation.
11. An inscription plate (with white letters on a black background) containing the tag no. & application shall be provided below each instrument.

06 Junction Boxes

1. Junction boxes shall be weather-proof. Enclosure degree of protection shall be minimum IP 65 as per IS 12063. Construction and testing shall conform to IS-2147.
2. Material shall be Die cast aluminum (LM-6 alloy).
3. Weather proof junction boxes shall have hinged type doors with door handle.
4. Terminal shall be spring loaded, vibration proof, clip-on type (Wago/Phoenix), mounted on nickel plated steel rails complete with end cover and clamps for each row. All terminals in JB shall be suitable for accepting minimum 4.0 mm² copper conductors.
5. Sizing shall be done with due consideration for accessibility and maintenance in accordance with the following guidelines.
   - 50 to 60 mm between terminals and sides of box parallel to terminals strip for up to 50 terminals and additional 25 mm for each additional 25 terminals.
   - 100 to 120 mm between terminals for up to 50 terminals and additional 25 mm for each additional 25 terminals.
   - Bottom/top of terminals shall not be less than 100 mm from bottom/top of the junction box.
6. All junction boxes shall be provided with external earthing lugs.
7. Junction boxes shall be provided with adequate supporting/fixing arrangement with nuts, bolts, washers, brackets etc., as required for installation on wall/structures.
8. All junction boxes shall be provided with 20% spare cable entries (minimum 1 no.) and terminals. All spare holes shall be covered with plugs.
9. For outdoor installation of JBs, cable glands and plugs shall be of SS 316/304 material and nickel plated brass material for indoor installations.
10. All junction boxes shall be provided with double compression glands and will be threaded to junction boxes.
11. JB shall have provision for keeping terminal detail’s of JB inside the junction box.

17. INSTALLATION OF INSTRUMENTS

1. For installation of instruments and primary sensors, standards practice of instrumentation according to the international standard shall be followed.
2. For installation of any kind of special type of instrument/ sensor manufacturer’s recommendation for installation shall be followed.
3. Plugging of extra holes in JBs, panels, cabinets, etc., plugging of extra holes for conduits, filling up the conduits & conduit opening with water proof sealing compound shall be done after completion of erection.

18. CALIBRATION

1. All instruments shall be calibrated as per manufacturer’s instructions prior to installation.
2. During the loop checking and commissioning, if required, to obtain the satisfactory performance of the instrument, the same shall be recalibrated as and when required.
3. All instruments shall be calibrated at 0%, 25%, 50%, 75% & 100% of the measured range for both increasing and decreasing values. Discrete instruments, switching devices shall be functionally checked for general performance and specially for assigned set points.
4. Hand-held calibrator shall also be used for calibration checks of transmitters.
5. All calibration reading shall be recorded in proper format and submitted.
19. TESTING & COMMISSIONING

01 Testing

1. All cables shall be tested for insulation with 1000V/ 500V megger before termination at panel & field. Insulation shall be checked from conductor to ground and between conductors in a cable. All conductors shall also be tested for continuity.

2. All impulse piping shall be tested hydrostatically/ pneumatically to 1.5 times the operating pressure after isolating the instruments. Lines shall be blown after hydro-testing.

3. Instrument air headers (N2) & air supply lines shall be cleaned and tested for leaks at a pressure 6-8 bar, before they are placed in service.

4. For all measurement & control circuits, loop testing shall be properly carried out. For overall integrated loop testing involving Automation System, Tenderer shall work in close co-ordination with the system supplier.

5. All results of site inspection, instrument site calibration, impulse pipe leak test, panel site test report and loop test results shall be recorded in the approved format. These results shall form part of the completion documents. Any work not conforming to the execution drawings, specifications or codes shall be rejected and the Tenderer shall carry out the rectification at his own cost.

6. Magnetic flow meters & Vortex flowmeters shall be tested by injecting frequency signal. Temperature transmitters shall be tested by simulating millivolt signals.

7. All the equipment required for erection shall be brought by Tenderer to site, on returnable basis.

8. All the required testing & calibration equipment shall be brought by Tenderer to site, on returnable basis, for testing & calibration work at site.

9. Quantity of all these items shall be as per actual requirement at site, to meet the erection schedule. All test & calibrating equipment shall be approved by NPL/IDEM/ ERTL authorities.

10. Loop test shall be performed after calibration of all instruments and leak test of instrument impulse lines. It shall be carried out to check the functional performance of all elements comprising the loop thereby ensuring proper connection of the following:

   I. All elements are properly installed, calibrated and function properly.

   II. All scales are introduced with proper ranges in DCS/PLC.

   III. All alarm units and shut down devices are set properly and accomplish their intended purpose.

   IV. Controller settings for various modes of operation in DCS/PLC (proportional band, reset and rate action) are at nominal values.

   V. The action (direct or reverse) of the controller is set as prescribed.

   VI. DP transmitter with DCS/PLC in the control room shall be loop tested by applying impulse signal to the transmitter by means of a squeeze bulb and a U-tube manometer at the field and performance of the receiver instruments/display in automation system in the control room shall be checked at 0%, 25%, 50%, 75% and 100% FS inputs in both ascending & descending modes..

   VII. Pressure transmitter with DCS/PLC in the control room shall be loop tested using a dead weight tester and a standard gauge with accuracy better than +
0.1% at field and performance of receiver/display in automation system in the control room shall be checked at 0%, 25%, 50%, 75% and 100% FS inputs in both ascending & descending modes.

VIII. For temperature loops with resistance thermometers in field and DCS/ PLC control room, known resistance shall be injected at signal cable near the resistance thermometer in the field through decide resistance box and DCS/PLC display shall be checked for input signals of 0%, 25%, 50%, 75% and 100% FS in both ascending & descending modes.

IX. For temperature loops with thermocouple in field and DCS/PLC display in control room, a known milli-volt signal shall be injected at the compensating cable end in the field from milli-volt simulator and DCS/PLC display shall be checked for input signals of 0%, 25%, 50%, 75% and 100% FS in both ascending & descending modes.

X. In case of control loops, the set point of PID controllers shall be adjusted manually from HMI for output of 0%, 25%, 50%, 75% and 100% FS and control valves shall be checked for rate strokes in both ascending & descending modes.

XI. Alarm system shall be checked by simulating abnormal conditions in the field mounted differential pressure switches by shorting the wires at terminals and the function of the alarm system.

02. Commissioning

1. This activity shall be planned in consultation with & as per the directives of Client/ Consultant.

2. Before commissioning, loop checking for all the measurement & control loops shall be completed and results shall be recorded in approved formats.

3. Initially, the instrumentation equipment & systems shall be checked & tested to establish their specified performance and to ensure readiness for integrated testing with the automation system and commissioning of the plant. All these results shall be properly documented for records.

4. Subsequently, when the plant units are to be commissioned, Tenderer shall actively participate in these activities by providing required manpower in general shift as well as in three shifts round the clock to ensure reliable & trouble-free performance of all the instrumentation equipment & systems supplied by him.

5. All the data/ performance of Instrumentation equipment/ system during commissioning & acceptance tests shall be properly documented & submitted.

20. QUALITY ASSURANCE PLANS (QAP):

Quality Assurance Plans shall be submitted by the vendor for each category of instrumentation & automation equipment, based on the sample QAPs included with this specification. The vendor’s QAPs shall include all tests / inspection procedures indicated in the sample QAPs, as minimum, which, after finalisation, shall form the basis of inspection procedures to be followed and complied with.

Inspection call shall be issued only after ensuring and confirming complete readiness of all the equipment/system in compliance with the finalized/approved drawings & documents. Inspection calls shall be accompanied with internal test, calibration certificates and material certificates, as applicable. If required, waiver of inspection can also be decided depending on type of instrument, completeness and correctness of
test and calibration activities as per the report submitted. Inspection can take place on either 100% of all the equipment or on a selective basis.

In addition, Vendor’s responsibility shall also include the following:

a) Issue of inspection call only after ensuring & confirming readiness of total/substantial amount of all the instrumentation & automation equipment at one location/manufacturer’s premises.

b) Minimum of 15 days prior intimation for each inspection.

c) Ensure participation of competent representative of vendor during the inspection.

d) Making available all the required drawings & documents, catalogues, relevant standards, norms, etc. as may be required for carrying out inspection activities successfully.

e) Arrange and provide facilities for test, calibration and performance of each equipment individually & also in integrated mode as per requirement.

f) Modify/repair/replace defective and damaged items/equipment, if found during inspection, to the satisfaction of the inspector.

g) Submission of results of tests, inspection reports etc. in required number of sets.
21.00 DCS BASED AUTOMATION SYSTEM

21.01 General

Adequate and appropriate automation systems shall be designed and engineered using state-of-art and field proven technology to facilitate monitoring, control and all other functions associated with operation of all the plant/shop units through user-friendly human-machine interfaces.

The Automation system shall be designed with geographical & functional distribution of hardware in a multi-level hierarchy, viz, Level-0, Level-1, level-2, level-3 etc, as applicable, to meet specific plant requirements for monitoring, control, process visualisation & optimisation of all the plants/shop units.

The instrumentation & automation system shall be structured in general, considering the following hierarchical levels:

Level-0: This level, also called field level, is functionally responsible for generation, transmission & conversion of signals for the process parameters compatible to the higher level equipment as well as signal based activation for the final control elements.

This level is realized based on the primary sensing elements, transmitters, switches, converters, microprocessor based intelligent systems and final control elements. The components of this level shall be grouped and distributed geographically around the plant as per main process equipment location.

Level-1: This level, also called supervisory level, is functionally responsible for supervision of the individual process equipment & functions, monitoring, control, visualisation and regulation of process parameters to the desired level based on the signals generated from the field level. This level is also responsible for processing of signals for generating compatible control commands to control the process parameters by activation of the final control elements.

This level is realized based on the controllers & systems, input & output systems, data base units, data communication, visualization system (HMI stations) and interface units for connectivity to the other levels of the instrumentation & automation system. In addition to routine PID functions, advanced process optimization functions comprising special control algorithms, mathematical computations etc. will be able to permit distribution of control and data acquisition functions throughout the entire plant.

Level-2: This level is functionally responsible for the process control functions through the Level-1 automation system by process guidance & optimization and control of process parameters to the desired level of perfection based on the available signals from the supervisory level. This level is also called process control level and is responsible for generating set points / control commands to the Level-1 equipment based on the pre-loaded process specific mathematical models. This level is realized based on the process computer & its own data base units, input & output systems, data communication systems, visualization system (HMI stations) and interface units for connectivity to the other levels of the instrumentation & automation system. Level-2 automation system has been covered under a separate General Specification.

The Level-1 automation shall basically comprise:

- Either a Distributed Control System (DCS) based automation system
- Or, a Programmable Logic Controller (PLC) based automation system
- Or, a combination of both, depending on project / application specific demands & requirements.
Basic design & selection criteria for Distributed Control System (DCS) based automation system have been indicated in this section of the General Specification, which read together with the main Technical Specification, shall cover the total requirements of DCS based automation system of the plant/shop units. In case of any conflict/discrepancy arising in these documents, the requirements indicated in the main Technical Specification shall prevail. DCS based automation system can also be designed using Foundation Field bus/ Profibus PA compatible field instrumentation equipment & Field bus interface modules in DCS, depending on plant specific applications.

The General Specification of Programmable Logic Controller based automation system has been separately covered under Electrical part the GS and shall be referred to wherever PLC based automation systems are to be used for any application. Where both the DCS and PLC based automation systems are required to be used in plants, these shall be interfaced on a common network under Level-1 for smooth and integrated operation of the plant.

21.02. **Salient Features**

This specification of Distributed Control System defines the minimum requirement of the system for smooth, reliable, safe, efficient & trouble-free operation with optimum monitoring and control of process plant and equipment.

1. The DCS shall be of proven technology, microprocessor based, built around minimum 32 bit processors with its control and monitoring functions distributed geographically & functionally and designed for fault avoidance by proper selection of components.

2. The system shall be based on the latest state-of-the-art technology and must be successfully operating in Industries for the last few years. It shall have high availability, high reliability & high maintainability.

3. The system shall be modular in nature and shall have facilities for easy expandability & upgradation of modules to enhance its functionality or performance, if required, in future.

4. The system shall be versatile, rugged and suitable for continuous duty in normal industrial environment.

5. The DCS shall be suitable to meet the specific process requirement including monitoring, control, interlocking & sequential operation of the process and shall also be designed accordingly. Application software of the DCS shall be developed by the system manufacturer/ supplier based on the functional requirements of the process.

6. The system shall comprise of a standard library of control, logic and computational functions that are preprogrammed and stored in memory. During the system configuration, user shall be able to select the appropriate functional blocks from the library, link them together, set the various inputs and tune parameters associated with each block. In case the process demands, the system shall also include fuzzy logic functional blocks in the library.

7. In addition to the required measurement and control of process parameters, DCS shall have provision for sequential logic functions, safety interlock logic function, real time monitoring & display of process operating conditions alongwith alarm & event recording functions.

8. The system shall be OPC compliant and based on the concept of open system architecture to enable easy integration with Level-2 automation system, Management Information System (MIS) and other systems for plantwide automation. The DCS shall also allow use of third party software (e.g. operation interface, optimization software or expert system) to make it an integral part of the overall automation system of the plant, if required. Communication with other systems/devices shall be via industry standard
protocols. System architecture & programming shall generally comply with IEC 61131.3 standard.

9. In case Level-2 automation system is envisaged for the plant, the DCS shall efficiently communicate with Level-2 automation system and proper interface modules shall be provided accordingly. The DCS shall be able to change its control algorithms and set points based on the process demands generated by the Level-2 automation system and control the process to have better co-ordinated operation of the complete plant.

10. The DCS shall be configured with independent work stations.

11. It shall be possible to remotely access the automation system using any standard off-the-shelf web browser such as Netscape’s Navigator or Microsoft’s Internet Explorer. All hardware and software needed to allow users to view process graphics and displays, events, and historic as well as real-time trends shall be listed. All information viewed remotely shall update in real time. All web browser access shall be secure. It shall be for viewing purposes only. It shall be possible to configure different security access privileges for each user.

12. In addition to the normal features to monitor & control the process, the DCS shall also have following software features as minimum:
   • Multi-tasking
   • Operation on Windows NT platform
   • Object linking and embedding (OLE)
   • OLE for process control (OPC)
   • Open Data Base System (ODBS)
   • 3D Graphics

13. For various signal inputs interfaced with the system, the DCS shall be capable of preventing noise errors due to EMI or RFI including disturbance signals from near by radio stations, walkie-talkie, Electrical storms, solenoids & relays or contactors carrying heavy current. Equipment shall meet all electromagnetic compatibility requirements of the IEC 61000-4-2, 61000-4-3, and 61000-4-4 standards. The system shall also be internally protected against system error & hardware damage resulting from electrical transients for both power & signal wiring, connecting/ disconnecting devices or removing or inserting PCB on DCS.

14. A single failure anywhere in the system shall not result in the loss of regulatory control to more control loops than those associated with a single process input/output card. Failure of any single device shall not affect the ability of the system to communicate with other devices in the system. Switchover shall not disrupt any system functions. Redundant equipment and software shall be continuously monitored for errors. All modules shall be diagnosed on-line. Errors shall be alarmed with an error message identifying the failed module.

15. The system shall work satisfactorily in hot & dusty atmosphere of steel plant, without any type of failure. It shall have the operating limit as per the following:
   • Operating Temperature: 0-45 degree C.
   • Storage Temperature: 20-60 degree C.
   • Relative Humidity: maximum 95% not occurring simultaneously with maximum temperature.

21.03. **Basic Structure**

The DCS shall comprise of Process I/O units, multiplexers, A/D converters, Communication electronics, hot (dual) redundant CPUs & its memory units, hot (dual) redundant Power supply modules for both controller & I/O racks, hot (dual) redundant I/O bus system with corresponding interface units for both controller & I/O racks, hot (dual) redundant main Data
Highway with corresponding interface units, Operator’s consoles with peripherals, hot (dual) redundant Network communication modules for Level-2 automation system (if applicable), marshalling/ field termination racks, desks, panels, etc. as may be required for completeness of the system to meet operational & functional requirements of the plant.

The above equipment/ items based on their specific functions shall be divided into modular subsystems classified as – Data Acquisition subsystem; Controller subsystem; Communication subsystem; Operator’s interface subsystem consisting of Engineering & Operator’s workstations.

21.03.01 Data Acquisition Sub-system

i. This subsystem basically comprises input / output (I/O) units alongwith other accessories. It provides the main interface between process/ instrumentation system and the control room automation system.

ii. Data acquisition subsystem shall interface all analogue and discrete inputs from various equipment/ instruments envisaged for this plant and shall also provide the final output to respective equipment/ instrument. The inputs shall include 4-20 mA DC, 1-5 V DC, all types of thermocouples (T/C calibration standard shall be DIN 43710/ ANSI-MC96.1/ IS 2054/ IEC60584, etc.), 2-wire/ 3-wire/ 4-wire RTD, pulse and discrete (digital) contact, etc., as may be required for this project. The outputs shall include 4-20 mA DC, 1-5 V DC, pulse and discrete (digital) contact, etc., as may be required for this project. Control valve actual position (in 4-20 mA) shall also be interfaced & displayed in the system for the respective control loop.

iii. I/O racks with necessary slots with complete wiring shall be provided for installing the analog and digital input/output cards and other modules & interface units. All the cards shall be modular & plug-in type. It shall have suitable mounting base for easy installation and online replacement without switching of the power supply or affecting other cards in the I/O rack.

iv. The field cables shall not be brought directly to the I/O cards. The same shall be routed through the field termination/ marshalling racks and will be part of DCS. All wiring inside racks / cabinets / back of the panels shall be housed in covered nonflammable plastic raceways arranged to permit easy accessibility to various equipment. The cable ducts inside DCS cabinets shall be of fire retardant type as per UL 94 VO.

v. The system shall be capable of checking signal validity, broken sensor check, input processing, linearisation & compensation for T/C inputs, linearisation of RTD inputs, square root extraction for flow inputs, temperature and pressure compensation & totalisation of flow inputs alongwith other mathematical functions as may be required for this project.

vi. 20% spare I/Os over and above the total requirement for respective type of inputs/ outputs shall be provided. Number of I/O cards shall be supplied & installed in the I/O racks accordingly. These installed spares shall be wired upto the terminal block.

vii. 4-20 mA DC analogue signal shall be with load driving capability of minimum 600 ohms at 24 VDC. Digital signals will be generally potential free contact type with load driving voltage derived from the in-built power supply of the DCS.

viii. Suitable redundancy shall be provided for data acquisition subsystem including processor. This redundancy shall be in such a way that the failure of processor, single hardware like I/O module, communication interface & cable, power supply, etc. in data acquisition subsystem shall not affect more than the analogue & digital inputs/ outputs connected to a particular I/O module. The redundant component shall take over in case of main component failure automatically. This shall exclude redundancy of I/O modules.
ix. The I/O units shall have suitable galvanic isolation. It shall have insulation voltage level of 1.5 kV between each terminal to ground, between input & output terminals, between power & ground, as applicable.

x. Individual fuse for each unit shall be provided for protection against fault.

xi. LED Status indication shall be provided for respective card/ channels.

xii. The I/O cards shall have protection against polarity reversal of signals.

xiii. Both analogue & digital output cards shall have configurable fail safe options such as, drive to zero or maintain last output value. These fail-safe actions, if configured, shall come into picture incase of processor halt or communication break between the controller and I/O module.

xiv. All digital I/O circuits shall be properly designed to ensure that accidental normal mode connection of upto 300 V AC/DC for an unlimited period of time shall not cause damage other than to the I/O module to which it is connected.

xv. For analogue input & output card, the best available accuracy in the manufacturing range shall be provided.

xvi. Analogue input cards shall be differential type and shall be of 8 or 16 channels. Analogue output cards shall be of generally 8 or 16 channels. Analogue input & output cards shall have necessary A/D / D/A converters having 12/14 bit resolution.

xvii. All the analogue I/Os shall be differential type with channel to channel isolation & isolation with power supply.

xviii. Digital input/ output cards shall be of 16 or 32 channels.

xix. Analog input modules shall be able to power 24 VDC power supply to 4-20 mA field instrumentation loops with a loop resistance of 600 ohms. Vendor shall properly clarify whether in case, each channel of input card is unable to provide the required 24 VDC power supply, separate dual redundant diode ‘OR’ed bulk power supply units shall be provided.

xx. The analog input card shall be intelligent type capable of carrying out functions like signal conditioning, conversion and limit checking. It shall also detect open and short wire condition. For connectivity of smart transmitters, corresponding terminal strip of the marshalling rack shall be provided with suitable resistance. Connection shall be such that on-line configuration (through handheld calibrator) of transmitters are possible from the marshalling cabinet itself without disconnecting any cable.

xxi. The digital input cards shall be capable of supporting both on/off and latched discrete input applications. Digital signal shall be sensed using 24 VDC power supply. This power supply shall be either generated internally in the card itself or by using separate bulk power supply units.

xxii. Digital input/ output card shall have suitable ON-delay & OFF-delay, for proper sensing and further operation.

xxiii. Digital output can be either discrete (ON/OFF) or single pulse. Duration of the single pulse output shall be configurable from the engineering workstation. All outputs shall be through separate 24 VDC relay with contact rating of 5 A, 240 VAC. Separate relay boards with mounting base shall be used for the mounting of the relays. Relay powering shall be arranged through separate bulk power supply units.
xxiv. For all the close loop controls, actuation of the electrical actuator of control valve shall be carried out through either by 4-20 mA DC outputs & separate hardware positioner or digital/pulse outputs, depending on system design. For digital/pulse outputs, the outputs through relays shall be interfaced with auxiliary contactor of MCC connected to power circuit of electrical actuators for phase reversal required for forward-reverse movement. For pneumatic actuator, 4-20 mA DC outputs shall be used. PID blocks/ algorithms shall be suitable to take care of such applications.

xxv. For internal wiring of all inputs/outputs up to marshalling terminals, flexible copper cables of minimum 0.5sq.mm size shall be used. No field inputs shall be terminated in terminals of I/O cards directly. Screened cables shall be used for milli-ampere/ milli-volt signals from I/O rack to terminal block.

xxvi. Compensating cables shall be used for thermocouple signals from I/O rack to terminal block compatible for compensating cable, if thermocouple signals are to be directly interfaced with input card. Separate cold junction temperature sensor shall be provided for each thermocouple input module.

xxvii. Fused Terminal Blocks with LED indication shall be provided for all input & output analog & digital signals, except for RTD & T/C inputs. The terminals shall be screw-less, clamp-on, single tier type and shall be suitable for termination of minimum 2.5mm2 copper cables from field.

xxviii. For different type of inputs /outputs, different coloured wires and terminal blocks shall be provided. All internal wires shall be neatly dressed, bundled together and routed in PVC channels / cable alleys with removable covers. The terminals for connection of external cables shall be located in marshalling panels. The size of marshalling panels shall be decided during detail engineering considering number of field cables to be terminated.

21.03.02. Controller Sub-system

i. The controller subsystem shall be built around 32-bit processor, easily configurable/programmable using user friendly software. The central processor shall be modular & plug-in type and shall have independent processor rack.

ii. Controller subsystem shall be provided as configured in dual redundant hot standby mode with smooth change over from working to standby unit without affecting the system and process.

iii. Hot standby processor shall regularly update the I/O information and shall also execute the program. However, the main/master processor shall only provide the final output.

iv. It shall carry out open loop process monitoring, closed loop control, sequential and logical operations including alarms & interlocking function alongwith other functions as may be required for operation of the process & control system.

v. The controller shall have advanced control algorithms to implement regulatory and advanced control strategies. These shall include PID adaptive, feedforward, cascade control, dead time, lead lag, high-high, high, low, low-low signal selection, realtime computational capability. The controller shall also have auto-tuning facility. Necessary software & functional blocks shall be provided accordingly.

vi. The central processor system shall be capable of handling 30% additional (future expansion) I/Os, over and above the installed I/Os. Maximum processor loading shall be limited to 60% for the intended applications.

vii. It shall have response time of less than 200 ms, which includes times for on-line system self-tests, data acquisition & validation, processing, synchronisation, redundancy
management, network communication, application software & commanding for all the applications. This response time shall include response time of less than 100ms for close loop control operation. Response time shall not be affected with inclusion of future I/Os as per the requirement indicated in the specification.

viii. The system shall have response time of 1 second from the instant of commanding from operator station, to the actual execution of command at the output module during peak load.

ix. The system shall have response time of 1.5 seconds from the time a change takes place at the input module, to the time it is displayed at the operator’s station.

x. The system shall have built-in simulation features to check the I/O channels individually, without activating technological elements.

xi. Each processor rack shall have hot redundant rack based power supply modules.

xii. The program memory shall be stored in EPROM/EEPROM or battery backed RAM. It shall be modular & plug-in type. It shall have 40% free space for future use. It shall be expandable in blocks. In case of rechargeable batteries, necessary charging circuit shall be provided. The system shall have provision for battery replacement without loss of data.

21.03.03. Communication Sub-system

i. For communication between controller and data acquisition system, hot redundant I/O bus shall be provided. It shall be capable for high speed data transfer.

ii. For interfacing of this redundant I/O bus, redundant communication interface modules shall be provided in each controller rack and in each I/O rack.

iii. Respective I/O rack shall act as a node to the I/O bus for interfacing with processor rack and shall not be interfaced through back plane extension between two or more I/O racks.

iv. Each controller rack shall communicate with operator workstations and other peripheral units through dual redundant Data Highway. The communication network shall be real time, switched Ethernet IEEE802.3 & IEEE802.3v compliant TCP/ IP type with modbus protocol and bus speed of 10/ 100 MBPS.

v. If more than one DCS based automation system have envisaged for the plant, then the above Data Highway shall be common for both the DCS for interfacing with the work stations and information exchange.

vi. Both the buses of redundant I/O bus and redundant Data Highway shall be active at all times. Periodic health diagnostic of each bus and communication interface modules shall be carried out automatically at regular intervals without affecting system operation. In case of any failure, it shall automatically transfer to the redundant device without interrupting the system operation and without any operator’s intervention. It shall also be possible to change the communication from the main bus to the redundant bus manually without affecting the system operation.

vii. Failure or planned shutdown of any one device connected to communication network shall not affect the ability of the system to communicate with any other device on the network.

viii. The system shall also have proper interface modules for communication with Level-2 automation system, if envisaged for the plant. These interface modules shall be hot redundant type.
ix. For applications involving interfacing of DCS with Level-2 automation and other systems, details of hardware/software, as may be required for establishing communication and integrated performance shall be provided.

x. Suitable isolation shall be provided between the bus and various nodes interfaced with it.

xi. Various communication links including bus shall be suitably designed to take care of the total requirement of information exchange including future expansion requirements. The overall system performance including display update time shall be independent of the loading of the bus and the bus loading shall be decided accordingly.

21.03.04 Foundation Field bus system

i. The Field bus interface modules (FIM) of the DCS shall be chasis based modules. These modules shall completely integrate Field bus devices with the DCS controller & HMI software. These FIM modules shall deliver system wide integration of data access, control, connections, diagnostics and alarms with the DCS system. LED indication of power, error condition & status shall be provided in each FIM module.

ii. DCS shall provide graphical support to the Field Bus Interface module to perform the functions of Link Active bus scheduler for a network. This will allow the system configuration engineer to see what’s going on and shall provide complete flexibility to adjust schedules based upon the needs of the control scheme. DCS shall also support Back-up Link active scheduler.

iii. All Foundation Field bus (FF) devices shall be registered with the Field bus Foundation at level I/T 4.0 or higher. Field bus interface modules & Field Bus Library manager shall be compatible with I/T 4.0 or higher version compliant devices. Field bus usage license shall be provided. All FF devices provided shall be polarity insensitive. All FF cables shall be of Type A.

iv. The DCS shall be certified for the Field bus Host Inter operability Support Testing (HIST) from Field bus organisation. HIST procedures provide a common methodology for assessing host inter-operability with registered devices.

v. DCS Software shall have the capability either to directly read Device description (DD), files from the Field bus devices or add these DDs/ Files to the library for Off-line & On-line configuration, or it shall perform this task through a separate software tool, Field bus library manager. It shall be possible for DCS based automation system to upload field device configuration changes implemented in the field. Once the configuration information is stored in the automation system, it shall be possible to download it to any other similar device, whether a new or replacement device.

vi. In case of a new device added to a Field bus segment, its presence shall be immediately shown in that segment. Important information about the new device including tag name, address, model and revision shall be immediately available.

vii. Downloading new software to Field bus devices shall be possible from the DCS. There shall be no need to physically change the firmware and to disconnect or remove devices for updating to the latest available revision. It shall be possible to simultaneously download the latest firmware to multiple field devices.

viii. Each Field bus interface module shall support minimum two segments. Each segments shall have the following features:

- Each segment shall be limited to twelve (12) devices with monitor only measurements if the loop execution rate is one (1) second.
Each segment shall be limited to twelve (12) devices including four (4) control valves if the loop execution time requirement is one (1) second.

Each segment shall be limited to six (6) devices including two (2) control valves if the loop execution time requirement is Five hundred (500) milli seconds.

Each segment shall be limited to three (3) devices including one (1) control valve, if the loop execution time requirement is two hundred fifty (250) milli seconds. Accordingly, number of Field Bus interface modules shall be decided. Maximum number of FIM module handling capacity of the DCS shall be indicated.

ix. The Network shall generally carry 50 messages per second and as such, shall be limited to only one (1) segment considering the scan rate required for the different process variables, measured by the Field bus devices, connected to the same network. Thus the use of repeaters (repeaters relay messages between segments & a repeater also counts as one device) shall normally be avoided.

x. The power for each Field bus segment shall be provided through a power conditioner to prevent the communication signal from being attenuated by the power supply & to eliminate cross talk between FF segments through a common power supply.

xi. Each device on a segment must receive at least 9 V DC. Voltage drop calculation shall be submitted for each segment of all the networks during detail engineering. Power supply on each segment shall be designed taking into account the power drawn by different devices connected in that segment. However, from modularity & spare inventory point of view, the power supply module of all the Non-I.S. of segments shall be designed considering the power requirement of that segment which requires maximum power + 30 % extra power for future provision.

xii. The Field bus segment shall be implemented either following Tree on Branch Topology or any combination of the two. The Tree topology consists of a trunk line (main segment) with multiple spurs coming off the trunk line at one point. The Branch topology consists of a trunk line with multiple spurs coming off the trunk line at multiple points.

xiii. A Branch topology shall be used to connect individual devices to the Field bus segment. Conduits, junction boxes and pull box assemblies shall be used to implement this topology. Wherever possible, quick disconnect junction boxes & quick disconnect ‘T’ devices shall be used to reduce wiring errors & simplify maintenance in the field. A daisy-chain topology shall not be used as disconnecting a single device may result in the loss of downstream devices.

xiv. All field bus devices on the field bus segment shall be able to communicate at 31.25 Kbits/sec. It should support peer-to-peer communication.

xv. The field bus device shall use device description technology in addition to having standard field bus function block as specified by the Field bus Foundation. The field bus device shall be able to perform continuous self-diagnostic to check its own health.

xvi. All the transmitters (based on FF) shall have the capability to become a device link master which means it can function as a Link active scheduler if both the Field bus interface module fails.

xvii. All field bus devices that require bus power shall be capable of utilizing voltage supply levels of any level between 9.0 and 32.0 V DC. Field bus devices that do not require bus power shall be capable of operating on the field bus without affecting the existing supply voltage on the segment. No device shall be used that requires more than 28 mA from the bus power supply.

xviii. Installation of all instrumentation devices in hazardous areas shall be made using intrinsically safe systems. A Field bus segment in a hazardous area may consist only of
the type and number of devices which will not cause the segment current draw to exceed the rating of the I.S. barrier. Area classification includes both class I Div 1 and class 1, Div 2 hazardous areas.

xix. The Terminators shall be impedance matching modules to be used at or near each end of a segment. There shall be two terminators per segment. The terminators prevent distortion and signal loss and shall be supplied as a pre-assembled, sealed module. Terminators shall be provided as per the requirement.

xx. For Field bus use, a power supply impedance matching network shall be provided. This shall be a resistive/inductive network and built into the Field bus power supply module.

xxi. Connectors as coupling devices shall be employed to connect the wire medium to a field bus device or to another section of wire. Standard field bus connectors shall be used. Specification shall be as per annexure A of the ISA physical layer standard and annexure A of the IEC physical layer standard.

xxii. Couplers shall be the physical interface between segment and spur or segment and Field bus device. Field bus couplers shall be as specified in the IEC/ISA physical layer standard and provide one or several points of connection to a field bus segment.

xxiii. Field bus Network/segment naming convention
The following recommended network/segment naming convention shall be followed:
   # NN MM P
   • #: Indicates the plant/area number to which the segment shall be connected.
   • NN: Indicates the node number/controller name.
   • MM: Indicates model number/card number.
   • P: Indicates segment or port number.

Loop & Instrument Naming convention
• Loop & Instrument naming convention shall be decided during detail engineering.

Spur Naming convention
• All spurs shall be labeled with Instrument tag name.

xxiv. Grounding: The instrument signal conductors shall not be used as a ground. Instrument safety ground shall be made through a separate conductor outside of the signal cable. The conductor may be in the same cable as the instrument signal conductors and shield, but shall be located outside the shield within this cable. Field bus devices shall not connect either conductor of the twisted pair to ground at any point in the network. The Field bus signals are applied & preserved differentially throughout the network. Network cable shield shall be earthed/grounded in one location only, at the field termination assembly (Host) end. At any field instrument, cable shield shall not be connected to the instrument earth/ground or chassis. The cable shields from different networks shall not be attached together in a field junction box. This will create ground loop & noise onto the network.

21.03.05. **Operator Interface Subsystem**

i. Operator interface subsystem shall provide centralised operation, control and information of the plant as well as engineering of the automation system.

ii. These workstations shall be used for operator interface, engineering, data logging, trending, alarm & graphic generation and Management information system.

iii. Irrespective of independent workstations, in the event of failure of any one station, the other stations shall be able to monitor and operate the complete plant.
iv. The system shall have global database available at each workstation. It shall be possible to change control assignments to allow control of any plant area from any operator workstation by using the appropriate access password.

v. The Operator workstations shall be provided with various menus, command buttons, facilities for selection of mode of operation, selection of working/standby, start/stop & facilities for control & monitoring of complete plant equipment.

vi. All displays & operation of the operator’s workstations shall be interchangeable. Under normal operating condition, each workstation shall be able to assign a specific task. However, in case of failure of one workstation, all the tasks assigned to that shall be possible to be done through any other workstation interfaced with the same bus.

vii. Any change made in the database of one workstation shall automatically update the database of other workstations of the same network system.

viii. All real time clocks in the system shall be synchronized with each other at regular intervals.

ix. The operator, as a minimum, shall have access to the following through the keyboard of operator workstations whenever required:
   - Selections of all the displays including the direct selection of loop in alarm, page turning facility for overview, group display, loop display selection etc.
   - Selection of loop for operation.
   - To acknowledge alarms as and when they are annunciated on the workstation.
   - Facility for easy selection of any parameter.
   - Facility to enter any changed parameter like set point, manipulated variable, digital commands and to cancel any wrong entry while making such change.
   - Auto/Manual/Cascade/ Computer mode changes for each control loop.
   - Selection of print outs for graphic page, log sheets, alarm history and assignable trend recorder points.

x. Operator workstations with its graphic interface shall have the following minimum features & display facilities with user friendly navigation keys:
   - Overview display of the plant & process.
   - Group display.
   - Loop display including control loop with facility for modification of its parameters.
   - Graphic display including 3D Mimic.
   - Alarm overview display.
   - Individual alarm page display.
   - Real time trend display.
   - Historical trend display.
   - Periodic Event & Alarm logging, report generation and printing.
   - System fault & error detection, broken sensor detection and their reporting.
   - Configuration display.

xi. Engineering workstation shall have the following minimum facilities for restricted user/engineer through keylock:
   - Data base configuration, including over view, group, loop, multi loop & multivariable control configuration.
   - Group or multi group alarm inhibits from a plant under maintenance.
   - Configuration of alarm settings and their values, addition & deletion of components in a loop.
   - Tuning of control loop including change of P, I & D parameters, dead time etc.
   - On line compilation of graphic displays using standard symbols. Graphic symbol library shall be developed & provided as per ISA-5.1 & 5.3. Additionally, standard industrial symbols shall also be provided. User defined symbols shall also be generated & used.
   - Report generation and modification
- System access configuration
- File access
- Diagnostics
- Workstation/monitors and keyboard plant area assignments.
- Utility program access.
- Setting of parameters to be logged and its addition/deletion.
- Setting of real time clock.
- Assigning parameters for historical trending.
- Access of detailed self-diagnostic for maintenance.
- A configuration tool shall be provided to generate or modify database and configuration data. The configuration tool shall employ fill-in-the-blanks or graphical block connecting format. It shall have step-by-step prompts to guide sequential actions followed by validation responses on completion of the actions. It shall request only applicable information based on previous responses.
- A common configuration tool shall be used for traditional and Field bus based control. It shall allow for selecting the location of control in the system controller or in the field device. Configuration of the control module shall be the same regardless of where the control is located.
- Configuration displays shall be provided to aid in system configuration. All displays and tags will reside in one global database shared by the entire system. No data mapping between systems shall be allowed. It shall be possible to show:
  - All tags in the system.
  - All parameters for each tag, including (as applicable) tag ID, tag descriptor, the hardware address, tuning constants, mnemonics associated with the tag, algorithm relating to the tag, and input/output details.
  - All configurable (or soft) keys and their function.
  - All hardware modules in the system and the configuration parameters for each.

d. For the engineering workstation, access shall be restricted to some select users with user identification & password. All programming shall be suitably protected from unwanted interference.

dii. When configuration data are downloaded to the automation system, invalid configuration entries shall be identified and the parameters affected shall be indicated.

div. Saving of all database and configuration data on both removable and non-removable media for back up purposes shall be possible without taking the system off-line.

dv. Redundant on-line storage media for configuration database.

dvi. After completion of configuration & programming, any change made therein shall be properly logged with user identification and time. This shall also be identified with proper revision number.

dvii. Changes made for any parameter in a particular display page shall be automatically updated on all displays configured for that input.

dviii. Engineering station shall be capable of ON line & OFF line programme development with necessary hardware interface and software. Facility shall be available for loading of programme developed on EPROM and CD/ floppy.

dix. Faults with description, date & time of occurrence shall be displayed on the Operator workstation with sound and shall flash with acknowledging facility. Once the fault is acknowledged, the flashing shall become steady. The fault shall remain on VDU screen till it is rectified.
xx. Shift-wise, daily, weekly, monthly, yearly logging of faults, events for various process & mechanisms and reports/data etc. shall be provided. Format for logging of reports/data shall be discussed with operation department, which shall be modified, if required, at site during testing and commissioning. Printing facility for the same shall also be provided.

xxi. Display of dynamic graphic of different section of plant on the VDU shall be provided. Graphic displays shall be field configurable. Different plant section’s dynamics shall be displayed on different pages. Graphic display shall be interactive type through which it shall be possible to control the process. It shall also be possible to send various start/stop & open/close commands and shutdown command etc., from graphics or loop display.

xxii. Moving from any graphic page to other related graphic page or any group view or alarm summary shall be achieved in single key stroke using soft key functions.

xxiii. The dynamic components (both binary state & analogue value) display the actual state of the plant section. Analogue values shall be represented as bar charts and/or numerical.

xxiv. Critical plant status shall be highlighted by different colours or by blinking. Description in clear text shall be provided to simplify Operator understanding.

xxv. All the display screens shall be finalised designed taking care of plant & process requirement during detailed engineering and also commissioning.

xxvi. Double clicking on any of the control valves in any of the menu/submenu pages shall invoke the corresponding PID loop display screen with controller facia displaying status and parameters (both in bar graph & digital) of each variable and real time trend for all variables of the loop. The remote manual functions and change of set points under auto mode shall be possible to be performed from these facias.

xxvii. In case of Cascade/Ratio control, the page shall show facia of all the controllers with the facility of maximising view of one of them, when selected. PID parameters can be changed only after validation of software password.

xxviii. Software lamps & push buttons as per the requirement shall be provided in respective graphic pages.

xxix. In any menu/sub menu page, double clicking on any tag shall invoke the trend menu of that particular tag. Based on the selection by the Operator either Historical or Real Time Trend menu shall be displayed. Provision shall be there so that Operator can include additional trends by entering the tag nos., in the same page, using the same time base for comparison purpose.

xxx. It shall be possible to configure any analog point for trending and also to trend at least six different analog points simultaneously on one real time & historical trend display. Real time trending for digital signal shall also be possible. Each trend display shall consist of the plotted trend graph(s) and a table showing trend parameters. When an analog point is not available (point off scale, out of range etc.) an unavailable code shall be entered in the history.

xxx. The automation system shall support historical process information recording & retrieval. This historical information shall be available for use in logs, trends, etc., requested at any workstation.

xxxii. The recorded process information shall include – measured value; alarm status; set point or desired value; control mode.

xxxiii. For both logging & historical trending the operator shall be able to specify the points to be recorded, the frequency with which the data is to be collected and the time base.
xxxiv. Historical data shall support the protocols like – OPC (Open Process Control); OLE (Object Linking & Embedding); ODBC (Open Data Base Connectivity) & API (Application Programming Interface).

xxxv. Zoom in/out and moving forwards and backwards in time shall be possible with no more than two operator actions. A mechanism for selecting a location on the trend, such as a hairline cursor and reading the digital values of the trends at that point in time shall be provided.

xxxvi. Scan time for trending of any tag shall be adjustable & user selectable. Display of trend shall have:

(a) Operator scalable X-axis from 60 seconds to 24 hours. For 24 hours history, trend shall be stored as 10 seconds scan for each variable.
(b) Operator scalable X-axis from 8 hours to one month. For one month history, trend shall be stored as 2 minutes average value for each variable.

xxxvii. Each event history file entry shall contain the time and date of occurrence, the tag ID, the tag description and Value/ State and the type of event.

xxxviii. All discrete process events like inputs changing state, analog inputs going into or out of alarm, equipment changing state (running/stopped, open/ closed), etc. shall be stored in history files.

xxxix. All operator actions, which affect the process, such as opening/ closing isolation valves, starting/stopping of pumps and motors, changes to set points, changing control blocks between automatic & manual, etc. shall be stored in history files.

xl. Irrespective of Operator activity and choice of display, an alarm situation shall always have priority and shall be brought to the attention of the Operator, quickly and automatically.

xli. Display containing alarms shall be selected by a single keystroke action. Alarms should automatically update in the event of an alarm operating i.e. it should not require operator intervention to update alarms either on process mimics or alarm summary format.

xlii. Alarm messages shall be time tagged to within 100 milliseconds (from detection at input card or receipt from data link) or less and are required to be displayed within 1.5 seconds from the time it has been sensed in the input module. Alarms shall be displayed in order of occurrence, and/or priority.

xliii. In order to facilitate easy recognition of alarm status by operators, annunciator colours and audio tones shall be easily distinguishable. All alarms and trips shall be annunciated by a screen message and an audible alarm. The alarms and trips shall flash in a highlighted form (e.g. reverse video) until acknowledged. When acknowledged from any CRT, the flashing and audible tone shall stop on all CRTs. When an alarm returns to normal, flashing shall return to normal on all CRTs provided the alarm has been acknowledged. Different display colours shall be used for various types of alarms.

xliv. All process variables and composed points shall have the possibility of being assigned at least two levels of high and two levels of low alarm values. All control loops shall have the possibility of being assigned high and low deviation alarm values. All alarms shall have a user-definable dead band. In addition to the above, an alarm shall be provided when analogue signals are less than 3.8 mA or greater than 20.2 mA. Rate of change alarms and set point deviation alarms shall be provided. All discrete inputs shall have the possibility of being assigned a change of state alarm.

xlv. It shall be possible to inhibit alarms by point of priority when the initiating device is faulty or being maintained. While inhibited, the point must still be scanned and archived. The removal of the inhibit shall be logged. A summary display containing all inhibited points shall be provided on demand. Alarm inhibition shall be permitted from any of the work stations by
authorized user only. Facilities shall be provided to mask out alarms from equipment which are not operational. These alarms shall be automatically or manually via keyboard, reinstated when the equipment is put back into service. Initiation and removal of inhibition shall be logged as an event and printed.

xlvi. Alarm displays shall take the form of a summary display of all points in alarm, and/or integrate the alarm message with associated item, group or overview data. Alarms shall be listed in order of occurrence, and for specific alarm displays the most recent alarm shall be shown at the top of the display. All alarms shall be identified by tag, description and the date and time of the occurrence, in hours, minutes and seconds. A banner type display showing a summary of alarms shall always be present at the top of the screen irrespective of main display.

xlvii. Alarms from an area shall be capable of being grouped in one or more Alarm Groups. A minimum of 30 Alarm Groups shall be provided. At least four levels of alarm priority shall be available, with configurable presentation/ background colour. A global alarm acknowledgment and reset facility shall be available. If unacknowledged, Alarm message stays on display until it is cleared.

xlviii. In addition to the alarms included in the point count, the DCS shall be capable of handling alarms and status points received via any interface module from any third party device to which it is connected.

xli. All actions by engineer/authourised persons, which change the control and monitoring of the process, such as placing stations and devices on-line or off-line, changes in alarm set points, inhibiting/enabling alarms, changes in tag parameters, etc. shall be stored in history files.

li. System events like failed process input/output modules, communication errors, program error message, switch over between primary & backup, failed controller modules, other function module failures, etc. shall be stored in history files.

lii. Each operator workstation shall be capable of storing sufficient number of events of each type and details for the same shall be indicated.

lii. Required utility packages shall be provided to generate report formats using a conversational, fill-in-the blank approach. No software programming shall be required to generate the reports. It shall be possible to use any variable in the system in a report. It shall be possible to activate report on the cases like on Operator’s request; Shift, daily and monthly; Event driven, etc.

liii. Facility to configure a report to accept manually entered data for specified fields shall be provided.

liv. The system shall provide facilities to program user defined reports using a high level programming language. The programming language shall be provided with the necessary system calls and access to generate a report from the real time database and the event history collection files.

lv. Reports to the same device are to be queued.

lvi. Graphic page shall not be locked for more than 5 seconds while taking the print for the display page. The configuration should not be erased even in the event of power failure and the system shall be operational immediately after power is resumed.

lvii. Each Operator & Engineering workstations shall comprise minimum configuration of :- Pentium-IV Processor with clock speed of 2.4GHz or higher; 21” high resolution colour LCD TFT monitor with touch screen facility; minimum 80 GB HDD with controller & 1 GB RAM; 1.44 MB FDD; 52x CD ROM drive & 52x DVD read-write drive/ Combo drive; Graphic Accelerator Card with minimum 8 MB on board RAM; Dual redundant interface modules for communication with system Data Highway; necessary serial ports, parallel ports, USB ports
& PS2 ports for interfacing with peripheral devices; Dust & drip proof flat keyboard; Built-in speaker with different type sound levels; etc. All the hardware & software shall be provided as per the latest proven & available models at the time of supply.

Iviii. The Operator & Engineering workstations shall be housed in suitably designed consoles to be finalised during detailed engineering stage. All the units shall be functionally assignable & interchangeable.

Ix. In addition to all the standard keys required for system, operation and data entry, the keyboard shall also have required numbers of one touch function keys with LED to initiate any application programme, calling any display pages/ graphic pages/ trend pages, etc. LED lamps shall blink for alarm condition.

Ix. System hard disk shall have capacity to take care of extra load due to future expansion of the DCS.

Ixi. Printers as per the following details shall be provided:
- A3 size colour ink-jet printer for graphic page printing.
- A4 size monochrome laser printer for report printing.
- A3 Dot matrix printer for alarm/ event printing.

Number of printers shall be as per the configuration diagram. All the printers shall be network compatible so that any workstation can access any printer whenever required. All the required printer papers, ink cartridges and other consumables shall be provided till handing over of the plant & equipment.

21.04. Self-Diagnostic & Monitoring Features

i. Respective DCS shall have exhaustive self diagnostic & monitoring features including the following:
   - Fault detection upto card level including failure/ status of central processor unit, memory, I/O status and power supply.
   - Parity errors, cycle errors and under voltage
   - Address monitoring.
   - Bus & Communication signal monitoring & all types of failure feedback.
   - Network diagnostic displays.
   - Broken sensor detection.
   - Automatic turning OFF of all outputs or optionally holding of all outputs in their last state on failure detection.
   - Indication of all other type of failures.

ii. On-line displays shall indicate the results of self-diagnostic tests. Failure diagnosis shall be sufficiently specific to indicate which modules, or devices are at fault. The displays shall be designed to help maintenance and engineering personnel to diagnose faults in the system and communications paths. Each category of diagnostic display shall be organized hierarchically.

iii. All events generated by the system shall be captured and electronically logged chronologically to the event database on a hard disk on one or more designated
workstations. Events shall be time-stamped by the event generator. Events and their
associated time stamp are passed on to the event handler for capture.

iv. It shall be possible to retrieve and sort events by time (ascending or descending order) or by
type. The Operator shall be able to filter the events on certain criteria such as time, tag
name, area name, or any specific event. Events and the historical trend information for a
control tag shall be integrated into a single view.

v. All events shall be time stamped at the point of origin. Events generated in the controller shall
be time-stamped in the controller. Those generated in the workstation shall be time stamped
in the workstation.

vi. Print on demand shall be included for all views possible with the event viewer application.

vii. Invalid value status shall be generated for inputs and calculated variables. A value shall be
declared invalid if any of the following conditions are true:

   a) If a value is out of range.
   b) If a value cannot be measured or calculated.
   c) If a value is declared invalid by an application program.
   d) If a value is declared invalid by the source instrument.

   Invalid value status shall be propagated through control schemes.

viii. It shall be possible to inhibit the detection and propagation of an invalid value status. This
selection shall be available on individual tag basis.

ix. It shall be possible for an invalid value status to be used as a logical input to initiate control
algorithm changes.

21.05  Power Supply & Distribution System

i. Power supply to DCS shall be from UPS :240V AC or 110 V AC, 50 HZ, as per plant
standard.

ii. Power supply feeder to Controller subsystem, Data acquisition subsystem and other
peripheral units shall be provided using individual DP MCBs. Further distribution of power
supply within the panel/ rack for respective modules/ units and derivation of required voltage
level shall be carried out as per the requirement.

iii. Each processor rack of Hot redundant Controller Subsystem and the I/O racks shall have hot
redundant rack based power supply modules.

iv. For output relay powering, powering field instruments (2-wire transmitters), input interrogation
(if required), etc., separate & independent dual redundant 24V DC power supply units of
suitable ratings and quantity shall be provided. Each I/O panel shall have one set of such
dual redundant power supply units.

v. The dual redundant 24V DC power supply units shall be Diode ‘OR’ed.

vi. Power supply equipment and the distribution system shall have surge voltage protection, fuse
protection in the input and output circuits, electronic over current protection, thermostat
protection against over temperature, etc.

21.06.  Software

i. Each DCS shall be supplied with all the required software for satisfactory operation of system
& process taking care of requirements stipulated in TS. All the software shall be of proven
technology and latest with copy right or trade mark registration and shall be from principal manufacturer.

ii. DCS system software shall be latest, Windows based, menu driven and shall support the following as minimum:

- Cyclic, Time Controlled, Interrupt controls.
- Retentive/ Non-Retentive timers, Bi-directional counters, Latches, etc.
- Internal Flag generated by the DCS along with internal timer & counter blocks.
- All Boolean Logic Functions.
- Data transfer, Block Transfer.
- Sub Routines.
- Computational Functions such as Addition / Subtraction, Ramp generator, Lead-lag, Integrator / Accumulator, Dead time, High/low select, Tangent, Multiplication / Division, Time averaging, Signal selection switch, Exponential polynomial, Logarithms, Square root, Absolute value etc. shall be supplied as standard function blocks.
- Communication functions with Remote I/O as well as Engineering station, Operators station.
- Closed loop PID control functions including cascaded loops. Number of PID Control loops including cascade loops which can be handled, shall be highlighted.
- For all the close loop controls with electrical actuators, actuation shall be carried out either by, 4-20 mA DC outputs & separate hardware positioner, or digital/ pulse outputs, depending on system design. For digital/ pulse outputs, the outputs through relays shall be interfaced with auxiliary contactor of MCC connected to power circuit of electrical actuators for phase reversal required for forward-reverse movement. Closed loop controls with electrical actuators shall be preferably independent of position feedback from the valve actuators, in which case, the position feedback signal shall be used for indication purpose only.
- For pneumatic actuator, 4-20 mA DC outputs shall be used. PID blocks/ algorithms shall be suitable to take care of such applications and shall have all the required software function blocks.
- PID Controller shall be able to operate in manual, auto or computer mode as configured or selected. Mode change over shall be easy selectable and bumpless.
- In computer mode, controller shall be able to communicate & track computer-generated set point and shall hold the last generated value in case of computer failure. In such case, controller shall change over to auto mode and continue to operate at the last received set point, in general. Other options like pre-defined set point operation & fail safe condition shall also be possible. On the resumption of computer set point, the controller shall not return to computer mode automatically and user intervention shall be required. Computer failure indication shall be provided at local & central level.
- PID Controller shall have auto-tuning facility.
- Linearisation function block shall be such that a table of values (X against Y) can be entered in a menu driven manner and for any particular field input X, the value of Y can be calculated using the values of table by interpolation method. Minimum 30-point
linearisation function block shall be considered and within this block number of linearisation point required in actual shall be user selectable.

- The following discrete control functions shall be supplied as standard configurable items:
  Logic functions -- and, or, not, nand, nor, xor; Change of state detect; Set/reset
  flip-flops; Timers and counters; Comparison elements -- greater than, less than,
  equal to, not equal to; Multiplexer; Positive, negative, and bi-directional edge
  trigger.

- The system shall be capable of performing the following sequential control without any
  modifications to the standard configuration software.
  Sequence Language: A structured, IEC 61131-3 compliant high-level control
  programming language shall be available and shall conform that:
  a) It shall provide the necessary facilities for real-time control of sequential processes.
  b) It shall have access to process control and other database information. It shall be
     possible to modify the program logic while other sequences are active.

- Totalisation of flow inputs.

- Broken sensor detection, Cold junction compensation for thermocouple inputs, etc.

- Other function libraries, etc.

iii. The application programme software of the DCS shall be based on Block diagram, statement
     form/etc. On-line programme editing facility shall be available. Necessary software
     debugging facility shall also be provided.

iv. Required software package for HMI programme shall be loaded in respective operators
    station & engineering station. It shall have the facility to perform multitasking, data
    acquisition, supervisory control, monitoring & control function development and routine
    software. It shall also have feature for graphic/ mimic generation, alarming, trending, data
    logging, production backup history, creation of shift reports, on-line printing of events. It shall
    have sufficient amount of tag (both analog & digital) handling capacity.

v. Operating System of the workstations shall be Windows or Windows NT or Windows 2000 or
   Windows XP, as applicable (Latest at the time of supply). HMI Software shall be Window
   based. Latest version, at the time of implementation, of HMI software with application
   development package shall be supplied. Data Base shall be ORACLE, SQL, etc. based with
   suitable front-end software, as per the requirement & supported by the system. It shall also
   have open database connectivity. Details of the same shall be indicated.

vi. All the above packages/ software shall have comprehensive self-diagnostic utilities, system &
    I/O configuration utilities, synchronisation utilities, various device drivers including network, its
    administration & redundancy management. This shall also include all the required testing
    software to check performance of the automation system. Details of all such software
    packages shall be indicated.

vii. Required numbers of software license for Purchaser shall be provided for DCS programming
    & application software including operating system, HMI operating system & programming
    software, redundancy management software, etc., as may be required to carry out
    engineering & operation activities from the complete automation system. Details of the same
    shall be indicated.

viii. The system shall allow for upgradation of operating software on all the applicable equipment
     without shutting down the process, without loosing operator interface and control functions.

21.07 System Cabinet & Console
i. The controller subsystem and data acquisition subsystem shall be mounted in suitable racks, which shall be installed inside system cabinets. All the workstations shall be installed on console desk.

ii. All the cabinets required for system, power distribution, marshalling, shall be of floor mounted, free standing, enclosed type. Cabinet structure shall be sound and rigid and shall be provided with removable lifting lugs to permit lifting of the cabinets.

iii. Cabinets shall be fabricated from cold rolled steel sheet of minimum 2.0 mm thickness for load bearing side & 1.5 mm thickness for the doors/ non-load bearing sides. These shall be suitably reinforced to prevent warping and bucking. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication.

iv. Each cabinet shall be of maximum 2100 mm height with a base channel of 100 mm & minimum depth of 800 mm. Width shall be suitably decided depending on requirement and considering ease in maintenance.

v. Construction of cabinets shall be preferably modular to accommodate 19” standard racks. Empty slots of the racks shall be provided with dummy cards for protection against dust and damage. All racks shall be of same height. Maximum swing out for pivoted card racks, doors and drawers shall be limited to 600 mm.

vi. Cabinets shall be equipped with front and rear access doors. Doors shall be equipped with lockable handles and concealed hinges with pull pins for removal of each door.

vii. Cabinets shall be designed for bottom cable entry with necessary gland plate & double compression cable glands.

viii. Suitable anti-vibration pads to withstand vibration shall be provided.

ix. For effectively removal of dissipated heat from the cabinets, suitable louvers, fan filter units, fan trays, etc as required, shall be provided within the cabinets.

x. Illumination shall be provided for all cabinets & consoles by fluorescent lamps and door operated micro switches. Switch & power socket shall also be provided inside the cabinets.

xi. Equipment within the cabinet shall be laid out in an accessible and logically segregated manner. Clamping rails shall be provided for incoming cables to prevent excessive stress on the individual terminal. All metal parts of the cabinet including doors shall be electrically continuous and shall be provided with a common grounding lug.

xii. For installation of workstations consisting of PCs, colour monitors, keyboards, mouse, printers, etc., suitable aesthetically designed consoles made up of 2.5mm thick CRCA sheet steel shall be used. The operator’s console shall also be provided with filler desks, corner pieces etc., as required. The console shall be designed considering ease of operation & maintenance. The console shall also be provided with fan-filter units.

xiii. All the cabinets and consoles shall be completely wired. Interconnections between cabinets shall preferably be done with the help of pre-fab cables.

xiv. All terminal blocks of marshalling rack shall be suitable for termination of maximum 2 numbers of 1.5mm2 copper cables from field. All the terminal blocks shall be screw less clamp-on type. For signal wiring, 2.5mm2 size & for power wiring, 4.0mm2 size terminals shall be used.

xv. Electrical voltage higher than 240 V AC/DC shall not be brought inside the instrument panel / cabinet.
xvi. Separate terminal strips shall be provided for 24 V DC, 240 VAC and intrinsically safe terminals.

xvii. Gland plate (to be located at bottom of panel) with single compression type brass cable glands shall be provided. Distance between cable gland plates & bottom of terminal strips shall be minimum 300 mm. For I/O cabinets installed outside the control room, double compression type SS cable glands shall be used.

xviii. A minimum of 20% spare terminals shall be provided in each terminal block.

xix. Power supply terminals (e.g. 240VAC or 110VAC or 24VDC) shall be labeled. In case a bus bar is used for power supply distribution, the bus-bar shall be shrouded with a transparent Bakelite plate. A power socket (of 240V AC, 15W rating) for soldering, etc. shall be provided.

xx. The panels shall be provided with earth strip made of copper, 25mm(W) x 3mm(T) and of required length. A pair of earthing bolts on the inner side of the panel door shall be provided for power earthing.

xxi. The panels shall also be provided with earth strip made of copper, 25mm(W) x 3mm(T) and of required length, mounted on an insulated base inside the panel with holes and nut-bolts, for instrument signal earthing.

xxii. Cabinets & consoles shall be dust and vermin-proof conforming to minimum IP-22 class, when located in air-conditioned room. Cabinets located in ventilated rooms shall have minimum IP-42 protection class & minimum IP-54 class in non-ventilated rooms.

21.08 Earthing

Vendor shall provide a separate electronic earthing system. Electronic components of workstations, cabinets, consoles etc. of DCS and drain wires of the instrumentation signal cables shall be connected to this earthing system.

The body earth of the DCS cabinets and workstations / consoles shall be connected to the 'Electrical Earth grid' in the plant, which shall be separate from the 'Electronic Earth'. The electronic earth pit(s) shall be at least 3 m away from the nearest electrical earth pit.

The design of the electronic earth pit shall be as per IS:3043, 1991 or based on the manufacturer's recommendation.

21.09 Training

Basic and advance training shall be provided on programming, operation and maintenance of DCS both at the factory & also at site. The time period and number of persons to be trained shall be decided as per requirement.

21.10 Quality assurance, Inspection and Testing

The automation system shall be designed, selected & supplied ensuring proper quality & performance. Vendor’s procedures for Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) shall be submitted at least 60 days prior to the scheduled conduct of these tests for review/acceptance.

The proposed FAT & SAT procedures of vendor shall be reviewed and modified as required to generate mutually agreed & finalised procedures, based on which these acceptance tests will be performed and supervised by authorized agency.
All system hardware & software used for testing shall be complete as specified and shall use actual equipment to be shipped to the site as per scope.

21.10.01 **Factory Acceptance Tests (FAT)**

i) The factory acceptance test shall be held at vendor’s works. Prior to the FAT, all the equipment shall be fully assembled, wired and properly connected & tested to establish all the specified features & functional requirements of the systems.

ii) During FAT, functional integrity of the system hardware and software shall be tested & demonstrated. All the necessary simulation kits as may be required for testing of software shall be arranged.

iii) Vendor shall perform functionality tests of complete system and satisfy himself of the results before giving notice regarding readiness of the system and its availability for FAT. Such notice shall be given minimum 15 days before the scheduled start of the FAT.

iv) The factory acceptance tests shall include visual and mechanical testing to establish correctness, completeness, good workmanship and functional testing.

v) The tests shall systematically, fully & functionally establish performance of all the hardware & software in presence of authorized representatives. All the sub-systems shall be interconnected to simulate, as close as possible, the total integrated system. Each test carried out shall be documented. Simulators shall be used for simulating field inputs. Any deficiency or problem faced shall be clearly brought-out and corrected.

vi) Before start of the FAT, the complete integrated system shall be kept powered on for 72 Hrs.

vii) All assemblies shall be aligned & adjusted and all test results shall be documented.

viii) For System Power up Test, Vendor as a minimum shall check the functions of all the system hardware and software including diagnostic software at sub-system levels with stimulated inputs.

ix) Functional testing shall include the simulation of each input and output to verify proper system response for both analog and discrete signals. This shall also include checking of various control loops, system scan time, checking of system loading including data highway, checking of system shutdown, alarm & interlock functions, checking of redundancy management, checking system diagnostics, checking various display parameters, etc.

x) The test log book shall contain the following information about the tests:

- Date/ time
- Assembly/loop tag number
- Test input
- Test results and sign off with personnel name
- Action required (if deficiency is detected).
- Actions taken, date of completion and sign off.
- Special test methods (including special equipment requirement, bypass used etc.).

xi) The automation system shall be shipped to site only after successful completion of FAT and receipt of dispatch clearance from authorized agencies.
21.10.02 Site Acceptance Test

At site, the system shall be properly installed taking care of manufacturer’s recommendation, after which Site Acceptance Tests (SAT) shall be carried out taking into the actual field instruments/equipment in the loops.

All the system and application software installed prior to FAT or during FAT, shall be re-loaded from beginning at site as per standard procedures & demonstrated in presence of client’s personnel.

The Site Acceptance Test shall be held at site after the system has been installed as per the finalised SAT procedures. The tests shall be witnessed by authorized representatives.

The minimum tests to be carried out shall be as indicated in clause no. 10.3.

A log of all failed/ mal-operating components /modules in a sub-system shall be maintained by Vendor, with description of the affected components /modules, cause of failure, effect of failure on the sub-system and number of hours of operation before it failed. This will start from the date of powering on of the system for cold commissioning.

21.10.03 Test Details

Following tests shall be performed as a minimum during both FAT & SAT, in presence of authorized representatives and documented test results shall be compiled:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Test Description</th>
<th>FAT</th>
<th>SAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Check of supply completeness</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2.</td>
<td>Visual &amp; dimensional check</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3.</td>
<td>Check of complete system configuration loading</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>4.</td>
<td>Check of system diagnostic features. These shall include failure of any sub-system, module, power supply, interface unit, failure of transfer to redundant module on main module failure etc.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5.</td>
<td>Power-off and power-on of any single unit</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6.</td>
<td>Test of alarm system</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7.</td>
<td>Check of correct functionality of keyboards</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8.</td>
<td>Testing of proper working of the printers</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>9.</td>
<td>Simulation of power failure and restart. Self-booting up of system configuration &amp; program after power restoration.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>10.</td>
<td>Fieldbus / Analog / digital input / output check</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>11.</td>
<td>Check of scan time for DCS</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>12.</td>
<td>Check of scan time, screen update time and loop cycle time</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>13.</td>
<td>Check of loop configuration for correct entry of ranges, limits etc.</td>
<td>✓</td>
<td>S</td>
</tr>
<tr>
<td>14.</td>
<td>Check of CRT displays (all kind of displays)</td>
<td>✓</td>
<td>S</td>
</tr>
<tr>
<td>15.</td>
<td>Checking of CRT refresh rate, data base update and display call-up time.</td>
<td>✓</td>
<td>S</td>
</tr>
<tr>
<td>16.</td>
<td>Check of system internal loading (processor, communication system etc.)</td>
<td>✓</td>
<td>-</td>
</tr>
</tbody>
</table>
### Test Description

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Test Description</th>
<th>FAT</th>
<th>SAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>Check of various log formats, shutdown reports etc.</td>
<td>✓</td>
<td>S</td>
</tr>
<tr>
<td>18.</td>
<td>Demonstration of all DCS system builder functions including addition/deletion of an input/output, addition/deletion of a rung or an element in a rung generation of dynamic graphics and other views, report generation etc.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>19.</td>
<td>100% checking of logic configured in the DCS by connecting switch/lamp at input/output.</td>
<td>✓</td>
<td>-</td>
</tr>
</tbody>
</table>
| 20.   | Redundancy check for DCS including correct change over of the back-up unit in case of failure of main unit. These shall be applicable for following:  
• CPU Redundancy  
• CPU Power supply redundancy  
• Each CPU to host system communication interface & communication link redundancy  
• I/O subsystem to processor system communication redundancy  
• IO rack power supply redundancy  
• Field bus interface module redundancy |

**FAT** = Factory Acceptance Test; to be performed at Vendor’s workshop  
**SAT** = Site Acceptance Test; to be performed at site.  
✓ = Complete test; 100% of devices/ functionality will be tested.  
S = Sample test

All the necessary simulation kits as may be required for testing of software shall be arranged.

Acceptance of any equipment or the exemption of inspection shall in no way absolve the Vendor of the responsibility for delivering the equipment meeting all the requirement specified in this specification and also as may be required for satisfactory operation of the process.
GENERAL SPECIFICATION

2.0 : INSTRUMENTATION AND CONTROL SYSTEM
## CONTENTS

<table>
<thead>
<tr>
<th>CLAUSE NO.</th>
<th>DESCRIPTION</th>
<th>PAGE NO(S.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>GENERAL</td>
<td>1</td>
</tr>
<tr>
<td>02.</td>
<td>ENVIRONMENTAL SPECIFICATION</td>
<td>2</td>
</tr>
<tr>
<td>03.</td>
<td>BASIC DESIGN CONSIDERATION</td>
<td>2-19</td>
</tr>
<tr>
<td>04.</td>
<td>GAS ANALYSIS SYSTEM</td>
<td>19-21</td>
</tr>
<tr>
<td>05.</td>
<td>LIQUID ANALYSIS SYSTEM</td>
<td>21</td>
</tr>
<tr>
<td>06.</td>
<td>CONTROL VALVES</td>
<td>21-25</td>
</tr>
<tr>
<td>07.</td>
<td>CALORIFIC ANALYSER</td>
<td>26</td>
</tr>
<tr>
<td>08.</td>
<td>FLAME DETECTOR</td>
<td>26</td>
</tr>
<tr>
<td>09.</td>
<td>CONTROL PANELS &amp; CABINETS</td>
<td>27-29</td>
</tr>
<tr>
<td>10.</td>
<td>ELECTRICAL SYSTEM</td>
<td>29-31</td>
</tr>
<tr>
<td>11.</td>
<td>PNEUMATIC SYSTEM</td>
<td>31</td>
</tr>
<tr>
<td>12.</td>
<td>CONTROL ROOM DESIGN</td>
<td>32</td>
</tr>
<tr>
<td>13.</td>
<td>CABLE LAYING</td>
<td>33-34</td>
</tr>
<tr>
<td>14.</td>
<td>IMPULSE PIPE LAYING</td>
<td>35</td>
</tr>
<tr>
<td>15.</td>
<td>EARTHING</td>
<td>36</td>
</tr>
<tr>
<td>16.</td>
<td>GUIDELINES FOR SELECTION OF ERECTION MATERIALS</td>
<td>36-38</td>
</tr>
<tr>
<td>17.</td>
<td>INSTALLATION OF INSTRUMENTS</td>
<td>38</td>
</tr>
<tr>
<td>18.</td>
<td>CALIBRATION</td>
<td>38</td>
</tr>
<tr>
<td>19.</td>
<td>TESTING &amp; COMMISSIONING</td>
<td>39-40</td>
</tr>
<tr>
<td>20.</td>
<td>QUALITY ASSURANCE PLAN</td>
<td>40-41</td>
</tr>
<tr>
<td>21.</td>
<td>DCS BASED AUTOMATION SYSTEM</td>
<td>42-65</td>
</tr>
</tbody>
</table>