

# **SCHEDULES TO EPC AGREEMENT**

**FOR**

**DESIGN, CONSTRUCTION, OPERATION AND  
MAINTENANCE OF RAW WATER PUMPING  
STATION AND RAW WATER TRANSMISSION  
MAIN FROM PIPLI PUMPING STATION  
(PARIYEJ RESERVOIR) TO WATER  
TREATMENT PLANT (WTP) AT TP1 IN  
DHOLERA SIR**

**Dholera Industrial City Development Limited (DICDL)  
6th Floor, Block No. 1 and 2, Udyog Bhavan,  
Sector-11, 'GH-4' Circle, Gandhinagar – 382017  
Gujarat, India**

## TABLE OF CONTENTS

|   |           |
|---|-----------|
| <b>Schedule A - Site of the Project .....</b>   | <b>7</b>  |
| 1    The Site .....   | 7         |
| Annexure I - Site .....   | 8         |
| Annexure II – Environmental Clearances .....  | 9         |
| Appendix A I – Index Maps and Location Maps .....   | 10        |
| <b>Schedule B – Development of the Project Works .....</b>  | <b>15</b> |
| 1.0    Development of the Project works shall include design and construction of the project works as described in this Schedule-B and in Schedule-C..... | 15        |
| 1.1    Introduction.....  | 15        |
| 1.2    Raw Water Pumping Station.....   | 16        |
| 1.2.1    Existing Raw Water Sump (Not in the Scope of work) .....   | 16        |
| 1.2.2    Pumping Machinery.....   | 16        |
| 1.2.3    Security Cabin.....  | 17        |
| 1.3    Raw Water Transmission Main.....   | 19        |
| 1.4    Water Treatment Plant (Under Separate Contract Package).....   | 20        |
| 2.0    Specifications and Standards.....  | 21        |
| 3.0    Change of Scope .....  | 21        |
| Appendix B I – List of Drawings .....   | 22        |
| <b>Schedule C - Project Facilities .....</b>  | <b>28</b> |
| 1.    Water Demand .....  | 29        |
| 2.    Raw Water Quality.....  | 29        |
| 3.    Raw water Pumping Station.....  | 29        |
| 3.1    Existing Raw Water Sump.....   | 29        |
| 4    Raw Water transmission main from the Raw water pumping station to WTP at TP1 .....   | 31        |
| 5    Stilling Chamber of Water Treatment Plant.....   | 32        |
| 6    Pipes & fitting, Valves and Mechanical equipment Specifications for the raw water Pumping Station works and raw water transmission main .....        | 32        |
| 7    List of Standards for various mechanical equipment .....   | 35        |
| 8    Standard Specifications for Submersible Pumps.....   | 38        |
| 8.1    Pump: .....  | 38        |
| 8.2    Impeller:.....   | 38        |
| 8.3    DRIVE MOTOR FOR MONO SUBMERSIBLE PUMP:.....  | 38        |
| 9    Electrical Specifications for raw water pumping station.....   | 42        |
| 9.1    Transformers 11/0.415 KV .....   | 42        |

|      |   |     |
|------|---|-----|
| 8.1  | Busbar Trunking (Sandwich Type).....                              | 49  |
| 8.2  | Low Voltage Switchgear & Control Gear Assembly.....               | 52  |
| 8.3  | Power Generating Set.....   | 86  |
| 8.4  | Starting of Motors.....   | 92  |
| 8.5  | 11KV Indoor Vacuum Circuit Breaker with air insulation.....       | 96  |
| 8.6  | Cabling.....  | 103 |
| 8.7  | Lighting.....   | 108 |
| 8.8  | Maintenance free Earthing.....                                    | 116 |
| 8.9  | Supervisory Control Panels and Associated Equipment.....          | 126 |
| 8.10 | Instruments.....  | 128 |
| 8.11 | Lightning Protection Unit.....                                    | 134 |
| 8.12 | Supervisory Control Panels and Associated Equipment.....          | 135 |
| 8.13 | Instruments.....  | 137 |
| 8.14 | Lightning Protection Unit.....                                    | 140 |
| 10   | Instrumentation, Control & Automation (ICA).....                  | 140 |
| 9.1  | General.....  | 140 |
| 9.2  | Instrumentation and Monitoring.....                               | 141 |
| 9.3  | Local Area Controls / DCS System.....                             | 142 |
| 9.4  | Communications.....   | 144 |
| 9.5  | General.....  | 145 |
| 9.6  | Distributed Control System.....                                   | 150 |
| 9.7  | Control System Application Software.....                          | 154 |
| 9.8  | Local Operator Panels.....  | 157 |
| 9.9  | Site DCS System.....  | 158 |
| 9.10 | Remote Terminal Units – RTU.....                                  | 166 |
| 9.11 | Water Leakage Management Software.....                            | 168 |
| 9.12 | Maintenance Management (MM) Software.....                         | 170 |
| 9.13 | Remote Management / Parameter Monitoring.....                     | 171 |
| 9.14 | Uninterrupted Power Supply for Control Panel and DCS Station..... | 173 |
| 9.15 | Control Center Console System.....                                | 175 |
| 9.16 | Factory Acceptance Test (FAT).....                                | 175 |
| 9.17 | Spare Parts, Start-up Supplies and Special Tools.....             | 175 |
| 9.18 | Fiber Optic Cables.....   | 177 |
| 9.19 | Instrumentation.....  | 182 |

|      |   |            |
|------|---|------------|
| 10   | Standards and Specifications for Civil and Building Works for Pumping Station.....  | 202        |
| 11   | Standards and specifications for Site Grading works for the Raw Water pumping station site .....  | 208        |
| 12   | Standards and Specifications for Architectural finishes for Pumping Station Site .....  | 208        |
| 13   | Standards and Specifications for Topographical and contour Survey for Raw water Pumping station site and Raw Water Transmission Main alignment..... | 210        |
| 13.1 | Pumping Station Site.....   | 210        |
| 13.2 | Raw Water Transmission main from Pumping Station at Pipli to WTP at TP1.....  | 212        |
| 14   | Standards and Specifications for Geotechnical Works at Pumping station site and Raw Water Transmission Main Route .....                             | 213        |
|      | <b>Appendix D I – List of Acceptable Makes of Equipment.....</b>  | <b>216</b> |
|      | <b>Schedule E – Operation and Maintenance Requirements.....</b>   | <b>225</b> |
| 1.   | Scope of Works for O&M.....   | 225        |
| 2.   | Contractor’s Organization & Administration of the Contract.....   | 228        |
| 3.   | Staffing for the operation of Raw Water Pumping station and Raw water transmission main .....   | 229        |
| 4.   | Operation Schedule for Pipe lines/Raw water transmission main.....  | 230        |
| 5.   | Maintenance Schedule for Pipe lines/Raw water transmission main .....   | 230        |
| 6.   | Records and Reports for Maintenance of Pipelines .....  | 232        |
| 7.   | Maintenance for Raw Water Pumping Station.....  | 232        |
| 8.   | Maintenance for Raw Water Sump .....  | 233        |
| 9.   | Safety/Security .....   | 233        |
| 10.  | Hazardous Waste .....   | 234        |
| 11.  | Technical Audit.....  | 234        |
| 12.  | Reporting .....   | 234        |
| 13.  | Site Order Book .....   | 235        |
| 14.  | Training for Employer staff .....   | 235        |
|      | Appendix E I – Repair/Rectification of Defects and Deficiencies for Raw Water Pumping station and Raw water Transmission Main.....                  | 236        |
|      | Appendix E II – Operating Details.....  | 239        |
|      | Appendix E III – Contractor’s Functional Guarantees .....   | 240        |
|      | <b>Schedule F – Applicable Permits.....</b>   | <b>243</b> |
| 1.   | Applicable Permits.....   | 243        |
|      | <b>Schedule G - Form of Bank Guarantee .....</b>  | <b>244</b> |
|      | <b>Schedule H - Contract Price Weightages.....</b>  | <b>253</b> |
| 1.   | Contract Price Weightages.....  | 253        |
|      | Appendix H I – Weightage in % for Contract Price for Design and Construction Work.....  | 254        |
|      | Appendix H II – Interim Milestone Payment for Construction .....  | 256        |

|   |            |
|---|------------|
| <b>Schedule I - Drawings.....</b>   | <b>260</b> |
| 1. Drawings.....  | 260        |
| 2. Additional Drawings.....   | 260        |
| Appendix I-I – List of Drawings.....                                      | 261        |
| <b>Schedule J - Project Completion Schedule .....</b>                     | <b>264</b> |
| 1 Project Completion Schedule.....  | 264        |
| 2. Project Milestone-I.....   | 264        |
| 3. Project Milestone-II .....   | 264        |
| 4. Project Milestone-III.....   | 264        |
| 5. Project Milestone-IV.....  | 264        |
| 6. Schedule Completion Date.....  | 265        |
| 7. Extension of time .....  | 265        |
| <b>Schedule K - Tests on Completion.....</b>                              | <b>266</b> |
| 1. General.....   | 266        |
| 2. Material and Instruments required for Testing.....                     | 266        |
| 3. Test Certificates .....  | 266        |
| 4. Schedule for Tests.....  | 266        |
| 5. Tests.....   | 267        |
| 5.1 Factory tests/ manufactures works inspection test and guarantees..... | 267        |
| 5.2 Onsite inspection, tests and pre-commissioning treatment .....        | 269        |
| 5.3 Environmental audit.....  | 272        |
| 5.4 Safety Audit .....  | 272        |
| 5.5 Visual and physical test.....   | 273        |
| 6. Agency For Conducting Tests.....                                       | 273        |
| 7. Inspection of Erection of Pipe lines & equipment .....                 | 273        |
| 8. Instrumentation and Control System.....                                | 273        |
| 9. Preliminary Commissioning Checks.....                                  | 273        |
| 10. Commissioning & Trial run .....                                       | 273        |
| 11. Final Acceptance Tests .....  | 275        |
| 12. Handing Over of Documents .....                                       | 275        |
| 13. Completion Certificate.....   | 275        |
| 14. Quality Control and quality checks.....                               | 275        |
| 15. “As Built Drawings” and “Operation and maintenance manual”.....       | 276        |
| 16. Asset Management.....   | 277        |

|   |            |
|---|------------|
| Appendix K I – Inspection, Testing, Erection, Commissioning of Electro-Mechanical Equipment of pumping station (Part-III) ..... | 278        |
| <b>Schedule L - Provisional Certificate.....</b>  | <b>296</b> |
| <b>Schedule M - Payment Reduction for Non-Compliance.....</b>   | <b>298</b> |
| 1. Payment reduction for non-compliance with the Operation & Maintenance Requirements .....                                     | 298        |
| 2. Percentage reductions in lump sum payments .....   | 298        |
| 3. Payment adjustment for variable water supply during O&M Period .....   | 299        |
| <b>Schedule N - Selection of Employer’s Engineer .....</b>  | <b>300</b> |
| 1. Selection of EMPLOYER’s Engineer .....   | 300        |
| 2. Terms of Reference .....   | 300        |
| 3. Appointment of Government entity as EMPLOYER’s Engineer .....  | 300        |
| <b>Schedule O - Forms of Payment Statements .....</b>   | <b>307</b> |
| 1. Stage Payment Statement for Works.....   | 307        |
| 2. Monthly Operation and Maintenance Payment Statement .....  | 307        |
| 3. Contractor’s claim for Damages .....   | 307        |
| <b>Schedule P - Insurance .....</b>   | <b>308</b> |
| 1. Insurance during Construction Period.....  | 308        |
| 2. Insurance for Contractor’s Defects Liability.....  | 308        |
| 3. Insurance against injury to persons and damage to property .....   | 308        |
| 4. Insurance to be in joint names.....  | 309        |
| <b>Schedule Q - BIM and CAD Requirements.....</b>   | <b>310</b> |
| <b>1. Objective.....</b>  | <b>310</b> |
| <b>2. Scope .....</b>   | <b>310</b> |
| 3. Schedule of Deliverables .....   | 313        |
| Appendix Q I – BIM Project Execution Plan (Sample Format) .....   | 314        |
| <b>Schedule R – Guideline for Health, Safety and Environment Plan.....</b>  | <b>331</b> |
| <b>Schedule S - Project Management Requirements.....</b>  | <b>332</b> |

## **Schedule A - Site of the Project**

(See Clause 2.1 and 8.1)

### **1 The Site**

- 1.1 Site of the Raw water pumping station at Pipli Pumping Station Premises and Raw water Transmission Main from Raw Water Pumping Station to Water Treatment Plant (WTP) at TP1 of DSIR for initial development of Activation Area are as described in **Annexure-I** of this Schedule-A.
- 1.2 An inventory of the Site including trees and any other immovable property on, or attached to, the Site shall be prepared jointly by the Employer's Engineer and the Contractor, and such inventory shall form part of the Agreement.
- 1.3 The status of the Environment clearances is given in **Annexure-II for Dholera SIR**.

## **Annexure I - Site**

(Schedule-A)

### **1.0 Site**

#### **1.1 Raw Water Pumping Station**

The site for the Raw water Pumping Station lies in the existing raw water Pumping Station premises at Pipli village (Pipli pumping station).

The contour level of the site varies by 4-9 meters. The subsoil water level at the site region varies from 2-3 m below natural ground level. Index map and Location Maps for the Raw water pumping station site is given at **Appendix A I**.

#### **1.2 Raw water Transmission Main**

The raw water transmission main will be from the Proposed Raw water Pumping at Pipli to Water Treatment Plant (WTP) at TP1. The transmission main alignment is planned along existing SH-6 and Kadipur Village Road.

#### **1.3 Water Treatment Plant**

The site for the Water treatment plant (WTP) lies within the TP1 (**Town Planning scheme 1**) area of DSIR development. The WTP is proposed in Survey No. 259/A/P within TP1 area.

#### **1.4 Seismicity**

The Dholera Special Investment Region falls under the Zone III of the Seismic zoning map of India – IS: 1893-2002.



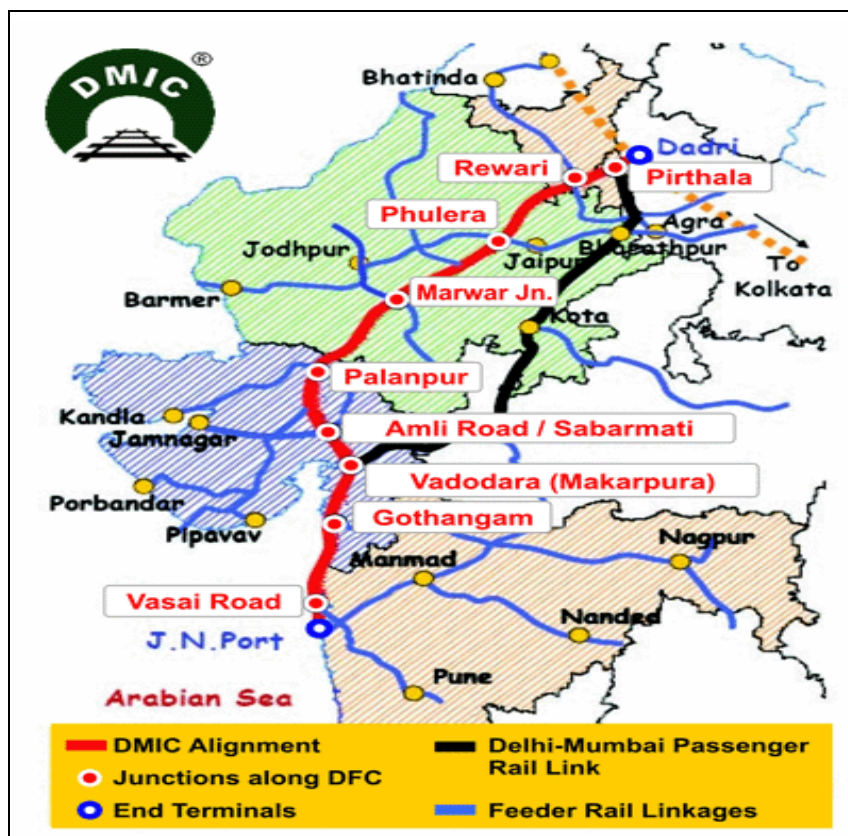
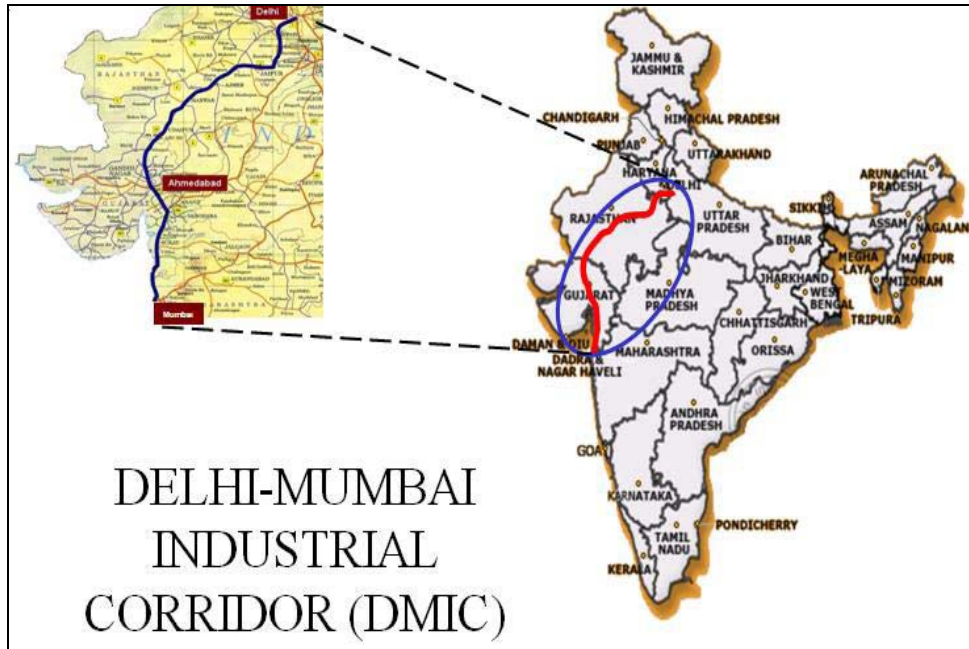
## **Annexure II – Environmental Clearances**

(Schedule-A)

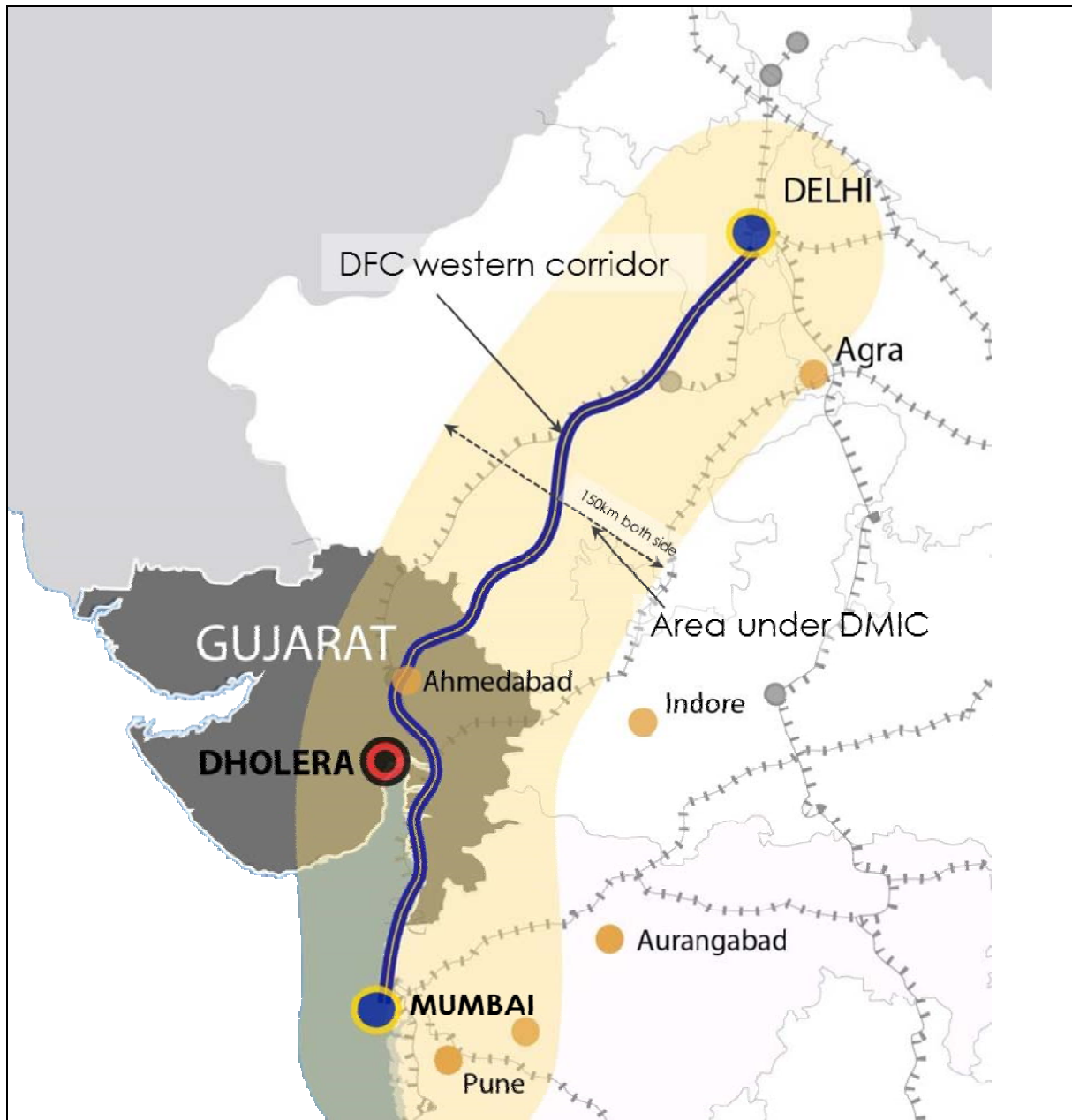
- 1.0 The overall Environment clearance for Dholera Special Investment Region (DSIR) has been obtained for Dholera SIR

**Appendix A I – Index Maps and Location Maps**

(Schedule-A)

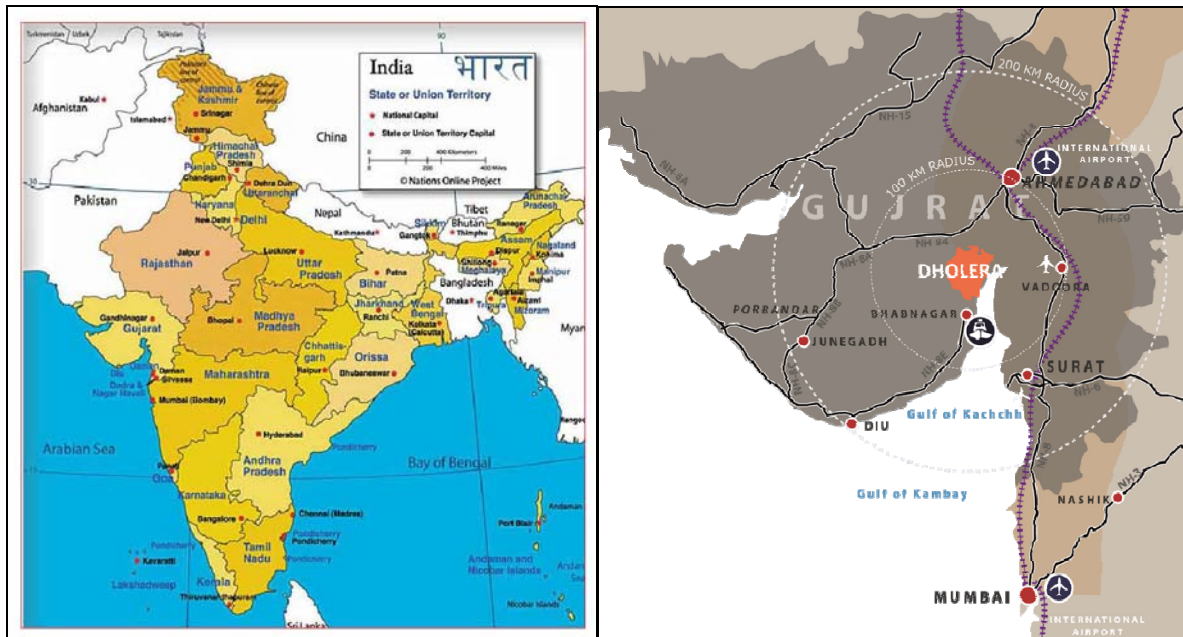


**DELHI MUMBAI INDUSTRIAL CORRIDOR (DMIC)**



**DHOLERA SPECIAL INVESTMENT REGION (DSIR)**

**INDIA/GUJARAT/Dholera Special Investment Region (DSIR)**

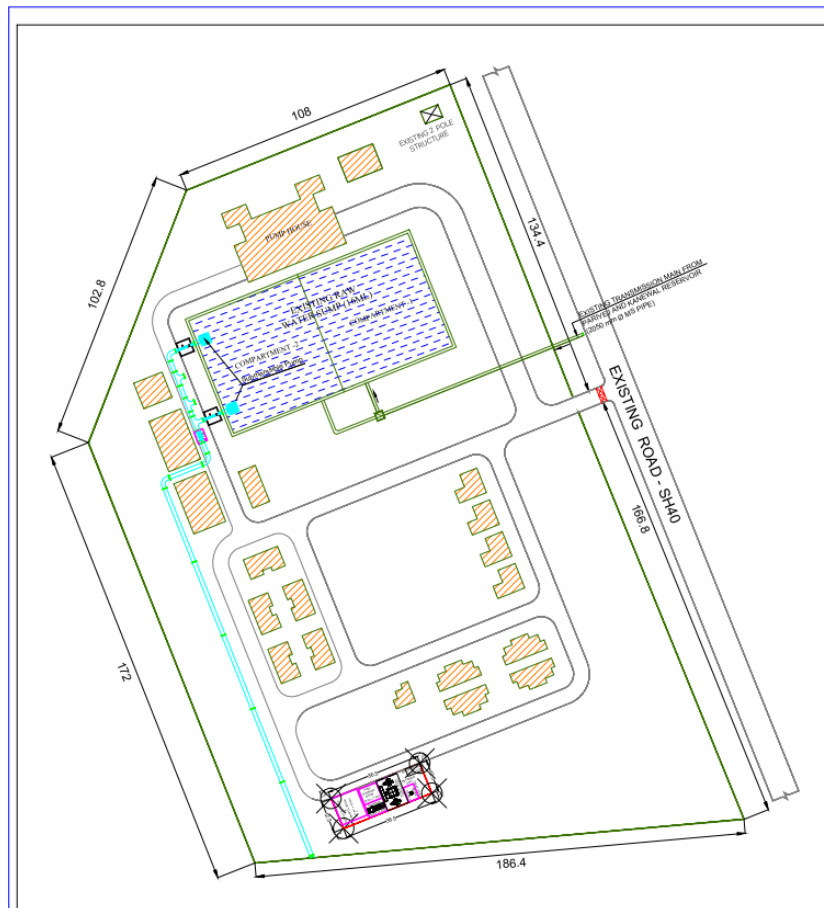


**LOCATION OF RAW WATER PUMPING STATION AND ROUTE ALIGNMENT OF TRANSMISSION MAIN FROM PIPLI TO WTP**

The Raw water pumping station site lies within the following Latitudes and Longitudes.

**Table 1: Coordinates for the Raw Water Pumping station site**

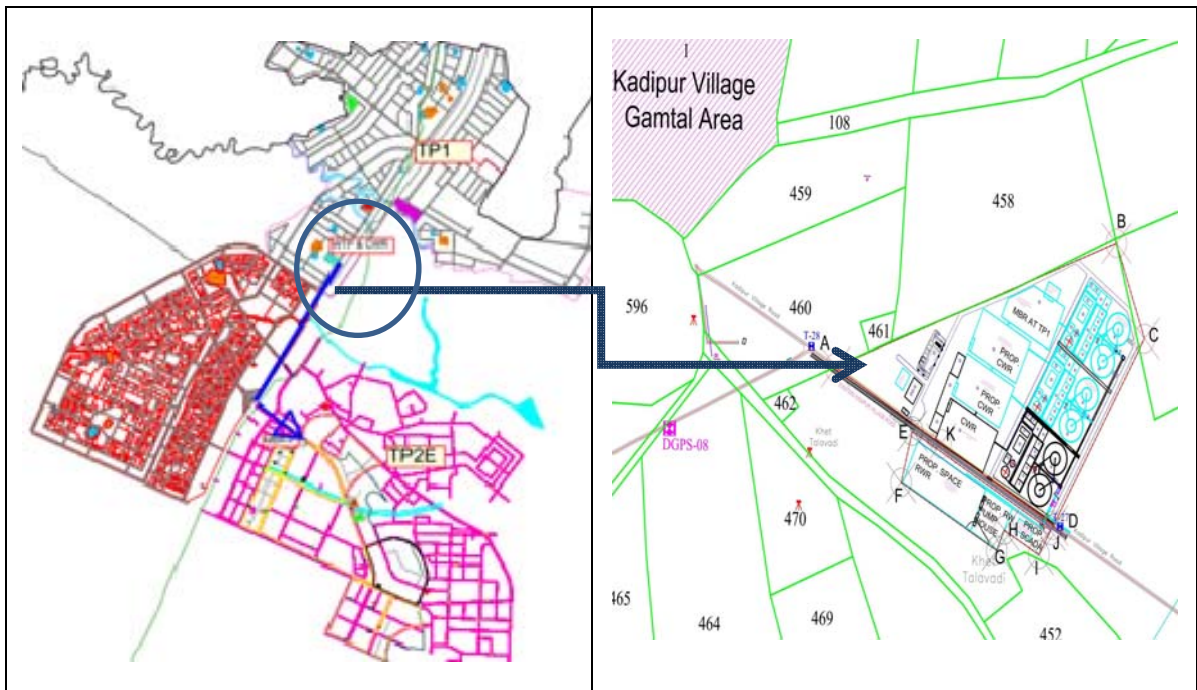
| Raw water pumping station (UTM) Site Location Coordinate |               |                |
|--|---------------|----------------|
| Points   | Easting (UTM) | Northing (UTM) |
| A  | 214945.99     | 2477834.68     |
| B  | 214950.62     | 2477823.25     |
| C  | 214917.08     | 2477809.92     |
| D  | 214912.29     | 2477821.27     |



The WTP site lies within the following Latitudes and Longitudes.

**Table 2: Coordinates for the WTP site**

| Water Treatment Plant (UTM) Site Location Coordinate |               |                |
|--|---------------|----------------|
| Points   | Easting (UTM) | Northing (UTM) |
| A  | 211609.54     | 2467268.73     |
| B  | 212033.47     | 2467403.36     |
| C  | 212075.66     | 2467299.48     |
| D  | 211938.42     | 2467096.41     |
| E  | 211725.57     | 2467199.10     |
| F  | 211708.66     | 2467142.95     |
| G  | 211852.85     | 2467068.78     |
| H  | 211864.29     | 2467091.02     |
| I  | 211917.05     | 2467063.87     |
| J  | 211935.13     | 2467090.33     |
| K  | 211768.63     | 2467185.23     |



## **Schedule B – Development of the Project Works**

(See Clause 2.1)

**1.0** Development of the Project works shall include design and construction of the project works as described in this Schedule-B and in Schedule-C.

### **1.1 Introduction**

Raw water transmitted from Pariyej and Kanewal Reservoirs to existing Raw water Sump (16 ML) in the raw water pumping station at Pipli village (Pipli pumping station) through raw water transmission main (2050 mm dia. MS pipe line) and Pariyej reservoir location is about 54 km from Pipli Pumping Station.

Raw water from the existing Raw water sump (16 ML) will be conveyed by pumping to stilling chamber of WTP at TP1 of Dholera SIR. The location of Pipli Pumping station is 13.5 km away from WTP at TP1 of Dholera SIR.

The raw water shall be transferred to Stilling chamber of Water Treatment Plant (WTP) by pumping system and the treated water from WTP shall be stored to clear water reservoir (CWR). From clear water reservoir the treated water shall be pumped to the potable water reservoirs (MBRs) located within different Town Planning (TP) Schemes areas (TP1, TP2E, TP2W and TP4).

The project components for the Potable water supply system for Dholera SIR will be as follows-

- Raw water pumping station at Pipli raw water Pumping Station
- Raw water Transmission
- Water Treatment Plant (under separate package)
- Clear Water Reservoir and Clear Water Pumping Station (under separate package)
- Potable Water Transmission Main (under separate package)
- Master Balancing Reservoir at TP2E & Potable water Pumping station at TP2E (under separate package)
- Potable Water Rising Mains From MBR-P To ESRs (under separate package)

The general scope of work covers the Design, Procurement, Construction, Installation, Testing, Commissioning, Trial Run of 3 months, 5 yr. O&M of all Civil, Mechanical, Electrical, Instrumentation and Automation Works for the following:

- Raw water Pumping Station including
  - a) Existing Raw Water Sump (not in the scope of work)
  - b) Pumping Machinery
  - c) Control Room

d) Security Cabin

- Raw Water Transmission Main of 13.5 km length

## 1.2 Raw Water Pumping Station

### 1.2.1 Existing Raw Water Sump (Not in the Scope of work)

Raw water from the existing raw water sump (16 ML) will be conveyed by pumping to stilling chamber of WTP at TP1 of Dholera SIR.

**Table 3: Details of existing Raw Water Sump**

| Parameter        | Description  |
|------------------|--|
| Type             | RCC structure- partially underground/ Above Ground and covered |
| Storage Capacity | 16 ML  |
| Size             | 45 m x 45 m x 4.2 m (2 Nos)                                    |

The Contractor shall coordinate with GWIL (Gujarat water Infrastructure Limited) for installation of pumping machinery and associated works into the existing raw water sump (16 ML) in Pipli pumping station premises.

### 1.2.2 Pumping Machinery

Submersible pumps to be installed in the existing raw water sump to transmit raw water from existing sump to WTP at Dholera SIR.

The scope shall include but not limited to pumping machinery, motors, motorized control valves/gates, chain pulley blocks of suitable capacity, Dewatering pumps, Suction and delivery piping manifold, pressure gauge/transmitters, bulk flow meter and a dedicated maintenance and unloading bay, necessary electrical installations with VFD, MCC room and instrumentation works as per standards and specifications as per schedule-D including designing and providing all automation requirements for Pumps, motorized control valves, water level transmitters, flow measuring and controlling mechanism, electromagnetic bulk flow meters for delivery pipe and common delivery header including water hammer control devices.

The scope also covers the design, supply, installation, testing and commissioning of SCADA/DCS system for controlling of pump house from control room, power cables ,communication cables, instrumentation cables, RTU (Remote Terminal Unit) and related instruments including the housing and protection system, connection of all cables for the RTU's , motorized Control valves (Inlet, outlet, & Interconnecting), pressure transmitters, electro-magnetic bulk flow meters, and water level indicators/ transmitters, CCTV surveillance requirements, all power supply points, clean earthing for all instruments etc.

The Layout drawing of raw water pumping station is given in **Appendix BI**.



The details of pumping machinery are described in the table below.

**Table 4: Pumping Machinery**

| Parameter                      | Description                    |
|--------------------------------|--------------------------------|
| Pump Type                      | Submersible Pumps              |
| No. of Pumps & Pumping Pattern | 2 Nos. -1 W + 1 SB * (Minimum) |
| Head                           | 25-30 m                        |
| Minimum Combined efficiency    | 75%                            |

\*W- Working, SB- Stand By;

### 1.2.3 Security Cabin

Security cabin shall be of size 3m x 6 m with Toilet, security arrangements including intercom system has been proposed at Pumping Station site.

Security cabin and security arrangements including intercom system shall be provided in accordance with the Standards and Specifications as referred in Schedule-D for the Pumping station.

### 1.2.4 Control Room

Control room shall be of size 11.2X 10.0 m. The tentative area requirements for different components are as below.

Control room shall be provided in accordance with the Standards and Specifications as referred in Schedule-D and for the Pumping Station.

**Table 5: Details of Control Room**

| Sr. No | Description     | Size (Length x Width) |
|--------|-----------------|-----------------------|
| 1.     | SCADA /DCS Room | 4.5 m x 6.0 m         |
| 2.     | Reception Area  | 6.0 m x 2.2           |
| 3.     | Staff Room      | 4.8 m x 3.8m          |
| 4.     | Store Room      | 4.3 m x 3.3 m         |
| 5.     | He Toilet       | 1.5 m x 2.1 m         |
| 6.     | She Toilet      | 1.5 m x 2.1 m         |
| 7.     | Pantry          | 2.8m x 2.1m           |

- Transformer yard, 11 kv substation, HT panel & IMCC panel etc. for Raw water pumping station including permanent power connection for operating Raw water pumping station site is covered in the scope.

- a) Transformer capacity shall be 2 Nos. (1W +1S), each of minimum 630 KVA with continuous duty cycle, Dry type, AN, 11kV/0.433V, 3 phase, 50Hz, Dyn-11 vector group, step down, completely encapsulated cast resin type, OFF load Tap Changer with Neutral Grounding Resistor for Raw water Pumping Station.
  - b) 11KV Switchgear capacity shall be of minimum 3 panel board (630Amp VCB-1 nos. I/Cs + 630Amp VCB-2 nos. O/Gs) indoor totally enclosed sheet steel clad floor mounting, vermin proof, minimum IP-44 fully interlocked Horizontal isolation, extensible, horizontal draw out, air insulated, metal clad switchboard having double isolation features complete with circuits suitable for operation on 11kV 3 phase, 50 cycle, earthed system with a rupturing minimum capacity of minimum 25KA at 11 kV ( may change depending on the incoming supply) complete with PTs and CTs, protective relays complete in all respect and compatible to DCS, etc., for Pumping Station site load requirements.
  - c) Double Pole 11KV Incoming Structure, Transformer Yard, 11Kv Substation and Switchgear, 415V Type Tested Assembly LT Switchgear panel, Intelligent MCC panel , earthing, power feeding equipment, lighting, lightning Protection system, Lighting distribution Boards, Transformer yard, Cables, etc. and all necessary accessories and equipment shall be provided.
  - d) Permanent incoming Power supply connection with n+1 redundancy for operating Pumping Station site load requirements and connection need to be obtained by the Contractor in coordination with UGVCL/State Discom.
- DG set to be provided for raw water pumping station site. DG set capacity is about 630 kVA for raw water pumping station including power supply to field instruments for raw water transmission main.
  - Electrical System including all power feeding equipment, lighting, lightning Protection system, etc. complete
  - Instrumentation & control system for the pumping station site with 100% power backup by UPS
  - The Control Room will have SCADA/DCS system for pumping station. The SCADA/DCS of raw water pumping station to be interlinked with the Distributed Control System (DCS) of WTP at TP1 of Dholera SIR. The SCADA/DCS system for raw water pumping station and WTP - DCS shall be further connected to the City's Command & Control Centre / ICT building over end to end Fiber Optic (FO) connectivity (complete and fully functional in all respects). This connectivity will be approved by Employer's Engineer in consultation with ICT Consultant and any suggestions by ICT Consultant shall be incorporated. The system architecture drawing is attached in Appendix B1.
  - The scope of work for SCADA/DCS system from the raw water pumping station shall include the following
    - a. Automatic Controlling and Monitoring of raw water pumping station ( all mechanical electrical and instrumentation units), RTUs, motorized control valves, motorized sluice gates, pressure transmitters, electro-magnetic flow meters, housing of RTUs, all online analyzers, electric motors, pumps, CCTV surveillance requirements for raw water pumping station site etc. This includes the power cables, fiber cables, instrumentation cables, clean earthing for all instruments etc.

- b. The laying of optical fiber cable from pumping station to Control room and to WTP – SCADA Control Room at Water Treatment Plant. The Control room of pumping station shall be linked with control system (through RTUs) of the raw water transmission main.

- CCTV system shall be provided for the raw water pumping station site

Fully functional CCTV based surveillance system including ICT shall be provided along the periphery of the pumping station site that includes laying of HDPE ducts and OFC cables (as needed) along with end to end and fully functional inside building cabling, Network Switches, Racks, Servers and Access Control and Security & Surveillance System, Video Management Software Application Platform etc. The Contractor shall be responsible to create an entrance facility for Ducts and OFC cables required to connect with Control Room.

The CCTV surveillance must be integrated and cock pits (one or multiple) be provided within the project components and all the feeds as required centrally in City's Command and Control Center/ ICT building and / or as needed will be with end to end fully functional infrastructure by the Contractor .

The above requirements shall be provided by the contractor in consultation with ICT consultant and approved by Employer's Engineer

#### **Asset Management**

- Each and every asset pertaining to project components must be engraved as per the city asset management tagging scheme and engraving specifications to be specified by Employer's Engineer/ Employer in consultation with ICT Consultant. Engraving methodology and materials (including painting, writing, character size etc.) and scheme must match with the above requirements.

Contractor will prepare an accurate and complete list of all the assets as per the format given by Employer's Engineer/Employer in consultation with ICT Consultant and will feed / upload in to local AM package (e.g. Maximo) as well as in ERP or central assets management package to be decided later. Aforementioned lists are to be fed / uploaded and will also have other details explained elsewhere including pertaining to planned maintenance, replacement requirements etc. over the envisaged life cycle of each and every equipment / asset to the lowest level.

Multiple hard copies of such lists will be handed over to Employer's Engineer for approval and upon transition (post completion of operations).

Contractor will also build end to end on line interface over enterprise service bus and / or application programming interface and /or any other means decided by Employer in consultation with ICT Consultant between local AM module (such as Maximo) and central ERP.

The assigned Plot area for Control Room about 0.05 Ha. The Contractor has to design the raw water pumping station and control room site layout in consultation with Employer's Engineer and GWIL.

### **1.3 Raw Water Transmission Main**

The raw water transmission main will be from the raw water pumping station at Pipli to the

Water Treatment Plant (WTP) within the TP1 area. Total approximate length of the raw water transmission main is 13.5 Km & working pressure in the pipeline will vary between 25-30 m.

The scope for this item covers designing, supplying, lowering, laying and jointing of pipes & valves (Air valves, Scour valves, Sluice/Butter fly valves) including all specials, excavation, backfilling, bedding, foundation, construction of thrust blocks, nallah/river crossings, valve chambers and water meter chambers and other accessory structures. The scope of work also includes the design of surge analysis and design and installation of surge protection devices as required in the raw water transmission main.

The scope further includes designing, supplying and installation of Field instruments e.g. RTUs (including the housing of RTUs), Motorized control valves, Online Analyzers (pH, Turbidity, TDS), Pressure transmitters and electro-magnetic bulk flow meters in the raw water transmission main to control and monitor the leakages in transmission main system at different locations and also at Nallah, Sukhbhadar river crossings. The field instruments along the raw water transmission main are to be controlled and monitored through SCADA/DCS system from the control room of raw water Pumping Station. The scope of work includes laying of power cables, CSS (compact substations), communication cables and instrumentation cables from the Raw water pumping station to WTP on as required basis.

Any existing Structures/ Existing Water supply lines /Electrical lines and poles /any other utilities/service shall be identified by the Contractor before the execution and these need to be shifted based on alignment of raw water transmission main. The alignment of Raw Water Transmission Main is given in **Appendix BI**.

The scope of this item includes supply of water for carrying out hydraulic test for raw water transmission main as and when required. The details of raw water transmission mains are as follows:

**Table 6: Details of Raw Water Transmission Main**

| S. No. | Description   | Value   |
|--------|---------------|---|
| 1      | Pipe diameter | 700 mm  |
| 2      | Pipe Material | DI K-9  |
| 3      | Length        | 13.5Km  |
| 4      | Alignment     | Along SH-6 & Kadipur Village road (refer Appendix B I for the route of the raw water transmission main) |

#### **1.4 Water Treatment Plant (Under Separate Contract Package)**

The Stilling chamber of WTP will receive raw water from raw water transmission main. The implementation of Water Treatment Plant (WTP) will be covered under the EPC contract for the “Design, Construction, Operation & Maintenance of Water Treatment Plant, Clear Water Reservoir (CWR) at TP1, Potable water transmission main and Master balancing reservoir at TP2E in DSIR”

The Contractor shall coordinate with the EPC Contractor for the “Design, Construction, Operation & Maintenance of Water Treatment Plant, Clear Water Reservoir (CWR) at TP1, Potable water transmission main and Master balancing reservoir at TP2E in DSIR” project for connection of raw water transmission main to inlet of Stilling chamber of WTP at TP1 of Dholera SIR. The Layout drawing of Water Treatment Plant is given in **Appendix BI**.

## **2.0 Specifications and Standards**

The project works shall be designed and constructed in conformity with the Specifications and Standards specified in Schedule-D.

## **3.0 Change of Scope**

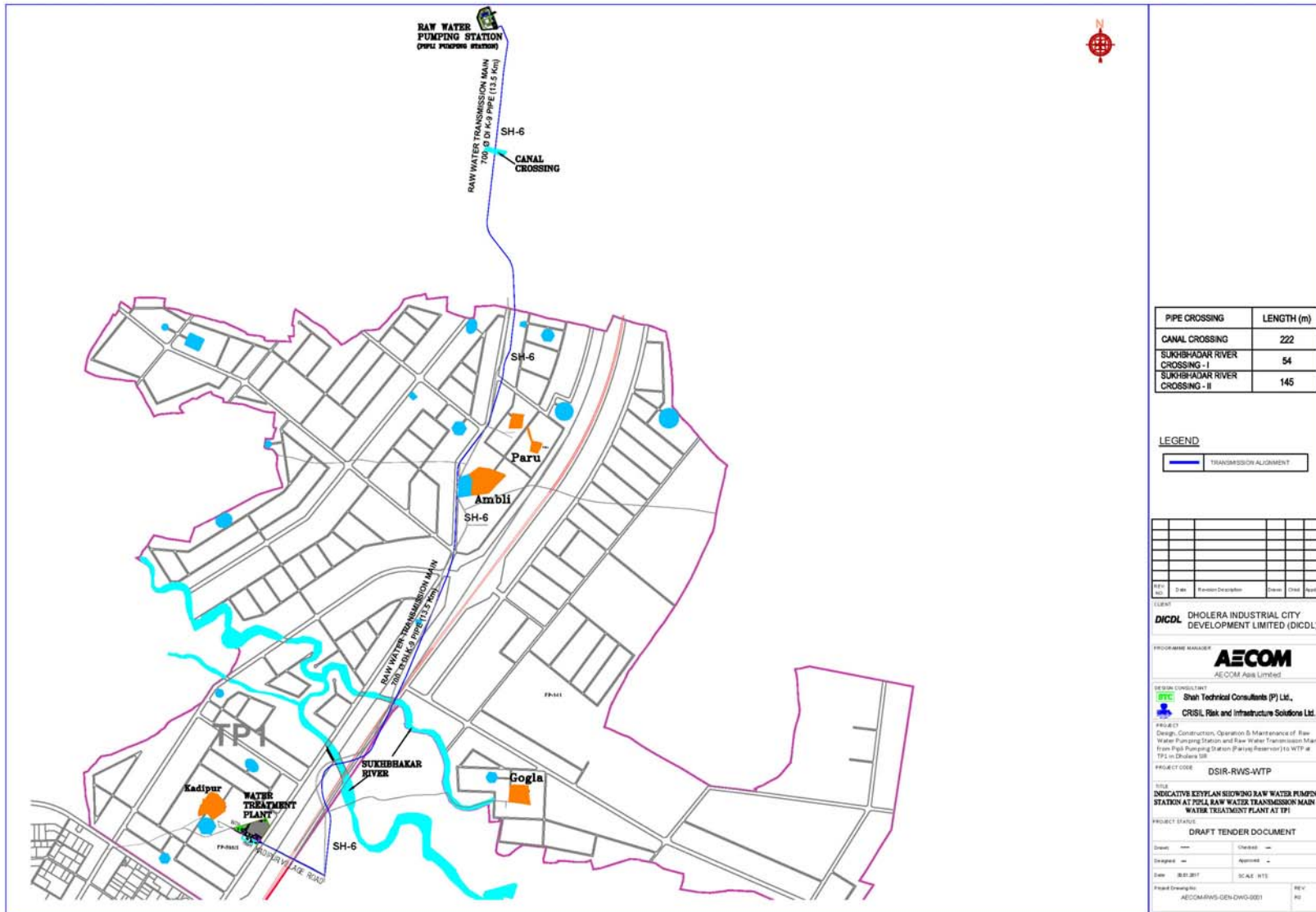
The work specified hereinabove shall be treated as an approximate assessment. The actual works as required on the basis of detailed design and investigations shall be determined by the Contractor in accordance with the Specifications and Standards. Any variations in the detailed design for the works specified in this Schedule-B shall not constitute a Change of Scope, save and except any variations in the works arising out of a Change of Scope expressly undertaken in accordance with the provisions of Article 13.

**Appendix B I – List of Drawings**

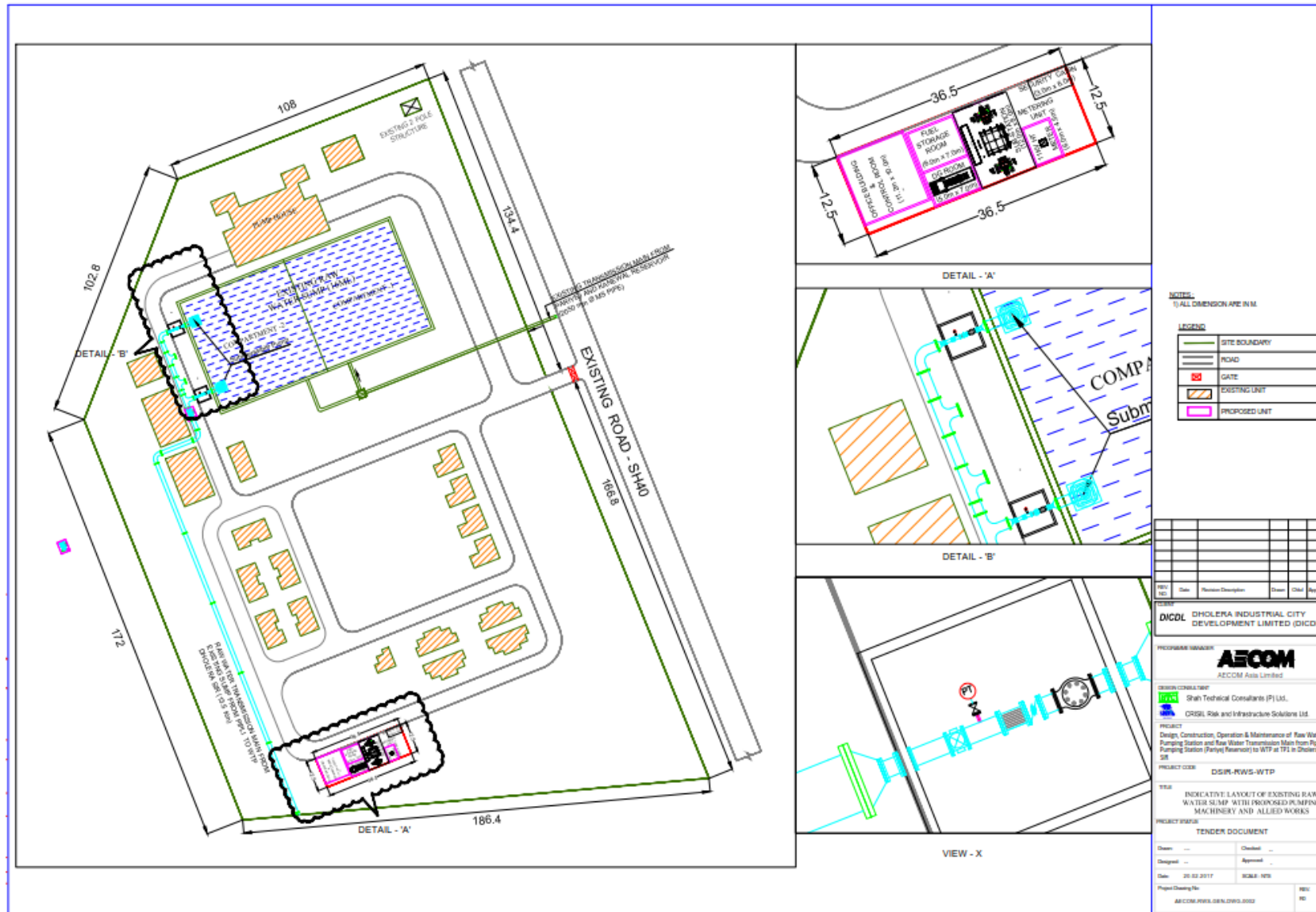
(Schedule-B)

| <b>Sl. No.</b> | <b>Description</b>   | <b>Drawing No.</b>     |
|----------------|--|------------------------|
| 1              | INDICATIVE KEYPLAN SHOWING RAW WATER PUMPING STATION AT PIPLI, RAW WATER TRANSMISSION MAIN & WATER TREATMENT PLANT AT TP1          | AECOM-RWS-GEN-DWG-0001 |
| 2              | INDICATIVE LAYOUT OF EXISTING RAW WATER SUMP WITH PROPOSED PUMPING MACHINERY AND ALLIED WORKS                                      | AECOM-RWS-GEN-DWG-0002 |
| 3              | TENTATIVE PLAN AND SECTION OF OFFICE BUILDING & CONTROL ROOM (11.2m x 10 m)  | AECOM-RWS-GEN-DWG-0003 |
| 4              | SCADA SYSTEM / DISTRIBUTED CONTROL SYSTEM(DCS) ARCHITECTURE FOR RAW WATER PUMPING STATION  | AECOM-RWS-GEN-DWG-0004 |
| 5              | INDICATIVE LAYOUT OF RAW WATER RESERVOIR (RWR) & PUMPING STATION (RWPS), WATER TREATMENT PLANT (WTP) & CLEAR WATER RESERVOIR (CWR) | AECOM-RWS-GEN-DWG-0005 |

Design, Construction, Operation & Maintenance of Raw water pumping station at Pipli and Raw water transmission from Pumping station to WTP at TP1 in DSIR

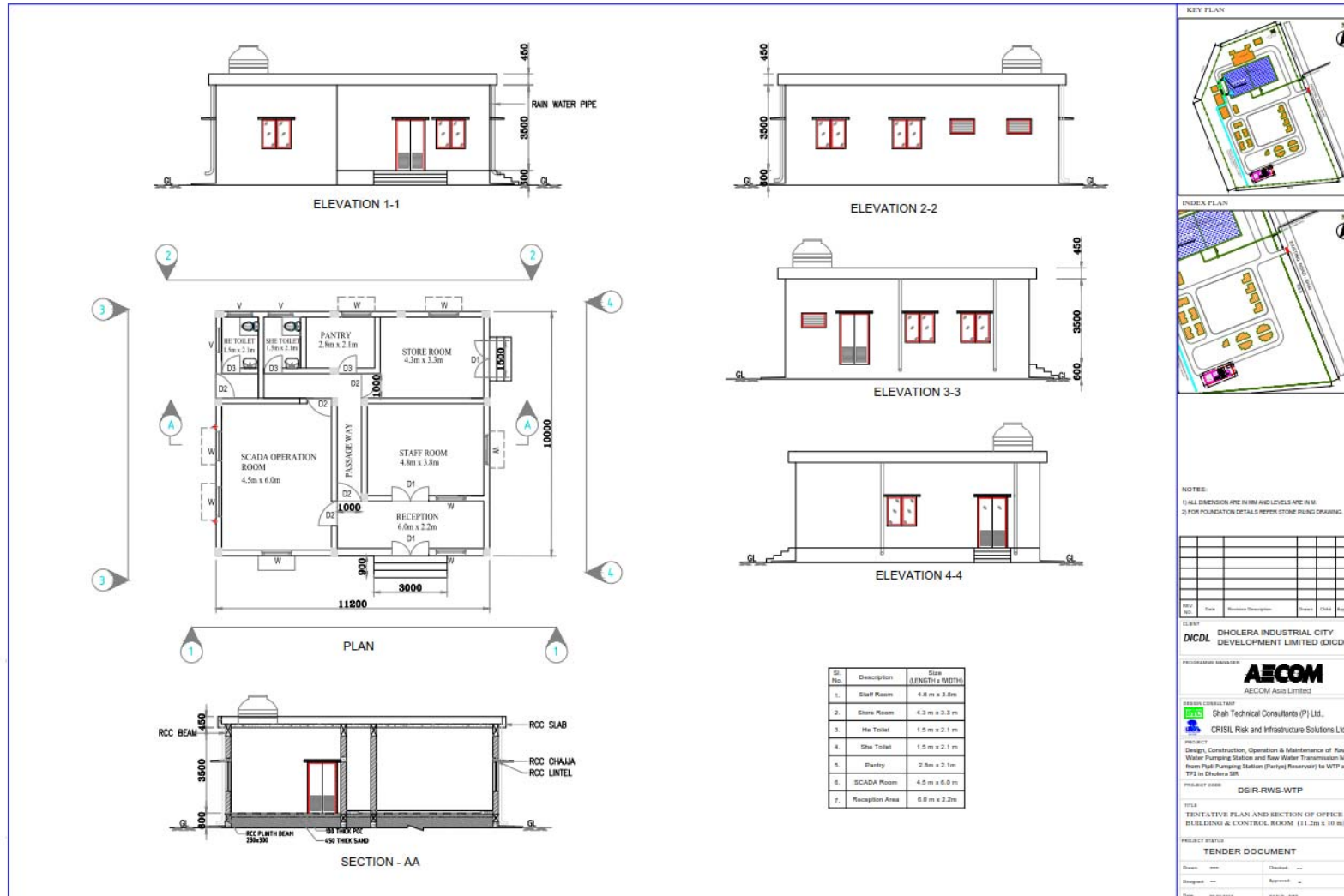


Design, Construction, Operation & Maintenance of Raw water pumping station at Pipli and Raw water transmission from Pumping station to WTP at TP1 in DSIR

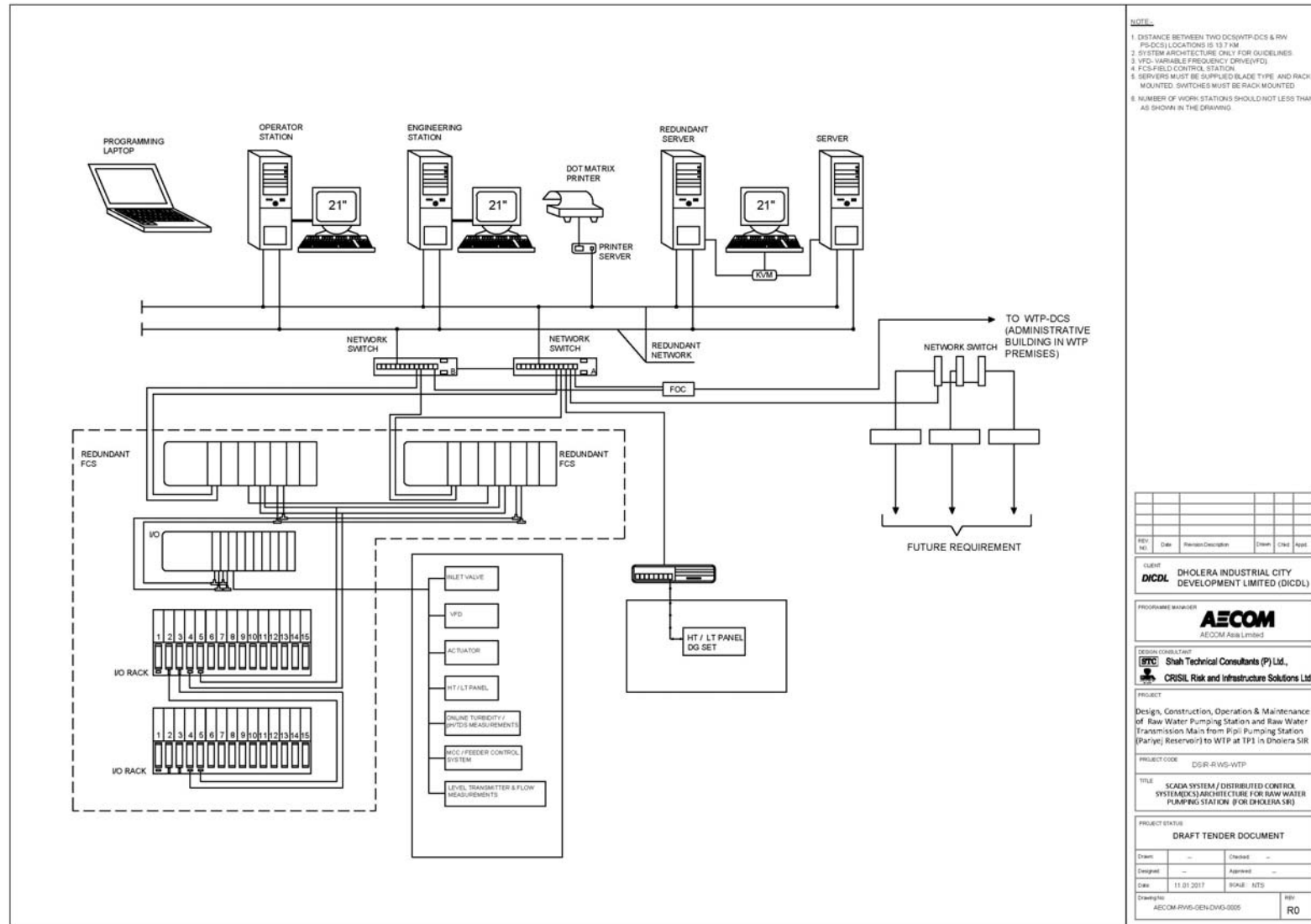




Design, Construction, Operation & Maintenance of Raw water pumping station at Pipli and Raw water transmission from Pumping station to WTP at TP1 in DSIR



Design, Construction, Operation & Maintenance of Raw water pumping station at Pipli and Raw water transmission from Pumping station to WTP at TP1 in DSIR



Design, Construction, Operation & Maintenance of Raw water pumping station at Pipli and Raw water transmission from Pumping station to WTP at TP1 in DSIR



**Schedule C - Project Facilities**

*(See Clause 2.1)*

*Deleted*

## Schedule D – Specifications and Standards

(See Clause 2.1)

The Contractor shall comply with the Specifications and Standards set forth in this Schedule D for Design and Construction of Project Works.

### 1. Water Demand

The DSIR of total area of about 920 sq. km is divided into six Town Planning Schemes. The project was envisaged to be developed over 3 Phases. Out of Six TP Schemes, TP1, TP2 and Part of TP4 cover the development in Phase-1. Year wise water demand for Activation Area/ Phase-1 development is given in the Table-9

**Table 7: Water demand for Activation Area/Phase -1 (in MLD)**

| Year           | Water Demand (MLD)                               |
|----------------|--|
| Year 2019      | 7  |
| Year 2020      | 14   |
| Year 2021      | 22   |
| Year 2022      | 30   |
| Year 2023      | 40   |
| Year 2024      | 50   |
| Year 2024-2028 | Up to 100 MLD depending upon pace of development |

*Note: The above water demand is for reference only*

### 2. Raw Water Quality

The expected quality of raw water parameters at the raw water pumping station is given below.

**Table 8: Raw Water Quality Parameters**

| Parameters | Value     | Unit |
|------------|-----------|------|
| Turbidity  | 50.00     | NTU  |
| Alkalinity | 70.00     | mg/l |
| pH         | 8.1 - 7.7 | mg/l |

### 3. Raw water Pumping Station

#### 3.1 Existing Raw Water Sump

The details of existing raw water sump & proposed pumping machinery for Dholera SIR are described in the table below.

**Table 9: Details of Existing Raw Water sump**

| Parameter                      | Description                                       |
|--------------------------------|---|
| <b>Existing Raw Water Sump</b> |   |
| Type                           | RCC structure partially underground/ above ground |
| Storage Capacity               | 16 ML   |
| Size                           | 45 m x 45 m x 4.2 m ( 2 Nos.)                     |

### 3.2 Pumping Machinery

The details of pumping machinery are described in the table below.

**Table12: Details of Existing Raw Water sump**

| Parameter   | Description                    |
|---|--------------------------------|
| <b>Proposed Pumping Machineries for Dholera SIR</b> |                                |
| Type  | RCC structure                  |
| Pump Type   | Submersible                    |
| No. of Pumps & Pumping Pattern                      | 2 Nos. -1 W + 1 SB * (Minimum) |

\* W= working, SB = standby

- **Pumping Hours:** The pumping hours are based on water requirement for Dholera SIR at different years

**Table 10: Raw Water sump & Pump House and Pumping Machineries**

| Year | Water Requirement(MLD) | Hours of Pumping |
|------|------------------------|------------------|
| 2019 | 7                      | 5.6              |
| 2020 | 14                     | 11.2             |
| 2021 | 22                     | 17.6             |
| 2022 | 30                     | 24.0             |
| 2023 | 30                     | 24.0             |

### 3.3 Control Room

The office building and control room should be designed as RCC framed structure. This office building and control room shall have the following rooms.

- SCADA/DCS Room
- Staff Room
- Store Room
- He Toilet
- She Toilet
- Pantry

- Reception Area

The roof terrace with parapet shall be accessible for inspection via a RCC staircase. The Control room shall be provided with all standard amenities. Minimum floor to ceiling height of these areas shall be 4.5 m. The office building and control room shall be provided with ladies and gents Toilet, pantry/ canteen. The look and feel of the Control room to be designed aesthetically and the architectural design to be approved by the Employer's Engineer. Air conditioning shall be provided in entire office building and control room.

#### 8.14.1 Control Room

The Control room shall be located such that entire raw water pumping station site shall be preferably visible to the operator through glazed windows.

The panel mounted indicators shall show the status of whole pumping station site. The control room shall be provided with false ceiling with decorative luminaries fittings, tiles/ marbles flooring. The necessary furniture shall be provided (minimum 4 nos. revolving chairs with armrest, minimum 2 nos. office tables with chair) 1 no. Almira for storage of manuals / drawings, 2 nos. suitable capacity air conditioners, etc.

The control room shall be provided with the hardware and software as detailed in the control system architecture and furniture specified elsewhere in the document.

#### 8.14.2 Intercom System

An intercom system shall be provided between the following points within the raw water pumping station :

- Control Room
- All pump house and compressor rooms.
- Security Cabin at the entrance of the campus
- Intercom between Pumping Station and WTP compound

### 4 Raw Water transmission main from the Raw water pumping station to WTP at TP1

Raw water from the existing Raw water sump (16 ML) will be conveyed by pumping to stilling chamber of WTP at TP1 of Dholera SIR.

Capacity of raw water Transmission pumping main is planned to meet the raw water requirement for initial development of Activation Area. The design parameters for the raw water transmission main shall be as follows –

**Table 11: Design Parameters for Water Transmission Main from Pipli to WTP**

| Parameter   | Parameters to be Considered |
|---|-----------------------------|
| Design Flow   | 1250 cum/hr                 |
| Minimum flow velocity in pipe                           | 0.8 m/s                     |
| Maximum flow velocity in pipe                           | 1.8 m/s                     |
| Minimum Residual head at lip of Stilling chamber of WTP | 2.0 m                       |

| Parameter                           | Parameters to be Considered      |
|-------------------------------------|----------------------------------|
| Clear cover above the crown of pipe | 1 m                              |
| Bedding                             | Type – Granular<br>Depth – 200mm |
| Max. Unit head loss in the Pipe     | 10 m/Km.                         |
| Pipe Material                       | D.I. K-9                         |
| Hazen William coefficient (C)       | 140 (Design purpose)             |

## 5 Stilling Chamber of Water Treatment Plant

### 5.1 Water Treatment Plant (WTP)

The 150 MLD water treatment plant planned to cater the potable water demand of Phase – 1 and partial potable water demand of Phase II.

#### 5.1.1 Stilling chamber

Raw water transmission main from raw water pumping station shall be connected to inlet pipe at upstream of stilling chamber.

#### Details of Stilling Chamber

| Parameters                       | Design Criteria          |
|----------------------------------|--------------------------|
| Flow for WTP (Stage I, II & III) | 150MLD + 20% overloading |
| HRT at average flow              | 30 sec.                  |
| Free Board                       | 500 mm ( Minimum)        |

## 6 Pipes & fitting, Valves and Mechanical equipment Specifications for the raw water Pumping Station works and raw water transmission main

The pipework layout within pumping stations shall have the approval of the pump manufacturer.

**Table 12: Design parameters for piping works in Pumping station**

| Parameter           | Description          |
|---------------------|----------------------|
| Suction pipe        | velocity - 2.0 m/s   |
| Inlet of bell mouth | velocity - 1.5 m/s   |
| Delivery pipe       | velocity - <2.5 m/s. |

The design and Construction of Pumping station and raw water transmission main shall confirm to design requirements and construction specifications set out in the following Indian and International Standards.



**Table 13: Relevant Indian Standards & Specifications**

| Sr. No. | Code or Standard                                    | Description  |
|---------|---|--|
| 1.      | Manual for Water Supply & Treatment                 | CPHEEO Manual for Water Supply & Treatment -1999- MoUD, GoI  |
| 2.      | Manual on operation and Maintenance on water supply | CPHEEO Manual on Operation and Maintenance of water supply systems, 2005 MoUD, GoI   |
| 3.      | SP 7 (Part-9 Section-1) 1983                        | National Building Code of India  |
| 4.      | SP 35   | Hand book on water supply & drainage   |
| 5.      | IS 3589-2000  | Electrically welded steel pipes for water, gas and sewerage (150 to 2000 mm nominal size)  |
| 6.      | IS 5822   | Code of practice for laying of welded steel pipes for water supply   |
| 7.      | IS 7322-1989  | Code for MS Specials   |
| 8.      | IS 4711   | Method for sampling of steel pipes, tubes and fitting  |
| 9.      | IS 10221  | Code of practice for coating and wrapping of underground steel pipelines   |
| 10.     | IS: 8329-2000                                       | Centrifugally Cast (spun) ductile iron pressure pipes for water, gas and sewage  |
| 11.     | IS: 5382-1985                                       | Specification for Rubber sealing rings for gas mains, water mains and sewers.  |
| 12.     | IS: 638   | Specification for rubber and insertion jointing.   |
| 13.     | I.S. 1538 (Part I to XXII) 1976                     | Specification for cast Iron fittings for pressure pipes for water, gas and sewage  |
| 14.     | IS: 3658-1981                                       | Code of practice for liquid penetrant flaw detection   |
| 15.     | IS 4984/1995  | High density polyethylene pipes for potable water supplies   |
| 16.     | IS: 9523  | Ductile iron fittings for pressure pipes for water, gas and sewerage   |
| 17.     | IS: 1500  | Code for Hardness test for DI pipes  |
| 18.     | IS 7634 Part-2 (2012)                               | Code of practice for plastic pipework for potable water supplies –Laying and jointing of polyethylene pipes                        |
| 19.     | IS 8360 :2003                                       | Fabricated high Density polyethylene (HDPE) fittings for potable water supplies  |
| 20.     | IS 8008   | Injection-molded HDPE fittings for potable water supplies  |
| 21.     | IS 11606-1986                                       | Methods of sampling cast iron pipes and fittings   |
| 22.     | IS 11906:1986                                       | Recommendations for cement mortar lining for cast iron, Mild steel and Ductile Iron pipes and fittings for transportation of water |

| Sr. No. | Code or Standard    | Description  |
|---------|---------------------|--|
| 23.     | IS 8062             | Code of practice for cathodic protection for steel structures                              |
| 24.     | IS 12288:1987       | Code of practice for laying of ductile iron  |
| 25.     | IS 779:1994         | Water meters (Domestic Type)   |
| 26.     | BIS IS 2104: 1981   | Water meter boxes (domestic type)  |
| 27.     | IS2373:1981         | Water meter (bulk type)  |
| 28.     | BIS IS 2401: 1973   | Code of Practice for fire selection, installation and maintenance of domestic water meters |
| 29.     | IS 6784:1996        | Method for performance testing of water meters (domestic type)                             |
| 30.     | IS 14846:2000       | Sluice valves for water works purposes (50 to 1200 mm size)                                |
| 31.     | IS 2906:1990        | Sluice valves for water works purposes (350 to 1200 mm size)                               |
| 32.     | IS: 13095 / BS 5155 | Butterfly Valves   |
| 33.     | IS 2685:1971        | Code of practice for selection, installation and maintenance of sluice valves              |
| 34.     | IS 3950:1979        | Surface boxes for sluice valves  |
| 35.     | IS 5312             | Swing check type reflux( non-return) valves for water works purposes                       |
| 36.     | IS 9739:1981        | Pressure reducing valves for domestic water supply systems                                 |
| 37.     | IS 210              | Specification for grey iron casting  |
| 38.     | IS 816              | Code of practice for use of metal arc welding for general construction in mild steel       |
| 39.     | IS 1367             | Technical supply conditions for threaded steel fasteners                                   |
| 40.     | IS 1387             | General requirements for the supply of metallurgical materials                             |
| 41.     | IS 1536             | Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage  |
| 42.     | IS 1537             | Specification for vertically cast iron pressure pipes for water, gas and sewage            |
| 43.     | IS 1538             | Specification for cast iron fittings for pressure pipes for water, gas and sewage          |
| 44.     | IS 1608             | Metallic Material tensile testing at ambient temperature                                   |
| 45.     | IS 1916             | Specification for steel cylinder pipes with concrete lining and coating                    |
| 46.     | IS 3658             | Code of practice for liquid penetrant flow detection                                       |
| 47.     | IS 5382             | Specification for rubber sealing rings for gas mains, water mains and sewers               |
| 48.     | IS 5504             | Specification for spiral welded pipes  |
| 49.     | IS 6587             | Specification for spun hemp yarn   |

| Sr. No. | Code or Standard | Description   |
|---------|------------------|---|
| 50.     | IS 7322          | Specification for specials for steel cylinder reinforced concrete pipes |
| 51.     | IS 3114          | Code of practice for laying of cast iron pipes                          |
| 52.     | IS 2379 1990     | Pipelines –Identification –Color Code                                   |

**Table 14: Relevant International Standards & Specifications**

| Sr. No. | Code or Standard | Description   |
|---------|------------------|---|
| 1       | ISO: 10803-1997  | Design method for ductile iron pipes  |
| 2       | ISO: 2531-1991   | Ductile iron pipes, fittings and accessories for pressure pipelines.                                      |
| 3       | ISO: 4179-1985   | Ductile iron pipes for pressure and non-pressure-Centrifugal cement mortar lining – General requirements. |
| 4       | BS: 3416         | Bitumen based coatings for cold application, suitable for use in contact with Potable water.              |
| 5       | ISO: 8179-1995   | Ductile iron pipes-External coating-Part-1 Metallic Zinc with finishing layer.                            |
| 6       | ISO: 4633-1996   | Rubber seals-Joint rings.   |
| 7       | AWWA C600        | Installation of ductile iron water mains and their appurtenances  |
| 8       | BSEN -545        | Code for Ductile Iron Flanges and Specials  |
| 9       | AWWA Manual M11  | Steel Pipe- A guide for design and Installation (Fourth Edition)  |
| 10      | AWWA Manual M41  | Ductile Iron Pipe and Fittings (Third Edition)  |

## 7 List of Standards for various mechanical equipment

The various standards referred to in the specifications are indicated below. Pipes and valves covered in the above table 25 and 26.

**Table 15: Relevant Indian Standards & specifications for Mechanical Items**

| Sr. | Code No | Description   |
|-----|---------|---|
| 1.  | IS: 5   | Colours for ready mixed paints and enamels  |
| 2.  | IS: 210 | Grey Iron Castings  |
| 3.  | IS: 318 | Leaded Tin Bronze Ingots and Castings   |
| 4.  | IS: 325 | Three Phase Induction Motors  |
| 5.  | IS: 807 | Code of Practice for design, manufacture, erection and testing (structural portion) of cranes and hoists. |

| Sr. | Code No   | Description  |
|-----|-----------|--|
| 6.  | IS: 1239  | Mild Steel tubes, tubular and other wrought steel fittings.  |
| 7.  | IS: 1554  | PVC insulated (heavy duty) electric cables   |
| 8.  | IS: 2062  | Steel for general structural purposes  |
| 9.  | IS: 2147  | Degrees of protection provided by enclosures for low voltage switch gear and control gear                          |
| 10. | IS: 3109  | Short link chain, Grade M (4)  |
| 11. | IS: 3177  | Code of practice for electric overhead travelling cranes and gantry cranes other than steel work cranes.           |
| 12. | IS: 3618  | Phosphate treatment for iron and steel for protection against corrosion  |
| 13. | IS: 3624  | Vacuum and Pressure gauges   |
| 14. | IS: 3815  | Point hooks with shank for general engineering purposes.   |
| 15. | IS: 3938  | Electric wire rope hoists  |
| 16. | IS: 4029  | Guide for testing three phase induction motors.  |
| 17. | IS: 4460  | Method for rating of machine cut spur and helical gears.   |
| 18. | IS: 4691  | Degrees of protection provided by enclosure for rotating electrical machinery                                      |
| 19. | IS: 6005  | Code of practice for phosphating of iron and steel   |
| 20. | IS: 11592 | Code of practice for selection and design of belt conveyors  |
| 21. | IS: 13349 | Cast Iron Single faced thimble mounted sluice gates  |
| 22. | BS: 436   | Spur and helical gears   |
| 23. | BS: 466   | Specification for power driven overhead travelling crane, semi goliath and goliath cranes for general use          |
| 24. | BS: 545   | Specification for bevel gears (machine cut)  |
| 25. | BS: 721   | Specification for worm gearing   |
| 26. | BS: 970   | Wrought steels for mechanical and allied engineering purposes  |
| 27. | BS: 1397  | Specification for industrial safety belts, harnesses and safety  |
| 28. | BS: 1400  | Specification for copper alloy ingots and copper alloy and high conductivity copper castings                       |
| 29. | BS: 1452  | Specification for flake graphite cast iron   |
| 30. | BS: 1663  | Specification for higher tensile steel chain Grade 40 (Short link and pitched or calibrated) for lifting purposes. |
| 31. | BS: 2573  | Specification for classification, stress calculations and design of mechanisms.                                    |
| 32. | BS: 2600  | Radiographic examination of fusion welded butt joints in steel   |

| Sr. | Code No    | Description  |
|-----|------------|--|
| 33. | BS: 2903   | Specification for higher tensile steel hooks for chains, Slings, blocks and general engineering purposes                       |
| 34. | BS: 2910   | Methods for radiographic examination of fusion welded Circumferential butt joints in steel pipes.                              |
| 35. | BS 3017    | Specification for mild steel forged ram short hooks  |
| 36. | BS: 3100   | Specification for steel castings for general engineering Purposes.   |
| 37. | BS: 3923   | Methods for ultrasonic examination of welds.   |
| 38. | BS: 4360   | Specification for weldable structural steels.  |
| 39. | BS: 4772   | Specification for ductile iron pipes and fittings Specification for approval testing of welding procedures.                    |
| 40. | Part – I:  | Fusion Welding of Steel Specification for approval testing of welders working to approved welding procedures                   |
| 41. | Part – I:  | Fusion Welding of Steel  |
| 42. | BS: 4942   | Short chain link for lifting purposes.   |
| 43. | BS: 5135   | Specification for arc welding of carbon and manganese Steels   |
| 44. | BS: 5316   | Specification for acceptance tests Part – 2 for centrifugal, mixed flow and axial pumps – Test for performance and efficiency. |
| 45. | BS: 6072   | Method for magnetic particle flaw detection  |
| 46. | BS: 6405   | Specification for non-calibrated short link steel chain (Grade 30) for general engineering purposes: Class 1 & 2               |
| 47. | BS: 6443   | Method for penetrate flaw detection  |
| 48. | ASTM A-36  | Specification for Structural Steel   |
| 49. | ASTM A-216 | Specification for steel castings, carbon suitable for fusion Welding for high temperature service                              |
| 50. | ASTM A-276 | Specification for stainless steel and heat resisting steel bars and shapes.  |
| 51. | ASTM A-351 | Specification for castings, Austenitic-Ferrite (Duplex), for Pressure Containing Parts.  |
| 52. | ASTM A-743 | Specification for castings, Iron-Chromium, Iron-Chromium-Nickel, and Nickel Base corrosion Resistant for General Application   |
| 53. | ASTM A-744 | Specification for casting, Iron Chromium-Nickel, Corrosion Resistant   |
| 54. | ASTM B-14B | Specification for Aluminium-Bronze Castings.   |
| 55. | IEC – 189  | Low frequency cables and wires with Part 1 & 2 PVC Insulation and PVC sheath   |

| Sr. | Code No        | Description   |
|-----|----------------|---|
| 56. | AWWA C 501     | Cast Iron Sluice Gates  |
| 57. | API 594 & 598  | Specification for Dual plate check valve  |
| 58. | IS: 3832       | Hand Operated Chain Pulley Blocks   |
| 59. | IS: 3177       | Code of Practice for Electrical Overhead Travelling Cranes & Gantry Cranes other than steel work cranes |
| 60. | IS: 14536      | Selection, installation, operation & maintenance of Submersible Pump set                                |
| 61. | ISO 1940       | Mechanical Vibration balance quality requirements of rigid rotors                                       |
| 62. | IS- 14220-1994 | Openwell submersible pumpsets — Specification   |

## 8 Standard Specifications for Submersible Pumps

### 8.1 Pump:

The pump Casing should be free from blow holes, sludge inclusion and other detrimental defects. Casing should be provided with renewable wearing rings except in radial flow pump set. Casing should be provided with wearing rings. Casing should be hydraulically tested up to 1.5 times shut off pressure. Shut off head shall be at least 120 % of duty Head.

### 8.2 Impeller:

Impeller should be of closed type, ensuring required performance and free of cavitation. The material of impeller will be SS CF 8M or as per Data Sheet.

### Shaft:

The common shaft of pump & motor below the impeller shaft assembly, shaft protection sleeve shall be provided. It shall have surface finishing of 0.75 Microns. The material of shaft shall be as per data sheet

### 8.3 DRIVE MOTOR FOR MONO SUBMERSIBLE PUMP:

The drive rating shall be maximum of following two condition

- 110% of maximum required pump input throughout the range of operation
- Margin above BKW of pump at duty point

| PUMP BKW      | F MARGIN FOR MOTOR DESIGN kW AT DUTY POINT |
|---------------|--|
| Upto 1.5 kW   | 150%                                       |
| 1.5 to 3.7 kW | 140%                                       |
| 3.7 to 7.5 kW | 130%                                       |
| 7.5 to 15 kW  | 120%                                       |

|             |      |
|-------------|------|
| 15 to 75 kW | 115% |
| Above 75 kW | 110% |

The submersible motor shall conform to IS / IEC with Latest revision. It should be totally enclosed squirrel cage induction type water - cooled and water lubricated sealed against entry from outside water.

The windings shall be of wet type. The thrust bearing should be of wet type water lubricated and designed to take all untoward load at most unfavorable running conditions. Front and Rear bearing housing and thrust bearing housing should preferably be fixed separate replaceable bolts/studs and (not threaded connections) to the starter to facilitate easy dismantling. Inspection agency will open the motor base and check the thrust bearing and mark the identification with hard punch or with indelible ink. If the fiber thrust bearing is provided then it shall be marked with indelible ink. Full proof sealing arrangement by sand guard shall be preferred in the Motor inlet body to prevent open well water impurities like sand, silt from entering the motor bearing Stator and Motor should be impregnated with a superior varnish class-B thermal insulation properties by vacuum pressure or epoxy paints on stator cold rolled stamping used and rotor shall be painted with Polyurethane paint & backed properly under controlled temperature condition and not by manual or gravity flow to remove air pocket so that these are thoroughly filled up by varnish. Motor rotor should be preferably lead shot blasted. Subsequently, rotor body should be baked repeatedly under controlled conditions to ensure long life of paint and hard finish to the surface to avoid corrosion before power coating.

The rotor shaft shall be with sleeves having materials as per data sheet. The windings should be accessible to facilitate checking and locating any faults without disturbing all the coils and also to enable replacement of any defective coils. It should be possible to rewind the Stator with readymade protested coils in order to save time during the repair. Kelvin bridge/digital resistance meter shall be treated preferable for measurement of hot and cold resistance of winding for evaluated temperature rise. Full proof arrangement should be made for stopping the rotating of shifting of stampings inside the stator body due to operation of pump sets. Earth leakage current should not be more than 50 milli-amperes at rated voltage.

Minimum H.P. rating shall not be less than the H.P. shown in the Data Sheets. However, the motor shall not get overloaded during the specified range. Also, the shut-off head of the pump shall be more than 15 % of the Duty point Head shown in data sheet

NOTE: Starting method: Up to 7.5 HP D.O.L. Starter / above 7.5, upto & including 20 HP Star Delta and . and above Auto Transformer Starting.

**CABLE:**

Motor shall be provided with Three Core Flat PVC waterproof and flexible copper submersible cable of min. 50 m length and of suitable size as per actual requirement. The cross sectional areas should be sufficient so as not to cause voltage drop of more than 2.5% of nominal voltage i.e. 10 V at 415V throughout the length of the cable size of flat cable as per Annexure - I. The submersible cable should be as per approved Vendors.

**MARKING:**

A Name plate of corrosion resistance material shall be affixed on pump sets with following details:

- a. Manufacture Name

- b. Model
- c. Sr. No.
- d. Delivery size in mm.
- e. No. of Stage
- f. Head in Meters declared at duty points.
- g. Operating Head range for over loading requirement.
- h. Overall Efficiency at Duty Point.
- i. Discharge at Duty Point.
- j. Motor Rating
- k. Rated Current.

### MATERIAL OF CONSTRUCTION

Unless otherwise specified in the Data Sheet, the materials of components of monoset Horizontal submersible pumps (as per IS- 14220-1994) shall be as follows:

|   |  |
|---|--|
| Motor casing, oil chamber & other parts | CI IS: 210 Grade FG 260 or GG25 or EN JL1040   |
| Rotor of submersed motor                | Aluminium Die Cast or Dual Cage Copper Bar (for motors < 300 HP)   |
|   | Dual Cage Copper Bar (for motors > 300 HP)   |
| Motor cooling jacket (if applicable)    | SS 202 or Epoxy Coated MS  |
| Mechanical seals                        | Primary (Inboard): Silicon Carbide v/s Silicon Carbide   |
|   | Secondary ( Outboard): Carbon v/s Cast Chrome Molybdenum Steel or Silicon Carbide or Tungsten Carbide  |
|   | Elastomers:<br>- All "O" rings of Viton only<br>- Bellows of either Viton or Nitrile   |
| Fasteners                               | AISI SS 304  |
| Auto coupling system (if applicable)    | Pedestal cum Delivery Bend 2% Nickel Cast Iron   |
|   | Slider Bracket<br>Ductile Cast Iron or Cast Steel (SG 400/12 or EN - JS1050 or GGG 40) or WCB  |
|   | Guide Rail Pipes/ Wires & F. Bolts SS 304 or Higher  |
| Pump (volute / bowl) casing             | Pumps with Head $\leq$ 80 m & Del Size $\leq$ DN 100 mm 2% Nickel Cast Iron  |
|   | Pumps with Head $\leq$ 60 m & Del Size $\leq$ DN 125mm<br>2% Nickel Cast Iron  |
|   | Pumps with Head > 60 m & Delivery Size > DN 125 mm or<br>Pumps with Head > 80 m Ductile Cast Iron or Cast Steel<br>(SG 400/12 or EN - JS1050 or GGG 40 or ASTM 80 -55 - 06 or WCB) |



|  |   |
|--|---|
| Suction bell mouth & miscellaneous pump parts  | 2% Nickel Cast Iron   |
| Impeller                                       | Cast Austenitic Stainless Steel (SS 316 or CF 8M or 1.4406)   |
| Wearing rings (suction head casing & impeller) | Cast Austenitic Stainless Steel (SS 316 or CF 8M or 1.4406) or Bronze   |
| Pump motor shaft                               | Stainless Steel (SS 410 or SS 430 or 1.4021 or 1.4460)**<br>Larger Motors (i.e. > 265 HP) may be supplied with High Carbon Alloy Steel Shaft (EN 8 or DIN 1.7225 or others) protected with SS 316 Shaft Sleeves |
| Suction strainer                               | MS (C15) Fabricated with Epoxy Coating  |
| Portable stand (if applicable)                 | MS (C15) Fabricated with Epoxy Coating  |

### **SPECIFIC REQUIREMENTS:**

Unless otherwise specified in Data sheet, the applicable specifications shall be as follows:

- a. Casing individually tested to hydraulic test pressure 1.5 times of shut off pressure.
- b. All rotating parts should be individually balanced on machine for rated RPM according to the relevant IS (and vibrations of the assembly during the testing shall not exceed to 80 micron peak to peak)
- c. Impeller closed type.
- d. Impeller material shall be SS CF 8M or as per BOQ/Datasheet
- e. Bearing bush materials SS 304.
- f. Motor as per IS: 9283 / 1994 with relevant latest amendment.
- g. Motor Wet type.
- h. Brass/Carbon steel drain plug provided
- i. Compensating device provided
- j. Stator varnished by vacuum pressure method or EPOXY painted (if cold rolled stamping used).
- k. Rotor varnished by vacuum pressure method or Epoxy Painted .
- l. Rotor painted and baked under controlled condition or powder coated.
- m. Winding easily assembles.
- n. Winding subjected to 1.5 KV for 30 Seconds.
- o. Matching grooves for stopping from rotation and shifting.
- p. SS 304/Brass suction strainer preferred.
- q. Stud and nuts shall be of alloy steel and nut shall be additionally “Nyloc Nut”
- r. Stator end ring shall be of bronze metal or M.S.
- s. Stator is rewind able with readymade protested coils in each type of motor offered
- t. Cable confirming to IS : 694

Note: The material component should be as per relevant ISS and with latest revision accept that shown in Data Sheet Volume III. If any details missing or further clarifications required the same should got clarify during Pre – bid meeting or otherwise the decision as may be taken their after shall be binding to all.

## **9 Electrical Specifications for raw water pumping station**

### **9.1 Transformers 11/0.415 KV**

#### **9.1.1 Scope**

The specification covers design manufacture, testing packing and delivery of 3 phase 50 Hz 11/0.415 KV Dry type Cast resin distribution transformer up to 630 KVA.

The offered equipment shall be complete with all components necessary for their effective and trouble free operation. Such, components shall be deemed to be within the scope of The Contractor's supply irrespective of whether those are specifically brought out in this specification and / or the commercial order or not.

The transformer status parameters shall be available for remote viewing in the pumping

#### **Tolerances:**

Tolerances on all the dimensions shall be in accordance with provisions made in the relevant IS/IEC standards/ and in these specifications.

#### **9.1.2 System Particulars**

The transformers shall be suitable for indoor installation with following system particulars and should be suitable for service under fluctuations in supply voltage as permissible under Indian Electricity Act & Rules there under.

- |   |   |                                |
|---|---|--------------------------------|
| a) Nominal System Voltage               | : | 11kV                           |
| b) Corresponding Highest System Voltage | : | 12kV                           |
| Neutral earthing (NGR)                  | : | Neutral grounding resistor     |
| c) Frequency                            | : | 50 Hz with $\pm 3$ % Tolerance |

#### **9.1.3 Service Conditions**

Equipment to be supplied against the specification shall be suitably designed to work satisfactorily under following tropical conditions:-

- |   |   |             |
|---|---|-------------|
| Maximum ambient temperature (Degree Celsius)  | : | 50          |
| Minimum ambient temperature (Degree Celsius): | : | As per site |
| Relative humidity (% range)                   | : | up to 95%   |
| Altitude                                      | : | <1000metres |

#### 9.1.4 Standards

The materials shall conform in all respects to the relevant Indian / International Standards with latest amendments thereof and not limited to:

|    |                            |   |
|----|----------------------------|---|
| a. | IS: 5                      | Colours for ready mixed paints and enamels.   |
| b. | IS:1180                    | Three phase distribution transformers up to and including 100 kVA, 11KV                           |
| c. | IS 11171/IEC 60076-Part 11 | Dry type transformer  |
| d. | IS:2099                    | Bushing   |
| e. | IS:3347                    | Dimensions for porcelain transformer bushing for use in normally and lightly polluted atmospheres |

#### 9.1.5 Technical Requirements

Nominal voltage ratings

- i) Primary voltage - 11 kV
- ii) Secondary voltage - 0.415kV

The vector group shall be Dyn11.

Percentage Impedance: 6.25% at 75deg C (subject to IS tolerance)

Temperature Rise;

- i) Average winding temperature rise over an ambient temperature of 50 deg. C shall not exceed 90<sup>0</sup> C by resistance method. i.e. maximum temperature of winding shall not exceed 155<sup>0</sup> C.
- ii) Core, metallic parts and adjacent material shall in no case reach a value that may damage these materials or reduce their life expectancies.

##### 8.1.5.1. Core

The core shall be of Prime grade cold rolled grain oriented (C.R.G.O) annealed steel lamination, having low loss and good grain properties, coated with insulation, bolted together to the frames firmly to prevent vibration or noise. All core clamping bolts shall be effectively insulated. The complete design of core must ensure permanency of the core losses with continuous working of the transformers.

Transformer shall be of BOLTLESS core design

Stage inspection of the core shall be done at manufacturer's premises & inspection call shall be given with following Documents

- a) Invoice of the supplier
- b) Mill's test certificate
- c) Packing list
- d) Bill of landing & Bill of Entry certificate by customs

#### **8.1.5.2. Winding**

H. V. & L. V. Coils

- i) LV Winding: LV Winding shall be made from Copper Pre Impregnated with class F epoxy resin.
- ii) The LV winding is produced using copper; this foil will be insulated between each layer using a heat-reactivated class F pre-impregnated epoxy resin film.
- iii) The ends of the winding are protected and insulated using a class F insulating material. The whole winding assembly will be polymerized throughout by being autoclaved for 2 hours at 130<sup>o</sup>C.
- iv) HV coil should be casted with Class F epoxy resin & should be premixed with active filler which should make the coil self-extinguishing & should comply to fire behavior class F1 as per IEC 60076.
- v) The HV windings will be vacuum cast in a class F fireproof epoxy resin casting system composed of:
  - an epoxy resin
  - an anhydride hardener with a flexibility additive
  - a flame-retardant filled
- vi) The flame-retardant filler will be thoroughly mixed with the resin and hardener. It will be composed of trihydrated alumina powder (or aluminium hydroxide) or other flame-retardant products to be specified, either mixed with silica or not.
- vii) The casting system will be of class F. The interior and exterior of the windings will be reinforced with a combination of glass fiber to provide thermal shock withstand.
- viii) Manufacturer should comply to Climatic test category of C2 & Environmental category of E3 as per IEC 60076 so as to withstand changing climatic variations & should be able to withstand high degree of pollution & humidity up to 95%.
- ix) Transformer shall be self-extinguishing - F1 Certified as per ISEC60076-Part 111.

### **9.1.6 Off Load Tap Changing Gear (OCTC)**

The tap changer shall be suitable for connection to tapping brought out from HT winding (delta connected) covering a range of from +5% to -5% in 5 steps of 2.5% each (-5, -2.5, 0, +2.5, +5) making a total of 5 positions (taps). All taps shall be rated for maximum continuous KVA rating of the transformer & shall be suitable for operation at sustained voltage of 110% of the rated tap voltage.

### **9.1.7 Clearances**

Clearances provided shall be strictly as per IS 11171 / IEC 60076-Part 11.

### **9.1.8 H. T. & L. T. Bushing**

For 11KV Bushing will be used and for 415 volts, 1 kV Bushing shall be used. Bushing of the same voltage class shall be interchangeable. Bushing with same plain shades as per IS 3347 amended up to date shall be mounted on the side of the enclosure and not on the top cover. Only sheet metal pocket shall be provided for mounting of HV bushing and the same shall not be fixed on pipes. Sheet metal pocket shall be designed in such a way that all HT bushing shall remain parallel and equidistant throughout. Bushing having type tested as per IS 3347 amended up to date shall only be acceptable.

### **9.1.9 Earthing & Neutral Grounding Resistor**

- Each transformer shall have 2 independent maintenance free earthing pits for body earthing.
- Each transformer shall have independent neutral grounding resistor of required rating.
- The NGR shall be used for medium resistance grounding of LV (415 V) system.
- NGR shall be connected between earth pit and neutral point of applicable transformer.
- The NGR shall be suitable for limiting the desired value of earth fault current and duty as arrived in detail design and approved by Employer's Engineer.
- The resistor unit shall be natural air-cooled type suitable for installation at outdoor/indoor locations.
- All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- Each Neutral Grounding Resistor shall be formed of non-aging (grade ASTM-A240/AISI-304 or better) corrosion resistant punched stainless steel elements for high value (say 300A/400/500A) of earth fault current and of FECRAL material for low value (say 1A) of earth fault current.
- Resistance material mentioned above shall have high electrical resistivity and low temperature co-efficient of resistance.
- Resistor bank shall be provided in series and parallel combination to achieve the overall resistance value. Minimum two banks in parallel shall be provided in the system, unless specified otherwise by Employer's Engineer.

- The resistor unit shall consist of suitable no. of elements. All the elements shall be mounted inside the cubicle so as to ensure ease of inspection and replacement of individual element. For Low value of earth fault current edge wound configuration of resistance material would be acceptable after approval of Employer's Engineer.
- All elements connection shall be bolted type to ensure stable resistance value throughout the working life of the unit.
- Wet process type brown glass porcelain insulators shall be used for supporting resistor elements and used to insulate the resistor element from enclosure. Porcelain insulators shall have high Creepage value (not less than 25 mm/per unit system phase to phase voltage) suitable for heavily polluted atmosphere charged with dust particles.
- The NGR shall be provided with suitable taps for cable/strip connection.
- Each neutral grounding resistor shall be housed in weather-proof enclosure having DOP of IP: 65. Enclosure shall be cold rolled sheet steel having a minimum thickness of 2 mm.
- The terminals for neutral and earthing connections shall be housed in separate vermin-proof, weather-proof terminal box with min. IP-55 degree of ingress protection.
- The enclosure shall be supported on insulators placed on mounting structure in such a fashion that it is not easily accessible for man standing on ground level. Any part of insulator shall be at a height 2500 mm above ground/plinth.
- All cubicle door hinges shall be concealed type. Each cubicle shall be complete with suitably mounted cable box fitted with removable gland plate of Aluminium of suitable thickness for fixing cable gland. Double compression brass Cable glands and cable lugs of tinned copper shall be used.
- The enclosure shall not be earthed to prevent bypassing of resistor in case of any inadvertent shorting of resistor from inside.
- Panel space heater arrangement along with thermostat, suitable for connection to 240V AC single supply, shall be provided at the bottom of the panel. The illumination arrangement and switch socket shall also be provided in the panel.
- For connection of other end of NGR to ground, 2 nos. earthing terminal/pad tapped holes and bolts for connection of 50X6 or 75X10 mm copper strip/aluminium strip or copper ground wire shall be provided.

#### **9.1.10 Inspection & Tests**

All acceptance and routine tests as per relevant standards shall be carried out by the manufacturer.

#### **9.1.11 Terminal Marking Plates and Rating Plates**

Terminals shall be provided with terminal marking plates. The transformer shall provide with riveted rating plate of minimum 8 SWG aluminum anodized material sheet in a visible position. The entries of the rating plate shall be indelibly marked (for example by etching, engraving or stamping).

The marking as 'DSIR' and 'Sr. No...' of Transformer will be engraved on Transformer enclosure, below L.T. Bushings.

The name of the company, order No., capacity, month and year of manufacturing shall be engraved on the enclosure of transformer just below the nameplate clearly visible. The engraving can be done on separate plate which shall be firmly welded to enclosure and shall form integral part of the enclosure.

C2/E2/F1 shall be engraved in the rating plate

#### 9.1.12 Other Parameters

|    |  |   |
|----|--|---|
| a) | Cooling                                | AN  |
| b) | Rated System Voltage                   | 11kV/415V   |
| c) | Phases                                 | Three   |
| d) | Impedance                              | 6.25% at 75deg C (subject to IS tolerance) for 2000KVA<br>5% at 75deg C (subject to IS tolerance) for 1000KVA |
| e) | Overload Capacity                      | As per IS2026   |
| f) | Vector Group (Three Phase)             | Dyn11   |
| g) | Climatic Class                         | C2  |
| h) | Environmental class                    | E3  |
| i) | Fire Class                             | F1  |
| j) | No load & Full Load losses as per ECBC | As per ECBC[Energy conservation building code] guidelines   |

### 9.1.13 Test And Inspection

#### **Routine Tests: Manufacturer's Lab should have NABL accreditation so as to ensure transformer's genuinity on various design parameters**

- i) All transformers shall be subjected to the following routine tests at the manufacturer's works.

The tests are to be carried out in accordance with the details specified in IS 2026

1. Measurement of winding resistance.
  2. Ratio, polarity and phase relationship.
  3. Impedance voltage.
  4. Load losses.
  5. No-load losses and No-load current.
  6. Insulation resistance.
  7. Induced over voltage withstand.
  8. Separate source voltages withstand.
- ii) All the routine tests shall be conducted in the suppliers' laboratory at their cost.
- iii) Heat run test shall be arranged free of cost on the unit selected from the 1st lot by Employer's Engineer. The test should be done at NABL accredited lab only.
- iv) The calculations to confirm the thermal ability as per Clause no. 9.1 of latest IS: 2026 Part-I or equivalent International Standard shall be submitted to Inspecting Engineer.
- v) Partial discharge test shall be carried out on one transformer & value shall be less than 10%.

### 9.1.14 Drawings

A set of following drawings shall be submitted by the Contractor.

- i) General Dimensional drawing
- ii) Core details drawing.
- iii) Rating & Diagram Plate Drawing.
- iv) HV/LV Bushings
- v) Operation and Maintenance Manual.



### **9.1.15 Leaning and Painting**

The surface of the enclosure shall be properly pre-treated / phosphate in a seven enclosure process and shall be applied with a powder coating of 40 microns thickness. The powder coating shall be of dark admirably green colour for transformer. Powder coating shall be suitable for outdoor use only.

The month and year of supply shall be painted in **red bold English** lettering at some conspicuous place on the transformer, which shall be clearly visible from the ground.

### **9.1.16 Acceptance tests**

The transformers shall be subjected to the following routine/ acceptance test in presence of purchaser's representative at the place of manufacture before dispatch without any extra charges. The testing shall be carried out in accordance with IS: 1180 and IS: 2026.

1. Checking of weights, dimensions, fitting and accessories, tank sheet thickness, oil quality, material, finish and workmanship as per GTP / QA Plan and contract drawings.
2. Physical verification of core coil assembly and measurement of flux density of one unit of each rating, in every inspection with reference to short circuit test report

### **9.1.17 Inspection**

All tests and inspection shall be made as per Schedule K.

The manufacturer shall provide all services to establish and maintain quality of workman ship in his works and that of his Sub-Contractors to ensure the mechanical / electrical performance of components, compliance with drawings, identification and acceptability of all materials, parts and equipment as per latest quality standards of ISO 9000.

## **8.1 Busbar Trunking (Sandwich Type)**

### **8.2.1 Range**

- Aluminium (all contacts should be silver/tin plated)
- Copper (Silver plated throughout the length)

### **8.2.2 General**

- The busbar trunking system (800A and above), both feeder and plug-in, shall be sandwich construction.
- All busbar trunking products and fittings (straight length, elbow, tees, flanged ends, cable tap box and circuit breaker, etc.) shall be in accordance with IEC 61439 Part 6 (2012) or UL857 and from the same manufacturer as the busbar trunking system. The degree of protection of the busbar trunking system should be of minimum IP54 in accordance to IEC 60529.

- Rated operation voltage of the busbar trunking is 1000V. 3 – Phase, 4 or 5 Wire with 50% capacity continual integral/internal earth busbar. The neutral conductor should have the same cross-sectional area as the phase conductor. The earth busbar must be one continuous piece without bolting on housing
- The Contractor shall be responsible for routing the busbar trunking to coordinate with the other trades. Final field measurements shall be made by the Contractor prior to release to the busbar trunking for fabrication by the manufacturer.

### 8.2.3 Certificate

- The busbar, of full range and each rating, should pass full type tests specified in IEC 61439 Part 6 (2012).
- The certificate shall be issued by an international independent testing authority. The busbar trunking system should pass seismic tests with actual physical product and being certified complying with UBC seismic Zone 4 condition by an international recognized earthquake research body, e.g. Asian Pacific Network of Centers for Earthquake Engineering Research (ANCER) or equivalent.

### 8.2.4 Short Circuit Ratings and Tests

The whole busbar trunking system shall be capable of withstanding the short circuit of the electrical installation without damaging the electrical, mechanical and thermal stress under fault condition at a service voltage of 1000V 50Hz. The minimum rated insulation voltage shall be 1000V.

The minimum certified short circuit ratings of the busbar trunking shall be as follows:

| Rating | KA/1 sec. | KA Peak | Rating | KA/1 sec. | KA Peak |
|--------|-----------|---------|--------|-----------|---------|
| 800A   | 40        | 84      | 2500A  | 75        | 165     |
| 1000A  | 50        | 105     | 3200A  | 90        | 198     |
| 1250A  | 50        | 105     | 4000A  | 100       | 220     |
| 1600A  | 60        | 132     | 5000A  | 120       | 264     |
| 2000A  | 60        | 132     | 6000A  | 120       | 264     |

### 8.2.5 Housing

- The busbar trunking housing shall be constructed of electro galvanized steel/ aluminium and shall be provided with a suitable protective finish of ANSI 49 grey epoxy paint.
- The busbar trunking housing shall be totally enclosed non-ventilated for protection against mechanical damage and dust accumulation. And it shall pass at least 1000 hours salt spray test to ensure the anticorrosion ability.
- The totally enclosed housing shall be manufactured by the busbar trunking manufacturer.

### **8.2.6 Busbars**

- Busbars shall be of tinned electrolytic copper of 99.9% purity.
- There shall be no bolts passing through the busbars of the busway.
- Each busbar shall be insulated with Class B (130 °C DuPont Mylar).
- The temperature rise at any point of the busbar trunking enclosure shall not exceed 55 degree Centigrade rise above ambient temperature when operation at rated current.

### **8.2.7 Joint**

- The busbar trunking joint shall be of the one-bolt type which utilizes a high strength steel bolt(s) and Belleville washers to maintain proper pressure over a large contact surface area.
- The bolt shall be torque indicating and at earth potential.
- The bolt shall be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench.
- Access shall be required to only one side of the busbar trunking for tightening joint bolts.
- It shall be possible to remove any joint connection assembly to allow electrical isolation or physical removal of a busbar trunking length without disturbing adjacent busbar trunking lengths.

### **8.2.8 Plug-in Opening**

- The connecting jaw of the plug-in unit shall plug directly onto the busbar and have full contact with busbar itself. Welded tab at plug-in busbar is not allowed.
- All contact on joint and plug-in opening should be silver plated copper.
- On plug-in busbar trunking there shall be three dead front, hinged cover type plug-in openings on each side.
- All openings shall be usable simultaneously.
- Busbar trunking shall be installed so that plugs are side mounted to permit practical use of all plug-in openings.
- It shall be possible to inspect the plug-in opening and busbars prior to the installation of the plug-in units.

### **8.2.9 Support of busbar Trunking**

- Hanger spacing shall be noted on layout drawings and shall not exceed manufacturer's recommendations.

- Indoor feeder and plug-in busbar trunking shall be approved for hanger spacing of up to 3 meters for horizontally mounted run and 4.88 meters for vertically mounted runs. Outdoor feeder busbar trunking shall be approved for spacing of up to 1.5 meters for horizontally or vertically mounted runs.

#### **8.2.10 Voltage drop**

- The voltage drop (input voltage minus output voltage) specified shall be based on the busway operating at full rated current and at stabilized operating temperature in 30 ambient.
- The three-phase, line to line voltage drop shall not exceed 3.4 volts per hundred feet at 40% power factor concentrated load which may exist during motor starting.\
- The line-to line voltage drop shall not exceed 4.1 volts per hundred feet at the load power factor which produces maximum voltage drop in the busway.

#### **8.2.11 Plug-in Units**

- The plug-in jaw shall be spring design composed of different metal to ensure the firm and tight contact with the busbar
- Plug-in Units should be type tested in accordance with IEC 61439-6 (Annex D: Part 1-5 and 9-13)
- The earthing contact of the plug-in unit shall always be made before that of the live conductors and the last to break during removal. And it must connect to the earth bar of busway to ensure the safety.
- Covers of all plug-in units must have interlocks to prevent the cover from being opened when the switch is in the ON position.
- Plug-in units (circuit breaker type or fusible switch type) shall be operated with visible blade quick-make and quick-break mechanism
- Presence of Transparent shield shall be inside to avoid direct contact of human
- The plug-in units shall be equipped with internal barriers to prevent accidental contact of fish tape and conductors with live parts on the line side of the protective device during time of wire pulling

### **8.2 Low Voltage Switchgear & Control Gear Assembly**

#### **General**

This section covers the detailed requirements of medium voltage switchboard for 415 volts, 3 phase, 50 Hz, 4 wire system.

#### **Standards and Codes**

Updated and current Indian Standard Specifications and Codes of Practice will apply to the equipment and the work covered by the scope of this contract.

|                                       |                            |
|---------------------------------------|----------------------------|
| Low Voltage switchgear Assemblies     | IEC61 439-1/2, IS 8623     |
| Low Voltage switchgear & control gear | IEC 60 947 /IS 13947: 1993 |

Part I : General rules

Part II : Circuit Breakers

Part III : Switches, disconnectors, switch disconnectors and fuse combination units

Part IV : Contactors and Motor starters

Part V : Control circuit devices and switching elements

Degree of Protection of Enclosures for low voltage switchgear - IEC60529 /IS 2147: 1962.

Internal arc – IEC 61641

Panels must conform to Totally Type Tested (TTA) as per IEC 61439-1/2. Panel assembly must be manufactured and tested in OEMs factory (as per IEC 61439-1 &2) manufacturing facility. The enclosures shall be designed to take care of normal stress as well as abnormal electro-mechanical stress due to short circuit conditions. All covers and doors provided shall offer adequate safety to operating persons and provide ingress protection of IP 54. Ventilating openings and vent outlets, if provided, shall be arranged such that same ingress protection of IP 54 is retained. Suitable pressure relief devices shall be provided to minimize danger to operator during internal fault conditions.

- The switchboard along with ACBs and connections should have been be type tested design at **CPRI** /Independent international test house for short circuit, temperature rise, protective earth short circuit test and dielectric tests of the ratings required .
- For operator safety IP2 X (touch proof) protection to be available even after opening the feeder compartment door. The compartmentalization to be achieved by using metal separators, use of PVC sheet / Hylem sheets shall not be allowed.
- The main switchboard shall be of form 4b type 6.
- Degree of Protection shall be IP54 Upto 2000A and IP42 above 2000A
- Switchboard panels and cubicles shall be fabricated with CRCA Sheet Steel of thickness not less than 2.0 mm and shall be folded and braced as necessary to provide a rigid support for all components. The doors and covers shall be fabricated from CRCA sheet steel of thickness not less than 2 mm. Joints of any kind in sheet metal shall be seam welded and all welding slag ground off and welding pits wiped smooth with plumber metal.
- LT Panel shall be ready with Ethernet (TCP/IP) communication i.e. All (Breakers & Cradle position) Status, release metering data and Multi-function meters (MFM) data shall be on Ethernet communication inside the LT Panel), which is reliable, faster communication and easy in integration.

Type Test Certificates for short circuit withstand of 50kA 1 sec along with Switchgear mounted in the Switchboards is mandatory for submission and panel shall be tested for ieuqsal or more than mpulse withstand voltage of switchgear installed.

It shall be suitable for Seismic Zone IV. The same shall be tested at ERDA / CPRI / International lab for all tests.

It shall pass Internal Arc Containment Test as per IEC 61641 50KA/65KA for 0.4 sec for ensuring human safety.

All switchgears shall be fully rated at an ambient of 50° C – for this, Contractor shall provide de -ration charts for their Switchgears.

Clearances between phases should be in line with IEC.Degree of Protection as per IEC 62262 against mechanical impact shall be IK 09.

### **Type test reports**

Switchboard configurations offered shall be CPRI /Independent international test house tested which are not more than 5yrs old for all the tests as per IEC61439-1 & 2 and internal arc tests. Copies of the test certificates shall be submitted with the tender.

### **Testing at Works**

Copies of type test carried out at ACB/ MCCB manufacturers works and routine tests carried out at the switchboard fabricators shop shall be furnished along with the delivery of the switchboards. Engineer-in-Charge reserves the right to get the switchboard inspected by their representative at fabricators works prior to dispatch to site to witness the followings.

- a) Physical variation and dimensional check
- b) Verification of bill of material
- c) Functional check
- d) HV test
- e) IR test

Main LT Panels, Sub-Distribution Panels and Final Distribution shall be covered under this section. Panels/Boards shall be suitable for operation on 3 Phase/single phase, 415/240 volts, 50 cycles, 4 wire system with neutral grounded at transformer. All Distribution panels shall be CPRI/ERDA or any other International Accredited Labs tested design and manufactured by an approved manufacturer. CPRI certificate shall be made available.

Distribution panels shall comply with the latest International Standards and Electricity Rules and Regulations and shall be as per Low Voltage switchgear & control gear IEC 61947. Switchboard shall be able to withstand Relative humidity 95% at 55 degree Centigrade.

### **9.3.1 Floor Mounting Panels**

Floor mounting panels, shall have rear access doors which shall have a flush appearance. The doors shall be fitted with lockable handles and shall have lift off type hinges so arranged that

one shank engages before the other to permit ease of fitting. No instruments or relays shall be mounted on the doors.

### **9.3.2 Wall Mounting Panels**

Wall mounting panels shall have hinged front doors fitted with lockable handles. The doors shall be of rigid construction and made of sheet steel of thickness specified above. The fixing details for the wall-mounted panels shall preferably comprise externally welded brackets. The panels shall be of pre-fabricated type with modular construction and powder coated as per (a) above.

### **9.3.3 Switchboard Components & Control Architecture**

This section covers specification of Low Voltage Switchboards incorporating items of switchgear like Air Circuit Breaker, Moulded Case Circuit Breaker, Contactor's, Relays, Metering etc.

All switchgear (ACB, MCCBs, MCB, RCBOs etc.) and control gear (Contactor, MPCBs etc.) shall be designed in compliance to latest environmental directives like RoHS (Restriction of Hazardous substance) & WEEE (Waste Electrical and Electronic Equipment) for easy de-assembly and recycling at end of life. All components shall be pollution degree 4.

### **9.3.4 Protection Co-ordination**

It shall be the responsibility of the Contractor to fully co-ordinate the overload and short circuit tripping of the circuit breakers with the upstream and downstream circuit breakers/fuses/motor starters, to provide satisfactory Total discrimination. LV Switchgear manufacturer shall submit Coordinated & Discriminated solution for LV network protection devices i.e. ACB, MCCB, MPCB & MCB for all incoming and outgoing devices for all Panels/ DB's with the help of published discrimination tables/charts and let through energy curves.

Total discrimination shall be provided up to the service short circuit breaking capacity of most downstream circuit Breakers.

### **9.3.5 Communication architecture**

The installation switchboard shall be equipped with a communicating system (MCBs, RCBOs, MCCBs, ACBs, Auxiliaries, Energy Meter and other modular device) that makes it possible to:

- Monitor modular protection and control units and provide the centralised management system (DCS, supervisor, management software, etc.) with information on their status.
- transmit orders from the centralised system to the switchboard control units.
- meter and transmit installation power consumption data to the centralised system.

The communicating system components (MCBs, RCBOs, MCCBs, ACBs, Auxillaries, Energy Meter and other modular device) shall be communication ready to indicate the status of the device (On/Off/Trip), Control wherever necessary, Number of On/Off cycles and Number of Tripping (or History) over universally open Modbus and Ethernet (TCP IP)

protocol so as to have seamless connectivity with any Energy and Building Management System.

Connectivity interface selection will be decided by client at the time of detailed engineering so that seamless and fast connectivity is done, as required to interface other equipment. Ethernet will be preferred.

Complete communication system to be tested in switchboard at OEMs manufacturing facility.

All individual components of control equipment associated with any item of plant shall be contained in a single control circle/ module or panel. Where a number of similar such items of plant are specified a composite cubicles or panel shall be provided.

All instruments, relays, switches, lamps, pushbuttons and the like shall be arranged on the cubical in a neat, functional and logical manner. The arrangement shall be subject to Engineer's approval. Spare contacts of relays and auxiliary devices shall be wired to terminal blocks.

Similar items shall be of the same type, style, pattern or appearance throughout. Control and changeover selection switches for various functional shall be of the same type but with a handle of different shape for each specific function.

Instruments, control devices and relays mounted on different panel sections but having similar functions shall be located in a physically similar position. Such equipment shall be mounted at a height not exceeding 1800 mm and not less than 450 mm above floor level.

### **9.3.6 Air Circuit Breaker**

#### **a) General**

Air circuit Breaker shall comply with latest IEC 60947-2/IS standards. ACB shall be fully rated up to 500C with no derating at specified temperature. In case of 4P ACB, the Neutral Conductor capacity should be 100% of that Phase. Breaking Capacity of Breaker in Main LT Panel shall not be less than  $ICS = ICU = 50kA$  & ICW shall not be less than 50kA.

Device insulation voltage shall be 1000 VAC and Breaker shall have impulse withstand voltage of 12 KV. Operating voltage is 415VAC.

The circuit breaker shall comply with the isolating function requirements of IEC60947-2 section 7.1.2. to facilitate safety of person in use.

All ACBs should have the moulded case design.

The accessories like shunt trip, closing trip coils should be continuously rated to avoid the Burning due to sustained command. The Accessories shall be accessible from the front and should not need removing of the breaker from its panel for the replacement.

ACBs shall have:-

- a) Necessary circuit breaker carriage with 3 position (isolate, test, service) draw-out mechanism with positive auto-locking feature at each position.



- b) Necessary isolating plugs and sockets.
- c) Necessary mechanism interlock and automatic safe shutters gear with arrangement for pad locking.
- d) The Air Circuit Breaker shall carry full rated current at 50 Degrees C without derating – Vendor shall furnish Deration Charts for the same. Necessary independent manual spring mechanism with mechanical On/Off indication as well as electrical On/Off indication.
- e) Necessary bus bars with bolted type neutral links.
- f) ACB shall be provided with microprocessor based releases having built in over load, short circuit & earth fault protection. Microprocessor release shall be EMI (electromagnetic induction) / EMC (electromagnetic compatible) certified. Necessary set of auxiliary switches.
- g) Necessary set of CTs with ratios as specified.
- h) Necessary identification, metering requirements as specified i/c. ON/OFF indication lamps, selector switches, fuses, ammeter, voltmeter etc.
- i) In case of 4 pole breaker neutral shall be fully rated with adjustable settings from 50% to 100%.
- j) ACB terminals shall be suitable/suitably brought out for direct aluminum termination as per IS 60947 Part II.
- k) Provided with 'red', 'green' and 'amber' indicating lamps to indicate 'closed' 'open' and 'auto-trip' conditions of the circuit breaker when breaker operation is controlled by a control switch.
- l) All indicating lamps shall be clustered LED type, with in-built short circuit, surge protections etc. Adequate number of contacts shall be provided to have remote annunciation of the breaker feeders:
  - Breaker 'ON'
  - Breaker 'OFF'
  - Breaker 'TRIP'
  - Breaker 'Service'
  - Breaker 'Test'
  - TCH
- m) Operating Mechanism
- n) The operating mechanism shall be of the Open/Closed/Open stored-energy type. The closing springs shall be able to be manually charged by operating the front lever
- o) The ACB (draw out or non-draw out) shall provide as a standard feature the following mechanical or electrical indicator on the front panel:-

- Contact position indicator (ON / OFF)
  - Stored energy status indicator
  - Connected / Test / Disconnected position. (DO version)
  - Trip indication on fault and fault differentiation (type of fault) i.e. Overload, short circuit or earth fault
- p) All circuit breakers should be provided with “Ready to close” contact which internally checks following conditions before closing the circuit breaker to enhance the safety and reliability of the circuit.
- 1) ACB is in OFF position
  - 2) Spring is Charged
  - 3) Shunt not Energized
  - 4) U/V Energized
  - 5) Fault trip signal is not present
  - 6) Remote trip signal is not present
  - 7) Device is completely racked in
  - 8) Device is not locked on OFF position
  - 9) Device is not interlocked with second device.

The circuit breaker shall be of trip free type and shall be provided with built-in mechanical Anti Pumping feature. Closing coil & other auxiliary devices shall be available in sufficient number for the purpose of indication, alarms, annunciations on switch boards as well as on respective remote control panel in control room & for the purpose of interlocking scheme shall be provided

There shall be three distinct & separate positions of the circuit breakers on the cradle as – Service / Test / Isolated. All position shall be positively achieved only through the racking motion of draw out mechanism & not by trail & error. There shall be indicator clearly showing the above 3 conditions

ACB shall have terminal adaptors on both incoming and outgoing side

The construction of circuit breakers shall be as per pollution degree 4 (as per IEC 60664-1).

Circuit breaker shall be convertible from MDO to EDO at site. The closing spring shall be manually charged, if EDO if failed.

Protection Function:

All ACBs shall have Microprocessor based releases capable of sensing true RMS

value of Current based on Digital Technology

Protection unit shall offer following as standard in all breakers.

- Long time protection with adjustable time delay.
- Short circuit protection with time delay. The short circuit setting (ISD) should necessarily be the function of the nominal current ( $I_n$ ) of the ACB. The instantaneous protection shall have the option of OFF position in case of certain conditions of discrimination.
- Earth fault protection with adjustable current settings in absolute values of the fault current. The adjustable time delay setting for tripping on earth fault shall be within 100 – 400ms. Also there should be provision to disable the Earth Fault Protection if required.
- Separate adjustable setting for instantaneous short circuit protection.
- Neutral Protection with a provision of Setting range off – 50% - 100%

All the adjustments (settings) of protection release should be on line & the circuit breaker need not be switched off while adjusting the settings.

Trip indicators shall be provided to display the exact nature of fault (i.e. O/L, S/C, and E/F) that caused tripping of circuit breakers. The circuit breaker will have to be necessarily with mechanical re-closing lockout. The trip indication shall need no external power supply for display. The control unit shall have thermal memory for repetitive over current faults for protecting the cables & loads.

ALL ACBs shall be equipped with an integral self-powered microprocessor based current & voltage release which works on true R.M.S values for ensuring accurate protection and integral LCD display which should show atleast current and voltage parameters and bar graph display for % loading of the phases.

The display should be visible with a minimum 20% loading of the phase currents.

Integral Test facility to test healthiness of release and the trip circuitry shall be provided on the release.

The microprocessor based release shall be capable of providing last 10 trip history on LCD display of release.

All ACBs should have Zone selective interlocking (ZSI) as inherent feature to help for Total Discrimination.

q) Communication

1. Release Feature

Where ever communication is required,

All the Breakers shall be able to -

- a. Communicate and display current voltage values, switching states, reasons for tripping.
- b. Release shall have facility to set limit values and probability of adding metering function.
- c. LCD Display to display all parameters of release.
- d. I<sup>2</sup>t characteristic curve for overload protection.
- e. Rating Plug option to reduce the Nominal current for optimum adaptation to the system shall be provided wherever required.
- f. The Breakers shall be compatible for integration with DCS System.
- g. The ACB shall be able to communicate the following via an integral Device / Release.
  - status of the main contacts,
  - spring charge and
  - Readiness to close depending on the status of the various internal auxiliary releases and interlocks to the upper level network.
  - Remote status monitoring
  - Service & Test Position
- h. Release shall have self-diagnostic feature with indication.
- i. Release shall have Neutral and earth fault protection as an inbuilt feature.
- j. The data shall continue to be stored and displayed even after opening the circuit breaker.

## 2. Implementation Architecture

ACB The vendor must define and submit the implementation architecture along with details of all devices/modules needed for implementation of the same, and to achieve the desired real-time data transmission speed on the network.

### 9.3.7 Moulded Case Circuit Breaker

All MCCBs shall be current limiting type with features of load line reversibility and suitable for Horizontal/Vertical mounting without any derating MCCBs shall have positive isolation as per IEC 60947-2. The MCCBs shall be used with terminal spreaders, where ever required. The MCCB should employ the double break arc chute system which would help to speed up the arc extinction in the event of fault so that lesser let through energy is exerted on the system.

The MCCB shall be employ maintenance free minimum let – through energies and capable of achieving discrimination upto the full short circuit capacity of the downstream MCCB. The

manufacturer shall provide both the discrimination tables and let through energy curves for all.

MCCB should be of Class - II front face devices for operator safety.

The MCCBs shall conform to the latest applicable standards (IEC 60947-2).

- The circuit breakers shall comply with latest IEC/IS standards.
- The breaking capacity performance certificates shall be available for category A to the above mentioned standards. The test shall be carried out under the breaking performance during the ultimate breaking capacity (ICU). Certificate for all the sequences should be available.
- All circuit breakers shall have a rated operational voltage of 415V AC (50Hz).
- Rated impulse withstand voltage shall be 8 KV.
- Thermal overload release adjustment can be done from a single point. MCCB cover need not be opened for doing such adjustment.
- MCCB till 250A can be thermal magnetic type (adjustable overload & fixed short circuit) and above 250A should have microprocessor release.
- Earth Fault module can be provided as inbuilt feature or add on module. User should be able to check Healthiness of ground fault protection module locally without tripping the MCCB.
- The breaker shall be maintenance free.
- It shall either be 3 poles or 4 poles.
- Production site organization shall be certified to comply with ISO 9001 standard.

All MCCBs shall be suitable for pollution degree 3 requirements as per IEC 60664-1.

MCCBs of 100A and above rating in main LT panel shall be with plug-in base; this is to ensure easy & faster replacement of MCCB and continuity of supply during maintenance in main LT panel.

a) Construction

- Operating mechanism shall be of the quick make quick break type, with the speed of operation independent of the operator, and mechanically trip free from the operating handle so as to prevent the contacts from being held closed against short-circuit and overload conditions (Conformity to positive isolation as per IEC 60947. The operating mechanism shall be constructed to operate all poles in a multi-pole breaker simultaneously during opening, closing and tripped conditions.
- It shall not require any external power supply to operate the tripping mechanism.

- The breakers shall be operated by a toggle which shall clearly indicate the three fundamental positions ON, OFF and TRIPPED.
- If required, the breaker will be equipped with rotary handles.
- The breaking and extinction of the electrical arc shall be achieved by means of non-welding contacts and an arc chute surrounding these contacts.
- If required all electrical accessories should be fitted by manufacturer to avoid tampering at site.
- Accessories should be common for entire range.
- MCCB should have cross bolted termination for easy connection on busbars.
- Each MCCB shall have a facility for padlocking in the off position.
- MCCBs shall have spreader links with phase barriers as standard feature.

b) Operation

- The breaker shall be provided with the facility for padlocking and door interlocking.
- The moulded case circuit breakers shall be equipped with a "push to trip" button in front to test operation and the opening of the poles.
- The circuit breaker rating, the "push to trip" button, outgoing circuit identification and the contact position indication must be clearly visible and accessible from the front, through the front panel or the door of the switchboard.
- Fault differentiation should be there between overload, short circuit & earth fault & should be wired upto panel door.

It should be possible to terminate Aluminium cable of required size for the defined current carrying capacity. The requisite size should be made available by means of extended terminals (as a standard offer) in case the direct terminals are not of adequate size. Adequate phase to phase clearance has to be ensured in case of extended terminations.

- c) The instantaneous short circuit release shall be so chosen by the Contractor as to operate at a current in excess of the peak motor inrush current and a range of settings shall be provided for the Employer's Engineer selection.
- d) MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.
- e) Minimum 2 no. of additional auxiliary contacts (for purchaser's use) shall be provided.

### 9.3.8 Multifunction Meters

#### **Multifunction meters at main HT Panel & LT panel incomers**

Meters shall conform to standard IEC 62053 for active and reactive energy. It should be

compliant with PMD standard IEC61557-12.

Multifunction meter shall have four line LCD display, Two DI/DO, RS 485 / Ethernet connectivity ports, 0.5s accuracy, 64 samples/cycle rate, 4 nos. time in day metering, individual harmonic measurement upto 31st harmonics, Current per phase, Voltage Total, per phase L-L and L-N, Frequency, Real, reactive, and apparent power. Total and per phase Signed & Four Quadrant, True Power Factor Total and per phase Signed & Four Quadrant, Displacement PF Total and per phase Signed, Four Quadrant % Unbalanced I, VL-N, VL-L, Min/max of instantaneous values plus phase identification, Energy values, Accumulated Active, Reactive and Apparent Energy - Received/Delivered, Net and absolute, Time Counters.

**Multifunction meters at main LT panel outgoing and SDBs incomers (where ever specified)**

- Meter shall have following features.
- LED panel for setup and 2 columns of LEDs for parameter identification.
- True RMS electrical parameters: per phase voltage, current, demand, W, VA, VAR.
- Integrated parameters: KWh, VAh, VAh.
- Neutral current, frequency, Power Factor, % Load, % Unbalance (V&I), Phase angle.
- Onhours, Runhours & Interrupts.
- 4 Quadrant energy: bi-directional, absolute & net.
- Class 1.0 accuracy.
- 64 samples/cycle and individual harmonics up to 15th.
- Meter with RS485 communication port.

**9.3.9 Miniature Circuit Breakers (MCB)**

MCBs shall comply with and be type-tested to IEC 60898 or EN 60898.

MCBs shall meet the following requirements:

- a) Number of poles: single-pole, double-pole, triple-pole or four-pole as specified.
- b) Protection against external influences: Enclosed-type,
- c) Method of connection: Bolted or Clip-on type and should have bi-connect facility to terminate fork type busbar and wires simultaneously,
- d) Rated operational voltage: 240 / 415 V AC,
- e) Rated current: 6 A, 10 A, 16 A, 20 A, 25 A, 32 A, 40 A, 50 A, 63A as specified. Above 63A, MCCB as specified above must be used.

- f) MCB's shall be used for out-going feeders. For incoming feeders irrespective of the ratings MCCB will be deployed in all Lighting Distribution Board.
- g) Rated frequency: 50 Hz,
- h) Range of instantaneous tripping current: MCB's shall be current limiting Type Energy Class 3 with range of instantaneous tripping current B, C or D type as appropriate or as specified,
- i) Rated short-circuit breaking capacity: not less than 10 kA unless otherwise specified,
- j)  $I^2t$  characteristic: suitable for load and circuit being protected,
- k) Degree of protection: IP-20 for MCB's
- l) Reference ambient temperature: 50°C.
- m) MCB's shall have minimum power loss (Watts) per pole as per the IEC and should be proven by published value by manufacturer.
- n) Slide latch release feature will also be considered.
- o) the manufacturer shall guarantee the following performance levels, defined by IEC60947-2 standards:
  - suitability for isolation (section 7.2.7)
  - rated insulation voltage (section 4.3.1.2) - 500 V (Preferred)
  - pollution degree (Part 1, section 6.1.3.2) - 3
  - Rated impulse-withstand voltage (section 4.3.1.3): 6 kV
  - Discrimination for power continuity – Validation with Standard Tables in catalogue
  - Validated Cascading tables as per standard IEC 60947-2
- p) The material used to manufacture MCB shall be 100% recyclable and must comply with RoHS and REACH standards.
- q) MCBs shall be suitable for field-fittable Protection auxiliaries (viz. Over-voltage release, Under-voltage release, Shunt trip) and Indication Auxiliaries (like Auxiliary Contact, Trip alarm contact).
- r) The circuit breakers shall be communication ready to indicate the status of the device (On/Off/Trip), Number of On/Off cycles and Number of Tripping over universally open Modbus and Ethernet (TCP IP) protocol so as to have seamless connectivity with any Energy and Building Management System.

The load handling contacts shall be silver/tungsten and the contacts and operating mechanism shall be designed so as to give a wiping action both at make and break. The breaker operating mechanism shall be of trip-free type. The breaker operating dolly shall be clearly indicated for the "ON" and "OFF" positions. It should be of Quick make and



Quick break type.

Circuit protection against overload and short-circuit conditions shall be provided by means of thermal-magnetic device. Double-pole, triple-pole, and four pole MCBs shall be integral units and interlocked internally so that an overcurrent through any pole shall trip all the poles of the MCB simultaneously. An assembly of two or three or four single-pole units mechanically strapped together is not acceptable.

Housing shall be heat resistant and having high impact strength. All DP, TP and FP circuit breaker shall have a common trip bar and should be mechanically coupled through a pin. It shall have an electrical endurance of the order of 10000 operation cycle for current rating of up to 50A.

### **9.3.10 Residual Current Breaker with Overload (RCBO)**

RCBOs shall be double pole or four-pole current-operated, housed in a totally enclosed moulded case, manufactured and tested in compliance with IEC 61009 or EN 61009.

RCBOs shall meet the following requirements:

- a) Number of poles: double-pole or four-pole as needed.
- b) Rated current (In): As per the load and rating of each outgoing MCB.
- c) Rated residual operating current: 30 mA.
- d) Rated voltage: 240 / 415 V AC.
- e) Rated frequency: 50 Hz.
- f) Rated short-circuit capacity: not less than 10 kA unless otherwise specified.
- g) Operating characteristics in case of residual currents with DC components: as specified.
- h) Method of mounting: distribution board type.
- i) Method of connection: connection shall be made with proper size of thimbles and number ferruling for circuit identification.
- j)  $I^2t$  characteristic: suitable for equipment and circuit being protected.
- k) Degree of protection: IP 3X to IEC 60529 or EN 60529.
- l) Reference ambient temperature: 50 °C.
- m) The tripping mechanism shall be of trip-free so that the unit cannot be held closed against an earth fault. Provision shall be made for testing the automatic earth - leakage tripping by an integral test device. A device shall be fitted for prevention against reclosing after the device has tripped on earth leakage.
- n) The rated earth-leakage tripping current shall be as indicated on the Board Details.
- o) RCBOs shall be equipped with an auxiliary connection wire that must be connected to the

earth busbar of the distribution board. This either enables the device to detect the missing neutral of the supply, causing the device to trip, or provides an alternative supply path for the tripping circuitry, enabling it to continue to function normally in the absence of the supply neutral.

### 9.3.11 Contactors

Contactors shall comply with IEC 60947-4-1 or EN 60947-4-1.

Contactors shall be electro-magnetically controlled, double air-break type. Contactors shall be four-pole, triple-pole, double-pole or single-pole as required and to be specified by Independent Engineer at the time of pre-design approval.

The mechanical endurance of the contactors shall not be less than 3 million no-load operating cycles.

Contactors shall be silver or silver-faced.

The contactor should be modular in design with minimum inventory requirements and built – in mechanically interlocked. They should be suitable for the addition of auxiliary contacts and other electrical auxiliaries without any compromise on the performance or the operation of the contactors.

The contactors for other applications shall have an un-interrupted rated duty and utilization category of at least AC3 at 415V and 50 Hz. The contacts should be of fast opening and fast closing type.

The making and breaking capacity values of the contactors should be as follows (as per IEC 947-4)

For AC3 duty

- Making capacity equal to or more than 10 Ie
- Braking Capacity equal to or more than 8 Ie
- For AC4 duty
- Making capacity equal to or more than 12 Ie
- Braking Capacity equal to or more than 10 Ie

The contactors should be capable of frequent switching and should operate without derating at 60oC for AC3 applications. They should be climate proof. The coil of the contactor should have class H insulation to support frequent switching. The Contactors shall operate satisfactorily between 85% to 110% of the rated voltage. The Contactor shall drop out at 70% of the rated voltage.

The rated voltage of the contactor and the rated insulation voltage shall be 690V. The rated impulse voltage of the contactor should be at least 8 KV.

The control and power terminals should be at separate layers preferably with colour coding (black/grey for power and white for control). All contactors power connection shall be finger

safe (IP 2X).

Contactors should be capable of being integrated into automated system (PLC's) without any interposing components in the minimum operating conditions.

All Motor starters should qualify Type 2 coordination chart requirement as per IEC 60947-4 & backed up by manufacturers selection chart.

### **9.3.12 Control Transformers**

Unless otherwise specified all control circuit supplies for contactor starters shall be obtained from a 110 volt 50 hertz integral control transformers contained in the breaker or starter cubicle. In the case of multi-motor and composite boards comprising circuit-breakers and starters one or more master control circuit transformers shall be provided for each section of bus bars in the switchboard to feed a group of outgoing starters and/ or outgoing breakers via bus wires in the board. Each control transformer shall be busbar connected and be provided with isolation facilities, and primary and secondary MCBs. Transformers shall be of the double wound pattern and be provided with earth screen between primary and secondary windings. One end of the secondary winding shall be earthed.

### **9.3.13 Indicating Lamps and Control Switches**

Indicating lamps shall be rated to withstand 20% continuous over voltage and shall be provided with series resistors designed to give adequate illumination. Indicating lamps in the form of LEDs are preferred.

Lamps shall be well ventilated and the design shall permit removal of lamp glasses and bulbs from the front of the unit. Switches, for control selection, motor control and other purposes shall have pistol grip type or alternative shape handles. Switches shall have adequate number of normally open/ normally closed (NO/ NC) contacts for functional use and spare sets of contacts.

### **9.3.14 Push Buttons**

Pushbuttons shall be colored as follows:

START - green, STOP - red. All other buttons shall be black

"Start" pushbuttons shall be effective only in selected circuits.

Emergency stop pushbuttons shall be provided and positioned in the immediate vicinity of the associated motor drive in all cases where,

- i) there is no direct line of sight between the motor and the controlling starter or
- ii) Where the distance between the motor and the controlling starter exceeds 5 meters.

Emergency stop push buttons shall be connected in control circuits such that they are effective under all conditions and shall have red mushroom headed pushes of the stay-put pattern. A deliberate reset action shall be required before the drive can be put back into service but resetting of the pushbutton shall not restart the drive. These pushbuttons shall be lockable type in pushed-in condition. All push button shall have adequate number of contacts to suit their functional requirements.

### **9.3.15 Operating Coils**

Where practicable all fine wire operating coils and wire wound resistors shall be vacuum impregnated with an approved insulating varnish.

### **9.3.16 Terminal Blocks**

Terminal boards or blocks shall be of approved barrier pattern, screw or stud type having covers of transparent, insulating material, which does not sustain combustion. Pinch screw type terminal blocks are not acceptable. Terminal blocks at different voltages shall be segregated into groups and distinctively labeled and the voltage grouping and terminal strip layout shall correspond with the wiring diagrams.

Terminals which may be alive when the main equipment is isolated from the mains supply shall be suitably labeled to reduce the risk of accidental contact. All terminals shall be a permanent identification number or letter.

Terminal strips shall be located adjacent to the point of cable entry adequate space being allowed for terminating the cable tails on site.

### **9.3.17 Space Heater and Cubicle Lighting**

Adequately rated anti-condensation space heaters shall be provided, one for each vertical cubicle of switchgear, for each separate control panel, for each distribution board, for each switchboard, and for marshalling kiosks. Space heaters shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1-phase, 50 Hz, AC system. Each space heater shall be complete with single pole MCB with overload and short circuit release in the phase, link in the neutral and a control thermostat to cut off the heaters at 45<sup>0</sup>C.

Each switchgear cubicle, control panel, control cabinet, and marshalling kiosk shall be provided with interior lighting, by means of a 20 W fluorescent tube lighting fixture. A lighting fixture "ON-OFF\*" switch shall be provided. The lighting fixture should be suitable for operation from a 240 V, 1-ph, 50 Hz, AC supply.

A 240 V, 1-phase, 5/15 A, 5 pin AC plug point shall be provided in the interior on each cubicle with an on-off switch for connection of hand lamps.

### **9.3.18 Indicating Instruments & Meters**

Electrical indicating instruments shall be either 144 mm square with 2700 scale or 100 mm square with 1400 scale. Taut band types of instruments are preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers.

Instrument dials shall be white with black numbers and lettering.

Normal maximum meter reading shall be of the order of 60% normal full-scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load upto six times the full load current.

### **9.3.19 Switchboard Anti-Condensation Heaters/ Panel Internal Illumination**

Each switchboard or cubicle shall incorporate wiring for supplies to anti-condensation heaters. The wires will be energized from a single-phase supply obtained from a separate

distribution board. The heater circuit shall be controlled by a rotary type ON/ OFF switch, HRC fuse and adjustable type thermostat. Multitier cubicles shall have cubicle heater and thermostat for each vertical panel section.

The heaters shall be located in cable alleys where such alleys are available or shall be located in the bottom portion. Panels/ panel sections shall be provided with fluorescent lamp lighting fixture of 20 w rating protected by H.R.C fuse and a switch. Alternative arrangement for panel internal illumination, if proposed, shall be subject to Engineer's approval.

### **9.3.20 Earthing Arrangement**

A continuous GI earth bus-bar of 65 mm x 10 mm size shall run the entire length of each switchboard/ MCC/ Panel and shall be bonded to the metal cladding or armoring of all incomings and outgoing cables, to the station earthing system, and components/ devices mounted within/on the panels. Earth bus bars of other size shall be subject to Engineer's approval.

### **9.3.21 Safety Arrangements**

All terminals, connections, relays and other components which may be "live" when front access doors are open shall be adequately screened/shrouded. It shall not be possible to obtain access to an adjacent cubicle when any door is opened. Components within the cubicles shall be adequately labeled to facilitate testing.

Where several outgoing circuits occupy a common termination chamber all bus work, cable lugs, terminations and terminal boards shall be fully screened or insulated to enable work on any one circuit to be earned out with other circuits live. Isolators, clearly labeled, shall be provided in such position and connected so that maintenance can be carried out with maximum safety. Screened or insulated to enable work or any one circuit to be carried out with other circuits live. Isolators, clearly labeled, shall be provided in such position and connected so that maintenance can be carried out with maximum safety.

This particularly applied to control circuits fed from a remote position. Where it is necessary to maintain certain components in a cubicle in a live condition' when the isolator is in the "off" position, such apparatus shall be so screened and labeled as to eliminate the possibility of accidents. Additionally, a system of removable insulated links or isolating type terminal blocks shall be provided to enable particular components to be isolated for maintenance purposes whilst retaining other essential circuits energized.

### **9.3.22 Auxiliary Switches**

Auxiliary switches/ devices shall be supplied as required for indication, protection, metering, control, and interlocking and supervisory purposes. They shall be readily accessible and enclosed in a transparent dust-proof cover.

Adequate secondary disconnects shall be included to enable the auxiliary switch to be wired to the fixed portion of the equipment.

### **9.3.23 Volt-Free Contacts**

"Volt-free" contact on any equipment, e.g. Contactor starter, etc. shall comprise a pair of contacts operated directly by the equipment but electrically separated such that no potential derived from the equipment appears at the contact. Volt-free contacts will be used to

complete external control alarm or indication circuits, the supplies for these circuits being obtained from an external source. Unless otherwise stated these supplies will be from low voltage AC or DC sources.

### **9.3.24 Protection Transformers**

#### **(a) Current Transformer**

Current transformers shall conform to IS: 2705. All current transformers shall have a short-time current rating of not less than that of the switch panel in which they are incorporated. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted, on the exterior of the mounting chambers, suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboards. Current transformers shall be of cast resin type and insulation class shall be "F" or better. Magnetization characteristics, calculated performance and protection setting shall be furnished by the Contractor.

Current transformers for use in conjunction with metering shall have accuracy class 1.0. Protective current transformer shall be of accuracy class 5P and accuracy limit factor not less than 10. CT parameters selected by the Contractor shall be subject to the Engineer's approval.

#### **(b) Voltage Transformers**

Voltage transformers shall be supplied where required. They shall have a winding ratio a three-phase voltage between lines of 110V on the secondary. They shall have a rated burden, at the stated accuracy, in accordance with the requirements of all connected instruments, meters and relays and of any instruments or meter to which they may be connected via test blocks.

The primary circuit shall be protected by H.R.C. fuses/ MCBs having a short-circuit rating of not less than that of the switchgear. The connections between the fuses/ MCBs and the switchgear primary conductors shall be capable of withstanding the short time current of the switchgear.

The secondary circuit shall be protected by MCB mounted as closely as possible to the secondary terminals.

Voltage transformers shall conform to IS: 3156. Windings for metering circuits shall have accuracy class 1.0 and those for protective circuits shall have accuracy class 3P.

#### **(c) Polarity**

The polarity of all apparatus shall be arranged as follows:

- (a) For two pole apparatus the phase or 'live' pole at the top (or left hand side) and the 'neutral' or 'earthed' pole at the bottom (or right hand side).
- (b) For three or four pole apparatus the phases in order red, yellow, blue and neutral reading from top to bottom or left to right in the case of horizontal and vertical layouts respectively, as viewed from the front.

### **9.3.25 Panel Internal Wiring**

FRLSH Cables shall be as specified in Chapter-2 MV Cables (BS 6724-multicore cable and BS 7211 for single core cable) of this Specification. All internal and control wiring shall be Low Smoke Zero Halogen (LSZH) copper conductor wires rated at 450/750 V complying with BS EN 50525 for this Specification. Insulation shall have a glossy finish, be resistant to oil and be incapable of supporting combustion.

Inside switch gears, motor control centers, annunciation panels, etc. the wiring for control, signaling, protection and instruments shall be done with PVC insulated copper conductors of minimum 1.5 sq.mm size. Wiring for CT circuits shall be with 2.5 sq.mm copper conductor. The insulation grade for these control wires shall be 650 volts. Inter panel wiring shall be enclosed in PVC wire ducts. Stranded copper conductor shall be used for control wiring.

Each wire shall be terminated at a separate terminal. Termination of two outgoing wires at a single terminal will not be acceptable.

Wiring for three phase circuits shall be color code red, yellow and blue for identification of relevant phases. For single phase AC circuits white colored wires shall be used for phase conductor and black colored for neutral conductor. Grey colored wire shall be used for DC circuits and green colored wires for earth connections.

Circuits in which the operating voltage exceeds 110 volts shall be physically segregate from all other wiring. All wiring shall be neatly and securely fixed by insulated cleats or run in insulated wiring troughs, wiring shall be so arranged that access to any apparatus or connection point is not impeded.

Wiring carrying low level DC signals shall be segregated from AC circuits and screened if recommended by the manufacturer of associated equipment/ instruments. Spare contacts available on relays/ devices etc. shall be wired up to terminal blocks.

Wires shall not be joined or tied between terminal points. Shorting links shall be provided for all CT terminals.

Each wire shall be identified at both ends by yellow color PVC ferrules marked with black letters/ numbers. The letters/ numbers used for marking on ferrules shall correspond with the appropriate wiring diagram.

Ferrules of other colors, if used, shall be subject to Engineer's approval.

Rubber grommets shall be provided so that metal parts should not come in contact with any power or control wires/ cables.

Minimum size of terminals for internal wiring shall be 6 sq.mm.

Stranded conductor shall be provided with copper lugs at both ends before connections are made.

### **9.3.26 Name Plates, Rating Plates and Labels**

Where appropriate, each item of plant shall have permanently attached to it in a conspicuous position, a label or labels upon which shall be engraved or stamped the manufacture's name, type and serial number of plant and details of the loading and duty at which the item of plant

has been designed to operate. A label denoting the plant or function identification number shall also be attached. Such label shall be of non-hygroscopic material to be approved by the Engineer. Labels shall also be provided to identify every instrument, relay or item of control equipment mounted externally and internally.

Externally fitted panel labels shall be of Perspex or other approved transparent material with letters and numbers rear engraved and filled with black. The back surface of each label shall be finished with a coat of paint of colour to be specified by the Engineers. Internally fitted panel labels shall be finished white with engraved letters or by other approved means wherever necessary to designate panel or panel sections, to describe or identify circuits or circuit components, to provide warnings or reminders of dangerous or potentially dangerous circumstances and wherever called for elsewhere in this specification.

Danger labels, e.g. "DANGER 415V. AC" shall be colored red with white lettering.

Caution labels, e.g. "CAUTION- ISOLATE BEFORE REMOVING COVER" shall be white with red lettering.

Details of proposed inscription shall be submitted to the Engineer for approval before any labels are manufactured.

### **9.3.27 Bus Bars and Primary Connections**

Busbars shall be made of high conductivity, and high strength Aluminum E91 grade as per IS 5082-1981. Busbars shall be of rectangular cross sections better suitable for full load current for phase bus bars and half/ full rated current for neutral bus bar or as stipulated in schedule of quantities. Busbar shall be suitable to withstand the stresses of fault level as specified in schedule of quantities.

The bus bars shall be supported on non-breakable, non-hygroscopic epoxy resin or glass fiber reinforced polymer insulated supports able to withstand operating temperature of 110<sup>0</sup> C at regular intervals, to withstand the forces arising from a fault level as stipulated in schedule of quantities. The material and the spacing of the Busbar supports should be same as per the type tested assembly (TTA). All bus bars shall be provided in a separate chamber and all connections shall be done by bolting.

The temperature rise shall be as per IEC -61439-1/2 with ambient of 50<sup>0</sup> C.

All busbars and primary connections shall be of copper and liberally rated for continuous operation. The mechanical strength of busbar and connection supports shall be able to withstand the electromagnetic forces arising under the most onerous short circuit condition. The size of busbar shall be subject to Employer's Engineer's approval. Busbar shall be provided with heat shrinkage PVC sleeves.

Busbar and primary connections shall be housed in air insulated enclosures, provided with suitable warning labels, which shall be arranged such that no direct access to or contact with live conductors is possible via slots or apertures. Suitable baffles shall be provided to prevent the accidental entry of tools etc. whilst maintenance work is being carried out in the vicinity. All busbar joints shall be bolted type. Spring washers shall be provided to ensure good contact at the joints. The busbars and primary connections shall have a short time rating not less than that of the associated switch gear. Busbar joints and bus tap joints shall be in plated.



### 9.3.28 Contractor Type Motor Starters

Motor starter Contactors shall comply with the requirements of IS: 2959 motor starters shall be of the electro-magnetic type rated uninterrupted duty as per IS. Contactors of DOL and Soft Starters shall be suitable for Class AC3 utilization category and contactors for reversing starters shall be of AC4 category. Contactors used for forward/ reverse shall be electrically interlocked. Main contacts of the contactors shall be silver faced. Insulation class of coils shall be Class 'E' or better. Operating coils shall be suitable for operation on 110V, 1 ph, 50 Hz supply. All three phase motor starters shall be complete with a triple pole hand reset thermal overload protection device with adjustable settings. Motors shall be provided with single phasing preventors which shall be either voltage operated type or shall be part of a combined thermal overload and phase unbalance relay. All contactors shall be provided with at least two pairs of NO & NC auxiliary contacts.

### 9.3.29 Intelligent Motor Control Centre

This specification describes the requirements for the low voltage intelligent motor control centre (IMCC). The IMCC is the equipment that provides comprehensive protection on motors by integrating intelligent motor protection relays (IMPR) or intelligent protection devices (IPD) inside the MCC switchboard. The IMCC should also bundle the bus communication with the most common protocols found in industrial networks (Modbus SL / Modbus TCP / Profibus / Ethernet IP).

Intelligent motor control cubicle (IMCC) shall be Form **4B**, Type 6 and IP54.

The IMCC offer should comply with the related national and international standards, including, but not limited to:

IEC 61439-1 &2

IEC 60529

IEC 60947

The IMCC switchboard must be a Type Tested Assembly (TTA), compliant with IEC 61439-1& 2. The switchboard type-test certificates shall be originated by a worldwide known third-party certification organization such as ASEFA, or KEMA. The supplier should be able to provide several certificates (not only one) upon request during the project. These certificates should either reflect the switchboard characteristics or allow understanding on how these characteristics are reached. In this second case, the manufacturer shall be able to show design tables (such as derating or co-ordination tables) formally originated from the iMCC original designer.

The selected switchgear and control gear brands shall be equal to the ones mentioned in the type tests reports of the equipment.

The switchboard should be designed to minimize the risks of occurrence of an internal arc, and whenever such an arc occurs it should prevent its effect on operators and material/equipment surrounding the switchboard. It should be in conformance with the requirements of IEC 61641

The switchboard should have the ability to withstand corrosion due to Sulphur Dioxide (SO<sub>2</sub>) and Hydrogen Sulphide (H<sub>2</sub>S) with necessary adaptations recommended by the iMCC

original designer. Inside the equipment, the appropriate coating should be done on conductors (busbars, connections) and metal elements (mechanisms, frames, casing). Also, the electrical and electronic equipment should show a compliance class relevant to the above pollutants. The manufacturer shall consider the power circuits' conductivity depending on the types of coatings used on these circuits. Upon request, the manufacturer shall be able to show the iMCC original designer specifications regarding the above mentioned facts.

### **Busbars**

To facilitate the connections and cable access, the main busbar should be installed at the top or bottom of the columns, with the design allowing for front or back cables' connection, via the top or bottom plates. All these interfacing possibilities should remain available even with no busbar position change.

The main busbar should be made of Aluminum bars spliced at each column level in order to achieve simplicity and flexibility in transportation, installation and maintenance. Sliding fishplates should be used to make the connection of the Aluminum bars between columns.

The IMCC offer should provide diverse functional units according to the different application requirements. Full withdrawable functional units (WWW) must be available for motor starters to achieve easy operation and maintenance.

There should be clear position indicators of the drawer, which indicate the connected, test and disconnected position. The drawer should provide an effective mechanical latch to prevent incorrect operation to avoid unexpected position changing from one position to another. The drawers should have the feasibility to be locked by 3 padlocks to prevent unauthorized insertion/withdrawal or OPEN / CLOSE operation.

In case those two drawers are of the same dimensions there shall be, as an option, a mechanical mean to prevent unwanted interchangeability of these drawers. Software-only means will not be accepted.

At the minimum, an intelligent MCC should be comprised of the following components and capabilities:

- Intelligent overload relays – The most common device in the MCC is the motor starter, so overload relay intelligence is paramount.
- Built-in network communication
- Input points (for monitoring disconnect or selector switch)
- Output points (for controlling contactor)
- LEDs for status indication
- Protective functions – thermal overload, underload, jam, current imbalance, stall, phase loss, zero sequence ground fault, and PTC thermistor input
- Programmable parameters for the protective functions – trip level, warning level, time delay and inhibit window

- Current monitoring – phase, average, full load, ground fault, imbalance percent and percent thermal capacity used
- Diagnostics – device warning and trip status; time to overload trip; history of last five trips; time to reset

Module size for drawer should be in multiples of 100mm

"For motors with ratings up to 30 kW, a three products architecture, Motor protection circuit breaker + Contractor + protection (IMPR) is acceptable as far as Coordination Type 2 is ensured. And above 30KW rating, Moulded case circuit breaker + Contractor + protection (IMPR) is acceptable."

### **9.3.30 Intelligent Motor Protection Relay**

This part of the specification describes the requirements for the low voltage Intelligent Motor Protection Relay (IMPR). This relay must be integrated in the global Motor Management System for use within standard IEC or NEMA, switchgear and control gear.

The nominal values, the standard documents and the relays minimum settings are defined in this document. Information regarding motors and current transformers is not included in the specification.

#### **a. General Requirements for the Intelligent Motor Protection Relay**

The Intelligent Motor Protection Relays (IMPRs) shall constitute of a complete control and self-sufficient expandable protection system. Each motor starter unit, whether of the direct-on-line or reduced voltage type or dual speed type etc., shall be equipped with a microprocessor based motor protection, monitoring and contactor control device. Intelligent Motor Protection Relays (IMPRs) shall provide protection, metering, control, monitoring, and historical logging for 1 $\phi$  and 3 $\phi$  AC induction motors up to 100 A using integral current transformers (CTs) or up to 810 A using inputs from external CTs. IMPRs shall have selectable trip classes from 5 to 30. The thermal overload trip curve shall be selectable between inverse ( $I^2t$ ) or definite time ( $Ixt$ ) curves. IMPRs shall have an IP20 rated enclosure for protection against direct contact and shall operate in temperature ranges of -4<sup>0</sup>F (-20<sup>0</sup>C) to 140<sup>0</sup>F (60<sup>0</sup>C) up to an altitude of 6560 ft (2000 m) without de-rating. The device should have integrated communication port for the direct link to the higher level bus system communicating through [Ethernet Modbus TCP / Ethernet IP][Modbus][Profibus DP][DeviceNET][CANopen].

#### **b. Environment, Ratings, and Applicable Standards**

1. The IMPR shall comply or be certified with the following national and international standards:
  - I. UL and CSA Certification
  - II. Bear the CE marking
  - III. CCC

- IV. EAC/GOST
- V. RCM/CTICK
- VI. Marine approved (BV, LROS, DNV, RINA, ABS )
- VII. Atex certified
- VIII. IEC/EN 60947-4-1 and Chinese deviations
- IX. UL 60947-4-1A
- X. CSA 22-2 n°60947-4-1.

- 2. The IMPR shall have the following environmental ratings:
  - a. Able to operate without de-rating to an elevation of 2000 m.
  - b. Capable of operating in an environment with a relative humidity range of 0 to 95%, non-condensing.
  - c. Rated for an operating environment of -20 to +60°C (-4 to +140°F).
  - d. Rated for application in Pollution Degree 3 environments.
  - e. Shall have an IP20 degree of protection.
  - f. The protection for the HMI mounted outside the switchboard shall be IP 54.
- 3. The IMPR shall be capable of operating on inputs of the following ranges:
  - a. 24 VDC
  - b. 100 - 240 VAC 50/60 Hz
- 4. All relay output shall be rated B300.

**c. Specific Requirements for the Intelligent Motor Protection Relay**

- I. The IMPR shall have Integrated Current Transformer up to 100A. For motors larger than 100 A, the connection of external current transformers shall be possible.
- II. The IMPR shall provide the following metering and monitor functions:
  - a. Line Currents @ 1% accuracy
  - b. Integrated Current Transformer up to 100A
  - c. Ground current @ 5% measured accuracy and 5-15% calculated non-measured accuracy
  - d. Average Current @ 1% accuracy
  - e. Current Phase Imbalance

- f. Thermal capacity Level
- g. Motor Temperature Sensor
- h. Protection Fault Counts
- i. Protection Warning counts
- j. Diagnostic Fault counts
- k. Motor Control Function counts
- l. Fault History
- m. Internal watchdog results
- n. Controller Internal Temperature
- o. Temperature Sensor Connections
- p. Current Connections
- q. Voltage Connections
- r. Control Commands (start, stop, run, check back and stop check back)
- s. Control configuration checksum
- t. Communication loss
- u. Motor control states motor starter/LO1 starts/ LO2 starts
- v. Operating time
- w. Motor starts per hour
- x. Last start max current
- y. Last start time
- z. Time to trip
- aa. Time to reset
- bb. Frequency
- cc. Line to Line Voltage @ 1% accuracy
- dd. Line Voltage Imbalance
- ee. Average Voltage
- ff. Power Factor @ 3% accuracy

gg. Active Power @ 5% accuracy

hh. Reactive Power @ 5% accuracy

ii. Active Power Consumption

jj. Reactive Power Consumption

III. The Ground Current shall be capable of being calculated from line currents or direct measurement through an external ground Current Transformer connected directly to the IMPR without the need of additional components or modules.

IV. The motor temperature measurement must be possible through several types of sensors including PTC binary, PTC analog, NTC analog and PT100. Without any additional component, the IMPR shall allow the connection of the temperature sensor.

V. Voltage measurement shall allow for line voltage up to 690V 50/60 Hz.

**d. Protection Functions**

The IMPR shall provide following Protection Function Capabilities:

I. Thermal overload

a. Trip curve shall be selectable between inverse ( $I^2t$ ) and definite time ( $Ixt$ )

b. Auxiliary Fan Cooling application shall be available

II. Current phase imbalance

III. Current phase loss

IV. Current phase reversal

V. Long start

VI. Jam (locked rotor during run)

VII. Undercurrent

VIII. Overcurrent

IX. Ground current (External Ground Fault CT not required)

X. Motor temperature sensor

XI. Rapid cycle lockout

XII. Voltage phase imbalance

XIII. Voltage phase loss

XIV. Voltage phase reversal

- XV. Undervoltage
- XVI. Overvoltage
- XVII. Voltage load shedding
- XVIII. Underpower
- XIX. Overpower
- XX. Under power factor
- XXI. Over power factor
- XXII. Voltage Dip Detection Automatic Restart]

**e. Electrical Connections**

- I. 1 $\phi$  or 3 $\phi$  current transformer inputs (integral sensing without CTs 0.4 to100 A)
- II. Wiring terminals shall provide IP20 Protection.
- III. Auxiliary Ground current sensor
- IV. Motor temperature sensor
- V. 6 discrete inputs [100-240 VAC][24 VDC] on core module
- VI. 4 discrete inputs [100-240 VAC][24 VDC] on expansion power module
- VII. [1 $\phi$  or 3 $\phi$  voltage inputs for enhanced functionality]
- VIII. Fault DPST relay output (5 A @ 250 VAC / 5 A @ 30 VDC)
- IX. Programmable SPDT relay outputs (5A @ 250 VAC / 5 A @ 30 VDC)

**f. Preconfigured Motor Control and Custom Logic Programming**

- i. The IMPR shall contain five pre-defined control modes: overload, independent, reverser, 2-step, 2-speed and a custom mode defined by the user using function block or structured text programming languages.
- ii. Custom programming of the IMPR should be available through PC-based programming software and application programs shall be provided on electronic media.
- iii. For each control mode, the IMPR shall come with the corresponding wiring diagram for 2 and 3 wires control.
- iv. The IMPR shall be capable of being set to compensate for a motor cooled with an auxiliary fan through an internal algorithm.

**g. Fault and alarm Monitoring**

- I. The IMPR shall include an Alarm management function and a Fault Management function, that can be independently enabled/disabled with the relevant threshold(s) for each protection function.
- II. The Faults reset mode must be selectable between manual reset, automatic reset after a set time and remote reset via communication.
- III. The Fault Management function shall also record the five most recent detected faults.

**h. User Interface**

- I. The IMPR shall have LEDS to indicate HMI Communication Status, Power, Alarm, Communication statuses.
- II. The IMPR shall have a dedicated external HMI Port.
- III. The IMPR shall have the option for a one-to-one Human-Machine Interface (HMI). This unit is to be used both for commissioning and/or for normal operation. It shall allow the configuration of the IMPR and the display of operating data such as measurements, counters, status, faults and warnings information.
- IV. The HMI shall have the capability to adapt to local languages by selection or download. During the operation of the IMPR, it shall be possible to select the HMI language between at least two languages. In addition it shall be possible to download other languages.

**i. Communication**

- I. The IMPR should have integrated communication port for the direct link to the higher level bus system communicating through [Ethernet Modbus TCP / Ethernet IP][Modbus][Profibus DP][DeviceNET][CANopen].
- II. [Ethernet Modbus TCP / Ethernet IP enabled IMPR shall be capable of providing Fault Device Replacement (FDR) functionality.]
- III. [Ethernet Modbus TCP / Ethernet IP enabled IMPR shall have Java-Free Webpages that provides monitoring, configuration, and statistical information.]
- IV. The IMPR shall communicate through an integrated communication port so that it can be connected to communications architecture with information remote access.
- V. The IMPR shall have the options to connect with these networks, one each per application, with native connectivity embedded directly from the factory.

**j. Configuration Software**

- I. The IMPR shall use a free user-friendly setting and operating multi-lingual software in a Windows environment with menus and icons for fast direct access to the data required, with guided navigation to go through all the data on the same function together in the same screen and with a file management.



- II. The IMPR shall allow customised logic by the end user to be programmed within the microprocessor.

**k. IMPR Dimensions**

- I. The dimensions of the IMPR shall not exceed 61 mm (2.4 in.) height x 91 mm (3.58 in.) width x 120 mm (4.72 in.) depth.
- II. The dimensions of the expansion power module shall not exceed 61 mm (2.4 in.) height x 45 mm (1.77 in.) width x 120 mm (4.72 in.) depth.

**9.3.31 Automatic Power Factor Control Panel (APFC)**

The APFC panel shall be suitably rust inhibited and stove enamelled. The panel shall have adequate space for mounting the capacitors. The panel shall be of dust and vermin proof construction with suitable ventilation arrangement for capacitors. Panels shall be of dead front pattern and floor mounting type.

The APFC panel shall generally comprise of following:

- a. Power factor correction relays with switching recording
- b. Step controller with reversing mechanism.
- c. Time delay and no-volt relays.
- d. Protection fuses.
- e. The Capacitor should be turned ON using Zero Cycle Crossing technology..
- f. Change over switch for manual and automatic operation
- g. Power factor meter with protection fuses.
- h. Indicator lamp for each bank.
- i. conductors with minimum cross section of 1.5 Sqmm for potential circuits and 2.5 Sqmm for current.

**Standards**

The capacitors shall conform to IS: 2834-1986 and 13340-1996 Shunt capacitors for power system.

**Construction**

The capacitors shall be suitable for operation on 433 V, 3 phase, 3 wire, 50Hz solidly earthed AC supply system.

The capacitor element shall of MPP with Aluminium Alloy sprayed with heavy edge. The film technology preferably be smooth, the elements are wound in concentric winding and form cylindrical shape which should reduce the spare and element should be capable of withstanding more than 200 times of normal KVAR current. Each capacitor should be of

pressure sensitive (over pressure tear off) arrangement.

The capacitor ratings can be from 10 KVAR to 50 KVAR single units or can be smaller units parallel to form a required KVAR / Bank.

The container of the element should be preferable impregnated with Sticky Resin / Inert gas (MPP (APP/MD-XL) and the capacitor unit is hermitically sealed to prevent ingress of air / moisture.

The capacitor shall be suitable for 440V and shall be continuously operating at a maximum of 480V for 8 Hrs. in a day

The capacitor shall be suitable for a rated voltage of 433 V and shall be of continuously operating at a maximum over-voltage up to 500V.

Solution chart for different filters with capacitors

| Sr. | Rating (Voltage 440V) | MH Value | Capacitor rating with Voltage |
|-----|-----------------------|----------|-------------------------------|
| 1.  | 10 kVAR               | 4.64     | 11.2 kVAR 480 V               |
| 2.  | 12.5 kVAR             | 3.71     | 14 kVAR 480 V                 |
| 3.  | 20 kVAR               | 2.32     | 22.4 kVAR 480 V               |
| 4.  | 25 kVAR               | 1.86     | 28.1 kVAR 480 V               |
| 5.  | 50 kVAR               | 0.93     | 28.1X2 kVAR 480 V             |

The rated frequency is 50Hz. The capacitor shall however, be suitable for continuous operation with a frequency variation of +/- 2% from the rated frequency. The capacitor shall be suitable for operation in maximum ambient temperature of 50 Deg. C as per IS:2834-1986 and IS:13340-1996.

The capacitor shall also be capable of carrying without injury an increase in current loading up to 50% of the rated current that may arise due to increase in voltage, increase in frequency, presence of non-sinusoidal voltage supply or other causes. The maximum continuous reactive output of the capacitor shall not exceed 50% over the rated reactive output.

All capacitors shall be suitably tropicalised and rated for the service conditions on site. The capacitors shall be designed and manufactured from the best materials for satisfactory operation under severe service conditions without causing any permanent injury or shortening of the life.

Discharge Devices

Each capacitor bank shall be fitted with a low loss continuously rated effective discharge device. It shall be designed to discharge the entire capacitor from the peak AC voltage to a voltage not exceeding 50 V measured at the terminals of the capacitor within a maximum period of 1 minute of disconnection from supply.

#### Specifications For MPP Heavy Duty Capacitors

1. Type of Capacitors : MPP
2. System Voltage : 415V +/- 10%.
3. Rated Voltage of capacitor : 433 V+10%
4. Rated frequency : 50Hz +/- 2%
5. Number of phases : 3
6. Max. permissible over voltage/duration for satisfactory operation : 10% over and above the rated voltage continuous
7. Rise in maximum temp on continuous: : 10 Deg C max. kVAR output under operating ambient temp. of 50 Deg C.
8. Watt loss per KVAR (Di-electric) : Max. 0.2 Watt / kVAR
9. BIL : 2.5kV AC
10. Connection : Internally Delta Connected.
  - a. Discharge Device : Internal resistor
  - b. Discharge time : Discharging to 50V in 60 sec
  - c. Min. time interval required between de-energisation and re-energisation of the capacitors with regard to the duty on discharge device. : 60 sec
10. Permissible limit of unbalance : 5%
11. Detailed technical particulars of the insulating medium in the capacitor :
  - a. Type of impregnation : Non-PCB, Non-toxic, Bio-degradable Gas Impregnated/Resin capacitor.
  - b. Type of container : CRCA / Extended Aluminium

- c. Thickness of container sides : 2.5mm
- d. Reference Standard : IS:2834-1986 and IS:13340-1996
- e. Total KVAR Rating : As per drawings.

#### Specification For Series Reactor

Standards: The reactor shall conform to IS 5553, IEC 60076-6.

#### Objective:

The objective of connecting a reactor in series with the capacitor is to avoid resonance between the inductive impedance of the supply transformer plus the line cabling and capacitors installed for power factor improvement in networks polluted with harmonics. In order to avoid resonance to the 5th harmonic and above, reactor impedance should be 7% of Capacitor impedance i.e., a resonance frequency of 189 Hz for 50 Hz network.

#### Construction:

The reactors should be built with a core made of oriented grain iron sheet with spilt air gaps so as to give excellent anti-saturation characteristics and very low losses. The coils can be made either with insulated aluminium sheet.

The input/output connections should be made through tinned Aluminium bars. The coil windings should be provided with ventilation space for allowing adequate heat evacuation even hot ambience. The reactor should be vacuum impregnated with a varnish having high insulation properties.

#### Technical characteristics of the Reactor

- Insulation level : 3.0 KV for 1 min
- Tolerance of L : +/-5%
- Linearity (5% OF L) to :  $1.66 \times 2 \text{ RMS} = 1.8 \text{ In}$
- Maximum ambient temperature : 50 Deg C.
- Internal insulation : Class H (155 deg C)
- Maximum Load – continuous : 1.1.In.
- Transient (1 min) : 2 In.
- Constructive standards : As per relevant IS/IEC Stds.
- Losses Temperature Protection : Below 8 watts / KVAR Micro switch (NC)

The Voltage Distortion subjected on the Transformer Incomer/**Feeder** should be less than 3 % and Current distortion to be less than 5%.

### **9.3.32 Automatic load transfer switches (ALTS) to be used in conjunction with Power Diesel Generator sets**

Automatic load transfer switches shall be composed of paired ACBs or MCCBs. ACBs and MCCBs used in Automatic Load Transfer switches shall be used as specified in this specification.

Paired ACBs or MCCBs (as specified above) shall be provided with motorized mechanisms for "ON/OFF" operation.

Each automatic load transfer switch shall be equipped with, but not be limited to, the following:

- a) Illuminated indicator for "Normal Supply On" and "Standby Supply On" to be provided at the front cover of the compartment housing the changeover switches.
- b) Transfer mechanism to facilitate automatic/ manual changeover from the normal source to the standby source.
- c) Automatic/manual change-over selector switch shall be provided. It shall be possible to manually operate the circuit breakers in the event of absence of control voltage.
- d) ALTS should have electrical interlocking along with mechanical interlocking through base plate to ensure that two MCCBs shall not be ON simultaneously.
- e) Interlocking facility to insure that normal breaker tripped on fault will not cause standby breaker to close or vice versa, unless the breaker are reset manually.
- f) A test switches to simulate mains power failure and indicate the changeover sequence to allow on load testing.
- g) Auxiliary relay and contacts to facilitate main power source failure for routine testing of the automatic change-over operation.
- h) 2 nos. each NO and NC volt free dry contacts shall be provided for each change-over circuit breaker unit.
- i) The change-over function shall work without auxiliary power supply with fail safe operation.
- j) All indications for all operations viz. ON, OFF, TRIP.

The changeover system between the normal and standby sources shall be as follows:

- a) 3 phase sensing circuits with adjustable time delay facility in the range of 0 to 15 seconds shall be provided to monitor the voltage condition of the normal and standby source.
- b) Failure of one or more phases of normal main supply or are reduction of voltage to a value of 90% to 70% (adjustable) of nominal value shall initiate the timing device. If the failure persists at the expiry of this present time delay, the changeover section will be affected provided that the voltage of the standby source reaches 90% of the nominal value.

- c) Upon restoration of the normal power supply, which has been determined stable after a time delay, the changeover switch shall automatically be restored to the normal supply. It shall also be able to switch the load back to the normal supply under manual control.

### **9.3.33 415v, 3 Phase Switched-Socket Outlets (Receptacles)**

The Contractor shall supply and install switched socket outlets suitable for operation on 3 phase, 4 wire, 50 Hz supply system, the switches and sockets shall conform to relevant standards. These units shall be housed in galvanised iron sheet steel boxes and shall be suitable for outdoor installation. The units shall be fed from power distribution boards/ switch gear etc. located in relevant areas. All supply and installation item associated with cabling, earthing, providing mounting structures etc. shall be deemed to be included to Contractor's scope. In outdoor areas one such unit shall be provided to cover area of 15m radius and in outdoor areas at intervals of 50m. Actual number of units shall be indicated by the Contractor on the basis of above guidelines and to suit layout design of the plant. The location of these units shall be indicated on the cable layout drawings to be prepared by the Contractor. Actual requirement of these outlets shall be finalized in consultation with the Employer's Engineer. Before procurement, samples of these shall be furnished to the Engineer for approval.

### **9.3.34 Control Schematic Drawings**

The Contractor shall furnish detailed schematic/ control drawings for all electromechanical equipment/ devices such as switchboards/ MCCs, blowers, pumps, compressors etc. indicating details like power/ control supply arrangement, indication/ annunciation/ interlocking circuits (if any), details and development for programme/ control selector switches etc. for the approval of the Engineer. A detailed write-up on the Control Scheme covering logic/ interlocks/ protections/ modes of operation etc. shall also be furnished for explanation.

## **8.3 Power Generating Set**

### **8.4.1 Diesel Generator**

#### **(A) General**

Specification for the DG set is as per CPWD, General Specifications for Electrical works, Part-VII (DG Sets).

Diesel Generator of required capacity 4 stroke shall be provided to generate rated KW load at 415V 3 phase, 50 Hz continuously comprising of totally enclosed water cooled diesel engine with multi-cylinders developing suitable BHP not less than 120% of rated BHP at 1500 RPM or 1000 RPM with 10% overload for 1 hour in 12 hours with starting lead acid batteries, necessary fuel storage, pumping and handling system and other standard accessories such as:

- a. Fly wheel with guard
- b. Battery charging alternator unit & voltage regulator, suitable for starting batteries, battery racks with interconnecting leads & terminals.
- c. Lube oil system shall comprise oil pump, strainer, lube oil cooler, oil filter, and bye pass filter & associated self-contained piping.

- d. Electronic governing system
- e. Cylinder head, cylinder jacket, lube oil shall be water cooled.
- f. Exhaust system with necessary supports, fittings, bellows and exhaust silencer shall be provided.
- g. 12/24 volts electric starting equipment complete with standard battery, static battery charger, cut outs, ammeter or compressor air start comprising of compressor, air bottle, air compressor motor, pressure gauge.
- h. Heavy duty domestic exhaust silencer and vertical hot air duct boot logged with wool and alum. Cladding inside Diesel Generator building along with exhaust piping of required length.
- i. Engine and alternator shall be mounted on a steel fabricated base plate. Access platforms and ladders shall be provided.
- j. Manual engine turning equipment.
- k. Crank case breather pipe.
- l. Lubricating oil cooler and lube oil, filters pressure pump gauge, pressuring (bulk fuel storage tank equal to 24 hrs. capacity with required pumps and piping with flame proof motors shall be provided to pump diesel to day tank).
- m. Complete wiring and protection system of diesel handling equipment in case of leakage. - All required instruments such as tachometer, pressure gauges, temperature gauges, protection devices, sensors and transmitters for safe and reliable working of the equipment shall be provided. Both the engine and alternator fitted on a common fabricated steel base plate with anti-vibration pads and both connected to each other by flexible flange coupling.
- n. As per CPWD general specifications for electrical works part-vii, the exhaust stack height in order to dispose exhaust above building height, minimum stack height should be as follows:

For DG set upto 1000KVA:

$$H = h + 0.2 \times \text{sqrt. (KVA)}$$

Where H = height of exhaust stack

h= height of building

#### **8.4.2 Silent Diesel Genset**

##### **(A) General Description**

The diesel generator shall be totally enclosed on the cold rolled sheet steel Acoustic Enclosure. The Acoustic enclosure shall be supported on a M.S. Channel Framework.

Suitable Insulated ducting is provided for air inlet/ outlet. Suitable louvers / sound attenuates/ bird guards are provided at all the openings for air inlet/ outlet top facilitate free airflow & to prevent sound leakage. Detachable partitions are provided inside the Acoustic Enclosure to prevent reverse flow of hot air. The insulated partition also helps in sound absorption. It is recommended that sufficient free space be provided on all the four sides for easy access. Generally the Acoustic Enclosure is delivered at site as single unit. However, it can also be fabricated in sub-assemblies & can easily be constructed at site, if so desired. These enclosures are designed to be installed outdoor. However, for any specific application of installing the equipment indoor, Acoustic Enclosure is designed as per ventilation requirement at site.

**(B) Insulation**

A layer of rock wool/ mineral wool is provided on all the sides of the Acoustic Enclosure, including base & roof. The rock wool / mineral wool is duly covered with tissue paper, which avoids any chances of small particles being sucked by the Diesel Engine air cleaner, at a later stage. The rock wool / mineral wool along with tissue paper is covered with G.L. perforated sheet to contain the insulating material in sheet framework, specially made for the purpose.

**(C) Doors**

Suitable doors are provided to facilitate easy access & maintenance of the engine.

**(D) Locking Arrangement**

Heavy-duty brass locks are fixed to provide air tight locking of the doors.

**(E) Packing**

Suitable size of rubber packing is fixed on all the doors. Suitable packing is also provided at all such joints where any two metal parts are bolted to avoid entry of dust / water.

**(F) Ventilation**

A careful study of the air requirement of the Diesel Engine ( as per manufacturer's recommendation) is kept in view to facilitate smooth running of the machine within specified parameters i.e. oil pressure, temperature, etc.

**(G) Lighting**

Suitable lighting arrangement is provided inside the enclosure to help easy maintenance of the Diesel Generator. The light point is required to be connected with 220V AC at site.

**(H) Exhaust Extension**

The exhaust gas is taken out through the roof of enclosure with the help of flexible connector & M.S. Pipe. The inside portion of M.S. Pipe is clad with glass wool & aluminium sheet to avoid any heat dissipation inside the enclosure.

Specially designed Residential silencer is mounted on roof tops of enclosure / any other convenient place. The exhaust gas can be further extended to any other convenient location with the help of M.S. Pipe.



**(I) Painting**

The Acoustic Enclosure is painted with two coats of polyurethane paint. Before painting, primer is applied after pretreatment by seven tank process, for making it suitable for installation in open areas.

**(J) Trunking**

Suitable trunking is provided in the enclosure for routing of cable with proper glands.

**(K) Control Panel**

If desired, the control panel for D.G. Set can be mounted inside the Acoustic Enclosure facing a glass window for each access. In such case the panel is required to be fabricated as per space availability inside the enclosure.

**(L) Batteries**

At your option batteries can be kept inside / outside the enclosure. If the batteries are required to be kept outside the enclosure, a separate battery stand is provided for easy maintenance and protection from weather conditions.

**8.4.3 Diesel Tank**

For easy filling & monitoring, it is recommended that the Diesel Tank should be kept outside the Acoustic Enclosure. In such case suitable openings are provided in the Acoustic Enclosure for fuel piping.

The tank shall have fuel level gauge, drain pipe with isolation valve. Output pipe complete with water trap and isolation valve and filling point at top of tank with removable gauze filter.

Tank should have the capacity to cater one day continuous operation of DG and diesel tank shall have minimum capacity of 990ltrs.

In case any license/permit is required for installing the diesel tank, the same shall be obtained by the Contractor in favor of SPV

**8.4.4 Alternator**

**(A) General**

Alternator and accessories shall include, but not limited to generator, excitation system, automatic voltage regulator, generator control panel and relay panels. Alternator shall be self-excited ventilated with drip proof open screen protected construction. Alternator insulation shall be of class 'H'. It should have capacity of supporting short circuit current in 3 phases for 3 seconds. Alternator shall have minimum reactance and low voltage waveform distortion. The line and neutral end of each phase winding of the Generator shall be brought out on six suitably located terminals. Contractor shall provide suitable clamping arrangement for connecting cable to the machine terminals. The terminals shall be suitably enclosed to prevent short circuits by rodents, etc. Suitable cable glands shall be provided on the enclosure to facilitate entry of the above cables. Voltage drop calculations shall be submitted to ensure that voltage drop during starting of biggest motor (when other loads are on) besides other loads does not exceed 15%. Suitable sizing shall be worked out and mentioned along with the

bid.

230V single phase space heaters of adequate ratings shall be provided in the lower part of the stator frame. The generator shall be provided two (2) grounding terminals with clamps suitable for connecting to the separate GI earthing system exclusively for generator body. Similarly minimum two copper earthing station pit shall be made of Generator neutral earthing resistance shall be maximum one ohm each for Generator body, Generator neutral.

**(B) Excitation System**

The excitation system shall have brushless type rotating field or static exciter with rectifier. The response ratio of the excitation system shall be not less than 0.50. The excitation system shall be so designed and or protected, that harmful over voltage cannot occur at the main exciter due to combined effect of maximum exciter field current and machine over speed.

**(C) Voltage Regulator**

- a. Continuous acting, non-dead-band type static automatic voltage regulators with accessories mounted in a suitable panel shall be provided for the generator. The automatic voltage regulator shall be capable of working over the whole load and voltage range of the generator.
- b. The voltage regulator shall be of continuously acting, high response, static type and shall be complete with the cross current compensation preferably of static type. The regulator shall be supplied complete with voltage setting device, all accessories and other contacts.
- c. AVR shall control generator voltage under steady state load conditions and over the whole of the operating range of exciter to within 1.5% of rated voltage.
- d. Voltage Regulator shall have three phase & 4-wire line-to-line sensing, Configurable torque matching, FET based full wave rectified voltage regulation and a PWM output for stable operation with all load types.

**(D) Control Panel**

Local engine control panel shall be provided for engine generator set. Also, a composite main control panel shall be provided for control, instrumentation and monitoring of the generator and associated equipment. The composite panel shall have all necessary metering, protection etc. for the isolated and synchronized operation of the diesel engine generating sets (if required).

The generator sets shall be provided with AMF panel. The control panel shall be floor mounted, comprising of volt-meter, ammeter, frequency meter, power factor meter, KW meter, energy meter, selector switches, circuit breakers of adequate capacity, indicator lamps duly wired with MCB.

Switch gear shall have draw-out circuit breakers with electro static over current, short circuit, earth fault with separate indications, ON/OFF indication, contactor ON indication, annunciator for all electrical & mechanical parameters with trip and alarm facility. Differential relay shall also be provided for alternators.

The alternator & control panel shall be connected with suitable capacity armored cable and complete with erecting, commissioning and testing as per manufacturer's requirements with

filling of fuel, oil etc., with guarantee of complete system for one year. Alternator box shall be amended accordingly to accommodate total number of cables. The Diesel Generator set shall have monitoring system to monitor and give alarm with indication in case any of the following parameters are not normal in such cases the engine can be automatically / manually stopped, Low lube oil pressure, High cylinder head temperature, High jacket water temperature.

**Control Panel should have:**

1. Remote/Auto start panel, SCADA Communications interface and bundle the bus communication with the most common protocols found in industrial networks (Modbus SL / Modbus TCP / Profibus / Ethernet IP/PCCNet).
2. Auto, manual, start, stop, fault reset and lamp test/panel lamp switches, Alpha-numeric display with pushbuttons, LED lamps indicating genset running, remote start, not in auto, common shutdown, common warning, manual run mode, auto mode and stop
3. LED backlight LCD for displaying electrical parameters like:
  - a) **Alternator data** - Line-to-neutral and line-to-line AC volts, 3-phase AC current, Frequency, kW, kvar, power factor kVA (three phase and total)
  - b) **Engine data** - DC voltage, Engine speed, Lube oil pressure, Coolant temperature/low level, Comprehensive FAE data (where applicable)
  - c) **Other data** - Start attempts, starts, running hours, kW hours, Load profile (operating hours at % load in 5% increments), Fuel consumption data log, Fault history, Data logging and fault simulation
4. Standard control functions like:
  - a) **AC protection** - Intelligent protective relay, over current and short circuit shutdown, over current warning, Single and three phase fault regulation, over and under voltage shutdown, over and under frequency shutdown, overload warning with alarm contact, reverse power and reverse var shutdown, field overload.
  - b) **Engine protection** - Battery voltage monitoring, protection and testing, Over speed shutdown, Low oil pressure, warning and shutdown, High coolant temperature warning and shutdown, Low coolant level warning or shutdown, Low coolant temperature warning, Fail to start (over crank) shutdown, Fail to crank shutdown, Cranking lockout, Sensor failure indication, Low fuel level warning or shutdown.
  - c) **Control functions** - Time delay start and cool down, Real time clock for fault and event time stamping, Exerciser clock and time of day start/stop, Data logging, Cycle cranking, Load shed/ dump as per configurable priority, 4nos. of Configurable inputs and outputs, Remote emergency stop, Auxiliary output relays and remote annunciators.
5. Paralleling control functions like, Digital frequency synchronization and voltage matching, Isochronous kW and kvar load sharing controls, Droop kW and kvar control, Sync check, Extended paralleling (Peak Shave/Base Load), Digital power transfer control (AMF) provides load transfer operation in open or closed transition or soft (ramping) transfer mode.

Control panel shall be Prototype tested: UL, CSA and CE compliant.

#### **8.4 Starting of Motors**

This shall be through Intelligent Motor Protection Relay [IMPR] with MPCB. No fuses shall be used.

##### **8.5.1 Direct On Line**

The DOL contactor starter module shall be considered for control of motors and shall be equipped with

- a. Power and auxiliary Contactors as required
- b. Start, stop and reset PB
- c. On, off and trip indication
- d. Digital Ammeter [3 line] Power and control circuit wiring and termination accessories
- e. Local/remote sel. Switch
- f. Auto / off / manual sel. switch as per requirement.

The specifications of the contactor to be used shall be as per clause 9.3.11.

##### **8.5.2 Soft Starter with IMPR**

- a. The soft starter module shall be considered for control of motors of rated above from 7.5KW.
- b. By incorporating Soft-Starter for starting of Squirrel Cage Induction Motor it will amount to reduction of starting torque & also the starting current. The electrical and mechanical stresses on motor will be reduced to a great extent. The soft starter shall be designed to operate with full starting current with adequate margin as safety factor.
- c. The specifications of the contactor to be used shall be as per clause 9.3.11.

#### **A. Construction**

- i. Power shall be supplied to each starter through two thyristors in anti-parallel configuration or bridge type /inverse parallel fully controlled / FCMA Type to reduce the starting current.
- ii. Controller shall also be mounted in the high voltage motor control panel.
- iii. Soft starter panel shall be indoor, metal clad with separate metal enclosed compartment for:
  - Control, metering and current transformers for differential protection.
  - Shorting (by pass) arrangement
  - Power cable termination
  - Push button with indicating lamps

- iv. Starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacture shall co-ordinate with motor manufacture for this purpose.
- v. Interlock shall be furnished to prevent operation of the isolating mechanism under load; opening of the high voltage compartment before the controller is isolated and closing the line contactor whiles the door is open.
- vi. Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.
- vii. Contractor shall furnish the losses of the soft starter and any clearance required for adequate cooling.

## **B. Controls**

### *a. Digital Input*

The Soft starter shall have digital input for 2 and 4- wire start/ stop and reset controls.

### *b. Relay output*

Three relay output shall be provided for remote monitoring of the controller. The programmable option below shall be included as minimum:

- i. By pass contactor control
- ii. Main contactor control
- iii. Alarm
- iv. High current flag
- v. Low current flag
- vi. Output on.

### *c. Local Control*

The starter shall have local stop, start and reset buttons and the ability to switch between these buttons and the remote input terminals.

### *d. Galvanic Isolation*

All digital control inputs and outputs shall be galvanically isolated from the mains supply.

### *e. Display and keypad*

The controllers shall have a digital display, keypad which can provide status information and can be used to configure the soft starter.

### *f. Keyboard lock*

It shall be possible to lock the keyboard to prevent unauthorized changes to parameters.

### **C. Main Bus Bars**

Bus bars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protection of all joints. Bus bars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit. Bus bars shall be hard drawn copper conductor and of high conductivity, EC grade copper of 99.75 purity.

### **D. Earthing**

A copper earthing shall be provided at the bottom and extended throughout the length of panel.

Assemblies shall be provided with earthing facilities as follows. For small single compartment assemblies an earth stud shall be provided. For large single compartment or multi-compartment assemblies a clearly marked continuous Alum./ GI earth bar of minimum 40mm x 5mm shall run the entire length of the assembly and shall be provided with terminals for connections to the metal cladding or armoring of all incoming and outgoing cables. The earth bus size shall be generally 10% of phase size subjected to meeting short circuit conditions and minimum size for any panel shall be 40x5mm. The temperature rise of the bus bar and connections under fault conditions shall not cause damage to the connections of any equipment to which they may be connected. The earth fault calculations shall be submitted along with detailed engineering. No earth terminal bolts or studs shall be less than 8mm diameter. An earth bond of minimum size 4 sq.mm. shall be made to all enclosure doors.

## **8.5.3 Variable Frequency Drives (VFD)**

- (A) The VFD module shall be considered for control of motors as per process requirement and shall be equipped with-
- i. The Frequency drives shall be of Current Source Inverter Pulse Width Modulated (CSIPWM) with IGBT/IGCT/SGCT/DTC technologies or later version, which performs precise speed and torque control of standard squirrel cage motors with optimum efficiency.
  - ii. Each drive must have a soft starting feature and a bypass arrangement for DOL starting of motors. All frequency drives shall be suitable for data connectivity with DCS system and shall have suitable communication port and protocol.
  - iii. The drives must be easily programmable. The drives shall be provided with surge protection, programmable lockable code. The Frequency drive shall have following characteristics:
    - Accurate open loop torque control
    - Torque step rise time typically less than 5 ms
    - Speed control inaccuracy typically 0.1% to 0.5% of nominal speed
    - 150% overload capacity for 60 second

- iv. VFD shall have integrated embedded web server and shall provide a Web server with native template to monitor the AC drive
- v. The AC drive shall provide advanced Ethernet services and shall be compliant with the Cyber security Management ISA Secure /Achilles.
- vi. The AC drive shall provide a detachable graphic display terminal
  - Keypad designed for harsh conditions IP65
  - Keypad with a graphic display.
  - Remote mounting shall be possible at a distance of 10m.
  - The display should have a programmable back-light display.
  - The display should have a coloured red back-light when a warning occurs.
  - The programming shall be able to operate in a multi-point connection.
  - Coded messages are not acceptable.

Total Harmonic distortion shall comply with the provisions of Standards. Necessary metering, self-diagnostic arrangement (including display and alarm facilities) shall be provided for local/ remote monitoring.

The programming terminal shall be able to display the “pump monitoring” data.

The programming terminal shall be able to display the “efficiency board”.

- CO2 savings
- Savings viewer
- Return of Investment

#### Pump Protection Functions

- The AC Drive should provide an Anti-Jam function in order to remove automatically clogging substances from the pump impellers.
- The AC Drive should provide a Pipe Cleaning function in order to start pump regularly to avoid sedimentation in pump impeller
- The AC Drive should provide a Cavitation Pump Protection
- The AC Drive should provide an Inlet protection in order to avoid system dry running system.

#### Pump monitoring

- The AC Drive should provide a Storage of the pump characteristics

- The AC Drive should provide a best efficiency points (BEP) function in order to run in optimum conditions and detect deviation from this point.

Advanced functions

- The AC Drive should provide a Scheduler based on Real Time Clock.

**(B) Standard control connections**

- i. 3 programmable differential analogue inputs (1 voltage signal, 2 current signals)
- ii. 7 programmable digital inputs
- iii. 2 programmable analogues outputs (current signal)
- iv. programmable digital outputs (from C relays)
- v. Optional analogue and digital extension modules can be added as well as a wide range of field bus adapters.

**(C) Protection**

- i. Over current
- ii. Short circuit at start-up
- iii. Input phase loss
- iv. Output phase loss
- v. Motor overload
- vi. Earth fault
- vii. Overvoltage
- viii. Under voltage
- ix. Over temperature
- x. Motor stall

**8.5 11KV Indoor Vacuum Circuit Breaker with air insulation**

The equipment offered shall be complete with all parts necessary for their effective and trouble-free operation. Such parts will be deemed to be within the scope of the supply irrespective of whether they are specifically indicated in the commercial order or not.

The equipment offered shall conform to the relevant standards and be of high quality, sturdy, robust and of good design and workmanship complete in all respects and capable to perform continuous and satisfactory operations in the actual service conditions at site and shall have sufficiently long life in service as per statutory requirements. In actual practice, notwithstanding any anomalies, discrepancies, omissions, in-completeness etc. in these



specifications, the design and constructional aspects, including materials and dimensions, will be subject to good engineering practice in conformity with the required quality of the product, and to such tolerances, allowances and requirements for clearances etc. as are necessary by virtue of various stipulations in that respect in the relevant Indian Standards, IEC standards, I.E. Rules, I.E. Act and other statutory provisions.

The Contractor shall bind himself to abide by these considerations to the entire satisfaction of the Employer and will be required to adjust such details at no extra cost to the Employer over and above the tendered rates and prices.

Tolerances on all the dimensions shall be in accordance with provisions made in the relevant Indian/IEC standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

### 8.6.1 Service Conditions

System particulars

|                         |   |                        |
|-------------------------|---|------------------------|
| Type                    | : | Indoor                 |
| Nominal system voltage: |   | 11kV                   |
| Frequency               | : | 50Hz                   |
| Number of phases        | : | 3                      |
| Short current rating    | : | minimum 25kA for 3 sec |
| Rated normal current    | : | 1250 Amp               |

### 8.6.2 Codes and Standards

The design, manufacture and performance of the equipment shall comply with all currently applicable statutes, regulations and safety codes.

Unless otherwise specified, the equipment offered shall conform to the latest applicable Indian, IEC, British or U.S.A Standards and in particular, to the following:-

|  |                              |
|--|------------------------------|
| Switchgear                                   | IEC 62271-200 / EN 62271-200 |
| Switchgear                                   | IEC 60694 / EN 60694         |
| Behaviour in the event of internal faults    | IEC 62271-200 / EN 62271-200 |
| Three-position disconnecter and disconnector | IEC 62271-102 / EN 62271-102 |
| Busbar earthing switch                       | IEC 62271-102 / EN 62271-102 |
| Circuit-breaker                              | IEC 62271-100 / EN 62271-100 |
| Current transformer                          | IEC 60044-1 / EN 60044-1     |
| Voltage transformer                          | IEC 60044-2 / EN 60044-2     |

|  |                      |
|--|----------------------|
| Voltage detection systems  | IEC 61243-5          |
| Protection against accidental contact, foreign Objects and water | IEC 60529 / EN 60529 |
| Installation   | HD 637 S1            |

### 8.6.3 General Technical Requirements

#### Operating Conditions

Operating Conditions according to : IEC 60694 / EN 60694

Temperature of ambient air:

Maximum value : 50<sup>0</sup> C

Average value over 24 hours : 35<sup>0</sup> C

Minimum value "indoor" : - 5<sup>0</sup> C

Installation altitude above sea level up to : 1000 m

#### Rated Normal Current

The rated normal currents of components are stated in the Technical data and shall be valid for design ambient temperature of 40<sup>0</sup> C.

The switchgear boards shall be indoor metal clad, single front, single tier, fully compartmentalized construction comprising of a row of free standing, floor mounted panels. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker, main bus bars, current transformers cum cable compartment and low voltage compartment. Each compartments of individual cubicle shall be segregated by earth metallic sheet. Cubicle should be type tested for internal arc in all three compartments for minimum 25KA for 3sec as per IEC 62271-200.

### 8.6.4 Type of Sheet Steel & Cubicle

The cubicle shall be of bolted construction with minimum thickness of 2.0mm and for other non-load bearing members such as inter compartment partition etc. can be of 1.5 mm. Sheet steel used for fabrication shall be cold rolled carbon annealed only and fabrication shall be done through CNC turret punch press and CNC bending machine. Sheet steel shall be of Aluzinc material without painting however the front sheet and rear sheet covers can be of CRCA powder coated painted. Width of cubicle shall be max 600mm/800mm up to 1250A. All covers & doors shall be of folded design type with viewing window at rear cover (box type) of polycarbonate.

### 8.6.5 Circuit Breaker

The circuit breaker shall be mounted on a withdrawable truck which shall roll out horizontally from service position to isolated position with ease and it shall also be possible to take out the breaker truck from cubicle smoothly on to the floor. It is preferable to provide with guides for withdrawal and insertion of truck into the cubicle with ball bearing arrangement on the top of

the truck. Circuit breaker shall be of vacuum only and the truck shall have distinct 'SERVICE' and 'TEST' position. Special multi point hinged locking arrangement shall be provided to prevent opening of door in the event of internal arc in breaker compartment. Isolation shall be horizontal.

All the three interrupters of individual phases shall be mounted on a common phase segregated epoxy/BMC body mounted on a truck for better insulation and avoidance of non-simultaneity of poles. Circuit breaker shall be vacuum type only. Interrupter mounted on the conventional individual insulators will not be accepted. No separate fiberglass sheet barrier to be used.

It shall be operated through a common motor wound spring charged mechanism with electrical release coil for closing and shunt trip coil for tripping. Operating mechanism must have manual charging, closing and tripping facility with the provision locking facility in push to close & push to trip mechanical push button.

The mechanism shall be such that motor will automatically recharge the mechanism springs after a closing operation enabling breaker to perform OCO operation. The charging time of motor shall be less than 15 secs making it suitable for rapid auto reclosing duty. Mechanical push to trip button shall be provided for manual tripping with front door closed. All the 'MS' components of circuit breaker mechanism shall be treated with zinc plating with passivation for longer life even in adverse climatic condition. Yellow passivation shall not be acceptable. All mechanism springs shall be powder coated. Plating on mechanism spring is not acceptable. The normal current rating of circuit breaker shall be in panel rating.

#### **8.6.6 Interlocks**

Circuit breaker can be inserted only in open position. Likewise circuit breaker in closed position cannot be withdrawn. Attempt to draw out closed breaker shall not trip the breaker.

The circuit breaker shall operate only in one of the three defined positions i.e. service, test and isolated. The breaker shall not close in any of the intermediate positions.

The circuit breaker cannot be inserted into service position till auxiliary contacts are made. Similarly interlock shall prevent auxiliary contacts from being disconnected, if circuit breaker is in service position.

#### **8.6.7 Safety Shutters**

Safety shutters shall be metallic and shall be provided to cover up the fixed High voltage contacts on bus bar and cable sides when the truck is moved to Test / isolated position. The shutters shall move automatically, through a Linkage with the movement of the truck and shall be of gravity fall type only. It shall be possible to padlock shutters individually.

#### **8.6.8 Fixed Isolating Contacts**

Switch gear cubicle shall have seal off bushing arrangement between the circuit breaker compartment and bus bar / C.T. cum cable compartment, i.e. the fixed isolating contacts shall be embedded in epoxy cast bushing so these act as seal off bushing to prevent transfer of arc from one compartment to the other in the event of internal arc within the cubicle & must be tested for internal arc in all three HV compartments as per new IEC 62271-200.

### **8.6.9 Cable Compartment**

It shall be at the rear side with rear bolted box type back covers. There shall be an inspection window at the rear back cover enabling operator to have visual inspection without opening back cover in live condition. Viewing window at the rear side shall be of poly carbonate only and shall be tested for internal arc. The gland plate of cable chamber shall be of minimum 3mm thickness MS sheet in two halves section.

Sufficient headroom shall be provided for cable termination. The distance between gland plate and terminal shall be minimum 600mm.

### **8.6.10 Low Voltage Compartment**

Low voltage compartment shall be mounted at the front on the top of breaker compartment and shall also have hinged type of door. All wiring shall be routed through PVC ducts and shall be terminated on to stud type terminal with plastic cover. For current transformer terminal shall be disconnecting link type only. The wire shall be of 1.1KV grade and suitable for 2KVrms for 1 minute power frequency high voltage.

### **8.6.11 Auxiliary Switch and Auxiliary Plug & Socket**

There shall be minimum 4NO and 4NC contacts in breaker auxiliary switch. In case of Additional contacts the same can be multiplied through contact multiplication relay type VAJC11 type electrically latched relay. Auxiliary plug and socket shall be of minimum 24 pin plug type and shall have scrapping earth feature. Auxiliary contacts shall be suitable for continuous thermal current rating of 10A.

### **8.6.12 Electrical & Mechanical Position Indication**

In addition to mechanical position indication in breaker for test and service position, electrical indication shall also be provided through limit switch. There shall be minimum 2NO +2 NC contacts available in each position for electrical indication and for any other interlocking purpose.

### **8.6.13 Control and Power Cable Entry**

Control cable entry shall be from front and there should be a possibility of terminating to LV chamber from both right hand and left hand side. Power cable entry shall be from rear bottom. Provision shall be available for entry of power cable from rear bottom. Control cable entry in LV compartment shall be through earthed metallic compartment segregated from HV compartments.

### **8.6.14 Pressure Discharge Flaps**

Pressure discharge flaps shall be provided at the top in all high voltage compartments for the exit of hot gases in the event of internal arc in any of the HV compartments.

### **8.6.15 Busbars**

Bus bar material shall be of high conductivity electrolytic copper or aluminum only and accessibility of the same shall be from top only. All bus bars shall be insulated with heat shrinkable PVC sleeves and joints shall have sufficient clearances in order to meet the BIL of

28kV RMS and 75 kVp withstand. Phase identification shall be made at the end by coloured tape. Bus bars shall be mounted on integral seal off bushings.

#### **8.6.16 Earth Bus**

There shall be a continuous copper/GI earth bus at the bottom of the panel. Earth bus shall be robust and shall be capable of carrying full short circuit current for 3 second. Doors, covers and all non-current carrying metallic parts shall be earthed through flexible copper wires. This also includes instrument casing and cable armour which are also connected to the earth bus. Earth bus must be tested for minimum of 25KA for 3 sec.

#### **8.6.17 Bus & Cable Earthing**

Separate earthing truck shall be provided for bus earthing and cable earthing. The earthing truck shall be so designed that it is impossible to earth a live. It shall be supplied with potential indicator and audio visual alarm .Incase of circuit being live. Earthing circuit shall be suitable of carrying full fault current for 3 second. Special electrical interlocking shall be provided for incomer earthing at cable side with secondary plug and socket arrangement.

#### **8.6.18 Current and Potential Transformer**

Current transformers shall be double core window/bar primary for higher rating or wound primary for lower rating. Maximum VA burden shall be of 15 VA and shall be rated for full short circuit current for 3 second.

Potential transformer shall be 3nos single phase with 100VA per phase of class 1.0 accuracy. Line P.T. shall be mounted in a separate drawout carriage. In case of truck mounted breaker, line P.T. shall be provided in a separate panel. For bus connected P.T. it shall be provided in a separate panel.

#### **8.6.19 Protection Relays**

Incomer & Outgoings (50, 50N, 51, 51N)

##### **A. Non-Directional Overcurrent and Earth Fault Protection**

- The relay should have 3 independent time delayed O/C stages.
- The first stage should be programmable to have either a DT characteristics or IDMT characteristics described as follows and shall have a current setting range of 0.1 IN to 5 IN and time setting range of 0 ms to 150 sec. The second and third stage should have a current setting range of 0.1 IN to 40 IN.
- The relay should have 3 independent time delayed E/F stages.
- Should have a current setting range of 0.005 IN to 8 IN and time setting range of 0 ms to 100 sec. The lower setting is critical to take care of systems, which have low earth fault currents.
- The relay should have front USB port for local communication with Laptop and rear RJ45 ports to communicate on native IEC61850 protocol for future integration. No protocol convertors shall be acceptable.

- Should be able to record atleast 5 oscillographic disturbance records each of minimum 3 seconds.
- Should have minimum of 8 programmable LEDs.
- Should be able to record 5 fault records and 75 event records.
- Current input should be rated for both 1A & 5A.
- Should have two independent setting groups.
- Should have in built MIMIC display.
- Should be provided with free software for programming and analysing the disturbance records supporting comtrade format.
- Should be able to measure and record harmonics apart from Current and frequency.
- In built trip circuit supervision is mandatory apart from CT supervision feature.
- All CT & VT Connections should be with ring terminals.

B. Incomer (Backup Earthfault Protection)

- The relay should have 3 independent time delayed E/F stages.
- Should have a current setting range of 0.005 IN to 8 IN and time setting range of 0 ms to 100 sec. The lower setting is critical to take care of systems, which have low earth fault currents.
- The relay should have front USB port for local communication with Laptop and rear RJ45 ports to communicate on native IEC61850 protocol for future integration. No protocol convertors shall be acceptable.
- Should be able to record atleast 5 oscillographic disturbance records each of minimum 3 seconds.
- Should have minimum of 8 programmable LEDs.
- Should be able to record 5 fault records and 75 event records.
- Current input should be rated for both 1A & 5A.
- Should have two independent setting groups.
- Should have in built MIMIC display.
- Should be provided with free software for programming and analysing the disturbance records supporting comtrade format.
- Should be able to measure and record harmonics apart from Current and frequency.

- In built trip circuit supervision is mandatory apart from CT supervision feature.
- All CT & VT Connections should be with ring terminals.

#### **8.6.20 Thermal Rating of Switchgear**

End temperature of all current carrying parts including breaker Relay shall be governed by IEC 62271-1. All isolating contacts shall be silver plated. All rating shall be in panel only.

#### **8.6.21 Auxiliary Supply**

Control supply for closing and tripping shall be 220 or 110Volts D.C. through external battery source. 230 Volts single phase A.C. supply shall also be available for the operation of spring charging motor and cubicle space heater. Wattage of closing and tripping coils shall be within 250 watts.

#### **8.6.22 Overall Dimension**

Width of the switch gear cubicle shall be maximum 600mm upto 1250A panels and maximum width must not exceed 800mm for higher rating. Depth without extension chamber for more no. of cables shall be restricted to 2000mm.

#### **8.6.23 Type Test**

Following minimum type test reports shall be submitted for the evaluation of offers.

- All short circuit duties from test duty 1 to test duty 5 including single phase and double line to ground as per IEC62271-100
- Short time rating of minimum 25kA for 3 seconds as per IEC 62271-100,62271-200
- Temperature rise test as per IEC 62271-200
- Capacitor bank switching for 400A minimum & cable charging 25 A test as per IEC 62271-100 For test duties 1 to 4
- Degree of protection test as per IEC 62271-200
- Upto 600 mm cubicle and upto 1250A tested for minimum IP-44
- Lightning impulse voltage test as per IEC 62271-100, 62271-200
- Internal arc test in all the three high voltage compartments 25 kA 0.1 sec as per IEC 62271-200

### **8.6 Cabling**

All cables shall be so connected between main switchboards, distribution boards, plant and accessories so that the correct sequence or phase colours are preserved throughout the system. Tinned copper lugs of appropriate size shall be used for termination of power cables.

All cable cores shall be identified with phase colours for three and four wire circuits and red and black for single-phase circuits. Cables shall conform to relevant Indian Standards and shall be of the heavy-duty type.

Cable shall be capable of satisfactory performance when laid on trays, in trenches/ conduits/ ducts and directly buried in the ground.

All types of power Cables shall conform to IS 1255.

Cable network should be so designed that cables are not loaded for more than 50% of rated capacity arrived after applying all the applicable derations.

All cables shall be delivered on robust cable drums with cable ends treated to form an effective seal. When a cable is cut from a drum, the cable end and the left on the drum shall be immediately sealed in an approved manner to prevent the ingress of moisture. Prior approval of the Engineer shall be taken to deliver the cable/s in a coil form, where the same cannot be delivered on a drum.

The Contractor shall ensure that the current rating of each cable is adequate for its duty under both normal and possible fault conditions. In assessing the rating and cross section required for each cable the following should be taken into account.

- Fault level and duration as governed by circuit protection relays/ fuse;
- Conditions of ambient temperature and method of installation and grouping;
- Voltage drop;
- Loading under steady state and transient conditions;
- Disposition of cables, whether in air or laid in the ground in groups or otherwise

#### **8.7.1 1.1 kV Power Cables**

The cable shall conform to relevant I.S and shall be of heavy duty type. Cables shall be 1.1 kV Grade, XLPE insulated, PVC inner sheathed, galvanized steel wire/strip armored and PVC overall jacketed/ sheathed PVC compounds for inner sheath and outer jacket shall be of ST1 type conforming to relevant IS. The inner sheath and outer jacket shall be extruded type.

The inner sheath and outer jacket shall be extruded type.

The outer sheath shall be resistant to fire i.e. FRLS type, water, ultra-violet radiations, fungus, termite and rodent attack. It shall be designed to afford high degree of mechanical protection and shall also be heat, oil, chemical and weather resistant. Common acid, alkalis and sealing solution shall not have adverse effect on material of PVC sheath.

Cable shall be suitable for laying in covered trenches as well as in HDPE ducts.

Conductor's up to and including 4 Sq. mm cross-section shall be of copper and those above 4 sq. mm shall be of aluminium. Constructional features shall conform to relevant Indian Standard. Cables shall be manufactured and tested in accordance with the relevant IS. Insulating material shall be XLPE type. A compound as per IS: 5831 no joints shall be made in any conductor after it is stranded.



### 8.7.2 11kV Cables

- The scope of this specification covers planning design, engineering, manufacturing, supply; transportation, insurance, delivery at site, unloading, handling, storage, installation (including civil works), termination, testing, commissioning and documentation of 11kV XLPE Dry gas cured insulated power cable for effectively earthed system. XLPE aluminum Cable for 11kV shall be with complete with all associated materials and accessories.
- 11 kV (E) Grade XLPE, 3-Core, power cable shall be of high conductivity, stranded compacted, H.D. aluminum circular shaped conductor with XLPE (cross linked Poly Ethylene) Dry/Gas cured insulation provided with shielding of extruded semi-conducting materials over conductor and XLPE insulation. Each insulated core shall have copper tape screen, laid together and provided with common covering of PVC Inner Sheath (Extruded). Overall galvanized steel strip armour and PVC outer sheath shall be provided. The specification for manufacture of cable shall be conforming to IS: 7098 (Part-II) 1985 (latest edition) for 11kV (E), 3-Phase, 50 Hz. Earthed systems.
- The inner sheath and outer jacket shall be extruded type.
- The outer sheath shall be resistant to fire i.e. FRLS type, water, ultra-violet radiations, fungus, termite and rodent attack. It shall be designed to afford high degree of mechanical protection and shall also be heat, oil, chemical and weather resistant. Common acid, alkalis and sealing solution shall not have adverse effect on material of PVC sheath.
- Cable shall be suitable for laying in covered trenches as well as in HDPE ducts.
- For installation and maintenance of 11kV/1.1KV cables IS 1255 should be followed along with other relevant international standards.

### 8.7.3 Control Cables

FRLSH Cables shall be as specified in Chapter-2 MV Cables (BS 6724-multicore cable and BS 7211 for single core cable) of this Specification. All internal and control wiring shall be Low Smoke Zero Halogen (LSZH) copper conductor wires rated at 450/750 V complying with BS EN 50525 for this Specification. Insulation shall have a glossy finish, be resistant to oil and be incapable of supporting combustion.

Control cables shall conform to the specifications for 1.1 V power cables in (b) above except that the conductors shall be of 1.5 Sq. mm copper and cores shall be color coded/ numbered for identification.

### 8.7.4 Installation Methods

#### a. General

All cables where required to be run on walls, ceilings or other building structures shall unless otherwise agreed by the Engineer be secured on tray or enclosed in HDPE conduit or trunking.

Every cable whether in or out of sight shall be neatly run vertically, horizontally or parallel to adjacent walls, beams or other structural members. Where the building structure incorporates purpose built covered cable duct/ trench systems for cables, power cables, control, protection

and instrumentation cables shall be segregated and installed on tray-work or otherwise secured to the walls of the trenches.

Where the structure incorporates general service ducts/ trenches containing pipe work, chemical lines and other services all cabling shall be segregated from other services and run on the trench walls.

Throughout the installation due regard shall be paid to prevent interference between power and signal cables and to avoid unnecessary crossovers. All cabling throughout the installation shall be fixed with purpose designed clamps, cleat or saddles. Saddles for power and control cables shall be fabricated from PVC covered metal strapping. Self-locking plastic buckle clips and strapping shall not be used. Cabling installation shall be tested as per relevant Standards.

#### **b. Tray**

All cable trays and accessories shall be of GI. Tray sizes shall be limited to 150, 300 & 450 mm. Supports as required shall be supplied and installed. Supporting structure for trays shall be MS and duly painted. Any damage caused by the Contractor to surfaces of buildings/ structures etc. during installation of trays shall be made good by the Contractor to the satisfaction of the Employer's Engineer.

Type of paint and its shade for supporting structures for use in normal/ corrosive atmosphere proposed by the Contractor shall be subject to Employer's Engineer approval.

#### **c. HDPE Conduits**

Conduits shall be run on the surface or embedded and shall be neatly arranged. When one or more cables are laid through a conduit, conduit size shall be that the total cross sectional area of the cables does not exceed 40 % of the internal cross-sectional area of the conduit.

The conduits shall be screwed into spout of conduit boxes or where fixed to boxes with properly sized clearance holes. They shall be secured by means of sockets and hexagonal bushes. All threads shall be cut clean and all burrs shall be removed with a reamer.

Particular care must be taken to ensure that no water is allowed to enter the conduit at any time and all conduits shall be arranged with adequate ventilation and drainage points, where necessary, as directed by the Employer's Engineer. Inaccessible junction boxes shall not be allowed.

Only continuous lengths of buried conduit shall be installed between boxes, no joint boxes being allowed in the floor screeds. Conduits crossing expansion joints shall be fitted with coupling of approved manufacture with an earthing clip at each side of the coupling, connected by the correct size of tinned copper stranded wire. The ends of the conduit laid or set in form work prior to concreting shall be temporarily sealed off with a coupler and solid brass plug.

Fixing to surfaces off walls shall be by means of spacers and saddles securely fixed by screws. Where conduits are concealed or laid constructional floors, they shall be held in position with substantial fixings. All conduit fittings shall be supplied with rubber gaskets/ covers/ plugs as applicable. Adaptors/ junction boxes shall be constructed using minimum 2 mm thick GI sheet sized to prevent the undue packing of cable in them.

Weather proof boxes and accessories shall be used outdoors. Adequate number of inspection boxes shall be provided where wiring is to be carried out in concealed conduit above false ceiling/ civil works. Junction and adaptor boxes shall be provided with gasketed flat covers secured with brass or plated screws.

**d. Identification**

Each and every cable shall be permanently identified at each and by its cable number as per the cable schedule. Cable markers shall comprise semi-rigid black PVC carrier strip and shall be fixed axially by means of two PVC covered aluminum strips with buckles. Cable markers shall also be installed at entry and exit points of buried ducts, road and drain crossings, and exits from building and in such other positions as are necessary to identify and trace the route of any cable. The marker shall be projected 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. Cable marker of other types shall be subject to approval by the Engineer.

In addition, control cables shall have individual cores identified by means of suitable permanent ferrules bearing the same numbers at both ends. Core identification shall occur at every point of termination using an approved system of ferrule markers. At those points of interconnection between wiring where a change of number cannot be avoided, double ferrules shall be provided on each wire. The change of numbering shall be shown on the wiring diagrams of the equipment at which the change is made.

Cables to be installed outside buildings shall be laid in RCC trenches with removable concrete covers.

**e. Electrical Installation Record Drawings**

All approved drawings shall where necessary be modified or updated during the progress of the installation and shall form the basis of the record drawing for the complete installation.

Record drawings for cabling and earthing installation shall include route drawings, block diagram and cable schedules. Within buildings, record cable route drawings shall show the location of all items of electrical plant, the route method of installation of all cables e.g. on trays, in trenches, on hangers, in ducts, conduits etc.

External cable route drawings shall show:

- i. the route of the buried cable/ conductor, laid otherwise;
- ii. the depths of laying including any deviations to avoid local obstruction;
- iii. position of joints (for cables only) located from marker posts or other agreed key points;
- iv. distances of cable runs from pipe runs or other buried services;
- v. position of earth electrodes, earth rods disconnecting chamber and interconnecting earth strips;
- vi. cable type, number as per cable schedule, number of cores and cross-section and purpose such as power/ control etc.;
- vii. Typical details for cabling and earthing system.

## **8.7 Lighting**

### **8.8.1 Lighting System Scope**

The scope covers supply and installation of all equipment necessary for a complete lighting system. Equipment shall include lighting panels, lighting distribution boards, lighting fixtures, poles, and cables, switches, ceiling fans, receptacles, HDPE conduits, wires and miscellaneous hardware necessary for complete lighting work.

Taking into account principles of vision, criteria of quality, and characteristics of sources and luminaries, Table given below gives for the desirable level of illumination which are recommended as per IUT (Institute of Urban Transport) & uniformity from IS:1944.

Following average levels of illumination shall be provided in the respective areas:

|                                     |   |         |
|-------------------------------------|---|---------|
| i) Offices                          | - | 250 lux |
| ii) Switch gear room                | - | 250 lux |
| iii) Control room                   | - | 300 lux |
| iv) All other indoor areas          | - | 100 lux |
| v) Roads                            | - | 30 lux  |
| vi) Outdoor areas not commonly used | - | 20 lux  |

Illumination levels shall be finalized in consultation with Employer's Engineer's. Contractor shall be required to measure levels of illumination after completion of lighting installation work. Shortfalls in illumination levels shall be corrected by the Contractor as required.

It shall be the responsibility of the Contractor to work out detailed lighting layouts with appropriate type (as approved by Engineer) of lighting fixtures in order to provide specified level of illumination. The Contractor shall be responsible for measuring the levels of illumination after installation and establish compliance with the specification. The types of fixtures offered shall be indicated in the Tender. Final lighting layouts shall be furnished for the approval of the Employer's Engineer, before commencement of installation. Each Street Light Pole shall have minimum one no. of maintenance free earth pit

### **8.8.2 Requirements**

The design, manufacture and performance of equipment shall comply with regulations and safety in the locality where the equipment will be installed.

Nothing in this specification shall be construed to relieve the Contractor of his responsibility.

All the indoor lights, emergency lights, outdoor lights and Street lights will be LED based conforming to below specifications and standards.

| Sl. No. | Criteria                                       | Specification for LED light fitting   |
|---------|--|---|
| 1.      | Luminaire configuration/ technical requirement | Shall consist of separate optical and control gear compartment. Both LED & Driver should be easily replaceable in the field condition.  |
| 2.      | Housing / Body of fitting                      | Pressure Die cast or extruded aluminum housing with powder coated surface.  |
| 3.      | Finish   | Aesthetically designed housing with Black / Grey / Cream color/ Silver corrosion resistant polyester powder coating.  |
| 4.      | Cover / glass                                  | All luminaries - Fixture cover - UV stabilized Polycarbonate/ Toughened Glass. Test certificate for the material of the fixture cover should be submitted to the Employer/Employer's Engineer for their approval.   |
| 5.      | Product qualities                              | Energy efficient, high quality consistency, glare control, lumen maintenance. LM 80 report to be submitted to the Employer/Employer's Engineer for their approval for LEDs to be used in each type of Luminaire.  |
| 6.      | Protection – IP                                | Optical compartment minimum IP 66 and control gear should be inbuilt in the luminaire with proper casing and minimum IP66 protection. IP 67 is desirable.   |
|         | Impact resistance                              | Impact resistance should be greater than or equal to IK 09  |
| 7.      | Optical assembly                               | Structured LED array for optimized roadway photometric distribution with photometric lenses designed to optimize application efficiency and minimize glare also to have optimized independent assembled LED modules for easy replacement at site. Excellent uniformity and glare reduction be ensured. Must have constant luminous flux control for exact and high energy efficient lighting throughout life. |
| 8.      | Operating voltage                              | 110-277 volt AC electronic driver.  |

| Sl. No. | Criteria   | Specification for LED light fitting   |
|---------|--|---|
| 9.      | Frequency  | 50 Hz (with 2 % variation on both sides).   |
| 10.     | Power factor                                       | > 0.95.   |
| 11.     | Fixture Ambient Temperature                        | 0° to + 50° C (MUST WITHSTAND Sun radiation continuous temperature of 84 ° C ) (Certification in this respect from an independent lab is needed).   |
| 12.     | Working Humidity                                   | 10% to 90% RH.  |
| 13.     | Driver Temperature                                 | ta=50°C; tc=90°C.   |
| 14.     | Storage Temperature                                | Range -30 ° C to +80 ° C.   |
| 15.     | Maintenance factor for lighting design calculation | Minimum 0.75 (Must be considered as minimum for illumination design calculations) (Acceptance tests for lux levels, after minimum of two years of operations will be carried out on the basis of $(1/0.75) * (0.9)$ , implying availability of higher lux level corresponding to aforementioned formula will be checked over and above specified by Indian standards, Ministry of Urban Dev guidelines and other applicable documents). |
| 16.     | Total Current Harmonic distortion                  | < 10%.  |
| 17.     | LED efficacy (lumen/watt)                          | Efficacy of bare LED should be greater than 135 lumens / watt.  |
| 18.     | LED Luminaire efficacy                             | The system lumen output of the Luminaire should be more than 95 Lumens/Watt supported with LM79 report at the time of installation. Total power consumption should be inclusive of driver wattage loss.   |
| 19.     | Power efficiency / LED driver efficiency           | The efficiency shall be more than 90 % in all the types of luminaires.  |

| Sl. No. | Criteria                           | Specification for LED light fitting  |
|---------|------------------------------------|--|
| 20.     | Calculated Lifetime                | 50,000 hr. @ Ta=35° C at (L70 F50).  |
| 21.     | Correlated Colour temperature      | Correlated Colour Temperature shall be in between 4000K to maximum 6500 K.   |
| 22.     | CRI                                | The value of CRI shall be more than 70.  |
| 23.     | Light distribution                 | Optimized roadway photometric distribution 75° X 150°.   |
| 24.     | Lux level for the given parameters | Lighting design shall conform to IS: 1944 (Part I & II). The recommended illumination level and uniformity for roads shall be as per IUT (Institute of Urban Transport) (Ministry of Urban Development, Govt. of India). As mentioned before, the street lighting should be designed with 0.75 maintenance factor or the factor applicable after 5-year operation (whichever is lower should be considered). |
| 25.     | Make of LED                        | Make of LED: Osram /CREE /Philips Lumileds / Nichia or equivalent.   |
| 26.     | Lens                               | Lens should be provided for each LED.  |
| 27.     | LED Drive Current                  | >=700 mA to <=1200 mA.   |
| 28.     | Driver Specification               | 110-277 Volt AC electronic driver with Internal surge protection of at least 6kV. Wide range of voltage to withstand the fluctuation.  |
| 29.     | Heat dissipation / heat sink       | Heat sink must be of aluminum extrusion with proper Thermal management system.   |
| 30.     | Warranty                           | 03 Years.  |
| 31.     | Heat Proof Internal Wiring         | Should be able to withstand heat up to 105 °C.   |

| Sl. No. | Criteria                           | Specification for LED light fitting  |
|---------|------------------------------------|--|
| 32.     | Electrical safety                  | As per IEC safety standards.   |
| 33.     | Luminaire Standards / Test Reports | The luminaire should meet IEC 60598-1, 60598-2-3, EN 55015 EMC radio disturbance, EN 61000-3-2 Harmonics and flickers, EN61547 EMC immunity requirements, EN62471 eyes safety requirements, JESD22 Reliability standard, Environment: ROHS, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-8 (All test reports and as asked by Employer's Engineer will be submitted before dispatch). |
| 34.     | Standard Compliance                | CE Conformity.   |
| 35.     | Driver Standards                   | IEC 61347-2-13, IEC 61000-3-2, CISPR 15, IEC 61547.  |
| 36.     | Mounting dimension                 | The fittings should be suitable for fixing to brackets having 50-60 mm dia. (OD) for street light and back mounting brackets for indoor lighting   |
| 37.     | Marking                            | LED street light fitting should be supplied with company name engraved on the fitting. The product label should mention: Name of Purchaser, Manufacturer, Street light fitting model name, Wattage of fitting and other relevant details.  |

### 8.8.3 Lighting Distribution Boards

The lighting panel shall be dust-tight, vermin-proof, sheet steel enclosed type. Sheet steel for fabrication shall be at least 2.0 mm thick and shall have a smooth surface free from flaws and warps. Louvers and vents provided shall be properly screened to prevent entry of insects and foreign materials. LDB shall be of form 4b type.

Sheet steel shall be powder coated with finished thickness of 60 microns.

All panels should be OEM factory built of L&T, Siemens, Schneider Electric, ABB, GE, Aрева or Alstom make only.

A TPN incomer essentially a MCCB with three lamps to indicate incoming supply of each phase is on. MCCB outgoing end should have indicating lamps for ON, SHUNT TRIP, OVERLOAD, EARTH LEAKAGE etc. as minimum and all the lamps should be flush on the panel door. An emergency push button shall be provided flush to panel to trip incomer in case of emergency.



Each outgoing feeder will have one TPN RCBO with ON indication lamp flush on panel door. Outgoing feeder's respective ratings will be decided during detailed Engineering by Contractor and approved by Employer's Engineer.

Each outgoing feeder shall have one power contactor having 3 main poles + 1 Neutral (Total 4 Poles) along with 2NO+2NC Aux potential free contacts shall be provided.

Sufficient no. of auxiliary contactors, push buttons and other hardware shall be provided to device balanced segment switching schemes per lighting distribution switchboard including for remote switching. Such schemes will be informed by Employer's Engineer at a later date.

DP MCBs shall be provided in required nos. for aux power supply. Power supplies for separate functions shall be separately sourced through separate double pole MCBs.

Over and above 2nos. of fully loaded / populated and wired spare feeders (all of the highest capacity of outgoing) shall be provided. Spare feeders will no way be different from outgoing feeders assigned for services already.

The panel shall be provided with all accessories necessary or usual for their efficient operation and shall be provided with adequate size cable gland for incoming circuits. Cable glands shall be of the compression type out outgoing circuits from top bottom. The incoming cable shall enter from the bottom knockout plates. For conduit entries at top and bottom for outgoing circuits and for spare circuits on each panel shall be provided. The lighting panel shall have adequate no. single/ three phase outgoing circuit and at least two spare circuits.

Circuit identification tags shall be provided on each incoming and outgoing circuit and shall be in the form of engraved or screen painted or anodized aluminum/plastic sheet.

The panel shall be provided with two distinct earthing terminals for connecting earthing conductor of size 25 mm x 3 mm galvanised iron flat.

Each LDB will have minimum of two nos. of maintenance free earthing pits.

#### **8.8.4 Receptacles**

Decorative and industrial type receptacle (receptacles means a combination of a socket and a switch) units make with switches conforming to IS: 3854 and sockets conforming to IS: 1293 shall be supplied. The units shall be suitable for mounting flush or within stove enameled sheet steel boxes generally conforming IS: 5133. Decorative receptacles shall be 5/ 15a rating with 5 pin sockets and 15a switches. Industrial receptacles shall be of 20a rating.

#### **8.8.5 Conduits**

All conduits shall be hot dip galvanized, enamel and painted conduits shall be run on the surface or embedded and shall be neatly arranged. When one or more cables are laid through a conduit, conduit size shall be such that the total cross sectional area of the cables does not exceed 40% of the internal cross-sectional area of the conduit.

The conduits shall be screwed into spout outlets of conduit boxes or where fixed to boxes with properly sized clearance holes they shall be secured by means of sockets and hexagonal bushes. All threads shall be cut clean and all burrs shall be removed with a reamer.

All bends and sets shall be formed in the conduit itself, factory made bends not to be installed without the written permission of the Engineer. The radius of bends shall not be less than that given in relevant Indian Standards.

Standard junction or adaptor boxes shall be provided at all junctions and at sharp changes of direction in addition to any other special positions where they are called for by the Engineer. Steel or malleable cast iron inspection couplers may be used in long runs to facilitate drawing in cable. In accessible junction boxes shall not be allowed.

Particular care must be taken to ensure that no water is allowed to enter the conduit at any time and all conduits shall be arranged with adequate ventilation and drainage points, where necessary, as directed by the Engineer. In accessible junction boxes shall not be allowed.

Only continuous lengths of buried conduit shall be installed between boxes, no joint boxes being allowed in the floor screeds. Conduits crossing expansion joints shall be fitted with couplings of approved manufacture with an earthing clip at each side of the coupling, connected by the correct size of tinned copper stranded wire. The ends of conduits laid or set in form work prior to concreting shall be temporarily sealed off with a coupler and a solid brass plug.

Fixing to surfaces of walls shall be by means of spacers and saddles securely fixed by screws. Where conduits are concealed or laid in constructional floors, they shall be held in position with substantial fixings.

All conduit fittings shall be supplied with rubber gaskets/ covers/ plugs as applicable. Adapter/junction boxes shall be supplied with rubber gaskets/ covers/ plugs as GL sheet and sized to prevent the undue packing of cables in them weather-proof boxes shall be constructed using minimum 2 mm thick number of inspection boxes shall be provided where wiring is to be carried out in concealed conduit above false ceiling/civil works.

Junction and adaptor boxes shall be provided with gasketed flat covers secured with brass or plated screws.

#### **8.8.6 Tests and Test Reports**

- (a) Routing tests on lighting panels, lighting fixture and accessories shall be carried out as per relevant standards.
- (b) Test certificates shall be furnished for tests conducted.

#### **Drawings and Data**

On award of the Contract, the Contractor shall furnish relevant technical/ descriptive and illustrative literature on lighting fixtures and accessories lighting panels, distribution boards etc. and the following drawings/ data.

- (a) Dimensional drawings
- (b) mounting details, weight and cable entry facility
- (c) light distribution diagram for fixture of each type (zonal and Isocandela)
- (d) light absorption and utilization factors for fixtures of each type.

- (e) lamp output V/s temperature curve.

The Contractor shall also submit for Engineer's approval typical installation detail drawings and detailed lighting layout drawings for each area showing layout of conduits/ cables, lighting panels, distribution scheme complete bill of materials and calculation for lighting design.

The Contractor shall furnish technical literature of each type of fixture, switch, receptacle etc., giving lamp output curves, utilization and maintenance factors. Also maintenance and operating instructions shall be furnished.

#### **8.8.7 Lighting Fixtures, Ceiling Fans, Receptacles etc. — Installation**

The scope of installation work shall include mounting of lighting fixtures, ceiling fans, receptacle units etc. at locations as approved by Employer's Engineer. All work and supply items associated with installation, such as provision and fixing of wooden blocks, balls sockets, hooks etc. As required, drilling holes in walls, ceiling, etc. or any works including scaffolding, provision of ladders, etc., shall form part of the Contractor's work.

#### **8.8.8 Wiring**

The work shall comprise wiring from lighting panel/ distribution boards in suitably sized HDPE conduits supported on walls, ceiling etc. at an interval of 500 mm, installation of light control switches and receptacles housed in/ mounted on stove enamelled steel boxes, earthing with 14 SWG copper conductor continuous wire run outside along the conduit and clamped at every 500 mm interval and termination of wires at lighting panel, light control switches, receptacles, lighting fixtures, etc. as required. Wall thickness of conduit upto 32 mm diameter shall be 16 SWG and that for 32 and above shall be 14 SWG.

Supply of all items for the work detailed above such as 650 V grade, 2.51 4 mm two copper conductor PVC insulated wires, 5, A/ISA switches, HDPE conduit and accessories (such as junction boxes, tees, elbows, etc.) suitable stove enamelled sheet steel boxes complete with gaskets, knockouts for conduit entries, earthing terminals with bolt, nut and washer, 14 SWG copper earthing wire flexible conduit, etc. shall be included in the Contractor's scope. All work necessary for fixing of boxes, conduits, etc. together with supply of necessary hardware, shall also be included in the Contractor's work. Wiring for outdoor areas shall be carried out by means of 1.1 kV grade armoured copper cables.

#### **8.8.9 Power Supply to Exhaust Fans**

The power supply to exhaust fans shall be derived from lighting circuit. The supply to the fan shall be arranged through a receptacle which shall be installed near the fan. The controlling switch for fan may be installed on the lighting switch board or any other suitable location.

#### **8.8.10 Ceiling Fans**

Ceiling fans shall be provided in areas such as offices, stores etc. adequate ventilation arrangements shall be made for enclosed areas where ceiling fans are not proposed to be installed or cannot be provided. Power supply for the ceiling fans shall be derived from lighting circuits ceiling fans shall be complete with all

The number of ceiling fans to be provided shall be governed by the following:

- One no. 1200 mm sweep fan shall service not more than 10 sq.m floor area.
- One no. 900 mm sweep fan shall service not more than 8 sq.m floor.

#### **8.8.11 Emergency Light Luminaires**

Emergency light shall be LED Luminaire indoor type for providing emergency light during failure of normal AC supply. The luminaire shall be with CRCA sheet steel enclosure, complete with metallized mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/ relay, two meter length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire. The luminaire shall be suitable for connection to 240V, 50 Hz single phase supply. On failure of normal A.C supply the luminaire shall pick-up automatically and on restoration of A.C supply the luminaire shall switch off automatically. The luminaire shall be suitable for florescent lamp up to 20 watts.

#### **8.8 Maintenance free Earthing**

The complete scope for collection of data, design of the system as per relevant national/international standards, preparation of layouts drawings, supply, installation and approval to the satisfaction of electrical inspector are in scope of Contractor's works under this Tender specification. Nothing in this standard shall be constructed to relieve Contractor from his responsibility.

Earthing and lightening protection system shall be provided to ensure equipment and personnel safety.

Approximate quantities of earthing conductors of various sizes and earth Electrodes shall be indicated in the Tender. The successful Contractor shall however base his earthing calculations on actual measurements to be carried out by him in the presence of the Employer's Engineer. The measurements shall be carried out during the summer months. Earthing system for the plant boundary limits shall be provided with its own independent earthing pits and integrated system for the entire premises. Conductors required for interconnection with adjacent existing grids shall also be supplied and installed by the Contractor.

The Contractor shall supply install bare steel wires/ strips required for system and individual equipment earthing. All work such as cutting, bending, supporting, coating, drilling, brazing, clamping, bolting and connecting onto structures, pipes, equipment frames, terminals, rails or other devices shall be in the Contractor's scope. The excavation and trenching and backfilling shall be carried out by the Contractor as required.

#### **8.9.1 Maintenance Free Earthing**

Where ever earth pits are needed maintenance free earth pits / system be deployed and the system shall consist of (but not limited to):

- a) Earth electrodes.
- b) Highly conductive and ecofriendly backfill compound.
- c) Earth termination clamps to facilitate connections to the equipment.

- d) Inspection chamber & masonry Work.
- e) Measurement & Prove out.

### **I. Earth Electrode**

The Earth electrode should have good electrical conductivity and should not corrode in a wide range of soil conditions. For an effective earthing system the earth electrode shall conform to the following specifications:

- a) The electrode shall be a solid steel rod made of high tensile low carbon steel, molecularly bonded with copper on the outside surface as per UL 467 / BS 4360 Grade 43 A or EN10025:2- 004 S275JR or relevant Indian standard.
- b) The thickness of the copper coating shall be at least 250 microns.
- c) The electrode diameter shall be latest 17 mm. The earth electrode shall carry manufacturer's name.
- d) The length of the electrode shall be minimum 3 mtrs. Length of the electrode must be increased in multiple of 1 meter to reduce earth resistance wherever required. To increase the length, pieces of similar rod shall be either exothermally welded to basic meter electrode or connected using socket of suitable size.
- e) The earth electrode can be visually inspected checked for dimensions and thickness of copper coating using micron gauge. The Contractor will arrange for such an inspection before dispatch if so desired by Employer's Engineer.
- f) Indian Standard markings, manufacturer's name or trade name, length, diameter, catalogue number must be printed on each and every earth electrode.
- g) The design of the electrode should be such as to have more than 15kA current carrying capacity for 1 second for LT line equipment and more than 40KA current carrying capacity for 1 second for HT line equipment.

### **II. Highly conductive and Eco friendly backfill material**

The backfill material shall be highly conductive and should be certified as non-polluting and safe for use near potable ground water systems by one of the National Laboratories in India.

The backfill Material shall be of low resistance, non-corrosive, highly conductive powdered material that improves grounding effectiveness, especially in areas of high soil resistivity such as rocky, marshy and sandy areas. This material shall be suitable to be installed in either slurry or dry form. The backfill material shall confirm to the following specifications:

- a. Shall be highly electrically conductive and non-soluble. Shall have high humidity retention capability.
- b. Shall not leach into ground.
- c. Shall have a resistivity of less than 1 ohm as per relevant standard.
- d. Shall be compatible with all copper grounding systems.

- e. Shall contain a corrosion inhibitor to mitigate corrosion of copper.
- f. Shall not contain hazardous chemicals and bentonite.
- g. Shall be certified to ANSI / NSF standard 60 as safe for use near potable ground water resources.
- h. Shall not be affected by drought or floods and shall be stable between -10° to +50° C temperature.
- i. Shall not depend on continuous presence of moisture for conductivity.
- j. Shall be suitable for any kind of soil. Suitable quantity of this backfill compound shall be used per earth pit.
- k. Shall not depend on continuous presence of water to maintain conductivity.
- l. Sample of Backfill material shall have to be approved by Employer's Engineer.
- m. Materials such as Cement, sand, salt, coke breeze, cinders and ash shall not be used because of acidic and corrosive nature.

### **III. Earth termination clamp**

- a) Earth Termination Clamps or Copper Bus Bars of below mentioned specifications should be used wherever necessary as per requirement suitable for 25x6mm GI Flat Strip or 16/35 sq.mm unarmored Al Cable conductors or tapes.
- b) Earth Termination clamps should be of Gunmetal material.
- c) Copper bus bar of size 250mm x 50mm x 6mm having electrical conductivity of 101% IACS, minimum 99.9% copper content shall preferably be exothermically welded to earth electrode or connected with the help of two number stainless steel nut bolts of appropriate size. This Bus Bar shall have 4 holes of 12 mm dia. (2 on each side) for connecting earthing conductor.
- d) Bi-metallic Connectors & Bi-metallic Lugs should be used for termination of 25x6mm GI Flat Strip or 16/35 sq.mm unarmoured Al cable conductors respectively.
- e) Three stainless steel washers & one spring washer shall be supplied along with each M12x50mm Long stainless steel nut & bolt for any necessary connection and termination.

### **IV. Installation of Earth system**

- a) The earth electrode shall be installed in a bore of min 300mm made by auguring the required depth of min 10ft to meet out the earth resistance value of lesser then one ohm.
- b) Wherever auguring is not feasible, pit shall be made and suitable size of PVC pipe shall be used to fix the electrode.
- c) At the center of the hole the electrode shall be driven and around the electrode the highly conductive and ecofriendly backfill material shall be filled. Highly conductive and eco-friendly backfill material can be poured in either dry or slurry form.

- d) Earth enhancement material (minimum around 15 kgs, to be increased as per resistance encountered) shall be filled into augured hole in slurry form and allowed to set. After the material gets set, the diameter of entire composite structure shall be minimum 300 mm or as per applicable standards covering entire length of cylindrical hole.
- e) The PVC pipe shall be removed simultaneously as the backfill compound is poured.
- f) If watering of Earth pit is required for curing, the same has to be done by Contractor.
- g) The pit should be very compactly rammed with watering for 2-3 days and extra soil should be added if required.
- h) Trench of 600 mm (depth) x 300 mm (wide) from the earth pit to the nearest point of connection should be made.

#### **V. Inspection chamber**

- a) A 400X400X400 mm (inside dimension) concrete box (wall thickness min. 50 mm) with smooth cement plaster finish shall be provided on the top of the pit. A concrete lid 25 to 50 mm. thick (or advised by Employer's Engineer), with pulling hooks, painted black shall be provided to cover the earth pit. PVC sleeve of appropriate size shall be provided in concrete wall to take out earthing.
- b) Connections.
- c) On the total height of the concrete inspection chamber, at least 250mm shall be provided below ground level. Necessary sand cushioning shall be done.
- d) The masonry work shall be white washed inside and outside.
- e) Care shall be taken regarding level of the floor surrounding the earth so that the connector is not too deep in the masonry or projecting out of it.
- f) On backside of the cover, date of the testing and average resistance value shall be written with yellow paint on black background.

Important – All the masonry works must have pre- approval from Employer's Engineer and must match with road works planned.

#### **VI. Measurement of earth electrode resistance**

- a) The earth resistance shall be measured using fall of potential method as per para 37 of IS: 3043.
- b) The successful working of the earthing pits implies that the Voltage between Neutral & Earth will never be more than 2 Volts.
- c) The effective earth resistance of each installation shall be less than 1 ohm in dry condition for all installations and less than 0.5 ohms for ATMs, Data Processing Centers etc.

#### **VII. Construction of ring earth by providing multiple maintenance free earth pits**

- a) Wherever it is not possible to achieve required earth resistance with one earth

electrode/pit due to difficult/rocky soil conditions, provision of ring earth consisting of more than one maintenance free earth pit shall be done. The number of such pits required shall be decided based on the resistance achieved for the earth pits already installed. The procedure mentioned above for one maintenance free earth pit shall be repeated for other such earth pits.

- b) The distance between two successive earth electrodes shall be minimum 3mtrs and length of electrode whichever is higher and maximum up to twice the length of the earth electrode.
- c) These earth pits shall then be inter linked using 25X3 mm copper strip to form a loop preferably using exothermic welding or with the help of at least two number of stainless steel nut bolts of appropriate size.
- d) The interconnecting strip shall be buried no less than 600mm (0.6m) below the ground level. This interconnecting strip shall also be covered with earth enhancing compound.

#### **VIII. Certificates**

The following certificates are to be provided before the commencement of work:

- a) Certificate of backfill, earth enhancement material and earth electrodes as per above clause.
- b) Valid calibration certificate from NABL accredited labs for the testing equipment used for earth pit measurement.
- c) Exothermic weld material shall be tested as per provisions of IEEE 837.

#### **IX. Maintenance Free Earthing Units**

- a) The acceptable earth resistance at earth busbar at any location / pint shall not be more than 1 ohm. Contractor when asked by Employer's Engineer should bring their own testing equipment for earth pit measurements for testing / checking purpose.
- b) Contractor must submit test reports for all the earth pits to Employer's Engineer for his review and approval.
- c) Number of maintenance free earth pits may be increased in order to get the minimum prescribed resistance, that is below 1 ohm and its construction should be as per clause discussed above.
- d) The connection from each maintenance free earth pit to the street Light poles shall be arranged by the Contractor by Bolting of 25x6mm GI strips using Bi-metallic Connectors & Stainless Steel M12x50mm Long bolt, nut, plain and spring washer.

#### **X. Earth Enhancement Material**

Material such as conductive cement, graphite, hydrous aluminium silicate, sodium montmorillonite etc. (and shall not contain bentonite) to be deployed for earth enhancement.



It shall have following characteristics:

- a) It should have low resistivity preferably below 0.2 Ohm-meters. Resistivity shall be tested by making a 20cm. cube of the material and checking resistance across the opposite face of the cube.
- b) It shall not depend on the continuous presence of water to maintain its conductivity.
- c) It should be a little alkaline in nature with pH value  $>7$  but  $<9$ , test certificate from NABL approved laboratory to be provided for the composition so designed.
- d) It should have better hygroscopic properties to absorb moisture. It should absorb and release the moisture in dry weather condition and help in maintaining the moisture around the earth electrode.
- e) It should have capacity to retain  $>10\%$  moisture at  $105^{\circ}\text{C}$ . Test certificate from NABL approved lab to be submitted for the composition so designed.
- f) It should have water solubility  $< 5\%$ . Test certificate from NABL approved lab be submitted for the composition so designed.
- g) It should be granular with granule size 0.1 mm to 3 mm.
- h) It should be non-toxic, non-reactive, non-explosive & non corrosive.
- i) It shall be thermally stable between  $-10$  degree centigrade to  $+60$  degree centigrade ambient temperature.
- j) It shall not decompose or leach out with time.
- k) It shall not pollute the soil or local water table and meets environmental friendly requirement for landfill.
- l) It should expand & swell considerably and removes entrapped air to create strong connection between earth electrode and soil.
- m) It should be diffuses into soil pores and creates conductive roots enlarging conductive zone of earth pit.
- n) It shall be permanent & maintenance free and in its “set form”, maintains constant earth resistance with time.
- o) It shall not require periodic charging treatment or replacement.
- p) It shall be suitable for any kind of electrode and all kinds of soils of different resistivity.
- q) It shall not cause burns, irritation to eye, skin etc.
- r) Minimum quantity of earth enhancement material to be included per pit:
  - ✓ For  $1.5\text{m} \times 1.5\text{m} \times 3\text{m}$ (Deep) = 25 Kg

✓ For 300mm bore type earth pit – Min 15 kgs per pit

- s) The Earth enhancement material shall be supplied in sealed, moisture proof bags. These bags shall be marked with Manufacturer's name or trade name, quantity, batch no & date of manufacture.

#### **XI. Others**

- a) All low voltage equipment shall be earthed by two separate and distinct connections with earth pits.
- b) All removable metal doors or metal frames shall be earth bonded.
- c) All non-current carrying metal parts of electrical installation shall be earthed properly. All metal conduits, cable trays, trunking, cable sheaths, switchgear, distribution fuse boards, light fittings and all other parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system. All earthing shall be in conformity with Indian Electricity Rules and CEA safety regulation in vogue.
- d) All non-current carrying metal work and for termination of the earthing conductors of all electrical lighting distribution boards, etc., shall be taken care.
- e) The joints in the run of the earthing conductors shall be welded type. Connections with equipment/ structure shall be of bolted type.
- f) Cable trays, steel pipes / conduits, steel columns, etc., shall not be used as earth continuity conductors.
- g) Earth connections for all sections of installation shall be electrically and mechanically sound.
- h) All works performed under this section shall also comply with the requirements of the local authority, IS 3043, 1987 and Earthing and Lightning Protection System- Notes and Details.
- i) All the lighting distribution boards, HT Panels, LT Panels, and three phase equipment shall have two separate and distinct body earths and single-phase equipment shall have a single body earth.
- j) All Street Light Pole shall have minimum one individual maintenance free earth pit.
- k) All cable trays / raceways and all other metallic and non-current carrying parts shall be properly earthed.
- l) All the earthing strips shall be buried in floor or wall as required and all the fastening (by nut bolts) of earthing strips shall be tag welded as well.

#### **XII. Standards**

The Earthing System shall comply with the latest versions of the relevant requirements of the Indian Standards, British Standards, and International Electro technical Commission (IEC) standards, European and other International Standards specified in the section of specifications or approved equivalent International standards.

(Note: In case of any contradiction between various standards mentioned, the latest and /or most stringent standard will apply).

- a) Earthing pads / terminals will be provided by the manufacturer of the apparatus/ equipment at accessible positions. The connection between the earthing pads/ terminals and earthing grids shall be made by short and direct earthing leads free from kinks and splices.
- b) Steel / RCC columns, metallic stairs, Hand rails, Cable trays, metallic, conduits, and pipes etc. shall not be used as earth continuity conductor.
- c) Electrical conduits, pipes and cable tray sections shall be bonded to ensure electrical continuity and connected to earthing conductors at regular intervals. Apart from intermediate connections end and beginning points shall also be connected to earthing system.
- d) A separate earthing conductor shall be provided for earthing lighting fixtures, receptacles, switches, junction boxes, lighting conduits, poles etc. This conductor in turn shall be connected to the main earth.
- e) Whenever earthing conductor crosses or runs at less than 300mm distance along metallic structures such as gas, water, steam pipes, conduits etc., and steel reinforcement in concrete, it shall be bonded to the same. In case earthing connection to pipe and conduit etc. at a distance higher than 300mm is required, the same shall be marked on the drawing to be submitted upon handover.
- f) Miscellaneous items such as junction boxes, field switches, cable end boxes/ glands, fitting and fixture shall be earthed whether specifically mentioned or not.
- g) In general minimum two earth leads shall be used for earthing each equipment / structure enclosing the power conductor operating at 250V.
- h) Earthing connections to equipment earthing pads / terminals shall be bolted type with GI bolts and nuts. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts (min.) shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti-corrosive paint/ compound.
- i) Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded / brazed type. For rust protection the welds shall be treated with red lead and afterwards thickly coated with bitumen compound to prevent corrosion.
- j) Steel to copper, copper to copper connections should be brazed type. Welding shall be adopted in case of steel. Welding to be done as per IS: 816.
- k) The jointing whether welded, brazed or bolted shall be such that the resistance of the joint is not more than the resistance of the equivalent length of the conductor.
- l) Welding / brazing surfaces shall be cleaned and made free of all oxide films, grease, oil or any foreign material. However, the joining surfaces should not be made too smooth /

highly polished, to prevent the joining material from flowing away.

- m) All brazing should be done by oxy- acetylene torch flame.
- n) All welded connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.
- o) Bending of large diameter rod / thick conductors shall be done preferably by gas heating.
- p) All arc welding with large diameter conductor shall be done with low hydrogen content electrodes.
- q) For brazing alloys of silicon bronze/ phosphor or copper/ phosphor-silver copper shall be used.
- r) Metallic sheaths, screens and armour of all multicore power/ control cables shall be earthed at both equipment and source or switchgear end.

Earthing shall conform to the Indian Standard Code of Practice IS: 3043 and Indian Electricity Rules, 1956. All material and fittings used in the earthing installation shall conform to the relevant Indian Standards or shall be as approved by the Employer's Engineer. Installation work shall be in accordance with approved earthing drawings (to be prepared by Contractor) and any change in routing, size of conductors etc. shall be subject to the prior approval of the Employer's Engineer.

Earthing conductors to be buried in the ground shall be laid 600 mm below finished ground level 1500 mm away from buildings. Metallic frames of all electrical equipment shall be earthed by two separate and distinct connections with the earthing system. Cable armour shall be bonded to the earthing system. Metal pipes and conduits through which cables run shall be efficiently bonded and earthed. For conduits, armoured cables and metal raceways, the connection to the earthing system shall be as near as possible to the point where conductors in the raceway receive supply. Earthing conductor crossing other metallic structures such as conduits, pipelines etc. shall be minimum 300 mm distance away from such structures.

All underground connections for the earthing system shall be welded connection to equipment and devices shall be of the bolted type. Neutral connection shall never be used for equipment earthing.

The work of embedment of earthing conductor in RCC floors/ walls along with provision of earth plate, inserts/ pads/ earth risers shall be done by the Contractor at the time of casting of floors and walls.

The tap connections (earthing leads) from the main earthing grid to the equipment of more than 500 mm long shall be embedded in the floor where required. The concrete cover over the conductor shall not be less than 50 mm.

The scope of installation of earth connection leads to equipment and risers on steel structures/ wells shall include laying the conductors, welding/ cleaning at specified intervals, welding/ brazing to the main earth grid's risers, bolting at equipment terminals and coating welded/ brazed joints by bituminous paint. Galvanised conductors shall be touched up with zinc paint where holes are drilled at site for bolting to equipment/ structure.

Earthing conductors along their run-on walls or columns shall be supported by cleaning/ welding at intervals of 1000 mm.

Wherever earthing conductors cross underground service ducts and pipes, it shall be laid 300 mm below them. If the distance is less than 300 mm, the earthing conductor shall be bonded to the service ducts/ pipes.

Wherever the earthing conductor crosses cable trenches they shall be buried below the trench floor.

Suitable earth risers approved by the Engineer shall be provided above finished floor/ ground level, if the equipment is not available at the time of laying of the main earth conductors. The minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided shall be marked in the Project Drawings.

Welding and brazing operations and fluxes/ alloys shall be of approved standards. All connections shall be of low resistance. Contact resistance shall also be minimum. Bi-metallic connections, if any, shall be treated with a suitable compound to prevent moisture ingress.

The lightning protection system down-conductors shall not be connected to their earthing conductors above ground level.

### **8.9.2 Lightning protection system**

The lightning protection air termination rods and/ or horizontal air termination conductors shall be fixed in such a way that they remain in their installed position even during severe weather conditions.

Air termination system will be connected to the earthing by down conductors as shown in various drawings. The down conductors shall follow a direct path to earth. There shall not be any conductors shall be bonded to the lightning system.

All joints in the down conductors shall be of welded/ brazed type. All metallic structures within 2 metres vicinity of down conductors shall be bonded to the lightning protection system.

Every down conductor shall be provided with a test joint at about 1000 mm above ground level. The test joint shall be directly connected to the earthing system electrode.

The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metal enclosures of electrical equipment.

### **8.9.3 Testing**

The Contractor shall test the continuity of conductors and joints. He shall measure earth resistance. The Engineer may ask for other tests, which in his opinion are necessary to prove that the system is in accordance with the design, specifications, code of practice and electricity rules. The Contractor shall have to bear the cost of all such test and provide necessary instruments, apparatus etc. required for testing.

#### **8.9.4 Drawings**

The Contractor shall submit the following drawings for approval, on award of Contract and before commencement of work:

- a) Layout drawings showing locations of earthing electrodes, grids, interconnection, earthing leads to various equipment accompanied by design calculations;
- b) Layout drawings of the lighting protection system along with design calculations showing layout of roof conductors, down conductors, earth pits, connections of grid etc.

### **8.9 Supervisory Control Panels and Associated Equipment**

#### **8.10.1 Scope**

Panels and components for supervisory, process control, instrumentation, alarms and monitoring purposes shall comply with the following requirements.

#### **8.10.2 Panel Design and Construction**

Instrument control panels shall be free-standing, floor-mounting cabinets of the cubicle, console or desk pattern.

The height of the cubicles, with or without desk sections, shall not be greater than 2100 mm overall. Front-of-panel instruments and controls shall be so mounted that the height of their centers above the floor shall be between 1800 mm and 900 mm. Control switches and push buttons shall be positioned below or adjacent to any associated reading instrument.

The design and dimensions of console or control desks shall be determined according to their intended function but the height shall not exceed 1400 mm including the height of the plinth.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and convenient access to all terminals and to parts requiring maintenance and in the case of footways between such apparatus the clearance shall be not less than 600 mm.

The control panel shall be prefabricated, having modular construction and shall comprise of rigid welded structural frames enclosed completely with specially selected smooth finished, cold rolled sheet steel of 2.0 mm thickness, internal mounting plate(s) including the gland plate shall be 3 mm thick. The panel shall be powder coated with finished thickness of minimum 50 microns. Sufficient reinforcement shall be provided in order to provide resistance to vibrations and impart sufficient rigidity during transportation and after installation.

Each panel shall be mounted on steel foundation channels and shall be provided with un-drilled gland plates fitted at the floor level. Removable sides covers to the gland plates shall be incorporated, or any other arrangement that shall give adequate access to the underside of the gland plates and at the same time ensure a vermin proof construction.

Panels shall be supplied with lockable hinged access doors. Doors shall be rigid and of folded construction and provided with close fitting flexible seals to prevent ingress of dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary removable access covers secured by quick release fasteners shall be provided to ensure ease of maintenance to all installed apparatus. No equipment other than

front-of-panel items shall be mounted on internal panel surfaces and adequate provision shall be included for mounting plates and brackets which shall if necessary be hinged or otherwise arranged to give quick and easy access when required to equipment, securing screws, terminals and wiring. The design of panels shall be such as to ensure adequate ventilation and air circulation without permitting the entry of vermin and the ingress of dust.

Temporary closures for panel opening shall be provided as necessary to prevent ingress of dust and vermin during transit and installation. The panels shall be further protected against damage prior to takeover provision shall be made for safe and easy handling during transit and at site. Lifting eyes, if used, shall be removable and panel tops shall be reinforced where necessary.

All panel constructional details and arrangements shall be approved by the Engineer before manufacture, which will be subject to inspection at agreed Modules.

### **8.10.3 Nuts, Bolts, Studs and Washers**

Nuts, bolts, studs, washers and other fixing devices shall be plated or galvanized or otherwise finished to an approved standard.

### **8.10.4 Panel Lighting**

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by a fluorescent type lighting fixture controlled from totally enclosed door operated switches. The lighting circuit shall be independently fused and designed to allow lamps to be replaced safely.

Each cubicle shall be fitted with one or more thermostatically controlled tubular heaters to prevent condensation and assist ventilation. The rating shall not exceed 60 watts per cubic foot and the surface temperature of any part that may be contacted accidentally shall not exceed 65°C. The heaters shall be so situated that no deterioration can be caused to any of the apparatus or wiring in the cubicle. The heating circuit shall be independently fused, and controlled by a suitably labeled rotary pattern enclosed switch mounted in an accessible position within the cubicle.

### **8.10.5 Panel Termination Blocks/Internal Wiring**

Provision shall be made to terminate all incoming and outgoing wires at terminal boards, which shall be mounted vertically where possible and not nearer than 230 mm to the floor or less than 230 mm from an incoming cable gland. They shall be spaced not less than 100 mm apart and set obliquely or otherwise arranged to permit convenient access to wires and terminals and enable ferrule numbers to be read without difficulty. Segregated from other cable terminations and shall be completely labelled to show the appropriate AC or DC working voltage. Other circuits shall be grouped according to voltage, which shall be clearly marked along the corresponding section of each terminal board, and Insulated barriers shall separate the groups of different voltage on the same board.

All connections shall be made on the front of terminal boards and no live metal shall be exposed at the back. Terminal boards and blocks shall be of the type, which clamps the wire securely and without damage between two plates by means of a captive screw. Pinch screw type terminal type blocks will not be accepted. The design shall be such that accidental contact between adjacent terminal blocks cannot occur. Connectors on terminal blocks shall have separate fixings for incoming and outgoing wires. It shall be possible to connect two wires on the same side of each terminal block, but not more than two shall be so connected. At least 25 per cent

spare terminals shall be provided over and above that required for use for the termination of spare cores of external multi-core cable.

Terminal block shall be numbered consecutively in a logical manner, which facilitates identification and location of terminals. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

Panel internal wiring shall be in accordance with Clause 4.20.

All terminal boards shall be sectionalized where possible to give access to group of terminal without uncovering all boards at the same time. Terminal which may be live when the equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact.

#### **8.10.6 Panel Earthing**

A copper earth bus bar of not less than 25mm x 3 mm section shall run the full length of each panel section and be bonded electrically to the main frame. It shall be provided with suitable terminals of not less than 8 mm diameter for connection to the metal cladding or armoring of all incoming and outgoing cable and to the site earthing system. Suitable terminals shall also be provided for connecting the earthing wiring of instrument cases equipment.

#### **8.10.7 Miniature Circuit Breakers (MCBS) and Panel Isolation**

Control panel shall be provided with necessary arrangement for receiving, distributing, isolating and protecting of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with two pole Miniature Circuit Breakers (MCBs). Potential circuits for relaying and metering also shall be protected by MCBs. Important MCBs shall be provided with additional potential free contact for connecting the same to alarm annunciator for generating MCB trip alarm.

Adequate fuse protection of circuits and sub-circuits shall be provided where MCB protections are not found suitable and shall be so arranged that any fuse causes minimum disturbance of plant and cannot result in any unsafe operating condition.

MCBs, clearly labeled, shall be provided for all incoming power supplies. They shall be of the quick make and break type with spring-loaded contacts that close fully without requiring full operation of the handle, which shall be so interlock with the cover that it cannot be operated when the cover is open. The 'ON' & 'OFF' position of each switch shall be unambiguously indicated. Wiring from each isolator to its fuse board shall be capable of carrying safely the isolator rated current unless a fused isolator is employed. Every indicating or recording instrument requiring a power supply shall be individually wired and fused so that in the event of a failure in one circuit the remainder are unaffected. For this purpose socket outlets with fused plugs may be used if considered more convenient or economical.

A 15 Amp, 3 pin switched socket outlet, suitable for 240 V, 1 phase, 50 Hz AC main operating voltage shall be fitted in each control panel.

#### **8.10 Instruments**

All instruments, gauges and control equipment shall be subject to the Engineer's approval and those which perform similar duties shall be of uniform type and manufacture throughout the



scheme in order to facilitate maintenance and the stocking of spare parts. Moving parts and contacts shall be adequately protected from the ingress of dusts and all instruments shall be protected by moisture and dust proof cases including those mounted in panels.

Panel mounted receiving instruments shall be of the electrically operated miniature flush mounting type unless otherwise stated. Where applicable each instrument chassis shall be easily withdraw able from its housing for charts changing or maintenance without interrupting its circuit. All instrument bezels shall be finished to a color to be specified by the Engineer.

Scales shall be clearly marked with black lettering and graduations on a white background. Instruments of the same type and range shall have identical scales.

#### **8.11.1 Push Buttons and Switches**

Push buttons for operational circuits shall be provided with a shroud, guard or other suitable means to prevent inadvertent operation. They shall be in accordance with the high standard generally required by the specification as a whole and by the equipment with which they are associated.

Illuminated push buttons where used shall be of a design that allows easy replacement of the lamps from the front panel.

If legends are engraved on the push buttons they shall be clear and concise and shall be approved by the Engineer before manufacture.

Switches shall be in accordance with the high standard generally required by the specification as a whole and by the equipment with which they are associated.

#### **8.11.2 Indicating Lamps**

Indicating lamps shall be of a type that gives adequate illumination in brightly-lit surroundings. They shall permit convenient replacement of lamp bulbs from the front of the panel and shall operate at a sufficiently low voltage to ensure safety during replacement without the need to isolate the electrical supply. Indicating lamps shall also conform to Clause 4.14.

The lamps shall be cluster LED type. Each lamp shall have either a descriptive label affixed beneath the light fitting or an engraving on the screen or the fitting. All wording shall be approved by the Engineer before manufacture.

#### **8.11.3 Interposing Relays**

Multi-contact interposing relays shall be incorporated into panel circuitry where only one pair of initiating contacts is provided for the operation of separate circuits performing different functions simultaneously e.g. a control initiation with alarm annunciation and data logging. The relays shall be so connected that a failure in anyone circuit shall have no effect on any other.

Independent relays shall be employed for this purpose and the use of spare contacts on interface relays within annunciator units or other secondary circuit equipment, or any other form of cascade operation in which the performance of one circuit is dependent on the correct operation of another, will not be accepted.

#### **8.11.4 Alarm Annunciators**

Microprocessor based alarm annunciators shall be provided for generating audiovisual alarms for each abnormal condition. Alarm shall be initiated by the opening and closing of volt-free contacts. Transparent glass shall be provided for alarm windows. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa at site. Alarm functions shall be indicated on internally illuminated annunciator units bearing appropriate legends and arranged on the panel in groups to be agreed with the Engineer.

Each alarm shall initiate the operation of both visual and audible devices. The bulbs in alarm annunciator shall be cluster LED type. A common audible alarm of approved type and intensity shall be mounted within the panel together with a muting switch for use during commissioning and testing.

Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds do not initiate any action. Isolation facilities shall be provided for the hooter.

Each annunciator shall have provision for a number of spare windows for possible future alarms. It shall be as compact as possible without unnecessary decorative trim.

The alarm indications on each annunciator shall be logically arranged in a format to be agreed with the Engineer. The legend area of each indication shall not be more than 40 mm high and 75 mm wide. The wording of all legends shall be approved by the Engineer before manufacture.

"Alarm accept", "lamp test" and "alarm reset" push buttons shall be provided on each annunciator panel.

#### **8.11.5 Alarm System Operation**

Panel alarm annunciator and audible alarms shall operate as follows:

- (a) When an alarm condition occurs a light behind the appropriate legend shall flash on and off intermittently and the audible alarm shall sound.
- (b) On pressing the "alarm accept" push button, the audible alarm shall be silenced and the flashing light shall become steady.
- (c) The alarm indication shall remain illuminated whether or not the alarm condition has returned to normal until the "alarm reset" push button has been operated, whereupon the light shall be extinguished if the fault condition no longer exists.
- (d) Operation of the "lamp test" push button shall cause all the alarm lamps to be illuminated simultaneously and the audible alarm to be sounded.
- (e) The alarm system shall respond to any new condition that might arise while an existing condition is being indicated whether accepted or not, and to any that might occur during a "lamp test" period. The alarm system shall be designed on the "fail safe" principle so that a fault in any circuit component causes an alarm to be given and shall operate on a power supply not greater than 1100 volts.

#### **8.11.6 Instrument Air Dryers**

Instrument air dryers shall be of the silica gel type. Each unit shall contain sufficient silica gel

for 24 hours operation and shall be provided with an embedded electric heater to reactivate the silica gel within 4 hours. Changeover from worker to standby shall be fully automatic by movement of an air operated four way plug valve. Moisture released by the heaters during the reactivation cycle shall be removed by bleed or dry expanded air.

### **8.11.7 Ultrasonic Level Measuring System**

Ultrasonic level measuring system shall comprise a level sensor, level transmitter cum computing unit, prefabricated cable connecting the sensor and transmitter, panel mounted digital level indicator and any other item required for completing the level measurement system.

The level sensor shall be suitable for flange or bracket mounting as required and have a minimum protection conforming to IP-68. It shall have ambient temperature compensation and adjustable datum setting facilities.

The overall accuracy of the level measurement loop shall be  $\pm 0.5\%$  of the measured value or better.

The level transmitter cum computing unit shall be provided in an enclosure conforming to IP-68 it shall be programmable with an integral programming keyboard. LCD display, relays for alarm, control and system fault and shall provide an isolated 4 to 20 mA DC output signal proportional to the level.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tube or other measure shall be provided to avoid effects on the measurement.

### **8.11.8 Ultrasonic Flow Measuring System in Closed Conditions**

Ultrasonic flow meters shall work on transit (time of flight) time principle.

Ultrasonic flow meters shall consist of multipath flow transducers as described below.

|    |  |  |
|----|--|--|
| I  | up to and including<br>1200 mm line size | two path measurements<br>(four Trans receiver transducers) |
| II | above 1200 mm<br>Line size               | four path measurement<br>(eight Trans receiver transducer) |

The transducer probe shall be of the wet insertion type with facility for online insertion and retraction. Prefabricated cable shall be provided between the transducer probe and the flow transmitter cum computing unit. The overall accuracy of the flow measurement loop shall be  $\pm 1\%$  of the measured value or better. The flow transmitter cum computing unit shall be microprocessor based, have LCD display and shall have facilities for on-line diagnosis, entering pipe size, engineering units, measuring span etc. The Contractor shall measure the exact inside

diameter of the pipe at the location of flow transducer and this data shall be used for flow computation.

#### **8.11.9 Conductivity Type Level Switches**

Level switches operating on the conductivity principle shall have three electrodes per relay or control unit except where a differential between the 'cut-in' and 'cutout' valves is not required or where two or more relays are associated with the same vessel, when a common 'earth' electrode shall be used.

Electrodes for the same vessel shall be mounted on a common plate which shall be made in sections if desirable to facilitate handling. Electrode heads designed for adjustment shall permit an adjustment in operating level of not less than 90 mm without necessitating cutting or extending electrodes. The electrodes shall be of stainless steel. The electrodes shall be rod type for length up to three meters and shall be rope type for lengths above three meters. Perforated stilling tubes of SS shall be provided to avoid effects of turbulence on measurement.

Multi electrodes systems shall be provided with insulated electrodes such that only the tip of each electrode is exposed to the liquid at the operating level. Electrodes shall be provided longer than necessary and cut-back at site if precise lengths cannot be established at time of order.

Relay or control units operating with level electrodes shall have adjustable sensitivity. Electrodes for use in fluids of low or variable conductivity shall have conductivity discs. The level control shall be provided in an enclosure conforming to IP-68.

#### **8.11.10 Buoyancy Level Switches**

Level switches of the buoyancy type shall consist of a micro switch with changeover action enclosed in a non-corrosive material. A balance weight shall also be incorporated in the switch to counteract the buoyancy effects for the specific gravity of the particular fluid. The connecting cable shall be sealed into the switch.

Buoyancy switches shall be installed with a minimum of one metre of spare connecting cable neatly coiled at a supporting bracket. The connecting cable fixing shall facilitate any alteration in operating level within the limit of the space cable referred to above.

Perforated stilling tube of SS shall be provided to avoid effects of turbulence on measurement.

The level switch shall have weather protection of IP-68

#### **8.11.11 Float Type Level Switch**

Float type level switch shall comprise of a float, float guide, micro switch assembly and any other item required to complete the switch assembly. The float and all the wetted parts shall be SS 316.

The level switch shall have weather protection of IP-68

#### **8.11.12 Level Indicators**

Level indicators of the sight-glass type shall be provided with shut-off cocks and flushing connections. The glass material shall be shatterproof.

Direct reading dial gauges shall have scales graduated in volumetric units all parts in contact with the fluid shall be resistant to corrosion by the fluid. Where float and board type level indicator is provided, float and wire shall be of SS 316. Nylon bushes, rollers and bearings shall be used in the system.

#### **8.11.13 Loss of Head (Differential Pressure) Measuring System**

The loss of head / differential pressure measuring system shall comprise of DP transmitter, panel mounted digital indicator and any other item required to complete the differential pressure measuring system.

The DP transmitter shall be diaphragm type. The DP transmitter shall be rugged in construction and shall be suitable for continuous operation. They shall be designed for operation over full range. They shall produce a 4-20 mA isolated DC signal proportional to differential pressure. The DP transmitters shall be digital indicating type having LCD display. The overall accuracy of the DP measurement loop shall be  $\pm 0.5\%$  of measured value or better.

The transmitters shall be connected to the pressure tapings via five-valve manifold, which will enable zero and full-scale differential pressure to be applied for calibration checking.

The transmitter shall be provided in an enclosure conforming to IP-65.

#### **8.11.14 pH Measuring System**

The pH measuring system shall consist of a pH electrode assembly, pH transmitter, panel mounted digital pH indicator and any other item required to complete the pH measuring system.

The pH electrode assembly shall be rugged in construction and shall be suitable for continuous operation with solid concentration greater than 5%. The pH electrode assembly shall include a measuring electrode and a reference electrode. Automatic temperature compensation shall be provided along with the pre-amplifier assembly all wetted parts of the assembly shall be of non-corrosive material. The electrode assembly shall be of such a design that it contains some water even when sampling pump is cut off and shall be provided with flow regulating device. Electrode assemblies shall be installed so that they are protected from accidental damage and yet readily accessible for maintenance.

The pH transmitter shall be suitable for field mounting and shall accept input from pH transducer. It shall provide 4-20 mA DC (isolated) output proportional to pH. The pH transmitter shall have an LCD display to indicate pH. Prefabricated cable shall be provided for connecting the pH electrode assembly and transmitter.

The overall accuracy of the pH measurement loop shall be  $\pm 1\%$  of measured value or better.

#### **8.11.15 Differential Pressure Flow Measuring System**

The differential pressure flow measuring system shall comprise of flow element, differential pressure (DP) transmitter, panel mounted digital flow indicator & integrator and any other item required for completing the flow measuring system.

The overall accuracy of the flow measurement loop shall be  $\pm 1\%$  of the measured value or better.

The primary element for any flow meter of the differential pressure type other than a Dall tube

shall be manufactured and installed in accordance with the requirements of BS: 1042 or equivalent approved. Dall tubes shall be installed in accordance with the recommendations of the manufacturer. The materials of which the primary elements are constructed shall be those recommendations by the manufacturer of the device as most suitable for the particular application.

The location of primary elements in pipe work shall be agreed with the Engineer.

The DP transmitter shall convert the differential pressure produced by each primary element to a 4-20 mA DC (isolated) current proportional to the flow rate. Each transmitter shall be connected to the tapings via a 5-valve manifold and provision made for easy connection of a U-tube manometer for the purpose of calibration. The DP transmitters shall be indicating type having LCD display for flow rates and integrated flows. The enclosure protection of the DP transmitters shall be conforming to IP- 68.

The Contractor shall arrange for calibration tests of primary elements to be carried out and witnessed by the Employer's Engineer and shall provide certified records of the test readings.

Where the transmitted signal is to be linearised a square root extraction feature shall provide an output signal proportional to flow of the same electrical range as the input signal and shall be solid-state device

After installation the calibration of each flow meter system shall be proved to the satisfaction of the Employer's Engineer by the application of fixed measured differential pressure to the input of the DP transmitter.

#### **8.11.16 Full Bore Electro-Magnetic Flow Meters**

The full bore electro-magnetic meters shall comprise of flow tube, flow transmitter cum computing unit with LCD display, panel mounted digital flow indicator cum integrator and any other item required to complete the flow measurement system. The flow tube shall be of SS 316 construction with Teflon lining. Other wetted parts shall be of SS 316 construction.

The overall accuracy of the flow measurement loop shall be  $\pm 1\%$  of the measured value or better.

#### **8.11.17 Pressure Gauges**

Pressure gauges shall be complying with IS: 3624. Glycerin filled dial shall be provided where the gauge is subjected to pressure pulsation and / or vibrations. The internal parts of pressure gauge shall be stainless steel.

The minimum diameter for round pressure gauges shall be 150 mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

The accuracy of the pressure gauges shall be  $\pm 1\%$  of full scale, accessories such as snobbery, isolation valve & drain valve shall be provided. Impulse tubing and fittings as required shall be provided.

### **8.11 Lightning Protection Unit**

Two numbers of lightening protection units shall be provided for each analog signal and power supply loop. The lightening protection unit shall be suitable for withstanding the surge arising

out of high-energy static discharge / lightning strikes and prevents the instrument from any damage. LPU shall provide three Modules of protection through a gas discharge tube, quick acting semiconductor like tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. LPU shall be a passive unit and shall require no power for its operation. During a lightning strike it shall clamp on the allowable voltage and pass the excess voltage to the ground. LPU shall be of self-resetting type to minimize the down time of the measurement loop. LPU shall have a weatherproof casting and shall be suitable for field/back of panel mounting. There should be total isolation between input, output and ground terminals. LPUs shall have a minimum surge rating of 10 kA.

## **8.12 Supervisory Control Panels and Associated Equipment**

### **8.13.1 Scope**

Panels and components for supervisory, process control, instrumentation, alarms and monitoring purposes shall comply with the following requirements.

### **8.13.2 Panel Design and Construction**

Instrument control panels shall be free-standing, floor-mounting cabinets of the cubicle, console or desk pattern.

The height of the cubicles, with or without desk sections, shall not be greater than 2100 mm overall. Front-of-panel instruments and controls shall be so mounted that the height of their centers above the floor shall be between 1800 mm and 900 mm. Control switches and push buttons shall be positioned below or adjacent to any associated reading instrument.

The design and dimensions of console or control desks shall be determined according to their intended function but the height shall not exceed 1400 mm including the height of the plinth.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and convenient access to all terminals and to parts requiring maintenance and in the case of footways between such apparatus the clearance shall be not less than 600 mm.

The control panel shall be prefabricated, having modular construction and shall comprise of rigid welded structural frames enclosed completely with specially selected smooth finished, cold rolled sheet steel of 2.0 mm thickness, internal mounting plate(s) including the gland plate shall be 3 mm thick. The panel shall be powder coated with finished thickness of minimum 50 microns. Sufficient reinforcement shall be provided in order to provide resistance to vibrations and impart sufficient rigidity during transportation and after installation.

Each panel shall be mounted on steel foundation channels and shall be provided with un-drilled gland plates fitted at the floor level. Removable side covers to the gland plates shall be incorporated, or any other arrangement that shall give adequate access to the underside of the gland plates and at the same time ensure a vermin proof construction.

Panels shall be supplied with lockable hinged access doors. Doors shall be rigid and of folded construction and provided with close fitting flexible seals to prevent ingress of dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary removable access covers secured by quick release fasteners shall be provided to ensure ease of maintenance to all installed apparatus. No equipment other than front-of-panel items shall be mounted on internal panel surfaces and

adequate provision shall be included for mounting plates and brackets which shall if necessary be hinged or otherwise arranged to give quick and easy access when required to equipment, securing screws, terminals and wiring. The design of panels shall be such as to ensure adequate ventilation and air circulation without permitting the entry of vermin and the ingress of dust.

Temporary closures for panel opening shall be provided as necessary to prevent ingress of dust and vermin during transit and installation. The panels shall be further protected against damage prior to takeover provision shall be made for safe and easy handling during transit and at site. Lifting eyes, if used, shall be removable and panel tops shall be reinforced where necessary.

All panel constructional details and arrangements shall be approved by the Engineer before manufacture, which will be subject to inspection at agreed stages.

### **8.13.3 Nuts, Bolts, Studs and Washers**

Nuts, bolts, studs, washers and other fixing devices shall be plated or galvanized or otherwise finished to an approved standard.

### **8.13.4 Panel Lighting**

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by a fluorescent type lighting fixture controlled from totally enclosed door operated switches. The lighting circuit shall be independently fused and designed to allow lamps to be replaced safely.

Each cubicle shall be fitted with one or more thermostatically controlled tubular heaters to prevent condensation and assist ventilation. The rating shall not exceed 60 watts per cubic foot and the surface temperature of any part that may be contacted accidentally shall not exceed 65°C. The heaters shall be so situated that no deterioration can be caused to any of the apparatus or wiring in the cubicle. The heating circuit shall be independently fused, and controlled by a suitably labeled rotary pattern enclosed switch mounted in an accessible position within the cubicle.

### **8.13.5 Panel Termination Blocks/Internal Wiring**

Provision shall be made to terminate all incoming and outgoing wires at terminal boards, which shall be mounted vertically where possible and not nearer than 230 mm to the floor or less than 230 mm from an incoming cable gland. They shall be spaced not less than 100 mm apart and set obliquely or otherwise arranged to permit convenient access to wires and terminals and enable ferrule numbers to be read without difficulty. Segregated from other cable terminations and shall be completely labelled to show the appropriate AC or DC working voltage. Other circuits shall be grouped according to voltage, which shall be clearly marked along the corresponding section of each terminal board, and insulated barriers shall separate the groups of different voltage on the same board.

All connections shall be made on the front of terminal boards and no live metal shall be exposed at the back. Terminal boards and blocks shall be of the type, which clamps the wire securely and without damage between two plates by means of a captive screw. Pinch screw type terminal type blocks will not be accepted. The design shall be such that accidental contact between adjacent terminal blocks cannot occur. Connectors on terminal blocks shall have separate fixings for incoming and outgoing wires. It shall be possible to connect two



wires on the same side of each terminal block, but not more than two shall be so connected. At least 25 per cent spare terminals shall be provided over and above that required for use for the termination of spare cores of external multi-core cable.

Terminal block shall be numbered consecutively in a logical manner, which facilitates identification and location of terminals. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made.

All terminal boards shall be sectionalized where possible to give access to group of terminal without uncovering all boards at the same time. Terminal which may be live when the equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact.

#### **8.13.6 Panel Earthing**

A copper earth bus bar of not less than 25mm x 3 mm section shall run the full length of each panel section and be bonded electrically to the main frame. It shall be provided with suitable terminals of not less than 8 mm diameter for connection to the metal cladding or armoring of all incoming and outgoing cable and to the site earthing system. Suitable terminals shall also be provided for connecting the earthing wiring of instrument cases equipment.

#### **8.13.7 Miniature Circuit Breakers (MCBS) and Panel Isolation**

Control panel shall be provided with necessary arrangement for receiving, distributing, isolating and protecting of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with two pole Miniature Circuit Breakers (MCBs). Potential circuits for relaying and metering also shall be protected by MCBs. Important MCBs shall be provided with additional potential free contact for connecting the same to alarm annunciator for generating MCB trip alarm.

Adequate fuse protection of circuits and sub-circuits shall be provided where MCB protections are not found suitable and shall be so arranged that any fuse causes minimum distribution of plant and cannot result in any unsafe operating condition.

MCBs, clearly labeled, shall be provided for all incoming power supplies. They shall be of the quick make and break type with spring-loaded contacts that close fully without requiring full operation of the handle, which shall be so interlock with the cover that it cannot be operated when the cover is open. The 'ON' & 'OFF' position of each switch shall be unambiguously indicated. Wiring from each isolator to its fuse board shall be capable of carrying safely the isolator rated current unless a fused isolator is employed. Every indicating or recording instrument requiring a power supply shall be individually wired and fused so that in the event of a failure in one circuit the remainder are unaffected. For this purpose socket outlets with fused plugs may be used if considered more convenient or economical.

A 15 Amp 3 pin switched socket outlet, suitable for 240 V, 1 phase, 50 Hz AC main operating voltage shall be fitted in each control panel.

### **8.13 Instruments**

All instruments, gauges and control equipment shall be subject to the Engineer's approval and those which perform similar duties shall be of uniform type and manufacture throughout the scheme in order to facilitate maintenance and the stocking of spare parts. Moving parts and

contacts shall be adequately protected from the ingress of ducts and all instruments shall be protected by moisture and dust proof cases including those mounted in panels.

Panel mounted receiving instruments shall be of the electrically operated miniature flush mounting type unless otherwise stated. Where applicable each instrument chassis shall be easily withdrawable from its housing for charts changing or maintenance without interrupting its circuit. All instrument bezels shall be finished to a color to be specified by the Engineer.

Scales shall be clearly marked with black lettering and graduations on a white background. Instruments of the same type and range shall have identical scales.

### **9.3.35 Push Buttons and Switches**

Push buttons for operational circuits shall be provided with a shroud, guard or other suitable means to prevent inadvertent operation. They shall be in accordance with the high standard generally required by the specification as a whole and by the equipment with which they are associated.

Illuminated push buttons where used shall be of a design that allows easy replacement of the lamps from the front panel.

If legends are engraved on the push buttons they shall be clear and concise and shall be approved by the Engineer before manufacture.

Switches shall be in accordance with the high standard generally required by the specification as a whole and by the equipment with which they are associated.

### **9.3.36 Indicating Lamps**

Indicating lamps shall be of a type that gives adequate illumination in brightly-lit surroundings. They shall permit convenient replacement of lamp bulbs from the front of the panel and shall operate at a sufficiently low voltage to ensure safety during replacement without the need to isolate the electrical supply. The lamps shall be cluster LED type. Each lamp shall have either a descriptive label affixed beneath the light fitting or an engraving on the screen or the fitting. All wording shall be approved by the Engineer before manufacture.

### **9.3.37 Interposing Relays**

Multi-contact interposing relays shall be incorporated into panel circuitry where only one pair of initiating contacts is provided for the operation of separate circuits performing different functions simultaneously e.g. a control initiation with alarm annunciation and data logging. The relays shall be so connected that a failure in anyone circuit shall have no effect on any other.

Independent relays shall be employed for this purpose and the use of spare contacts on interface relays within annunciator units or other secondary circuit equipment, or any other form of cascade operation in which the performance of one circuit is dependent on the correct operation of another, will not be accepted.

### **9.3.38 Alarm Annunciators**

Microprocessor based alarm annunciators shall be provided for generating audiovisual alarms for each abnormal condition. Alarm shall be initiated by the opening and closing of volt-free

contacts. Transparent glass shall be provided for alarm windows. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa at site. Alarm functions shall be indicated on internally illuminated annunciator units bearing appropriate legends and arranged on the panel in groups to be agreed with the Engineer.

Each alarm shall initiate the operation of both visual and audible devices. The bulbs in alarm annunciator shall be cluster LED type. A common audible alarm of approved type and intensity shall be mounted within the panel together with a muting switch for use during commissioning and testing.

Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds do not initiate any action. Isolation facilities shall be provided for the hooter.

Each annunciator shall have provision for a number of spare windows for possible future alarms. It shall be as compact as possible without unnecessary decorative trim.

The alarm indications on each annunciator shall be logically arranged in a format to be agreed with the Engineer. The legend area of each indication shall not be more than 40 mm high and 75 mm wide. The wording of all legends shall be approved by the Engineer before manufacture.

"Alarm accept", "lamp test" and "alarm reset" push buttons shall be provided on each annunciator panel.

#### **9.3.39 Alarm System Operation**

Panel alarm annunciator and audible alarms shall operate as follows:

- (a) When an alarm condition occurs a light behind the appropriate legend shall flash on and off intermittently and the audible alarm shall sound.
- (b) On pressing the "alarm accept" push button, the audible alarm shall be silenced and the flashing light shall become steady.
- (c) The alarm indication shall remain illuminated whether or not the alarm condition has returned to normal until the "alarm reset" push button has been operated, whereupon the light shall be extinguished if the fault condition no longer exists.
- (d) Operation of the "lamp test" push button shall cause all the alarm lamps to be illuminated simultaneously and the audible alarm to be sounded.
- (e) The alarm system shall respond to any new condition that might arise while an existing condition is being indicated whether accepted or not, and to any that might occur during a "lamp test" period. The alarm system shall be designed on the "fail safe" principle so that a fault in any circuit component causes an alarm to be given and shall operate on a power supply not greater than 1100 volts.

#### **9.3.40 Instrument Air Dryers**

Instrument air dryers shall be of the silica gel type. Each unit shall contain sufficient silica gel for 24 hours operation and shall be provided with an embedded electric heater to reactivate the silica gel within 4 hours. Changeover from worker to standby shall be fully automatic by movement of an air operated four way plug valve. Moisture released by the heaters during the reactivation cycle shall be removed by bleed or dry expanded air.

## **8.14 Lightning Protection Unit**

Two numbers of lightning protection units shall be provided for each analog signal and power supply loop. The lightning protection unit shall be suitable for withstanding the surge arising out of high-energy static discharge / lightning strikes and prevents the instrument from any damage. LPU shall provide three stages of protection through a gas discharge tube, quick acting semiconductor like tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. LPU shall be a passive unit and shall require no power for its operation. During a lightning strike it shall clamp on the allowable voltage and pass the excess voltage to the ground. LPU shall be of self-resetting type to minimize the down time of the measurement loop. LPU shall have a weatherproof casting and shall be suitable for field/back of panel mounting. There should be total isolation between input, output and ground terminals. LPUs shall have a minimum surge rating of 10 kA.

## **10 Instrumentation, Control & Automation (ICA)**

### **9.1 General**

- 9.1.1 A complete instrumentation, control and automation (ICA) system shall be provided to ensure the full automatic control of the Pumping Station. The system shall be supplied, installed and commissioned by the original manufacturer of the equipment itself. No third party system integrator should be assigned for the installation, testing and commissioning.
- 9.1.2 This system shall operate with the electrical motor control centres and local control panels to provide a complete control system operating in accordance with the control philosophy of the Pumping Station.
- 9.1.3 The system shall comprise the following main elements:
  - (a) Pumping station instrumentation providing information relating to Pumping station operation and performance.
  - (b) DCS based control system providing local area automatic control and monitoring including generating alarms requiring operator response.
  - (c) The controllers are named as Field Control Stations (FCS). At least one (1) FCS controller would be located at the switchgear panel room. The FCS controller communicates with the central control room HIS (Human Interface Station) over a Vnet/IP Local Area Network (LAN) operating at 1 GBPS. Local HMI's shall be connected to each of the FCS controllers to provide access to all of the control and information data within the FCS controller using graphic displays
  - (d) The DCS controller communication is based on an open system concept. Vnet/IP network has open standards architecture using Ethernet interface 1 GBPS.
  - (e) All network hardware requirements (cable, switches, hubs etc.) are based on common off the shelf standard equipment.
  - (g) Access to control and information data is proposed to be available in both the DCS operation Room and at the local equipment areas (Remote Electrical switch rooms). Data is presented to the operator using graphical displays developed to reflect the plant design and geographical layout. Control functions and motor stop/start functions are access via the graphical displays, events such as alarms, starting and stopping of equipment is

logged and presented to the operator in a chronological event list. Each event is logged with date; time, event description and event type e.g. event notification, event alarm accepted, event cleared.

- (h) The Distributed Control System is constructed along conventional DCS lines where the HIS station will be located in the DCS operation Room and the Vnet/ IP (compatible to both IPv4 and IPv6) network communicating with the local FCS controllers in the remote equipment areas via network cables, routers and switches. HIS operating system shall be latest Windows based OS.
- (h) Communications and data gathering facilities at all levels to enable the transfer of information between levels of the overall ICA system.
- (i) Any hardware, software etc. required to link the DCS system and the stage 2 and 3 (future) system shall be under this scope.

- 9.1.4 A proposed control system architecture is shown on the Appendix B drawings for reference only:

#### Main Control System Architecture

The complete engineering, supply, installation and commissioning of the control system shall be done by the manufacturer with the required warranty.

- 9.1.5 The Contractor shall in any case engage the services of an ICA manager or Project Engineer (PE) for the purposes of managing the work of the system integrator. This Manager/PE shall facilitate system and operational liaison with the Purchaser during the whole life of this aspect of the Contract. He shall also manage the co-ordination of the design work between the system integrator and all third party package Sub-Contractors in order to ensure a smooth interface and flow of information between these parties.

## **9.2 Instrumentation and Monitoring**

- 9.2.1 Instrumentation to be provided on the WTP shall be generally as shown on the P&IDs, and instrumentation schedule which are intended to illustrate the minimum level of monitoring and control. Where additional instrumentation is required by the Contractor's detailed design of the process for control or monitoring purposes, this shall be provided and installed in accordance with the Specification.
- 9.2.2 Monitoring instrumentation shall be located as close to the point of measurement as possible without compromising access for maintenance of the instrument.
- 9.2.3 Instrument transmitters shall be located adjacent to sensors on the plant to provide secure signals to the control systems. The Device level communication protocol will be HART/FF/Profibus.
- 9.2.4 All outputs from instrumentation provided under the Contract shall be monitored remotely by the main control system. These signals shall be provided to the DCS system via the area FCS controllers.
- 9.2.5 When shown on the P&IDs, instrument transmitters shall be provided with an indicator so that measured parameters can be read at the relevant location. Where the instrument product has no indicator built into the transmitter unit, a separate indicator shall be provided and

located adjacent to the transmitter.

- 9.2.6 Where instruments require sample systems, the length of the transport systems shall be kept to a minimum in order to minimize sample time delays. Gravity sample systems shall be utilized where possible, but sample pumps shall be installed where a gravity supply cannot provide the required transportation of the sample.

### **9.3 Local Area Controls / DCS System**

#### **9.3.1 ICA Cabinet General Design**

- 9.3.1.1 Each area MCC shall be provided with an ICA end section. This section shall be of a "wardrobe" design and shall house a local FCS controller and operator HMI panel and all necessary power distribution and control equipment associated with the specific area.

- 9.3.1.2 The operator HMI panel shall be installed on the front of the ICA section, to provide local indication of all parameters measured. The HMI panel shall be touch screen type and large for the operator access and controls.

#### **9.3.2 Control system selection and Design**

- 9.3.2.1 All system equipment and software (except for local HMI's and standard computer components) shall be selected from the latest products/release of the manufacturer.

- 9.3.2.2 This shall incorporate the use of latest FCS controllers, and programming software.

- 9.3.2.3 The Contractor shall provide a fully functional control system to provide all control and monitoring facilities in accordance with the Contractor's operating and control philosophy and Pumping station design.

- 9.3.2.4 The system shall be fully networked and integrated to provide the control of the WTP as a whole and shall incorporate all necessary hardware, software and communications equipment. This shall include means for providing communications between FIELD CONTROL STATIONS and the DCS HIS Stations for transfer of data and control actions.

- 9.3.2.5 The system shall be designed to enable ease of extension, interconnectivity and compatibility, utilizing the ISO standard for open systems interconnection (OSI) model as a basis for system design.

- 9.3.2.6 Each FIELD CONTROL STATION shall be designed to re-initialize all programs on restoration of power supply in order to start operation from a known position. However all current equipment and process set-points shall be retained by the FIELD CONTROL STATION when power is lost and subsequently restored.

- 9.3.2.7 Safety procedures shall be incorporated in the design of the system hardware and software such that that under fault conditions the most appropriate safe action is employed. In particular the following shall apply:-

(a) The FIELD CONTROL STATION shall continue to hold on to last known analogue values or digital states on failure of a device or instrument.

(b) The FIELD CONTROL STATION shall shut down the process or move it to a safe state as required by the operating and control philosophy of the pumping station.

- (c) In the event of FIELD CONTROL STATION / network failure, drives and valves will be locally operated, with protection provided by the hardwired interlocks.

### 9.3.3 Operator Facilities at MCCs

9.3.3.1 The operator HMI panels shall comprise a touch-screen minimum 21” on the front of the ICA section of each MCC to enable the operator to assess the current status/operation of the equipment. Approval shall be gained from the Employer’s Engineer to use lesser size touch-screen HMI’s in application areas with simple process mimics. E.g. Transformer sub-stations.

9.3.3.2 The following functions shall be provided from the operator HMI panels:

- (a) Indication of local alarms with a 24 hr rollover.
- (b) Indication of analogue values on bar scales and trending of analogue values.
- (c) Status overview in a block diagram format of each process block showing status and Measurement (e.g. a single filter).
- (d) Manual control of local operating sequences such as filter back-washing.
- (e) Overview block diagram showing status and Measurement.
- (f) Duty/standby selection of equipment and the ability to manually alter local set points.
- (g) Manual operation of actuators or drives shall be provided
- (h) Ethernet and Compact Flash Card connectivity shall be provided as a minimum.

### 9.3.4 Automatic Control of Equipment

9.3.4.1 All equipment shall be controlled automatically. The control shall be distributed; i.e. control shall be located at the local areas, operated by the FIELD CONTROL STATION software.

9.3.4.2 The system shall be designed such that if the DCS system fails, then the equipment will continue to operate automatically.

9.3.4.3 Under normal operation the FIELD CONTROL STATION’s shall run the equipment and the DCS system shall provide operator management of all control systems.

9.3.4.4 The equipment shall be provided with a start-up and shutdown routine, which can be initiated either from the HIS Station or by automatically set parameters, which can be altered from the DCS HIS/ENG Station.

9.3.4.5 The local FIELD CONTROL STATION shall operate local equipment management, e.g. duty standby operation, washing sequences or maintenance cycles, automatic stopping and starting, automatic speed control of dosing pumps, etc.

9.3.4.6 All settings to enable this control shall be operated from the DCS system.

9.3.4.7 In addition, the FIELD CONTROL STATION system as a whole shall operate works

shutdown and start up procedures, co-ordinated from the DCS system.

### 9.3.5 Fail Safe Operations

9.3.5.1 All FIELD CONTROL STATION software and hardwired circuits shall be designed for failsafe operation. i.e. any failure of an instrument or element in a system shall operate the equipment to a safe position.

9.3.5.2 Hardwired backup systems shall be provided for systems that are critical to the process, e.g. Chlorination, which shall take over the control of the system on failure of the main control system, whilst alerting operators of the change to control.

### 9.3.6 Programming

9.3.6.1 The DCS software Engineering function will be located in a HIS Station selected to be the HIS/ENG (Engineering Station) located in the Central Control area. The DCS database will be maintained and controlled from the HIS/ENG. Access to the engineering function is controlled by password protection.

9.3.6.2 Integrated asset management system (computerized maintenance management system) for all pumping station equipment and system shall be provided under DCS system.

9.3.6.3 All programming tools and software with licensee shall be handed over by the Contractor to the Employer.

9.3.7 All Power monitors shall read T.H.D values, and shall communicate with DCS

## 9.4 Communications

### 9.4.1 DCS and FIELD CONTROL STATION Communications

9.4.1.1 The DCS system components shall be linked around the WTP by a dual redundant fibre optic communications network.

9.4.1.2 Secure FIELD CONTROL STATION and DCS communications shall be provided by the use of optical fibre cable systems. DCS Communication diagnostic software/tools to be provided

### 9.4.2 Device Level Communications

9.4.2.1 Process device networks may be used in place of analogue circuits to provide monitoring of instruments and the monitoring and control of field mounted control devices such as valve actuators.

9.4.2.2 Where this arrangement is provided, a separate network shall be used between process streams and between duty and standby devices in order that a device level network failure does not result in total pumping station failure.

9.4.2.3 Where device level communications is utilized, from controlling FIELD CONTROL STATION's, a single device level protocol shall be adopted for the site.

9.4.2.4 Where this arrangement is used for motor starters in Motor Control Centres, a dual network shall be used separating duty and standby units between the networks.



- 9.4.2.5 The device level communications network shall be compatible with the FIELD CONTROL STATION's.
- 9.4.2.6 Network performance shall not to inhibit operation of the pumping station in any way.
- 9.4.3 DCS Internet Access
  - 9.4.3.1 A facility shall be provided to access the DCS system via the Internet utilizing a fully secure server with password protected access.
  - 9.4.3.2 The following functions shall be provided from the Internet:
    - (a) Full navigable graphical representation of all process areas.
    - (b) Indication of alarms with a 24 hr rollover.
    - (c) Indication of analogue values on bar scales and trending of analogue values.
    - (d) Status overview in a block diagram format of each process block showing status and Measurement (e.g. a single filter).

## 9.5 General

The Pumping station shall be provided with a fully functional DCS operation room. This control room shall be the centre of operation for the WTP and CWR and MBR pumping stations. The system provided shall be expandable for the stage-2 and stage -3 of the works in future.

- A. DCS system shall be installed in the control room to provide a central location to carry out the following functions:
  - (a) Historical recording of measured values to provide performance records for the works.
  - (b) Alarms handling facilities.
  - (c) On line graphical information (mimics, trends etc.) to provide means of "on line" analysis of pumping station condition/performance.
  - (d) Setting of pumping station control parameters (e.g. adjustment of flow or level set points, dosing rates, etc.).
  - (e) Remote control of equipment
- B. The DCS system shall utilize latest releases of the Manufacturer's system and application software and current entry level PC technology as a minimum and shall utilize standard technology to provide the functionality of the system.
- C. The DCS system shall be constructed in redundant format with the exception of the field input/output modules.
- D. Operator interface to the DCS system shall be provided by colour graphical displays, which represent the equipment under control. These shall be based on the P&IDs for

the plant. All functions shall be mouse operated and the software graphics shall be Windows based to enable operators with PC skills to operate the system with ease.

- E. Any additional Client licenses required for the DCS system shall be provided for portable or desk top PC's, so that key personnel (e.g. operations manager/maintenance superintendent) can access the DCS system from remote locations via the internet, in order to initially assess any reported operational problems without having to attend site. This arrangement shall not allow remote operator functions such as control, alarm accept and changing parameters from remote Clients via this communications route. Use of a restricted access web server facility may be considered as an alternative for the provision of this facility, subject to approval of the Client.

F. Reports

The system shall be configured to produce scheduled reports at specified periods for the following information:

- (a) Total key flows for all process areas and average, maximum and minimum flow rates, daily and weekly.
- (b) Key quality Measurements for all process areas, with average, maximum with time/date, minimum with time/date daily and weekly.
- (c) Chemical usage.
- (d) Electrical consumption and peak demand for all process areas.
- (e) Mains import of power daily and weekly.

G. Power Management Controls

A series of power management control pages shall be provided on the DCS HIS Stations. The power management pages shall provide indication of data from the power metering and generator plant controls. This information shall include:

- (a) Power equipment running and status of switchgear, including mains supply and the on-site generator.
- (b) Output voltages.
- (c) Power output from source equipment including KVA and KVA<sub>r</sub> metering at each MCC.
- (d) Main loads connected and power consumed.

- H. The system shall also provide a sequencing page that will provide the power management system with controls for the selection of drives and the sequence of starting/stopping of drives when running under standby or restricted power arrangements.

- I. The system shall allow the selection and removal of drives from each list and the DCS system shall monitor and display the kW loads added or subtracted and shall provide an indication when the loads added to the list exceed a preset kW limit for each condition.

J. All instrumentation and transmitting facilities to provide the power management data shall be installed in each of the MCC's.

K. Control System Performance Requirements

General

The DCS including the FIELD CONTROL STATIONS and local HMIs shall be designed to work as a complete system and shall meet the following requirements for operational performance.

DCS Work Station Operations

The following performance parameters refer to the operation of controls and display functions by an operator working at a DCS HIS station.

| Item | Description of Action   | Average Response Times (Seconds) | Maximum acceptable response times (Seconds) |
|------|---|----------------------------------|---|
| 1    | Display refreshes time to maintain current data.  | 1                                | 5   |
| 2    | Request for a mimic or other display to completion of the display on the screen (including current live data) | 3                                | 5   |
| 3    | Display alarm list.   | *                                | 5   |
| 4    | Display trend (up to 4 items, 7 days at 30 minute intervals)  | *                                | 10  |
| 5    | From request for current data to display the data.  | *                                | 5   |
| 6    | From Screen dump/plot command to start plot   | *                                | 10  |
| 7    | Speed of screen response to keyboard or mouse operation   | 0.1                              | 0.1   |
| 8    | Speed of update of information passed between work station and a FIELD CONTROL STATION or HMI and vice versa. | 1                                | 1   |

\* Denotes average response times to be notified by the Contractor.

L. Control Action Responses

The following table defines the requirements for the response of control actions by a request from an operator either working at a DCS HIS station or an HMI terminal.

| Item | Description of Action                         | Average Response Times (Seconds) | Maximum acceptable response times (Seconds) |
|------|---|----------------------------------|---|
| 1    | Speed of a control action and acknowledgement | 2                                | 5   |

| Item | Description of Action  | Average Response Times (Seconds) | Maximum acceptable response times (Seconds) |
|------|--|----------------------------------|---|
| 2    | From an alarm occurrence/clear to completion of display                        | *                                | 5   |
| 3    | From an alarm occurrence/clear to logging message on alarm printer.            | *                                | 5   |
| 4    | From alarm acceptance to silencing alarm.                                      | *                                | 5   |
| 5    | From selection of a control point to check back                                | *                                | 2   |
| 6    | From issue of an execute command to commencement at the FIELD CONTROL STATION. | *                                | 2   |

#### M. Interfaces with the FIELD CONTROL STATION System

The following table defines the requirements for updating the DCS system database and or display to the change of a parameter at the FIELD CONTROL STATION. These times shall also apply to updating the display data on an HMI.

| Item | Description of Action  | Average Response Times (Seconds) | Maximum acceptable response times (Seconds) |
|------|--|----------------------------------|---|
| 1    | Speed of change of state at any site device to display at an operator terminal (DCS HIS or HMI)              | 2                                | 5   |
| 2    | Speed of response from occurrence of an alarm on the WTP to display on the alarm system (on DCS HIS and HMI) | 3                                | 5   |
| 3    | Request of data from assured point to the relevant screen display.   | 1                                | 2   |

#### N. Interfaces with Peripheral Devices

The following table defines the requirements for the speed of response of peripheral devices such as printers etc. with operations on a DCS HIS operator station.

| Item | Description of Action   | Average Response Times (Seconds) | Maximum acceptable response times (Seconds) |
|------|---|----------------------------------|---|
| 1    | Initiation of a print out of a screen plot or report to a printer or plotter to the start of printing | 5                                | 10  |

|   |   |   |    |
|---|---|---|----|
| 2 | The retrieval of data from archive storage (either from the hard disc or from a portable storage device) to display on the appropriate screen display | 3 | 10 |
|---|---|---|----|

O. Work Station Responses

The following table defines the requirements for the speed of response of the DCS Operator stations.

| Item | Description of Action                                      | Average Response Times (Seconds) | Maximum acceptable response times (Seconds) |
|------|--|----------------------------------|---|
| 1    | Speed of Retrieval of data from the database to the screen | 0.5                              | 2   |
| 2    | Speed of system initialization (Startup sequence)          | 10                               | 50  |

P. Verification of System Performance

- (a) The Contractor shall include in his factory and site testing programme certain tests that will verify the performance requirements specified above.
- (b) Where a test fails to meet the criteria, the Contractor shall provide the appropriate equipment, software or re-configuration necessary to achieve the performance requirements above.

Q. It will be Contractors' responsibility to provide all parameters over type of interfaces to be decided by Employer in consultation with ICT Consultant. All the required interfaces (including interface arrangements to be decided such as enterprise bus) will be fully configured by Contractor in its scope of work on both sending and receiving ends for all or part of the parameters as per the requirements to be laid by ICT Consultant for integrating with city ICT infrastructure for control, display, monitoring, reporting etc. at different places in the city including in City's Command & Control Centre/ ICT building. The Contractor's scope of work also includes to provide as required Hardware and Software to fulfil aforementioned requirements. Interfaces will be functional over future firewall (depicted in System Architecture)

R. Contractor will provide SCADA operations panel replica (complete infrastructure - along with all the accessories including end to end power and OFC cabling done) in City's Command & Control Centre / ICT building. In case the ICT building is not ready then full DCS/SCADA operations panel replica will be installed fully operational in one of the selected Service area as approved by Employer which will be alternate operations centre for all the project components in scope.

S. This document does not fully describe all the components of control and instrumentation works for project components in scope but yet Contractor is responsible to build fully complete and functional system in end to end manner matching to the requirements of a SMART city and as per global practices.

T. All the necessary IT/ICT elements such as for process control and instrumentation encompassing control and optic fiber cables, fiber and/or Ethernet switches, media

convertors, multiplexers/demultiplexers, terminators, etc. are in scope of Contractor to make the system fully functional. The control and instrumentation scheme must be pre-approved Employer in consultation with ICT consultant and Employer's Engineer before procurement and implementation. All the makes of control and instrumentation equipment must be from top 5 vendors (revenue wise for applicable product) and acceptable to Employer and Employer's Engineer Employer and/or Employer's Engineer reserve the right to change the scheme, makes and types of equipment, make it more feature rich and add equipment as felt appropriate and there will be no implication to client for additions in these respects (The entire infrastructure must meet requirements of a SMART city). As far as possible most of the equipment must be proposed in redundant manner, the level of acceptable redundancy will be also decided by Employer and Employer's Engineer and the same will be binding to Contractor with no implication to client.

- U. All the costs with respect to the hardware, software, interfacing, Ethernet Fiber optic networking for the Control, level monitoring etc. shall be included in the Contractors scope.
  
- V. It will be the Contractors responsibility for the application engineering and development of detailed control strategies and logics for control of all treatment facilities and auxiliaries.
  
- W. It will be the Contractors responsibility to develop all operator interface displays (trends, logs, faceplates etc.) and graphics utilizing P&ID's and other, Mechanical and Electrical drawings. All third party device interface gateway hardware and software, as required, for bi directional communication between the DCS and all remote controllers will be the part of Contractors scope including complete system and application engineering, including data base generation, development of control strategies custom graphic development and generation, custom log, trend and report development and generation, development of all operator interface displays, loop configuration, loop diagrams generation, performance optimization and monitoring, control logic drawing development and configuration.
  
- X. The Supplier shall be a firm that is engaged in the manufacturing of distributed process control systems. The system shall be in regular production with pre designed hardware and software for distributed process control. The Supplier shall have the complete team of professionals to implement the DCS at site. No third party System Integrators shall be engaged for the above requirement.
  
- Y. Contractor will provide all the equipment such as Network active and passive devices, firewalls, Access and Identity Management packages, Surveillance packages along with cameras, video analytics, audio visual equipment (all over the buildings), building management system, local back up devices , tools for DB tuning, up keep etc. after approval by the Employer in consultation with ICT Consultant..

## **9.6 Distributed Control System**

### **9.6.1 General**

- 9.6.1.1 All Distributed Control System equipment provided for the pumping station project shall be with Open Architecture.

- 9.6.1.2 Each unit and its installation and operation shall comply with all relevant requirements of this ICA specification and with the Electrical Specification.
- 9.6.1.3 The DCS FCS controllers shall be selected to meet the performance requirements of the system.
- 9.6.1.4 The processor type and size, once selected, shall be consistent across the Plant for all equipment area FCS's in order to maintain full interchangeability between units and to limit spares holding requirements.
- 9.6.1.5 All electronic boards shall be coated version against corrosion and shall have gold-coated connecting pins for long life.
- 9.6.1.6 The processor memory shall be sized such that its utilisation for the application does not exceed 50% of its capacity at completion of the Contract.
- 9.6.1.7 The Field Control Station (FCS) shall include for all communications ports for connection to the site wide DCS network and for connection to any required slave racks or remote I/O racks. Other communications networks may be serviced via separate rack mounted network cards.
- 9.6.1.8 The FCS rack shall be back plate mounted such that the cards can be visible from the front of the ICA panel.
- 9.6.1.9 All rack configurations/set up shall be consistent across the Plant. Rack mounted cards shall be grouped such that common card types are located in adjacent slots in a rack and that card grouping is consistent in all installations across the Plant.
- 9.6.1.10 All rack slots shall be clearly labelled with the card type (DI, DO, AI, or AO), the logical rack and the logical slot numbers.
- 9.6.1.11 Dual redundant control should be provided to avoid all the units going out of service when the controller is faulty.
- 9.6.2 Modularity
  - 9.6.2.1 The FCS controllers are of modular construction with individual modules being readily removable without disturbing wiring or other modules.
  - 9.6.2.2 The range of modules shall include, but not be limited to:
    - a) Power supply unit.
    - b) Central processor unit.
    - c) Analogue inputs with differential isolation.
    - d) Analogue outputs with differential isolation
    - e) Digital inputs with opto-isolation
    - f) Digital outputs with opto-isolation and buffer relays according to design.

- g) Communications.
  - h) Watchdog relay via a hardware bus monitor card and panel indication.
- 9.6.2.3 Each module shall be equipped with status LEDs indicating I/O states and fault conditions for diagnostic facilities.
- 9.6.2.4 Modules shall be installed such that they are accessible and easily removed with means of protection against insertion into an incorrect location and against reverse polarity of inputs or power supply.
- 9.6.3 Power Supply Requirements
- 9.6.3.1 The DCS controller main power supply shall operate at 230V AC and shall be rated such that it is capable of powering the full card complement of the installed rack system. In order to ensure the requirement the rating calculation shall include all installed cards plus the requirements of the largest load module in the specific DCS range installed in each of the remaining spare slots.
- 9.6.3.2 Volatile memory shall be provided with a dedicated, on-board battery back-up, providing memory retention for minimum 3months.
- 9.6.3.3 All input/output systems shall be powered at 2 V DC, using the ICA panel power supply.
- 9.6.3.4 Exceptions to this shall be analogue -20mA input signals powered from the instrument/signal transmitters and actuated valve control circuits, which shall be powered from the actuator.
- 9.6.4 Maintenance Power Supply
- 9.6.4.1 Within each FCS controller enclosure, the Contractor shall provide a 230V, 13A, BS 13 3, twin switched socket outlet, protected by a 30mA RCD, for the connection of test and diagnostic equipment.
- 9.6.5 Communications
- 9.6.5.1 Each FCS controller shall be provided with at least two communications ports for the following purposes as required by the specific system design:
- a) Serial RS232 connection to a local HMI terminal
  - b) Ethernet network connection
- 9.6.5.2 The Contractor shall provide details of all protocols employed and be responsible for verifying the compatibility and performance of all communications interfaces. Universally accepted protocols shall be used wherever possible.
- Where required the FCS control stations shall communicate by means of a bus communication system to the drives, instrumentation, valves etc. this shall be arranged with adequate redundancy so that a single network failure will not affect both duty / standby drives etc. A single network failure of field instruments shall not reduce the plant capacity more than 50%.



#### 9.6.6 Watchdog

- 9.6.6.1 A watchdog relay shall be included to monitor the controller in a fail-safe mode. When the watchdog circuit trips, all control outputs from the controller shall be disconnected, the alarm condition signalled and fall back modes of operation instigated.
- 9.6.6.2 Watchdog operation shall be electrically signalled and visually indicated. The unit shall continuously monitor power supply and control system status, operating upon failure or abnormal conditions.

#### 9.6.7 I/O Configuration

- 9.6.7.1 I/O shall be configured such that failure of a single card (or rack in large multiple rack systems) does not cause total area shut-down. Duty and standby equipment I/O shall not be connected to the same card (or rack on large multi-rack systems).
- 9.6.7.2 I/O shall be configured and installed in logically grouped and repeated patterns.
- 9.6.7.3 Single equipment devices shall have their inputs and outputs on adjacent cards in the same rack with this pattern repeated for other equipment units.
- 9.6.7.4 Where on-board isolation of I/O is not available, external signal isolation shall be provided.
- 9.6.7.5 A minimum of 20% spare capacity of each type of I/O shall be provided, wired down to terminals. This number of spare I/O shall be considered as minimum and maintained as such by the Contractor until completion of the Contract.
- 9.6.7.6 Terminals shall be grouped to reflect the I/O card functions and groups.
- 9.6.7.7 Provision shall be made for easy disconnection of the equipment signals enabling modules to be removed or test units to be connected in a fast, simple manner, without disturbing the field wiring. This arrangement shall be consistent for all controllers across the Plant.

#### 9.6.8 Analogue Inputs

- 9.6.8.1 Analogue inputs shall be configured to accept 4-20 mA continuous, linear signals and shall exhibit an input impedance of less than 250 Ohms. To facilitate removal of circuit boards in current loop circuits an external zener diode shall be provided on each channel to avoid loop interruption.
- 9.6.8.2 Analogue to digital conversion shall be at least 10 bit resolution having linearity within  $\pm 1\%$
- 9.6.8.3 and overall accuracy of  $\pm 0.1\%$  span or better.
- 9.6.8.4 All analogue inputs shall be provided with “out of range” flags monitored by the control system. “out of range” flags shall be provided with adjustable tolerances of  $\pm 1\text{mA}$  of the nominal zero or full-scale values of the input signal in order to allow for hysteresis in the analogue measuring circuit.

#### 9.6.9 Analogue Outputs

- 9.6.9.1 The analogue output modules shall be configured for 4-20 mA and capable of driving into an impedance of 1000 Ohms.
- 9.6.9.2 Digital to analogue conversion shall be at least 10 bit resolution having an accuracy of  $\pm 0.1\%$  span or better.
- 9.6.9.3 The output shall be electrically isolated from other outputs and earth. It shall have an insulation resistance of at least 1 Megohm when tested for one minute at 500 V DC. On multiple output units, system functionality shall be maintained when each output is earthed in turn.
- 9.6.9.4 Output current shall not vary by more than 0.1% of span when load resistance is varied from 0 to 1 000 Ohms.
- 9.6.9.5 Peak to peak amplitude of internally generated ripple, noise or other unwanted component appearing on the output signal, shall not exceed 0.1% of the selected output span.

#### 9.6.10 Digital Inputs

- 9.6.10.1 All digital inputs shall be optically isolated from other signals, circuits and input channels.
- 9.6.10.2 Such inputs shall comprise volt free contacts wetted by 24 V DC at 5 to 25 mA nominal current. Input filters shall be provided where contact bounce may occur, such debouncing may be carried out in either hardware or software.

#### 9.6.11 Digital Outputs

- 9.6.11.1 Digital outputs shall be in the form of volt free contacts capable of switching an inductive load 2A at 24Vdc or 2A at 230Vac. Outputs shall be sustained, not fleeting, arranged for fail safe operation (e.g. normally open to trip or signal alarm).
- 9.6.11.2 Where necessary, RC networks may be fitted to digital outputs when switching non-resistive loads.
- 9.6.11.3 Surge Suppression diodes shall be fitted to all relays operated from digital output circuits.

### **9.7 Control System Application Software**

#### 9.7.1 Software Design

- 9.7.1.1 The DCS Software shall be utilized to provide all control system application software for the system.
- 9.7.1.2 Software shall be designed, developed and tested in accordance with BS EN 61131-3 (IEC 1131-3), utilising standard function blocks for all common applications.
- 9.7.1.3 All software shall be properly structured, developed to strict quality control standards (BS 5750 Part 13) (BS EN 29000-3) (ISO 9000-3) and written to allow non-expert personnel to be able to read, understand, maintain and modify.

- 9.7.1.4 Software shall be designed and implemented in a structured and modular fashion to reflect the hardware divisions and equipment groupings. Programme structure and use of standard modules shall be consistent in all controllers across the site. A file allocation list shall be developed and submitted for the approval of the Employer/ Employer's Engineer prior to commencement of software development. This file allocation shall be consistent in all controllers across the Plant.
- 9.7.1.5 Module types shall be dedicated to sensors, loops, equipment items and automatic sequences as required by the application.
- 9.7.1.6 Software shall be structured in a hierarchical layered manner.
- 9.7.1.7 Transactions such as inter-unit communication, alarm generation, manual input points, shall all be produced in a similar and easily recognised fashion.
- 9.7.1.8 The installed software shall enable the system to carry out a range of functions which include, but shall not be limited to:
- a) Status and alarm monitoring of equipment and sensors.
  - b) Data acquisition of analogue values.
  - c) Transmission of monitored and logged data to other systems.
  - d) Sequence control of the equipment.
  - e) Closed loop process controls.
  - f) Fail safe actions in the event of failure of power supply, circuitry, instruments, sensors, communications or process equipment items.
  - g) Controlled start-up or shut-down of plant under all circumstances.
- 9.7.1.9 Data tables shall be structured in contiguous blocks to facilitate block transfers to other controllers or systems at variable scan rates. A structured list of data tables shall be agreed prior to commencement of software development. This list shall be used in all controllers across the Plant.
- 9.7.1.10 The system shall be configured with password security features to prevent unauthorized access to set up files, program files and data tables.
- 9.7.1.11 Application software shall have safe power on and power off sequences to ensure that equipment is in safe state at all times. On power up, the controller shall operate an initialisation sequence to ensure that all applications start up from a known position. However, all current control system set points and settings shall be retained on loss of power to ensure that the process continues in the same manner as prior to the loss of power.
- 9.7.1.12 Set points, software derived alarm settings, process control and P&ID control parameters etc. shall not be embedded in the controller application code or software modules. These settings shall be adjusted via suitably security protected DCS HIS Stations to enable changes to process control or alarms operating values to be made without changing the application code.

- 9.7.1.13 Individual field controllers shall continue to operate independently of the main system when communications are lost with the network. Where the controller relies on remote data, it shall revert to a set of look up tables for that function. The look up tables shall operate over a selectable 24 hour or 7 day period and the values shall be determined during commissioning of the controller.
- 9.7.2 Software Documentation and Quality Control
- 9.7.2.1 The Contractor shall operate a quality control system for controlling all software design, development, installation and commissioning.
- 9.7.2.2 This system shall incorporate the control of the following documents at various project stages:
- a) Operating and control philosophy.
  - b) Functional design specification.
  - c) Software development/installation version control system.
  - d) Commissioning data/test schedules and plan.
- 9.7.2.3 The software version control system shall ensure that all versions of software installed in DCS on the Plant are left at a known state of completion. The system shall record:
- a) Software name and version installed.
  - b) Date of installation.
  - c) Set-up parameters.
  - d) A changes mode to software and date of change.
  - e) Results of tests on software changes.
- 9.7.2.4 Once the Plant is under commission or operation, the Contractor shall operate a permit to work system to ensure that all software changes are carried out under a safe manner of working.
- 9.7.2.5 Back up versions of all software shall be made at appropriate Contract stages. In particular, during commissioning, software shall be backed up at the end of each commissioning session. Previously loaded versions of the code shall be kept on the same backup media in order that the equipment under commission can be restored to its previously known state should recent changes during commissioning prove problematic to the equipment.
- 9.7.2.6 HMI software version control shall be matched to that of the controllers. This is to ensure that incompatible versions of HMI software are not retained in the HMI unit when controller software is upgraded. In the case where no changes are necessary to the HMI software when its associated controller software is upgraded, then the HMI software version number shall be upgraded anyway to maintain a match with that of the controller software.

- 9.7.2.7 The Employer's Engineer shall have the right to audit the Contractor's software control system at any time to ensure that the requirements of the specification are being met. All non-compliances shall be rectified immediately.
- 9.7.2.8 Software documentation shall be produced in accordance with the "Guidelines on the Documentation of Software in Industrial Computer Systems", published by the Institution of Electrical DMs (ISBN 086341 0464).
- 9.7.2.9 All software licence or registration requirements shall be forwarded to the DM. Sole rights to all software systems, specially developed for the control system, shall become the property of the DM after Take-Over of the equipment.

## **9.8 Local Operator Panels**

### **9.8.1 Human Machine Interface Units (HMIs)**

- 9.8.1.1 The Contractor shall provide an HMI with a key pad and flat screen, as manufactured by Proface or equivalent. Touch-screen interfaces are preferred. The size of the screen shall be large enough for the local operation. There shall also be a Local PC workstation; Industrial type with HMI shall be installed. The PC shall be installed in each Control room of MCC's with all required hardware. Suitable furniture shall be provided for each HMI work station operation for the Staff & Operators
- 9.8.1.2 Operation of the unit, access to controller data, parameter and data editing or other functions, shall not require software language programming skills but shall be executed via selection from screen menus.
- 9.8.1.3 Facilities and displays shall include:
- a) A minimum of three levels of password protection for access:
    - Level 1 shall permit operator access for monitoring, alarm acceptance and equipment duty selection etc.
    - Level 2 shall permit supervisor access for changing operating parameters (e.g. pump start/stop levels, time intervals) and forcing controller outputs to start/stop equipment, open/close valves etc. in remote manual mode.
    - Level 3 shall permit engineer access for changing critical control parameters such as PID loop settings and software modifications.
  - b) Overview menu.
  - c) Alarm list for the last 64 (approximate number) alarms, displayed with date and time on a rolling log, together with operator's alarm handling facilities.
  - d) Event log for the last 20 (approximate number) events or operator changes etc., displayed with date and time on a rolling log.
  - e) Set point display list with editing.
  - f) Current value of analogues with editing.

- g) Display of equipment status and alarms.
- h) Display of control programs with edit facility for PI&D loop parameters etc.
- i) Operator control commands, or changes to data or parameters, to be on a select and execute basis with abort/cancel option.
- j) Live mimic displays and trending facilities.

## **9.9 Site DCS System**

### **9.9.1 General Requirements**

- 9.9.1.1 A DCS system shall provide the monitoring and control of the whole plant from a central control room location.
- 9.9.1.2 The DCS system shall be constructed in redundant format except for field I/O modules. Multiple operator workstations will be provided for monitoring, control; data acquisition, data storage and archiving; alarms handling; graphical trending of data and equipment and system status and statistics reporting. This shall include:
  - a) All equipment described in the process control philosophies.
  - b) All equipment and main site power systems.
  - c) Field Controller systems diagnostics and communications.
- 9.9.1.3 Where any specified function is not specifically inherent in the software package, the function shall be provided by writing or altering the appropriate section of source code or software module to provide that function. The use of third party commercial software packages to provide these specified functions is acceptable providing the links to the function do not require navigation through the operating system platform i.e. the link to the function is direct from the operator interface software.
- 9.9.1.4 All system equipment including servers, workstations, terminals, communications and networking equipment shall be backed by a UPS system which shall provide a minimum of hrs backup.
- 9.9.1.5 The system shall be arranged such that it will auto-recover in the event of a power failure.

### **9.9.2 System Architecture**

- 9.9.2.1 The DCS system shall be constructed with dual redundant processors, power supplies, and bus architecture. Input / Output modules shall be non-redundant.
- 9.9.2.2 The Operator Interface (HIS Station) shall be based on a desk top PC, industrial type using Microsoft Windows operating system. The PC shall be suitable for safe operation in corrosive environment. Disk drives shall be provided for data storage and archive purposes. The Operator Interface shall be supplied complete with mouse and keyboard and 21" colour TFT monitors as a minimum 21" monitors may be used for engineering terminals installed in secondary locations.

- 9.9.2.3 The engineering terminal PC's shall comprise the latest, entry level microprocessor and hardware suitable to meet the performance requirements of the system. The hard disk drive shall be a minimum 2 TB and shall have a Windows current operating system installed. DCS Engineering and operation software and all peripheral's driver software and virus checking software loaded on it. All Software licenses shall be supplied with the PC.
- 9.9.2.4 The engineering terminal PC's shall each be fitted with DVD+/-RW drive for data archiving purposes.
- 9.9.2.5 The engineering terminal PC's shall also include all necessary communications interfacing hardware and software in order to provide the communications interfaces with the DCS communications network.
- 9.9.2.6 Two printers shall be provided adjacent to the control room. The printers shall be connected to the Vnet/IP network to enable operators to automatically print from any HIS Station to the appropriate printer required.

The two printers shall be as follows:

- a) Black inkjet type printer for alarms and events logging for A3 width scrolling sheets;
  - b) Colour/Black inkjet type printer with integral colour and black cartridges for printing colour screen dumps and reports for A4 and A3 size prints.
- 9.9.2.7 All necessary interconnecting communications and power leads and the consumables required for testing and commissioning shall be provided.

### 9.9.3 System Security and Access Levels

9.9.3.1 The system shall be configured with the following four user levels:

- a) Guest - view only (User).
- b) Operator - view, accept alarms, run historical trend utility, remote manual control of pumps, drives and actuators (User).
- c) Supervisor - as Operator, but able to modify control set points (User).
- d) Engineer - full system access.

The system shall log all actions attributed to a particular user when that user is logged onto a particular operator terminal. The log shall include all actions taken during the login period including a record of action taken; the relevant equipment item; date and time (in Hours; Mins; Secs format) of the action. This user table shall be retrievable only at Engineer level.

### 9.9.4 System Transfer Requirements

- 9.9.4.1 The system shall monitor all alarms generated on the equipment by discrete devices or derived in the field controllers from analogue equipment measurements.
- 9.9.4.2 The system shall monitor all analogue measurements.

- 9.9.4.3 The system shall provide all necessary set-point change interaction with the field controllers.
- 9.9.4.4 The system shall monitor and log all field controller diagnostics information.
- 9.9.4.5 The system shall provide all necessary control interaction with the field controllers, including pump, drive and actuator enable/disable functions; alarm and equipment reset functions.
- 9.9.4.6 Common data groupings shall be used for typical equipment items, determined in line with mimic dynamic symbols.
- 9.9.4.7 Scan times for data transfer shall be determined by the application in respect of meeting the performance requirements of the system.

#### 9.9.5 Graphical Display Requirements

9.9.5.1 To ensure a common "look and feel" at all terminals and HMIs, graphical displays shall be configured as detailed below. In general, equipment symbols shall comply with BS 1 Parts 1-3 (ISO 3511/1-3), BS 11 2 Part 3 (ISO 07/2), BS 1553 Part 1 and follow the conventions adopted on the P&I diagrams.

9.9.5.2 Graphics shall be drawn in two dimensions

Colours used for graphical displays shall generally be as follows:-

- a) Display backcloth shall be light grey
- b) Equipment outlines shall be black.
- c) Text shall be white.
- d) Equipment symbol colour fills shall be:

| <u>Colour</u>        | <u>Function</u>   |
|----------------------|---|
| Green                | Open/running  |
| White                | Closed/stopped  |
| Red                  | Close/Stop  |
| Amber                | Accepted alarm  |
| White                | Fail/Trip   |
| Flashing amber/red   | Unaccepted alarm  |
| Flashing amber/white | Unaccepted alarm (cleared on equipment)                           |
| Flashing white/green | Control valve travelling  |
| Cyan                 | Invalid status (e.g. running and stopped received simultaneously) |
| Cyan                 | Analogue out of limits  |

- e) Process line colour fills for shall be as per IS: 2379 -1990 (Reaffirmed 2006)

However the line colours shall be finalized in discussion with the Employer.



- f) Process flows shall be of a uniform thickness and shall be from left to right and top to bottom. Off-screen flows shall enter from the left and leave on the right and process flow lines shall be vertical and horizontal only.
  - g) Analogues shall be displayed in engineering units as either a numerical value or, where specified, as a bar graph. Where an analogue is being controlled, the actual and desired values shall be displayed. By clicking on the analogue, further information regarding the analogue set-up shall be presented via a pop up window showing tag reference and description, range, alarm settings and a link to a trend of the analogue.
  - h) It shall be possible to navigate between mimics for associated equipment areas without return to a plant overview or menu page.
  - i) Main process lines shall be represented as thicker lines on mimic diagrams to chemical dosing, secondary system or sample lines.
  - j) Mimics shall have a title bar incorporating Date, Time and Mimic title logged on user reference.
  - k) Text shall be lower case with leading upper case. The exception to this being equipment tags names which shall be all upper case.
  - l) Tag names shall be inserted below or to the right of equipment symbols. Where either position would be possible, the preferred position is below the symbol. Equipment status shall be inserted below the tag name of the appropriate symbol. Essential information shall not be indicated by colour alone.
  - m) Common function devices on mimics shall be placed in consistent positions. e.g. Help, Trend and Alarm summary selection.
- 9.9.5.3 A consistent and structured approach shall be used in the design of graphical displays so that the final group of displays form a logical set. For example a Plant requiring four levels of display may have the following levels:
- a) Plant geographical overview;
  - b) Process area;
  - c) Equipment level.
  - d) Process unit.
- 9.9.5.4 The display navigation shall be designed to enable the operator to follow the process stream "horizontally" along any of the three levels without having to move up or down a level.
- 9.9.5.5 The display navigation shall also enable the operator to zoom up and down to the next level and to return to the geographical overview from any display.
- 9.9.5.6 The graphical display screens shall be designed utilising a standard symbols library of static and dynamic symbols developed and agreed with the Employer's Engineer at the commencement of the Contract prior to the development of equipment mimics. Once agreed standard symbol sizes shall remain the same on all mimics i.e. symbols shall not be scaled.

9.9.5.7 Text shall utilise an Arial font and for mimic titles shall be 20 point, all other text shall be 10 point. Other sizes of text shall not be used. Text shall not be scaled on a mimic or symbol.

9.9.5.8 Dynamic text shall remain Green in all normal cases except for analogue values and in the case of loss of communications. For analogue values the following shall apply:-

| <b><u>Text Colour</u></b> | <b><u>Function</u></b>                                    |
|---------------------------|---|
| White                     | Normal conditions (all dynamic text)                      |
| Red                       | Abnormal/alarm state (analogue only)                      |
| Cyan or similar           | Invalid data or loss of communications (all dynamic text) |

9.9.5.9 Each mimic shall have direct access to help facilities, control functions, historical trends and real time trends. All parameters shall be available for trending by manual selection.

9.9.5.10 Each help page shall provide on screen display (in Microsoft Word 7 format or better) of the relevant page in the FDS pertaining to the item of equipment from which the help was generated. Exiting from this page shall return the operator to the display screen from which the help was generated. The Help pages shall have an edit facility to enable operators to add "notes" to help pages.

9.9.5.11 Where applicable to the relevant process, windows, or links to other screens, shall be provided to enable the operator to view process or equipment data. This shall include windows of the following type:-

- a) Control Window - Shall facilitate the manual control of equipment items, when it is appropriate.
- b) Trend Window - Shall display a real time trend of a selected analogue equipment instrument.
- c) PID Window - Will display the current PID parameters associated to a control loop.
- d) Statistics Report - Will display the current running hours, no. of starts etc. for an equipment item.
- e) Sequence Window - shall facilitate current sequence status, adjustment of parameters and inhibit and initiate controls.

9.9.5.12 Graphical displays shall provide operator details of the Plant electrical distribution system. These displays shall show the status of the equipment and any measured or available analogue values associated with it. The display shall also show identity tags of the main interconnecting cables and equipment.

#### 9.9.6 Data Storage Requirements

9.9.6.1 Short term data storage shall be provided in the system for:-

- a) All events and alarm states.

- b) All measured analogue values.
- 9.9.6.2 Measured analogue values shall be stored at a minimum of 15 minute intervals.
- 9.9.6.3 Short term stored data shall be held in the system for a minimum of 0 days and shall be on line at all times for direct retrieval for the provision of reporting and trending.
- 9.9.6.4 All stored data shall be time and date stamped.
- 9.9.6.5 Long term archive storage facilities shall be provided via an optical disc storage system. The optical disc system shall be set up to provide automatic backing up of the main system short term storage every week.
- 9.9.6.6 The system shall provide warning to operators when an optical disc is full and requires replacement.
- 9.9.6.7 Grouping of data shall be provided to enable easy recovery of archived and stored data.
- 9.9.6.8 Groupings shall be nominally as follows:-
- a) Operational (equipment status etc.).
  - b) Flow data.
  - c) Analytical and consents information.
  - d) Fiscal metering information.
  - e) Energy consumption and power import information.
  - f) All Tank levels in the chemical house
- 9.9.6.9 Data shall be filtered by site and equipment area for recovery purposes. Data and time outer limits for data recovery shall also be provided for filtering.
- 9.9.6.10 In addition to data archiving a system for total system backup shall be provided on separate media.
- 9.9.7 Alarm Handling
- 9.9.7.1 Alarm zones shall be set up by equipment area. Alarms shall then be grouped by the following classifications.
- a) Emergency (Personnel Safety).
  - b) Plant Critical (potential to result in a process failure, failure of discharge consent failure of major equipment item).
  - c) Plant Warning.
- 9.9.7.2 Alarms lists for the Plant shall be developed with the Project Manager in accordance with these groupings and classifications.

- 9.9.7.3 The system shall operate such that when an alarm is cleared and reset at an HMI then it shall remain on the DCS system until it has been cleared at the HIS Station or engineering terminal. However, if the alarm is cleared and reset at an HMI then this shall be indicated at the HIS Station by a change in colour of the alarm banner for the particular alarm entry.
- 9.9.7.4 If an alarm generated is reset and cleared at a HIS Station, then this shall also clear the alarm from the current alarms page on the HMI. The historical alarms log on the HMI shall indicate that the alarm was cleared at the DCS HIS Station.
- 9.9.7.5 Alarm banners shall be displayed on the DCS HIS Station screen. The alarm banner shall provide a link to the relevant mimic. The following information shall be provided on the alarm banner for each alarm:-
- a) Alarm tag ref. /plant target.
  - b) Alarm description.
  - c) Equipment area.
  - d) Time of occurrence
  - e) Time cleared.
  - f) Accept button.
  - g) Navigation to relevant mimic.
- 9.9.7.6 The alarm banner shall have a flashing background until accepted. The background colour shall be red when active and green when cleared on the equipment. When the alarm is accepted and cleared on the equipment, it shall be removed from the screen.
- 9.9.7.7 The alarm banner on the DCS HIS Station screen shall hold a maximum of equipment alarms. These shall be the last occurring alarms.
- 9.9.7.8 All alarms shall be held in an alarms register which shall be accessible for viewing via the DCS HIS Station screen. The alarm accepts function shall be operable from the register. As a minimum, the alarms register shall display the same information as the alarms banner.
- 9.9.8 Requirements for Trends
- 9.9.8.1 The system shall be configured to provide both real time and historical trends.
- 9.9.8.2 An instant real time trend facility shall be available for all analogue signals including inputs and outputs. These trends shall start when called by the operator and shall continue logging as background tasks as required.
- 9.9.8.3 All analogues shall be trended. Trend logging shall at selected intervals. All data shall be stored in 2 hour files. There shall be no tolerance configured.
- 9.9.8.4 Historical trends shall provide the operator and manager with information about the performance of the Plant. These shall be configurable by the operator to selected time bases ranging from one hour to one month.

- 9.9.8.5 Historical trends shall be capable of displaying up to eight analogue configured points on one trend graph and shall have the capability to switch on and off data markers. Scales for each point used shall be indicated on the trend.
- 9.9.8.6 The system shall be set up to access a number of pre-configured historical trends associated with the main plant flows and systems. These shall operate such that the operator can select the trend from a menu or on screen button and then select the required time base.
- 9.9.9 Requirements for Plant and System Reports
- 9.9.9.1 The system shall provide the facility for generation of reports on plant and system data. Two types of report shall be available:-
- a) Scheduled reports - (generated automatically from the system at periodic intervals).
  - b) User definable reports - (allowing operators to construct a custom report based on data and boundary conditions selected from the database).
- 9.9.9.2 The Contractor shall develop a standard form layout for use as the basis for reports which shall be developed with and approved by the Employer's Engineer. Each type of report layout shall contain standard basic information as follows:-
- a) DM name and standard logo.
  - b) Site name.
  - c) Date of report.
  - d) Date and time of information included in report.
  - e) Name of user generating the report.
  - f) Equipment area/equipment item to which the report refers.
  - g) Process stream.
  - h) Type of report.
- 9.9.9.3 The development of reports shall be carried out in liaison with the DM to detail the reporting requirements based on the operating criteria for the plant.
- 9.9.9.4 The final content and layout of these reports shall be agreed and approved by the Project Manager.
- 9.9.9.5 The scheduled reports shall be compiled and shall generate automatically at a pre-set appointed time. The system shall store back reports for retrieval at any time.
- 9.9.10 Clock Synchronisation
- 9.9.10.1 All nodes on the DCS Vnet/IP network must be continuously synchronised to the master clock.

9.9.10.2 A facility to change the DCS real time clock shall be possible without entering the Windows operating system.

#### 9.9.11 Historical Storage and Retrieval of Data

9.9.11.1 The hard disk storage on the DCS system PC's shall be sufficient to provide a minimum of 30 days of data acquired from the field controllers. All stored data shall be available for retrieval/viewing and printing in the appropriate formats.

#### 9.9.12 Data Archiving Requirements

9.9.12.1 Facilities shall be provided for data and system archiving by use of an optical disk writer.

9.9.12.2 DVD re-writable media used shall be capable of updating both the whole system configuration and the databases by selection.

9.9.12.3 During the commissioning of the system, weekly system backups shall be made and database archive updating shall be continuous.

9.9.12.4 All back-up and archive media shall be provided for the period of the Contract including the defects and liabilities period.

The DCS system shall be configured to enable retrieval of data from back-up and archive media to provide listings, reports and trends of archive data using the same methods as those for normal system operation.

### 9.10 Remote Terminal Units – RTU

#### a) General

The remote terminal units shall be of modular construction and housed in floor mounting cabinets dust and damp proof to IP 65. The cabinets shall house all the supply and marshalling terminal section for interfacing and connection with the master station, communications links and field equipment. Where transducer remote electronic equipment is provided for level measuring devices may be incorporated within the remote terminal unit cabinet subject to the approval of the Employer's Engineer. The whole RTU shall be rated for 70<sup>0</sup> C operating Temperature. Cabinet and panel arrangements shall be submitted for approval by the Employer's Engineer.

#### b) Future Expansion

Sufficient plug in modules shall be provided and wired to terminals ready to accept future signals of up to 30% or a minimum of one module, for each remote terminal unit. Each remote terminal unit shall be able to accept at least two more I/O modules of each type without requiring replacement of the original equipment.

#### c) Hardware

Each controller shall be mounted in an IP 65 weatherproof, Vandal proof, double skin enclosure (Stainless Steel- SS316) and constructed to allow easy replacement and maintenance modules. Particular attention shall be given to the ability of the remote terminal unit, all the related accessories and its enclosure to minimum 70<sup>0</sup>C operating Temperature and withstand the harsh environment prevailing in Dholera SIR. All the

RTU's shall be shaded from sunlight with proper arrangements. The remote terminal units shall be intelligent devices that can collect data, generate alarms, perform process and control functions. The microprocessor based remote terminal unit will be the main device used to control loops in each lake unit. The remote terminal units shall be able to receive analogue and digital inputs from the field, perform processing and alarm checking, perform the algorithms control, and output to valves. The RTU's shall be DCS system based and with open architecture fully compatible with the DCS system.

The RTU's shall have Ethernet communication protocol over Fiber optic network.

Each remote terminal unit shall be sized for controlling the required input/outputs and future expansion. The program & data held within the memory shall remain intact and error free if all external power is removed from the remote terminal unit for a minimum period of two weeks.

All field connections shall be made in terminal blocks located for easy access. They shall be clearly marked and identified. Terminals carrying voltages in excess of 24 V shall be fully shrouded. All terminals shall be of the flip up isolator type with test points.

A hand held programmer, shall be provided for local display of signals, programming and fault diagnosis.

LED's indicating status of input and output digital signals shall be provided on the input/output modules. The RTU's shall be provided with minimum 4 line LCD display to show the measured parameters. The Display shall be rated for 70<sup>0</sup>C operating Temperature.

RTU's shall be configured such that a single RTU or RTU module failure will not interrupt or degrade plant monitoring and control functions. RTU failure shall be alerted to the operator at the highest alarm priority.

Surge protection shall be provided in accordance with the latest BS/IEC requirements.

#### d) Remote Terminal Unit Software

The RTU shall be capable of processing locally input plant information before transmitting it to the master station.

The software programs shall be written such that they facilitate easy alterations and additions. Structured programming techniques shall be followed and accompanied by flow diagrams. The programs should be extensively annotated and be self-documenting. The system shall be supplied with programs that use a high level language for the operator's works stations.

Total internal scan time interval for all inputs and outputs in an RTU shall not exceed 1s.

The RTU shall operate on a report by exception basis.

The RTU's shall have sophisticated in built control facilities to permit control loop configuration using simple building blocks. These blocks shall sequence control, three term control and other control routine components as required. The RTU shall be capable of routine signal processing including integration, summation, subtraction and totalization of one or more inputs. Control loops shall incorporate deviation and rate of change

alarms, bumbles transfer facility, set point and output high and low limits.

The RTU shall be capable of executing sequential control logic Programming of sequential control shall be by means of high level function block language or ladder diagram format as part of an integrated package.

The RTU's shall have standalone capability able to continue monitoring the system and executing control loops if the communication link to the master station fails. In the event of such a failure the RTU shall log all alarms and required analogues until the entire tool memory is filled. When the communication link is restored the RTU will automatically upload the logged data to the data archiving system.

The RTU's shall have a watchdog function and full self-diagnostics capable of detecting and reporting faults to the master station and displayed locally.

The DCS system manufacturer shall program the RTU's fully under this Contract. It shall be possible to modify the programs remotely by downloading from the master station.

It shall be possible to initial current data retrieval on demand, from the master station, leaving the original RTU data contents intact for routine up-loading.

The RTU's shall be provided all the hardware for the Fiber optic interfacing and Ethernet communication protocol to the MBR Control Room.

#### **9.11 Water Leakage Management Software**

- a) Provide a total Water Leakage Management system with all necessary hardware and software supplied by reputed specialist proven in this field. The Contractor shall submit for approval the specialist details with their previous experience in this type of application. The system shall provide information at the Control room at WTP(s) leak detection in the water transmission line. The Software shall be Windows based and shall have the general features as of the SCADA Man Machine Interface Software. The Contractor shall provide a trial version of the software for demonstration with the required inputs simulated for the approval of the Employer's Engineer. Any modification to the trial version of the software as instructed by the Employer's Engineer shall be taken into account before the final delivery of the product.
- b) The data for the Leak detection shall be available through the RTU's installed at the network as required by the pipe line hydraulics and specified elsewhere. The RTUs shall be part of the leak management system supplier. A dedicated FOC shall be laid along with the Pipe line for gathering the data from the RTU's. The communication between the RTU and the server at the control room shall be of ring topology. The RTU shall be suitable for 70<sup>0</sup> C operating temperature and robust in nature and meant for outdoor application. The pressure transmitters, flow meters or any field devices all as required to have the leak management system in total shall be the scope of the leak management specialist Contractor. The power supply to the RTU shall be taken from the WTP, LV panels with suitably sized cables as specified elsewhere in the document.
- c) The software shall provide a real-time data analysis system to perform algebraic and statistical calculations and display the results in a graphical format. The software shall provide data analysis capabilities to:
  - Allow analysis sessions and procedures to be saved to files for future use.



- Remember and save menu choices to build analysis procedures.
  - Analyze real, integer, digital and floating point data types.
  - Retrieve input data from a text file, snapshot buffer, the data archive, and previous analysis sessions.
  - Retrieve data by different methods including average, total, standard deviation, minimum, maximum, calculation, compressed, evenly spaced, and filters.
  - Manipulate data by editing, averaging, cross-correlations, and equations.
  - Plot data trends and histograms including time-based plots and x-y plots of any combination of variables.
  - Plot statistical quality charts such as average, range, standard deviation, defect, defects/sample, and cumulative sum.
  - Allow all plots and displays to be printed.
- d) The software shall provide the actual geographical view of the area covered for potable water network, recycled water network, sewage pumping main, industrial effluent pumping mains and shall have the ability for the use to view time-based data points in a color graphic environment. The software shall provide data trending capabilities to:
- Support time-based graphic display of data points with labels and fields for identification such as data point value, tag name, tag description, plant location, time stamp, time-base and units of measurement.
  - Support graphic representation of bad, missing, or out-of-bounds data values.
  - Allow user to specify changes to the horizontal and vertical scales of trend displays. This may include changes in numerical scale values, upper and lower limits, and units of measurement.
  - Allow multi-variable graphics of historical and real-time data concurrently.
  - Allow display of graphs with different time scales concurrently.
  - Allow display of graphs with different measurement scales concurrently.
  - Allow trend data to be graphed both horizontally and vertically.
  - Take data snapshots at a particular time to view individual data point values of multiple tags for calculation purposes.
  - Allow trend screens to be printed.
  - Provide for user-specified event logs to be generated upon request by the user. The logs shall allow the user to specify criteria for which data points are selected from the database. Only the points that meet these criteria are presented to the user on the associated displays or are included in the associated reports.

- Allow for future user-configurable trend displays and reports.
- The Software shall have the following.
- Shall work on the Aspect Integrator Platform and shall monitor and perform loss calculation based on data acquired from field devices such as Flow meters and Pressure Transmitters.
- The system software shall allow for integration software for HMI, Customer Information system (CIS), Network simulation software, Production database or Geographical Information System (GIS). The Contractor shall include in his offer all these items/ software and the database management in his offer to make this fully functional to the complete satisfaction of the Employer's Engineer.
- Water losses shall be broken down into background losses and bursts components. It shall also provide for data batching and trend analysis.
- The software shall provide detailed navigation screens of the water transmission network. The operator shall be able to visualize the nature of the leakage and shall enable him to prioritize the resources for repair and maintenance. The software shall be provided with integrated online repair monitoring module, which allows for easy tracking of when repairs were done and by whom.
- The inputs for water leakage analysis shall include infrastructure data for the network such as length of mains, length from service connection to edge of street, length of edge of street to the Flow meter, Density of connections etc.
- The results shall be presented as reports, trends or graphs all subject to the approval of the Employer's Engineer.

#### **9.12 Maintenance Management (MM) Software**

A separate MMS package, (e.g. Maximo) shall be provided. It is EPC Contractor's responsibility to install the software in the MMS Computer Data base and provide links to various other program of the DCS. The scope of the MMS database shall be equipment associated with this contract as well as the equipment associated with the companion project, by others, for the construction of potable water supply, recycled water supply, Sewer network, industrial effluent networks.

Provide for the identification and coding of all plant equipment, with pertinent information regarding costs, manufacturer, alternative sources, etc., arranged in a relational manner (i.e. parent/child hierarchy of assemblies and subassemblies).

Create and schedule various types of maintenance work orders. Record estimated and actual manpower and parts list and costs. The completed work orders form the historical data on the work done on equipment. Standard practices, detailed instructions, safety rules, special tools required, etc. for work which is performed periodically, must be able to be included on specified equipment basis.

Prepare a preventive maintenance program, and automatically prepare work orders at appropriate times.

Allow entry of the time that individuals charge to the various work orders at appropriate times.

Allow specific work to be scheduled according to certain criteria such as chronological order, trade or persons to be assigned, etc.

Maintain an inventory database that can handle multiple stores and bulk material receipts. Provide ability for parts and their equivalents and alternatives, which are below their minimum to be requisitioned semi-automatically.

Create purchase orders for both inventoried and non-inventoried items.

Support input/output devices such as handheld computers or bar code readers used to implement paperless MM system.

Support reports on equipment down time, labor utilization, inventory levels, preventive maintenance schedules, etc.

Exchange information with control system and Historical Computer's Database.

### **9.13 Remote Management / Parameter Monitoring**

Measurement of parameters from all field and other devices should be made and written in respective data bases of SCADA on continuous basis.

A comprehensive list of parameters to be displayed, monitored and reported for WTP project components will be submitted by Contractor in accordance with practices of smart city for Employers approval. The list should also state things like origin, conditioning / computing measures (applied) in respect of respective city parameters to be deployed for usage for remote purposes etc. After approval of aforementioned list, the Contractor will do all the needful (in terms of Hardware and Software etc.) for extending access of the parameters for remote control, display, monitoring etc. at City's Command & Control Centre /ICT building and prepare connectivity and correspondence diagrams to cover all of them for integration in to city's ICT infrastructure.

Contractor will provide fully prepared interfaces (both sides – sending and receiving) for all the approved parameters to be captured in city wide ICT infrastructure. Such interfaces will be built by Contractor for Enterprise Service Bus and / or Application Programming Interface (API) and other suitable means, as to be decided by Employer in consultation with ICT Consultant. In this respect Contractor's scope of work also includes providing of all Hardware and Software components fully commissioned and operational as per equipment specifications.

Aforementioned parameters are needed for remote control (selective at few places), display, eventing, alarming etc. on city portal, city's cock pit, city wide dash boards etc., including complete sourcing and shall be in scope of Contractor.

All the parameters must be directly retrievable on line with data up to past 12 months from respective project components / application's data base. Such retrieval must be without applying archived data. All data base sizes, schemes etc. will be approved by Employer in consultation with ICT Consultant. Contractor will provide all the requisite materials in end to end manner for storing the archived data up to three years.

Multiple equipment specifications for regular back up and storing archived data on various devices (as required per global practices) for all project components will be approved by the Employer's Engineer/ Employer in consultation with ICT Consultant before supply, installation and commissioning by Contractor.

In order to achieve operational optimization across all the city disciplines such as utilities, infrastructure, packages, systems, subsystems, components, elements etc. being sourced by respective disciplines individually in smart city Dholera, the Contractor will study the components of automation, control, monitoring, display, alarming, reporting etc. that will influence project components in scope, in order to suggest detailed framework for achieving high degree of automation, optimization, monitoring, displaying, controlling, reporting at Contractors and other ends.

For the purpose of completeness, all the needful in regards to civil, mechanical, electrical disciplines such as electrical switch boards, UPS, Diesel Generator, cabling, raised flooring / false roofing, optimal layout working, mechanical- precision HVAC/ chillers, physical security devices, fire detection and protection equipment, etc. will be provided as needed per global smart city practices for implementation is the responsibility of the Contractor.

Contractor will provide complete Hardware and Software equipment on as required per best practices basis on both ends for feeding all the parameters (repeat all parameters) in to GIS and BIM systems in ICT building.

### **Communication Infrastructure**

The Contractor shall provide complete ICT infrastructure within all the project components in the scope as per details given below (in addition to details stated elsewhere in this document).

1. Contractor shall be responsible for supply, Installation, Testing, Commissioning and Integration of complete end to end Active and Passive ICT Network Infrastructure components including OFC cables (with HDPE ducts), inside building cabling, Racks and Servers, air-conditioning equipment, Un Interrupted Power Supply equipment, Switchboards, Auto Mains Failure switchover etc. , as required for the all project components / buildings in Contractor scope and as per practices of global smart cities. The requirement shall be suggested by Employer/ in consultation ICT Consultant.
2. Implementation of the entire ICT infrastructure should be redundant and scalable for the future expansion.
3. The Contractor shall be responsible to create an entrance facility for Ducts and OFC cables etc.
4. The Contractor shall be responsible for end to end supply, Installation, Testing commissioning of Identity and Access Control System (ACS) and Security & Surveillance System including video analytics features for the project components in scope.
5. The Contractor shall also be responsible for supplying, Installing, Commissioning, Testing and Integration of Video Walls (100 inches minimum) for monitoring the entire plant facility from the central location and from the console / control room within the facility. The video walls will also be replicated in ICT Building. The Console / Control room should have requisite such as air-conditioning, UPS, auto main failure switchover, electrical switchboards etc., stated separately or as required.

6. The Contractor shall be responsible to provide the interface to connect the ICT infrastructure including ACS & Security & Surveillance System with City's Command & Control Centre/ ICT building for the monitoring purpose
7. All the IT / ICT equipment must be compatible for IPv4 as well as IPv6.
8. Hardware and Software arrangements must exist to display any and multiple displays on Video walls from respective work stations
9. There should be physically separate local area network built for SCADA and other purposes.
10. The Contractor will provide all the equipment and essentials of modern buildings including complete local area network (active and passive with racks), local network management SW (integrated with central NMS), Audio Video (AV) solutions, Surveillance packages along with camera and analytics, BMS, access and identity control etc. (all fully set up) and on as required basis for entire set of packages within / for all the premises of in scope facilities.

It is expected each work bench will have 4 LAN ports and two AV ports fully wired and set up. EPABX (or equivalent) with both Audio and Visual facilities will be provided. Telephone instruments will be provided for all facilities (both audio and video facilities).

Each work bench referred in this document will have at least two multi-screen supporting high definition 21" (minimum) monitors. Servers should have corresponding cards for supporting HD and multi screens. Each of the work benches should be provided with dual monitors (minimum) per system architecture drawing enclosed separately (though in system architecture drawing at places only one monitor has been shown).

All servers (wherever mentioned) should be blade type and be supplied in 19 inches racks. Racks shall be supplied complete with all accessories.

#### **9.14 Uninterrupted Power Supply for Control Panel and DCS Station**

The UPS (Uninterrupted Power Supply) shall be floor mounted; self-contained and metal clad and shall be suitable for supplying a nonlinear load.

It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact touch.

The UPS shall be online type incorporating minimum six plus rectifier and pulse width modulating inverter technology with microprocessor control. It shall incorporate a static bypass switch that shall operate in event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.

The UPS shall incorporate DC under voltage trip circuit to electromechanically trip the UPS output in order to protect the batteries.

The noise level of the unit shall not exceed 60 dB (A) at 1 m from the UPS cabinet.

The output of the inverter shall be a sine wave having less than 2% THD for linear loads and less than 4% for 50% nonlinear loads. It shall be suitable for load power factors 0.7 lag to 0.9 lead.

The unit shall have a dynamic response such that 100% step load causes an output voltage transient of less than +/- 4% with a recovery of less than 5ms. The load crest factor shall not be less than 3:1.

Indicators shall be provided for the following

- UPS Status
- PS alarm conditions
- The UPS shall provide output for the following purpose:
- Warning (Viz., low battery voltage)

The batteries shall be housed, within a separate matching battery cubicle suitable for location adjacent to the UPS. The batteries shall be of the rechargeable, sealed maintenance free lead acid type. The battery supply to the UPS shall be via a fused load break switch dis-connector circuit breaker. The battery recharge time to 90% of full charge shall be approximately ten times the discharge time at full load.

Terminals shall be shrouded to prevent accidental contact.

Battery bank should be sufficiently designed and sized to cater minimum of 3 hours of continuous UPS operation after mains failure.

The Uninterruptible Power Supply (UPS) system with SMF Lead Acid Battery shall conform to the minimum following specifications:

a) Input

- Input Voltage: 230 V. +/- Frequency : 50 Hz +/- 5%
- Nominal DC input: Contractor to design and submit calculations (Battery)

b) Output

- Output: 230 V AC, applicable KVA with 25% margin as per load calculation
- Regulation Mode : +/- 1%
- Load power factor : 0.8 to unity
- Duty : Continuous
- Ripple on DC : < 2%

c) General

- a. Principal of operation: Shall be solid state, pulse with Modulation (PWM)
- b. Cable entry : Bottom cooling method : Forced air
- c. Type of Battery : Sealed Maintenance Free

### **9.15 Control Center Console System**

The control center manufacturer shall be in the engineering, design, manufacture, and commissioning of control center consoles of comparable size to that being proposed. The manufacturer shall be required to have in-house capability to engineer, design, fabricate, and install the complete control center console.

The Consoles shall accommodate a variety of computer, communication, display and operator interface devices. The Consoles shall satisfy the functional, ergonomic and aesthetic requirements of the operational working environment.

The Consoles shall be of modular construction, facilitating future equipment retrofits and full re-configurations, without major modification to structure or exterior elements. The consoles with all other furniture for minimum 5 future work stations shall be included in the scope of work.

The control center console furnished hereunder shall be suitable for continuous use in the intended application. The console shall consist of current production products of a single manufacturer. Console shall be of a design that allows field modification.

Terminations:

- a) Provide separate cable ways for network cables.
- b) Provide cable ways for equipment power.
- c) Provide grounding for console and operators.
- d) Provide console of the manufacturer's latest design.

Design console to operate on 240V AC, +/-10%, at 50Hz, except as specifically noted.

### **9.16 Factory Acceptance Test (FAT)**

Factory Acceptance Test (FAT) shall be offered for full function DCS system requiring correctness of wiring/panel as approved drawings and providing necessary simulation test at manufacturer's works. DCS hardware and software shall be as per manufacturer's test certificates confirmations.

Factory inspection and clearance by Employer's Engineer shall in no case relieve the Contractor of his responsibilities for the correctness of operation of the offered system/equipment as per application/logic requirement.

The Contractor shall submit quality/inspection plan for all major equipment including stage/final inspection as specified above for the approval in Employer's Engineer and shall follow the same.

### **9.17 Spare Parts, Start-up Supplies and Special Tools**

#### **Spare Parts and Startup Supplies:**

1. An inventory of spare parts and subassemblies for all supplied equipment shall be provided and shall consist of following as a minimum:

- a. One I/O module of each type used.
  - b. Ten of every fuse and indicating lamp, and one of each power supply assembly used in equipment.
  - c. One complete set of the UPS supplier's recommended spare parts for each system.
  - d. All expendable parts and supplies used until completion of installed system test in order to maximize available operation time.
  - e. Any other spare parts required for the startup and commissioning.
2. Quantities specified here represent a minimum. Other spare parts necessary to maximize operational readiness of control system or to complete the Installed System Test shall be maintained on site by the Contractor.
  3. All spare parts recommended by the manufacturer for 5 year of continuous operation shall be supplied.
  4. Spare parts provided shall be same, not an equivalent replacement, as available from equipment manufacturer.
  5. All spare parts shall be individually packaged for protection against dirt corrosion and moisture. Each shall be labeled as to its contents with a description and part number.

**Special Tools:**

6. Furnish two sets of any special tools necessary for normal maintenance and calibration.
7. Furnish maintenance panel for use in troubleshooting. Maintenance panel shall include all switches and indicators necessary to display instructions, data and I/O addresses, as well as CPU status and I/O data. Panel to be equipped with switch register for adding memory address, memory and I/O data into processor. Diagnostic programs shall include CPU memory, input/output subsystem and data highway checkout capabilities.
8. Furnish simulation panel as specified under factory acceptance test.

All spare parts and special tools shall become property of Employer. Spare parts inventory level shall be maintained at no cost to Employer. All parts and tools consumed during the testing periods and warranty period shall be replaced.

Contractor shall warrant availability of spare parts and/or functional replacement subassemblies for a period of ten years after final acceptance by Employer. The Manufacturer shall provide a system which is of current design and manufacture and which is in service commercially. The manufacturer of the equipment shall also guarantee that it intends to continue manufacturing the proposed system for at least the duration of this Contract, and will continue to support it with parts and services for at least 10 years after final acceptance by Employer.



## 9.18 Fiber Optic Cables

### A. Description

- Provide and test a fiber optic data network for use with the whole DCS System and RTU network system, wherever applicable for the project.
- The system shall include fiber optic cables (suitable numbers of fiber, direct burial type cables as per detailed design by Contractor and as approved by Employer's Engineer) and accessories for a plant-wide network between buildings and Valve chambers as indicated in the Control System Architecture Drawing and the cable route drawing.
- Provide all new conduits (interduct) for fiber optic data highway network.
- Provide all fiber optic cabinets with patch panels and required accessories.
- Provide all fiber optic data trunk cables.
- Terminate fiber optic data trunk cables in fiber optic cabinets at patch panels.
- Test all fiber optic data trunk cables.

### B. Fiber Optic Cable

The OFC, control cable and local power supply cable routes will be decided by ICT consultant and approved by Employer's Engineer/Designated Employer's Representative. Other than RTU no equipment will be mounted on the road side, all the equipment will be in WTP or MBR. Fiber cables will run through HDPE Ducts.

Provide multi-mode, buffered, optical glass fiber cores compatible with LED based transmission systems. Maximum attenuation losses shall be 3.4 dB/km or less at a wavelength of 850 nm and 1.0 dB/km or less at a wavelength of 1300 nm. Minimum bandwidth shall be 200 MHZ-km at 850 nm and 500 MHZ-km at 1300 nm. Fiber core size shall be 62.5 micron unless otherwise directed by Section 13300 supplier. All plastic fiber core construction shall not be acceptable.

Fiber Optic Non- Breakout Cable: Heavy duty, tight buffer construction with additional strength members, and oil, water, and chemical resistant, UV stabilized, flame retardant, PVC outer jacket, UL listed OFNR. Fiber cladding shall be 125 micron and fiber buffer shall be 900 micron.

Cable Specifications: Fiber Count: Minimum 144 fibers

- a. Long Term Application Load: minimum 14 lbs [63.5 g] (minimum)
- b. Minimum Crush Resistance: minimum 80 lbs/inch [3.2 kg/cm]
- c. Operating Temperature: -10 to +50 degrees C [14 to 122 degrees F]

### C. Terminal Connectors

Connectors: Type ST compatible design with ceramic ferrule and strain relief boot. The epoxy used to attach connectors to the individual fibers shall be a heat cure type featuring an accelerated cure cycle and color change upon cure completion. Connector specifications shall be as follows:

Insertion loss (typical): 0.5 dB.

Durability (mating cycles): 1000 (minimum)

Repeatability: Less than 0.2 dB.

Operating Temperature: -40 to +80 degrees C [-40 to +176 degrees F]

#### **D. Patch Panels**

##### Patch Panels:

Function: Provides industry-standard rack mounting system for the interface between the fiber optic backbone and equipment cables. Provides a secure place to terminate fiber optic cables. Panels shall be suitable for multimode system operation at 800 and 1300 nanometers.

Features:

- a. Accommodates up to 576 fiber terminations.
- b. Accepts connector module housing and splice housing within the same rack.
- c. Coil Former: Former to wind slack cable around, which provides controlled long-radius bends.
- d. Jumper routing and storage: Organization guides designed into the frame, storage and routing shelf within the rack.
- e. Connector: Provide 120 percent additional connection space for expansion and building usage.
- f. Foot and End Caps: Included in final assembled unit.
- g. Ancillaries: Jumper troughs and covers, cable tie brackets.

Enclosures: Panels shall be NEMA 12 construction and lockable, unless otherwise indicated on the drawings.

#### **E. Splice Closures**

Splice Closures: Constructed of thermoplastic, suitable for "butt" or "through" cable entry, moisture tight sealing arrangement, removable splice tray organizer, splice trays for mechanical splices, suitable for multimode system operation at 800 and 1300 nanometers, grounding lugs or equivalent for grounding cable armor.

## **F. Jumper Cables**

In accordance with requirements of TIA-568-A 12.5.

Fiber Characteristics: In accordance with requirements for fiber optic cable.

Tube Configuration:

1. Individual tubes.
2. Protected with Kevlar strength members and enclosed in thermoplastic jacket.

## **G. Execution**

General:

- Provide all material, equipment, and labor to install the fiber optic cables as indicated and as specified.
- Installation shall be in accordance with the National Electrical Code and all local codes.

## **H. Installation**

- Install cables in accordance with manufacturer's printed instructions.
- Install multi-fiber cables in underground ducts. Rod and swab out ducts prior to installing cables.
- Install non-breakout cables in the conduit systems provided inside buildings and structures.
- Install cable directly from shipping reels. Ensure that cable is not:
  1. Dented, nicked, or kinked.
  2. Subjected to pull stress greater, or bend radius less, than manufacturer's specification.
  3. Subjected to treatment which may damage fiber strands during installation.
- Conduit: Install fiber optic cable directly in conduit/inner duct in accordance with manufacturer's printed instructions. Terminate all inner ducts in conduit with fabricated termination kits.
- Identification: Identify each cable on both ends and in all manholes and pull points it goes through.
- Sequencing: Provide cables in accordance with sequencing requirements.
- Sealing: Seal cables into inner ducts to stop ingress of water and grit with expansion plugs or duct seal. Seal empty inner ducts immediately after installation. Seal gaps between inner ducts and conduit with sealing compound such as 3M duct seal.

- Manholes:
  - a. Provide supports for cables at maximum 300-millimeter centers along sides of manholes.
  - b. Provide a minimum 1200mm coil of spare fiber in each manhole throughout the cable length.
- Lubricate cables with lubricants specially formulated for fiber cabling jackets during installation. Do not exceed cable manufacturers specifications for tensile strength and bending radius. All pulleys used to aid in the installation of the fiber optic cable must be sized according to the minimum bending radius.
- Provide breakout kits, splice closures, patch panels, pigtails, and jumpers as required and as indicated to install a complete data highway communications network as indicated. Patch panels shall be wall mounted plumb and level. Splice closures shall be installed in pull boxes.
- Splices: Splices shall be made only where indicated. Provide adequate put-up lengths on cable reels to make termination-to-termination runs without splices. Where splices are indicated provide mechanical splices with attenuation losses of 0.3 dB or less. Make splices watertight and provide mechanical protection equal to the cable jacket, or better.
- Support cables in riser conduits at intervals as required by the National Electrical Code.
- Installation tools and materials shall be provided by the cable manufacturer.
- The polishing process of terminal connectors shall be a two stage wet process using 3.0 micron lapping film for an initial polish followed by 0.3 micron lapping film for the final polish.

#### **I. Identification**

- Label each termination point.
- Tag each cable in junction boxes, manholes, and handholes. Provide permanent nylon/plastic tie-wrap type tags with waterproof markings.

#### **J. Cable Terminations**

- Terminate cables in accordance with TIA-568-A.
- Fan out fibers to allow flexibility and ease of installations for future expansion at connection points. Provide a metal or high density plastic fan-out collar to relieve the stress on the individual fibers. To protect the individual fibers, provide sleeves from the fan-out collar to the terminal point. Terminate all fibers in each cable with a suitable connector as specified below.
- Fiber connectors shall be bayonet-type with “twist-lock” mounting for quick and secure installation. Connectors shall be pull-proof with a durable ceramic tip to

protect the fibers from damage during installation and frequent rearrangements. “Push-pull” couplings are unacceptable. Provide a sample of the connector to the engineer for inspection and approval prior to installation.

- Provide all equipment, mounting kits and consumable materials required for a proper installation as defined by the manufacturer.
- Each individual cable shall be clearly and uniquely identified. At a terminal cabinet or backboard provide a type written directory listing the cable, identification code and type of signal. The directory shall be mounted within the termination cabinet or on the backboard and protected by a clear plastic cover.
- Provide a minimum of 20 feet [6 meters] of neatly coiled, slack fiber optic cable at each terminal cabinet or backboard for flexibility.

#### **K. Reference Standards**

National Fire Protection Association (NFPA):

- NFPA-70: National Electrical Code (NEC) Article 770.

Underwriters Laboratories, Inc. (UL):

- U.L. 1581 VW-1: Vertical Tray Cable Flame Test
- U.L. 1666: Riser Cable

Institute of Electrical and Electronics Engineers (IEEE)

- IEEE Standard 383: Flame Retardancy.

American National Standards Institute (ANSI):

- ANSI/TIA-568-A.
- ANSI/TIA-569.
- ANSI/TIA-607.
- ANSI/TSB-36, 40 and 50.
- ANSI X3 T9.5.

NETA: The International Testing Association Acceptance Testing Specification.

Submit a drawing showing the routing for the fiber optic network. Include the following information:

- Routing, length, and attenuation based on TIA-568-A.
- Cable and conduit identification.
- Locations of manholes, pull boxes and patch panels.

### Test Documentation

- Document results of tests and submit copies of documents to Employer's Engineer as tests are completed.

## **9.19 Instrumentation**

### **A. Instrumentation, Power Supply Cables, Instrumentation Signal And Control Cables**

Signal cables are to be considered for transmitting the analog signal from their respective transmitter to DCS and then to respective panel instrument in the control panel. These shall be screened cables with copper conductors, PVC insulated, PVC sheathed and armored.

The control cables are to be considered for i) transmitting the digital signal from level switches to DCS console and the instrument panel cum control desk ii) For field powering to field instruments. This cable shall be armored, PVC insulated, PVC sheathed and with a copper conductor.

All conduits and cables entering control panels shall be gland sealed to prevent the intrusion of gas and moisture.

All signal cables for carrying 4 to 20 m A, 1-5 V, low level transducer outputs etc. shall be copper PVC insulated twisted pairs, individually screened with tinned copper drain wire, overall screened, steel wire armored and overall PVC sheathed.

The twisted pairs shall be constructed with 24-30 twists per meter.

Power for all control valves, RTU'S, field devices and accessories for Potable water transmission main, and rising main from MBR to respective ESR shall be under the scope of the Contractor and may be sourced from nearest WTP/ MBR / CSS respectively. HT/LT cables shall be buried in ground in HDPE Ducts. Inspection chambers shall be planned at suitable locations for cables.

Presently power source availability along 8.5km of Transmission main is not available; hence 11kV 3core XLPE cables shall be laid between WTP & MBR along transmission main. As understood, there shall be 8 such locations for field devices (RTU's, valves instruments etc.) with 1km to 1.5km separation between any two such field devices. For easy operation, it is proposed to have 100kVA Compact substations (CSS), with back up standby generators placed near to each field device. Contractor shall suitably plan these substations along with necessary cabling, civil requirements and safety equipment.

These substations shall provide 400V or 230 V supply to field devices. Contractor shall make necessary arrangements to meet the power demand requirement for field devices along with CSS planning and cable sizing and earthing system etc. while sizing 400V LT cables, fault current and voltage drop shall be maintained as per relevant Indian standard / IEC / CBIP etc.

Around 8 nos.100kVA CSS, are proposed to be planned over 8.5km transmission stretch. LT supply to these devices shall be through CSS. If supply from nearest power source happens to be MBR or WTP, the same may be explored.

The rated working voltage shall be 100V RMS and the maximum working voltage shall be 600 V RMS. The continuous current rating shall be at least 5A

Screening shall provide a minimum of 95% coverage of copper braid or mylar blackened aluminum foil. Individual shields in multi-core cable shall be insulated from each other and from the overall shield and armoring.

Insulation between conductors and the earth shall not be less than 10 mega ohms at 500 V.

The different types of signals shall be segregated from each other and shall be contained in separate cables.

Multi stranded cable of a minimum conductor size of 24/ 0.2 mm plain copper to BS 6360 shall be used.

Strict segregation shall be followed with not more than one type of signal run in any multi-core cable.

#### **B. Instrumentation Circuit Routes**

Signal cables shall not be run in the same conduit, duct or cable tray as power cables. Separate installation in GI cable tray, GI rigid steel conduit or GI steel trucking or HDPE ducts is to be carried out.

Wherever signal and power cables cross they shall do so at right angles.

All cables running from the field instruments to the control panel shall be a single, continuous length, without joints, except at marshalling boxes. The boxes shall have terminal blocks with 20 percent spares in addition to terminals for all wires including spare wires. Special care shall be exercised to carry earthing lines through marshalling boxes with the least possible resistance. Multi-Core cables shall be used between marshalling boxes and control panels.

#### **C. Laying of Cables**

A minimum distance of 300 mm shall be maintained between the cables carrying low voltage AC and DC signals and a minimum distance of 600 mm shall be maintained between cables carrying HT and LT signals. Each instrumentation and power supply cable shall be terminated to individual panel or terminal box. Identification of each cable shall be by proper ferrules at each junction as per the cable schedule to be prepared by the Contractor.

Cables shall be laid in accordance with the layout drawings and the cable schedule which shall be prepared by the Contractor and submitted for the Employer's approval. The instrument cables shall be laid in GI cable trays properly supported in pedestals or through the HDPE ducts.

All cables routes shall be carefully measured. Cables shall be cut to the required lengths, leaving sufficient amount for the final connection of the cable to the terminals on either end. Various cable lengths cut from the cable reels shall be carefully selected to prevent

undue wastage of cables. A loop of minimum 1 meter shall be left near each field instrument before terminating the cable.

Cables shall be complete uncut lengths from on termination to the other.

All cables shall be identified close to their termination point by cable numbers as per the cable interconnection schedules. Identification tags shall be securely fastened to the cables at both the ends.

Cables shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports, or cable trays or HDPE ducts.

#### **D. Instrumentation Earthing**

Earthing shall comply with the regulations and conform IS 3043. The earthing arrangements shall be as follows.

- a) Earth electrodes (40 mm diameter GI Pipe) shall provide adequate conductive capacity for the system.
- b) 200 mm x 200 mm inspection pits shall allow ready access to the electrodes connections.
- c) An earth continuity conductor 50 x 6 mm GI flat between each control panel earth bar and the earth electrode shall be supplied.
- d) A bolted removable tinned copper link mounted in a suitably located link base shall be supplied.

The earth electrodes shall be in the form of 40 mm diameter GI conduits/pipes suitably grouped and connected

All metal works, other than current carrying parts of the instrumentation system, shall be properly bonded to the earth using 8 SWG GI wire.

#### **E. Junction Boxes**

In order to make the most economic use of cable ladder/tray and duct capacity, multi core cabling shall be utilized in order to connect instrumentation groups by using suitably located sub-distribution junction boxes.

The junction boxes shall have weather protection suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labeled. Junctions boxes shall be constructed of die cast aluminum and provide degree of protection as per IP 65

Separate cables shall be used for digital and analog signals.

Wire and terminals for the digital and analog signals shall be segregated within junction boxes.



#### **F. Surge Protection Devices**

Two number of surge protection (SPDs) shall be provided for each signal and power loop for field instruments located outdoors. One SPD shall be provided in the field near transmitter and the other SPD of the loop shall be mounted in the control panel/ console. SPDs shall also be provided in the 240 V AC incoming power supply to panels/ consoles.

Surge protection Devices (SPDs) shall be suitable for withstanding the surge arising out of the high energy static discharge/lightning discharge and protect the instrument to which it is connected against damage, SPDs shall provide protection through the use of quick acting semiconductors like Tranzorb, Zener diodes, visitors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self-resetting to minimize the down time of the measurement loop.

SPD shall have a weatherproof casing and shall be suitable for field/back of panel mounting. There should be total isolation between input, output and ground terminals. The rating and the type of SPDs shall be as per the instrument manufacturer's recommendation and shall be subject to Employer's Engineer approval.

#### **G. Intrinsic Safety Barriers**

Intrinsic safe barriers shall be provided for all analog signals coming from hazardous area. The following points must be taken into consideration while selecting I.S. barriers.

- Safety barriers must be based on entity concept.
- Each instrument in the loop must be certified intrinsically safe by a statutory authority.
- Each input/output in the loop shall have a separate I.S barrier. No barrier shall be shared between two loops/inputs/outputs.
- All safety barriers shall be isolating type, as far as possible.
- All safety barriers shall be of standard make.

#### **H. Earthing Pit**

Supply, Erection, Testing and commissioning of earthing station having 'Pipe in Pipe' technology using Safe Earthing Electrode. The special type back filling compound having inherent moisture absorption characteristics must be used to make the earthing station maintenance free and no periodic water pouring should be required. The work shall include excavation refilling providing manhole cover, chamber etc. the earthing station shall as per IS 3043: 1987 requirements.

Earthing station shall be provided for Instrumentation/DCS system as per above technology. Earthing station shall be provided having G.I. electrode 3000 mm long, outer diameter of minimum 50 mm and inner diameter of minimum 25 mm with GI earthing strip to have a total clean earthing system.

Multiple earth connection shall be taken from suitably located earth plates connected to earth loop. All hardware used for earthing installation shall be hot dip galvanized or zinc passivized.

Spring washers shall be used for all earthing connections of equipment. Unless otherwise specified, earthing connections to individual equipment shall be done in accordance with standard equipment earthing schedule.

Pumping station instrument system clean earthing and UPS system clean/safety earth shall be separate from the electrical earthing system.

Earth connections shall be made through compression type cable lugs I by welded lugs. All hardware used for earthing installation shall be hot dip galvanized or zinc passivized. Spring washers shall be used for all earthing connections and all connections adequately locked against loosening.

Method of Measurement:

- Provision of earthing station complete with excavation, electrode, watering pipe, soil treatment.
- Masonry/ RCC chamber with cast iron cover etc. shall be treated as one unit of measurement Test:

The entire earthing installation shall be tested as per requirements of Indian standard Specification IS: 3043.

The following earth resistance values shall be measured with an approve earth megger and recorded.

- Each earthing station.
- Earthing system as a whole.
- Earth continuity conductors

Earth conductor resistance for each earthed equipment shall be measured which shall not exceed 5 ohm in each case.

Measurements of earth resistance shall be carried out before earth connections are made between the earth and the object to be earthed.

All tests shall be carried out in presence of the Corporation's representative. Recommended Size of Earthing Conductors:

Below are the recommended minimum sizes of earth conductors. However, Earthing Strips/conductors, if required of higher size as per Ground Fault Calculations, should be laid.

- Type of Equipment: Earth conductor size.

- Small equipment and instrument: 8 SWG GI solid wire through min. 1.5 sq. mm earth conductor of power cable.
- Lighting, Power and Instrument Panels: 1 mm dia GI wire rope or 25 x 3 mm GI Strip.
- Push Button Stations (LCS): 8 SWG GI solid wire 27.1 1.

## FIELD INSTRUMENTATION SPECIFICATION/ DATA SHEETS

### 1. Pressure Gauges

Pressure gauges shall be complying with IS: 3624. Glycerin filled dial shall be provided where the gauge is subjected to pressure pulsation and / or vibrations. The internal parts of pressure gauge shall be stainless steel.

The minimum diameter for round pressure gauges shall be 150 mm unless specified otherwise or where the gauge forms part of a standard item of equipment

The accuracy of the pressure gauges shall be  $\pm 1\%$  of full scale, accessories such as snobbery, isolation valve & drain valve shall be provided. Impulse tubing and fittings as required shall be provided.

### 2. Electro-Magnetic Flow Meters

The electro-magnetic meters shall comprise of flow tube, flow transmitter cum computing unit with LCD display, panel mounted digital flow indicator cum integrator and any other item required to complete the flow measurement system. The flow tube shall be of SS 316 construction with Teflon lining. Other wetted parts shall be of SS 316 construction.

The overall accuracy of the flow measurement loop shall be  $\pm 1\%$  of the measured value or better.

|                    |   |   |
|--------------------|---|---|
| Tag No.            | : | EPC Scope                                 |
| Pipe Size          | : | 90 mm to 800 mm (as per P& IDs developed) |
| Conn. Type         | : | FLANGED                                   |
| Fluid              | : | Water                                     |
| Operating Temp     | : | 4 Deg. C to 70 Deg. C.                    |
| Operating Pressure | : | 1 TO 8 bar                                |

### METER

|   |                    |   |  |
|---|--------------------|---|--|
| 1 | Tube Material      | : | CARBON STEEL OR 304 STAINLESS  |
| 2 | Liner Material     | : | POLYURETHANE OR COMPLY TO THE IP REQUIREMENT OF CHEMICAL/BIOLOGICAL IMPACT |
| 3 | Electrode Type     | : | FLUSH MOUNT for 600 mm and below   |
| 4 | Electrode Type     | : | REMOVABLE for meters over 600 mm   |
| 5 | Electrode Material | : | 316 STAINLESS OR EQUIVALENT  |
| 6 | Electrode Cleaning | : | AS RECOMMENDED BY MANUFACTURER   |
| 7 | Enclosure Class    | : | NEMA 4X, IP 68   |
| 8 | Power Supply       | : | 240 V AC, 50 HZ- No External Power Supply                                  |
| 9 | Grounding Type     | : | STRAP AND RING   |

### TRANSMITTER

|    |                    |   |   |
|----|--------------------|---|---|
| 1  | Type               | : | INTELLIGENT, FOUNDATION FILED BUS BASED |
| 2  | Mounting           | : | WALL OR FLOOR STAND                     |
| 3  | Transmitter Range  | : | VARIES, SEE PROCESS DATA.               |
| 4  | Enclosure Class    | : | NEMA 4X                                 |
| 5  | Power Supply       | : | 240 V AC, 50 HZ                         |
| 6  | Analog Output      | : | 4 - 20 m ADC                            |
| 7  | Elect. Class       | : | GENERAL PURPOSE                         |
| 8  | System Accuracy    | : | +/- 0.15% OF FLOW RATE                  |
| 9  | Sys. Repeatability | : | +/- 0.1% OF FULL SCALE                  |
| 10 | Empty Pipe Detect. | : | REQUIRED                                |
| 11 | Local Indicator    | : | REQUIRED, 0 - 100%                      |
| 12 | Local Totalizer    | : | REQUIRED, 6 DIGIT, NON RESET            |
| 13 | Cable Length       | : | APPROX. 20 meters (AS REQUIRED)         |
| 14 | Input Impedance    | : | 12 OHMS OR GREATER                      |
| 15 | Process Connection | : | IP 68                                   |

#### NOTES.

- a) Provide one suitable calibrator for all magnetic meters in contract if calibrator is required.
- b) Wet calibrate all meters (at 5 points over the specified flow range) by gravimetric or volumetric methods that are traceable to NIST (National Institute of Standards and Technology).
- c) Contractor to provide all power and signal cable in rigid conduit or liquid-tight conduit. as per the specifications .
- d) Contractor to provide grounding from ground rings to meter and meter to ground, using green size 10 AWG (6mm) ground wire. The Contractor shall install ground as directed by the meter manufacturer or to nearest water pipe. Contractor is responsible for all connections.
- e) Remote communication must not interfere with the analog output signal. Use frequency shift keying (FSK) technique for communication.
- f) The cable between the flow sensor and the transmitter shall be factory fitted to comply with the IP68 process connection.

### 3. Valve Actuator

#### Specifications of Electrical Actuator

|                             |                                    |
|-----------------------------|------------------------------------|
| Type of duty                | S2 - 15 min                        |
| system voltage              | three phase current, 400 V / 50 Hz |
| running time                | 16 s                               |
| connecting flange dimension | square drive                       |

|                                    |  |
|------------------------------------|--|
| flange for electric actuator       | F05  |
| Heater in switch compartment       | 110 V to 250 V   |
| electrical connection - plug cover | with M-threads (1 x M20 x 1.5 / 1 x M25 x 1.5 / 1 x M32 x 1.5) |
| temperature range                  | standard -40°C to +70°C  |
| corrosion protection               | standard KN  |
| Colour                             | grey   |
| Control Function                   | SMART  |

#### 4. Pressure Transmitter

|    |                      |   |  |
|----|----------------------|---|--|
| 1  | Type                 | : | INTELLIGENT, MICROPROCESSOR BASED, to IP68 protection.   |
| 2  | Element              | : | CAPACITANCE CELL, RESONANT WIRE OR PIEZORESISTIVE SENSOR/SILICON RESONANT SENSOR. The Diaphragm material shall be Hastelloy or 316L or Ceramic |
| 3  | Remote Calibration   | : | ZERO AND SPAN VIA HANDHELD TERMINAL, WITHOUT ADDITIONAL HARDWARE, AT ANY TERMINATION POINT IN LOOP   |
| 4  | Transmittal/Terminal | : | TWO WAY COMMUNICATION VIA LOOP WIRING (SEE NOTE a)   |
| 5  | Self-Diagnostics     | : | CONTINUOUS   |
| 6  | Ambient Temp. Comp.  | : | AUTOMATIC  |
| 7  | Power Supply         | : | 240 V AC   |
| 8  | Output Signal        | : | 4 - 20 mA DC OR DIGITAL  |
| 9  | Dir/Rev Acting       | : | DIRECT   |
| 10 | Turn Down            | : | 6:1  |
| 11 | Span                 | : | SEE TABLE  |
| 12 | Accuracy             | : | +/- 0.1% OF CALIBRATED SPAN  |
| 13 | Repeatability        | : | +/- 0.05%  |
| 14 | Local Indicator      | : | REQUIRED   |
| 15 | Indicator Display    | : | DIGITAL; ENGINEERING UNITS, SIGNAL OUTPUT AND DIAGNOSTICS  |
| 16 | Bypass Manifold      | : | REQUIRED, 2 VALVE TYPE, 316 LSS (SEE NOTE b)   |
| 17 | Span (Elev/Suppr)    | : | UP TO 500% OF CALIBRATED SPAN  |
| 18 | Enclosure            | : | NEMA 4X/IP65/NEMA 7 CLASS I DIV 1 GROUPS A, B, C, D LOCATIONS, AND NONINCENDIVE  |

|    |                     |   |  |
|----|---------------------|---|--|
|    |                     |   | FOR CLASS I DIV 2, GROUPS A, B, C, D LOCATIONS |
| 19 | Elec. Class         | : | AS PER THE ELECTRICAL ZONES                    |
| 20 | Mounting            | : | WALL OR PEDESTAL                               |
| 21 | Process Connections | : | ½ INCH NPT                                     |

**Materials of Construction**

|   |              |   |   |
|---|--------------|---|---|
| 1 | Body         | : | LOW COPPER ALUMINUM   |
| 2 | Wetted Parts | : | 316L SS. FOR CORROSIVE CHEMICALS PROVIDE TANTALUM DIAPHRAGM AND TEFLON GASKETS AND HASTELLOY BODY, PROCESS FLANGE AND SENSOR WITH TEFLON GASKETS. The Diaphragm material shall be Haste alloy or 33 316L or Ceramic |
| 3 | Fill         | : | SILICON OIL. FOR OXYGEN SERVICE USE FLUORINERT  |

**Service Conditions**

|   |               |   |                |
|---|---------------|---|----------------|
| 1 | Fluid         | : | Water          |
| 2 | Ambient Temp. | : | 5 TO 50 DEG. C |

**NOTES:**

- a. Remote communication must not interfere with the analog output signal. Use frequency shift keying (FSK) technique for communication.
- b. Provide standard manifold mounting bracket. Mount the manifold not the transmitter such that the transmitter may be removed for service by removing the four transmitter bolts and disconnecting the signal leads. Provide block/bleed/vent/drain.
- c. Provide block/bleed/vent/drain of SS body, AMS SS mount and H5VIS-22 drain valve.
- d. Provide 316 LSS ½-inch rigid tubing for connection between process measurement primary and process transmitter/manifold. All tubing shall be cut and bent with tube manufacturer approved tools.
- e. Provide SS 316L tubing connectors.
- f. Provide cleaning and preparation for oxygen service as required based on process application.
- g. Temperature required for LOX service.
- i. The cable between the transmitter and sensor shall be factory fitted to comply with IP 68 connection.

## **5. Differential Pressure Flow Measuring System**

The differential pressure flow measuring system shall comprise of flow element, differential pressure (DP) transmitter, panel mounted digital flow indicator & integrator and any other item required for completing the flow measuring system.

The overall accuracy of the flow measurement loop shall be  $\pm 1\%$  of the measured value or better.

The primary element for any flow meter of the differential pressure type other than a Dall tube shall be manufactured and installed in accordance with the requirements of BS: 1042 or equivalent approved. Dall tubes shall be installed in accordance with the recommendations of the manufacturer. The materials of which the primary elements are constructed shall be those recommendations by the manufacturer of the device as most suitable for the particular application.

The location of primary elements in pipe work shall be agreed with the Engineer.

The DP transmitter shall convert the differential pressure produced by each primary element to a 4-20 mA DC (isolated) current proportional to the flow rate. Each transmitter shall be connected to the tapings via a 5-valve manifold and provision made for easy connection of a U-tube manometer for the purpose of calibration. The DP transmitters shall be indicating type having LCD display for flow rates and integrated flows. The enclosure protection of the DP transmitters shall be conforming to IP- 68.

The Contractor shall arrange for calibration tests of primary elements to be carried out and witnessed by the Employer's Engineer and shall provide certified records of the test readings.

Where the transmitted signal is to be linearised a square root extraction feature shall provide an output signal proportional to flow of the same electrical range as the input signal and shall be solid-state device

After installation the calibration of each flow meter system shall be proved to the satisfaction of the Engineer's Representative by the application of fixed measured differential pressure to the input of the DP transmitter.

## **6. Level Transmitter (Ultrasonic Type)**

Ultrasonic level measuring system shall comprise a level sensor, level transmitter cum computing unit, prefabricated cable connecting the sensor and transmitter, panel mounted digital level indicator and any other item required for completing the level measurement system.

The level sensor shall be suitable for flange or bracket mounting as required and have a minimum protection conforming to IP-68. It shall have ambient temperature compensation and adjustable datum setting facilities.

The overall accuracy of the level measurement loop shall be  $\pm 0.5\%$  of the measured value or better.

The level transmitter cum computing unit shall be provided in an enclosure conforming to IP-68 it shall be programmable with an integral programming keyboard. LCD display, relays for alarm, control and system fault and shall provide an isolated 4 to 20mA DC output signal



proportional to the level.

The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

If turbulence exists, shielding, stilling tube or other measure shall be provided to avoid effects on the measurement.

|    |                  |   |  |
|----|------------------|---|--|
| 1  | Type             | : | ULTRASONIC   |
| 2  | Display          | : | REMOTE LCD IP65 NEMA 4X  |
| 3  | Display Units    | : | 4 DIGIT W/ DECIMAL POINT   |
| 4  | Measuring Range  | : | 0-7 M  |
| 5  | Agitator Filters | : | REQUIRED   |
| 6  | Input Power      | : | 24 V DC  |
| 7  | Output           | : | 4 - 20 m ADC ISOLATED  |
| 8  | Resolution       | : | 2.5mm (0.1 INCH)   |
| 9  | Accuracy         | : | +/- 0.5% OF SPAN   |
| 10 | Adjustments      | : | DIRECT SETTING BCD IN INCHES   |
| 11 | Alarms           | : | LOSS OF ECHO AND NEAR ZONE USER CONFIGURABLE FOR HIGH OR LOW LEVEL CURRENT     |
| 12 | Material         | : | ALUMINUM   |
| 13 | Mounting         | : | INTEGRAL OR REMOTE   |
| 14 | Temp             | : | -40° TO 70° C  |
| 15 | Enclosure        | : | IP65 NEMA 4X, CLASS 1 DIVISION 1   |
| 16 | Enclosure        | : | INTEGRAL OR REMOTE WITH ELECTRONIC UNIT  |
| 17 | Material         | : | CPVC, PFA  |
| 18 | Mounting         | : | 50mm NPT CONDUIT CONNECTION OR FLANGE  |
| 19 | Frequency        | : | 53 KHz   |
| 20 | Temperature Comp | : | INTEGRAL WITH TRANSDUCER   |
| 21 | Interconn. Cable | : | 15M (50 FEET) OR GREATER SO THE TRANSMITTER CAN BE MOUNTED FOR OPERATOR ACCESS |

**NOTES:**

- a. Provide all necessary mounting hardware.
- b. Provide detailed instructions for proper installation of sensor, transmitter and mounting hardware.
- c. Provide 316 SS wall sleeve w/ 150mm flange for mounting in top of tanks or wells.
- d. Provide 316 SS (fiberglass for chemical applications) UNISTRUT® floor or wall bracket for indicator or remote mount transmitter.
- e. Provide linearization functions to measure flow in open channels or weirs. Provide linearization calculations to determine tank volumes.
- f. The mechanical and instrumentation drawing shall be submitted for approval along with the instrument approval submission at each location as applicable.
- g. The cable between the transmitter and sensor shall be factory fitted to comply with IP 68 connection.

**7. Level Sensor (Float Switch)**

Float type level switch shall comprise of a float, float guide, micro switch assembly and any other item required to complete the switch assembly. The float and all the wetted parts shall be SS 316.

The level switch shall have weather protection of IP-68

**Level Sensor**

|                                | <b>Ex-approved version</b>  |
|--------------------------------|---|
| Cable lengths                  | Suitable  |
| Liquid density                 | Between 0.95 and 1.10 g/cm <sup>3</sup>   |
| Materials                      | Body: Conductive polypropylene/carbon black (suitable for raw sewage application)<br>Bending relief: NBR/PVC rubber Cable: NBR/PVC  |
| Liquid temperature             | Min. 0°C, Max. 60°C   |
| Ingress protection             | IP 68   |
| Electrical range (microswitch) | Interrupting capacity:<br>AC: 250 V/10 A resistive load<br>AC: 250 V/3 A inductive load at cosφ = 0.5 DC: 24 V/ 10mA min., 6 A max. |
| Certifications                 | CE, SEMKO, NEMKO, DEMKO, ATEX/IECEX   |

**8. Float & Board Type Level Gauges**

|   |                    |
|---|--------------------|
| Raw water sump and other if indicated elsewhere shall be provided with local level indication | As per Tank Height |
|---|--------------------|

|   |   |
|---|---|
| gauge. Gauges shall be mounted in a manner that it is easily visible to the operator. Meas. Range |   |
| Float Size / MOC  | 300mm dia. / SS316  |
| Float Wire Size / MOC   | 0.5-1.6 mm / SS316  |
| Guide Wire Size / MOC   | 3 mm / SS316  |
| Guide Pipe  | SS – 316  |
| Scale   | MS, 125 mm wide, White background, Minor marking at every 50 mm in Black, Major marking at every 1000 mm in Red |
| Pointer   | MS (Cd Plated), painted in red  |

## 9. Cabinets for field Instruments

A cabinet shall be provided for enclosing instruments and associated accessories which mounted outside the control panel such as transmitter, LPU, terminal blocks etc. at all measurement locations.

It shall be fabricated from cold rolled steel with powder coating sheet of standard gauge and shall be suitable for wall mounting or pedestal mounting as required.

The cabinet shall be properly painted from inside by white paint and from outside by paint shade 631 of IS: 5.

The cabinet shall conform to IP-65 and shall have built in locking facility.

The cabinet shall be earthed properly. A steel plate / pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories.

## 10. Digital Panel Meters

Digital Panel Meters (DPM) shall be microprocessor based and modular in design. They shall accept 4-20 mA DC signals from transmitters. The DPM's shall provide an output of 4-20 mA DC proportional to input signal for retransmitting. It shall also provide relay outputs for high and low alarms. The DPM's shall have backlit LCD display. The DPM's shall have a RS 485 communication port with MODBUS slave protocol. Digital panel meters shall provide excitation voltage to the respective transmitters.

## 11. Flow indicator and flow integrator

Digital flow indicator and flow integrator shall be modular in design. It shall consist to two separate dedicated backlit LCD display for flow rate indication and total flow indication. It shall accept 4-20 mA DC input from flow transmitters. It shall have a battery backup for flow totaliser. Manual reset facility for flow integrator (key operated) shall be provided along with applicable and updated communication port with MODBUS slave protocol. It shall generate a retransmission output of 4-20 mA (isolated) and two numbers relay outputs for high & low alarms. The flow indicator and flow totaliser shall have a facility for changing the multiplying factor. Facility shall be provided for selecting the engineering unit for display.

## 12. CCTV SYSTEM

### 1. Description

- a) Provide and test a complete Closed Circuit TV system(s) with Cameras, Control Units, Video matrix, DVR, Monitors etc. as required to monitor the total pumping station stie
- b) The CCTV system shall monitor the places in the pumping station. The monitoring shall be through the FOC between WTP and MBR but through different fibers of the same FOC cable for DCS.
- c) The location of the Cameras and number of cameras required to be finalized for a proper view and monitoring of the place, by Contractor.
- d) The monitors shall be placed in the pumping station control room (or additional as needed) as shown in the system architecture.
- e) Provide DVR at the MBR control room and shall have minimum 3 month data of storage.

### 2. System Architecture

The system architecture described below is for guiding purpose only, however, all the equipment needed will be designed and supplied per specifications.

CCTV system should be designed such as to cover the strategic locations and sensitive areas of pumping station. High end cameras with Day/Night features to be installed for outdoor and perimeter security application, these cameras shall be IR Compatible so that IR Lamps can be introduced at a later stage to enhance night vision. All Speed domes shall be rugged and shall be weather proof as per specifications. The fixed dome cameras shall necessarily be of Varifocal / fixed lens as per detailed specifications. Day/Night Cameras with built in zoom lenses shall be provided for select indoor/outdoor locations. Also the systems should utilize only industry standard protocol.

System should be programmed such that operator's intervention if required shall be minimal and the system should provide features like guard tours, preset positions and the preset positions will be linked to perimeter protection system/intrusion system in future. The DVR's should allow for recording of events both continuous and motion triggered as per requirement and recordings should be able to create evidences and support post event analysis.

All Cameras, DVR and Matrix System must be of the same make, weatherproof/vandal proof and up to date system at the time of supply and installation.

### 3. Technical Specification

The Technical Specification described below is for guiding purpose only, however, all the equipment needed will be designed and supplied per specifications..

#### a. Indoor Dome CCTV Camera

| Camera Characteristics                   | Minimum Specifications  |
|--|---|
| Image sensor                             | 1/2.7" Progressive Scan CMOS  |
| Lens                                     | 3 to 9 mm   |
| Field of View                            | 37.5° ~ 103.7° (horizontal)<br>21.6° ~ 71.2° (vertical)<br>42.6°~111.21° (diagonal)   |
| Day and Night                            | Automatic/manual/scheduled  |
| Minimum Illumination / Light Sensitivity | Color mode: F1.2 @ 0.4 lux, Black and white mode: F1.2 @ 0.2 lux  |
| Video Compression                        | H.264 Motion JPEG   |
| Resolutions and frame rates (H.264)      | 1920 x 1080 @ 30 fps (1080p) 1280 x 720 @ 30 fps (720p) 1024 x 576 @ 30 fps, 960 x 544 @ 30 fps, 704 x 480 or 576 @ 30 or 25 fps (4CIF), 640 x 368 @ 30 fps, 352 x 240 or 288 @ 30 or 25 fps (CIF)  |
| PoE                                      | 802.3af compliant (Class 3)   |
| Camera Adjustment Angle                  | Pan: 350°<br>Tilt: 80°<br>Rotate: 350°  |
| Remote, Auto Focus support               | Yes   |
| Motorized Lens                           | Yes   |
| Digital I/O ( Audio I/O, Alarms)         | Audio in x 1 (Φ3.5 miniature jack)<br>A/V out x 1 (Φ3.5 miniature jack)<br>DI x 1, DO x 1   |
| Local storage ( S.D or Micro SD )        | MircoSD/SDHC  |
| Supported Protocol                       | Dynamic Host Control Protocol (DHCP), Hypertext Transfer Protocol (HTTP), Secure HTTP (HTTPS), Network Time Protocol (NTP), Real-Time Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP), Simple Mail Transfer Protocol (SMTP), Secure Sockets Layer/Transport Layer Security (SSL/TLS), TCP/IP, Secure Real-Time Transport Protocol (SRTP), Bonjour, Simple Network Management Protocol (SNMP), and Secure Shell (SSH) Protocol. Differentiated-services-code-point (DSCP) marking and class-of-service (CoS) marking |
| ONVIF                                    | ONVIF 2.0 Support   |
| Operating Temp                           | -10 to 50°C   |
| Auto Detection & Configuration           | The camera should be automatically discovered and configured when connected to VMS or Network Switch, to set the right network  |

|                |  |
|----------------|--|
|                | parameters for the video stream on the network |
| Certifications | UL,FCC, EN                                     |

**b. Outdoor Pan Tilt Zoom (PTZ) CCTV Camera**

| Camera Characteristics                                  | Minimum Specifications  |
|---|---|
| Image sensor  | 1/2.8" CMOS Sensor  |
| Lens  | f= 4.7 - 94.0 mm F1.6 (wide) F 3.5 (tele)   |
| Field of View   | H: 55.4 (W) ~ 2.9 (T)°  |
| Day and Night   | Automatic/manual/scheduled  |
| Minimum Illumination / Light Sensitivity                | 0.02 Lux / F1.6 0.15 lux @ 1/30 sec, 50IRE color 0.001 @ 1sec, 50IRE color and BW   |
| Video Compression                                       | H.264, MPEG-4, Motion JPEG  |
| Resolutions and frame rates (H.264)                     | 30 fps at 1920x1080   |
| PoE   | PoE+  |
| External Power - D.C / A.C                              | 24V AC  |
| Env Certification ( IP6x - Salt Spray/corrosion, IK10 ) | IP66  |
| PTZ   | Yes   |
| Camera Adjustment Angle                                 | Pan speed: 0.05° ~ 450°/sec, Tilt speed: 0.05° ~ 450°/sec Pan: Continuous 360°, Tilt: 220°, Zoom: 20x Optical, 100 Presets  |
| Remote, Auto Focus support                              | Auto Focus  |
| Motorized Lens  | Yes   |
| Digital I/O ( Audio I/O, Alarms,                        | Audio in x 1 (Φ3.5 miniature jack)<br>Audio out x 1 (Φ3.5 miniature jack)<br>DIx4 DO x 2  |
| Local storage ( S.D or Micro SD )                       | MircoSD/SDHC  |
| Supported Protocol                                      | Dynamic Host Control Protocol (DHCP), Hypertext Transfer Protocol (HTTP), Secure HTTP (HTTPS), Network Time Protocol (NTP), Real-Time Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP), Simple Mail Transfer Protocol (SMTP), Secure Sockets Layer/Transport Layer Security (SSL/TLS), TCP/IP, Secure Real-Time Transport Protocol (SRTP), Bonjour, Simple Network Management Protocol (SNMP), and Secure Shell (SSH) Protocol. Differentiated-services-code-point (DSCP) marking and class- |

|                                |   |
|--------------------------------|---|
|                                | of-service (CoS) marking  |
| ONVIF                          | ONVIF 2.0 Support   |
| Operating Temp                 | -5 to 55 °C   |
| Auto Detection & Configuration | The camera should be automatically discovered and configured when connected to VMS or Network Switch, to set the right network parameters for the video stream on the network |
| Certifications                 | UL, FCC, EN   |

### c. Video Management System Software

#### General Requirements

The surveillance system shall provide a highly scalable and reliable platform to enable customized, network-based surveillance applications. The surveillance system shall be open standard supporting multiple vendor IP cameras and encoder manufacturers within the same system. The system shall support seamless integration of all ONVIF compliant cameras.

The system shall support digital pan-tilt-zoom on live or archived video.

The surveillance system viewing system should be in thick client for local viewing and thin client through http browser for remote viewing.

Both thin and thick client shall provide the capability of viewing single or multiple live and archive cameras, control PTZ camera.

The proposed surveillance system can be supported by the existing network infrastructure. The System shall support the scalability of additional camera installation beyond the originally planned capacity.

The proposed video management system shall support deploying the software on Virtual servers, thus minimizing the hardware foot print for the project. The system shall have capability to stream video at remote sites by optimizing the bandwidth on WAN.

The system shall be able to trace the end to end video traffic and shall be able to pinpoint the problematic nodes on the network that will affect the quality of video being streamed from the camera to servers. Auto-discovery and provisioning Simplify trouble shooting with end-to-end visualization of video flows and on-demand.

Enables fast, accurate resolution of wired or wireless performance issues for end-to-end

traffic

Easily fix video performance issues

Perform pre-deployment assessment and capacity planning

#### System Features

Video Surveillance Storage System – The video surveillance storage system shall provide multiple options to store video. Server internal storage shall be augmented by Direct Attached, SAN. The video surveillance storage system shall store video in loops, one-time archives, or event clips triggered by alarm systems. It shall provide for RAID 6 storage.

The system shall support Video display up to 16 cameras per screen, and 2 screens per workstation.

The Video display shall be intelligent that can be automatically change view based on the event such as motion started/stopped, video analytic, camera digital input contact closed/opened,

The system shall provide for integration with other software applications through an open and published Application Programming Interface (API). Such applications shall include, but not be limited to, access control, video analytics, and other alarm and sensor inputs.

The system shall support the Redundancy / Fail-over feature in case of failure of NVR/Camera server the relevant cameras shall automatically switch over to the redundant NVR/Camera Server.

The system shall support the camera storage redundancy with the following different options.

Primary camera stream to primary NVR / Camera Server and secondary stream to secondary NVR/Camera Server.

Primary camera stream to both the primary and the redundant NVR/Camera Server.

Both camera primary and secondary streams to both the primary and the redundant NVR/Camera Server, The system shall provide the Audio record option on Live Only, Live & Archive, Audio Recording Off. The Audio recording shall be configurable on per camera basis, or template based for a group of cameras.

The system shall have a centralized server that will be installed at Primary Data Center for all configuration and access management. The system shall have the capability and facility to distributed architecture in the future.

System shall have both video management and video stream storage management. Recording frame rate, resolution, bit rate with respect of individual channel shall be programmable.

The system should ensure that once recorded, the video cannot be altered; ensuring the audit trail is intact for evidential purposes.



The area under surveillance shall be monitored and controlled through workstations and Video display Monitors

The system must provide a built-in facility capable of embedding digital signature for irreversibly embedding information to the video to ensure tamperproof recording.

In order to optimize the memory, while recording, video shall be compressed using MPEG-4, Motion JPEG, H.264 or better standard over the network and can be viewed on the control room workstation.

The system software shall support flexible 1/2/4/16 Windows split screen display mode or scroll mode on the PC monitor or on Video preview monitor as per site requirement.

All camera recordings shall have camera ID and location or area of recording and shall be programmable by the system administrator with user ID and password.

The system shall provide the facility of viewing, recording and replay simultaneously and shall be capable of frame by frame analysis.

The offered system shall have the facility to export the desired portion of clipping on CD, DVD or any storage device. Viewing of this recording shall be possible using standard media players.

The software should be able to control all cameras i.e. PTZ control, Iris control, auto manual focus, color balance camera, video tour selection etc.

The software is required to generate reports of stored device configuration. It is required to provide alarm and alarm log and shall be able to be archived, printed and displayed.

The system shall provide User activity log (audit trail) with user ID, time stamp and action performed, etc.

System shall support camera template to define the resolution, frame rate, recording duration, and then apply to a group of cameras. The modification of the template will be reflected to all the cameras under the template.

It should provide programmable motion detection and recording, to be defined area-wise. The system must be able to support video motion detection algorithms to detect moving object or person.

The system software for clients should also be working on a browser based system for remote users. This will allow any authorized user to display the video of any desired camera on the monitor with full PTZ and associated controls.

The system administrator should be able to add, edit and delete users with rights. It shall be possible to view ability or rights of each user or the cameras which can be viewed and controlled as per the permission assigned by the administrator.

The system shall support local administration role. Each local administrator shall be able to add, manage and remove local users.

The system shall provide sufficient storage of all the camera recordings for a period of thirty (30) days using necessary compression techniques.

The system shall have the provision to automatically over-write the old information after the period of thirty (30) days and necessary script or algorithm in the application.

The video surveillance application should allow retrieval of data instantaneously or any date or time interval chosen through search functionality of the application software. The system should also allow for backup of specific data on any drives like CD, DVD, external storage or any device in a format which can be replayed through a standard media player. Log of any such activity should be maintained by the system which can be audited on a later date.

The system shall support Bulk Action to allow searching and performing administration activities on multiple cameras.

The system shall support Bulk import of cameras from file such as excel, .csv, or other standard file format. The files shall include camera name, ip address, server, template, location, camera username and password

#### Operator Console Features

The system shall support security operation client for day-to-day operation only. This client shall not have the system level management capability. The security operation client shall be able to leverage the dual screen capability.

The system shall support the map capability. The map shall have hierarchy with the root map at the top, and then the lower level of maps based on the locations. They system shall allow the importing of the user maps in the format of JPEG, GIF, PNG, BMP, TIFF.

The system shall support to overlay of cameras on the map. The camera icons shall be rotatable toward direction that it is facing.

Allow user to choose camera from maps to view live video.

Allow user to choose camera icon from map to view recorded with the capability to play, pause, stop, fast-forward, rewind, and play recorded video from preset time.

Allow user to choose camera icon from map.

Allow user to choose camera and toggle full screen view.

Allow user to choose camera from map to move PTZ cameras.

### **10 Standards and Specifications for Civil and Building Works for Pumping Station**

Materials and workmanship shall comply with the relevant current Indian Standards (with amendments), or with the requirements of any other authoritative standard approved by the Engineer, which shall be no less exacting in the opinion, of the Engineer than the corresponding standard quoted herein.

Where the relevant standard provides for the furnishings of a certificate to the Employer, at his request, stating the materials, supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Employer's Engineer..

These standards and specifications also cover the design and construction of the Office Building, DCS operation/Control Room, pump houses, Security room, all other buildings / structures within the pumping station premises.

The specifications, standards and codes listed below are made part of this specification. All standards, tentative specifications, specifications, codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

**a) Materials**

| <b>Sr. No.</b> | <b>Code or Standard</b> | <b>Description</b>  |
|----------------|-------------------------|---|
| 1.             | IS : 269                | Specification for ordinary Portland cement  |
| 2.             | IS : 383                | Specification for coarse and fine aggregates from natural sources for concrete.   |
| 3.             | IS : 428                | Specification for distemper, oil emulsion, colour as required.  |
| 4.             | IS : 432                | Specification for mild steel and medium tensile steel (Part I& II) bars and drawn steel wire for concrete reinforcement                         |
| 5.             | IS : 455                | Specification for portland slag cement.   |
| 6.             | IS : 458                | Specification for concrete pipes.   |
| 7.             | IS : 650                | Specification for standard sand used for testing of cement.   |
| 8.             | IS : 651                | Specification for salt glazed stone-ware pipes and fittings.  |
| 9.             | IS : 13753 to 13756     | Specification for glazed earthenware wall tiles.  |
| 10.            | IS : 808                | Dimensions for rolled steel beam, channel and angle sections.   |
| 11.            | IS : 814                | Specification for covered electrodes for metal arc welding of carbon and carbon manganese steel.  |
| 12.            | IS: 1003                | Specification for timber paneled and glazed shutters. (Part 1 & 2)  |
| 13.            | IS : 1038               | Specification for steel doors, windows and ventilators.   |
| 14.            | IS : 1077               | Specification for common burnt clay building bricks.  |
| 15.            | IS : 1148               | Specification for hot rolled steel rivet bars (upto 40 mm diameter) for structural purposes.  |
| 16.            | IS : 1149               | Specification for high tensile steel rivet bars for Structural purposes.  |
| 17.            | IS : 1230               | Specification for cast iron rainwater pipes and fittings.   |
| 18.            | IS:1363(Parts1-3)       | Specification for black hexagonal bolts, nuts and lock nuts (size range M5 to M64) of grade C and black hexagonal screws (diameter 6 to 24 mm). |
| 19.            | IS: 1364(Parts 1-5)     | Specification for precision and semi-precision  |

| Sr. No. | Code or Standard | Description  |
|---------|------------------|--|
|         |                  | hexagonal head bolts, screws, nuts of product grades A & B size range M 1.6 to M 64).      |
| 20.     | IS: 1367         | Technical supply conditions for threaded fasteners. (Parts 1 to 18)                        |
| 21.     | IS: 1489         | Specification for Portland - pozzolana cement. (Parts 1 & 2)                               |
| 22.     | IS: 1566         | Specification for hard drawn steel wire fabric for concrete reinforcement.                 |
| 23.     | IS: 1580         | Specification for bituminous compounds for waterproofing and caulking purposes.            |
| 24.     | IS: 1786         | Specification for high strength deformed steel bars wires for concrete reinforcement.      |
| 25.     | IS: 1852         | Rolling and cutting tolerances for hot rolled steel products.                              |
| 26.     | IS: 1948         | Specification for aluminum doors, windows and ventilators.                                 |
| 27.     | IS: 1977         | Specification for structural steel (ordinary quality)                                      |
| 28.     | IS: 2016         | Specification for plain washers.   |
| 29.     | IS: 2062         | Specification for steel for general structuring purposes.                                  |
| 30.     | IS: 2074         | Specification for ready mixed paint, air drying, red oxide zinc chrome and pruning.        |
| 31.     | IS: 2185         | Specification for concrete masonry units, hollow and (Parts I & II) solid concrete blocks. |
| 32.     | IS: 2202         | Specification for wooden flush door shutters. (Parts I & II)                               |
| 33.     | IS: 2645         | Specification for integral cement water proofing compounds.                                |
| 34.     | IS: 2750         | Specification for steel scaffoldings.  |
| 35.     | IS: 2835         | Specification for flat transparent sheet glass.  |
| 36.     | IS: 3384         | Specification for bitumen primer for use in waterproofing and damp proofing.               |
| 37.     | IS : 3502        | Specification for steel chequered plates.  |
| 38.     | IS : 3757        | Specification for high strength structural bolts.  |
| 39.     | IS : 4021        | Specification for timber door, window and ventilator frames.                               |
| 40.     | IS : 4350        | Specification for concrete porous pipes for under drainage.                                |
| 41.     | IS : 4351        | Specification for steel door frames.   |

| Sr. No. | Code or Standard | Description   |
|---------|------------------|---|
| 42.     | IS : 4990        | Specification for plywood for concrete shuttering work.   |
| 43.     | IS : 5369        | General requirements for plain washers and lock washers.  |
| 44.     | IS : 5372        | Specification for taper washers for channel (ISMC)  |
| 45.     | IS : 5374        | Specifications for taper washers for I beams (ISMB)   |
| 46.     | IS : 7215        | Specifications for tolerances for fabrication of steel Structures                                   |
| 47.     | IS : 7280        | Specifications for bare wire electrodes for submerged arc welding of structural steel               |
| 48.     | IS : 8500        | Specifications for structural steel micro alloyed (medium and high strength qualities)              |
| 49.     | IS : 9862        | Ready mixed paint, brushing bituminous black, lead fire acid, alkali, water and chlorine resisting. |
| 50.     | IS: 10262        | Recommended guidelines for concrete mix design.   |
| 51.     | IS: 12330        | Specification for sulphate resisting Portland cement  |

**b) Tests**

| Sr. No. | Code or Standard | Description   |
|---------|------------------|---|
| 1.      | IS: 516          | Method of test for strength of concrete.  |
| 2.      | IS: 1182         | Recommended practice for radiographic examination of fusion-welded butt joints in steel plates. |
| 3.      | IS: 1199         | Method of sampling and analysis of concrete.  |
| 4.      | IS: 2386         | Methods of test for aggregate for concrete (Parts 1 to 8)                                       |
| 5.      | IS: 2720         | Methods of test for soils. (Parts 1 to 41)  |
| 6.      | IS: 3025         | Method for sampling and test (physical and chemical) (Part 1 to 44) for water and wash water.   |
| 7.      | IS: 3495         | Method test for burnt clay of building bricks. (Part 1 to 4)                                    |
| 8.      | IS: 3613         | Acceptance tests for wire flux combinations for submerged arc welding of structural steel.      |
| 9.      | IS: 4020         | Methods of tests for wooden flush doors; shutters; type tests.                                  |
| 10.     | IS: 4031         | Methods of physical tests for hydraulic cement. (Parts 1 to 15)                                 |

| Sr. No. | Code or Standard | Description   |
|---------|------------------|---|
| 11.     | IS: 5807         | Methods of test for clear finishes for wooden furniture. (Parts 1 to 5)         |
| 12.     | IS: 7318         | Qualifying tests when welding procedure approval is (Parts 1 & 2) not required. |

**c) Codes of Practice**

| Sr. No. | Code or Standard                 | Description   |
|---------|----------------------------------|---|
| 1.      | Uniform Plumbing Code-India      | Uniform Plumbing Code-India, 2011 (Illustrated Training Manual)                           |
| 2.      | SP 7 -1983<br>(Part-9 Section-1) | National Building Code of India   |
| 3.      | IS 13920-1993                    | Detailing of reinforced concrete structures subjected to seismic forces                   |
| 4.      | IS 1992-1969 / IS 6403-1971.     | Code for exploration to find the safe bearing capacity                                    |
| 5.      | IS 2309-1969                     | Code for Lighting arrestors   |
| 6.      | IS 7357                          | Code of practice for structural design of tanks   |
| 7.      | IS: 8112                         | Specification for 43 Grade ordinary Portland cement.                                      |
| 8.      | IS. 226-1975                     | Specification for Structural steel  |
| 9.      | IS 5477                          | Methods for fixing the capacities of reservoirs   |
| 10.     | IS 12183: 1987                   | Code of practice for plumbing in multi- storied buildings Part-I water supply.            |
| 11.     | IS 210                           | Specification for grey iron casting   |
| 12.     | IS 1536                          | Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage |
| 13.     | IS 1537                          | Specification for vertically cast iron pressure pipes for water, gas and sewage           |
| 14.     | IS 2911                          | Code of practice for Design of Pile foundations   |
| 15.     | IS: 456                          | Code of practice for plain and reinforced concrete.                                       |
| 16.     | IS: 783                          | Code of practice for laying of concrete pipes.  |
| 17.     | IS: 800                          | Code of practice for use of structural steel in general building construction.            |
| 18.     | IS: 806                          | Code of practice for use of steel tubes in general building construction.                 |
| 19.     | IS: 816                          | Code of practice for use of metal arc welding for general construction in mild steel.     |
| 20.     | IS: 817                          | Code of practice for training and testing of metal arc welders.                           |

| Sr. No. | Code or Standard       | Description   |
|---------|------------------------|---|
| 21.     | IS: 875 (Parts 1 to 5) | Code of practice for design loads (other than earthquake) for building structures.                        |
| 22.     | IS: 1081               | Code of practice for fixing and glazing of metal (steel and aluminum) doors, windows and ventilators.     |
| 23.     | IS: 1172               | Code of basic requirements for water supply, drainage and sanitation.                                     |
| 24.     | IS: 1477               | Code of practice for painting of ferrous metals in (Parts 1 & 2) buildings.                               |
| 25.     | IS: 1597               | Code of practice for construction of stone masonry. (Parts 1& 2)  |
| 26.     | IS: 1742               | Code of practice for building drainage,   |
| 27.     | IS: 1893               | Criteria for earthquake resistant design of structures.   |
| 28.     | IS: 2065               | Code of practice for water supply in buildings.   |
| 29.     | IS: 2212               | Code of practice for brickwork.   |
| 30.     | IS: 2338               | Code of practice for finishing of wood and wood based (Parts 1 & 2) materials.                            |
| 31.     | IS: 2394               | Codes of practice for application of lime plaster finish.   |
| 32.     | IS: 2395               | Code of practice for painting concrete, masonry and (Parts 1 & 2) plaster surfaces.                       |
| 33.     | IS: 2470(Part 1)       | Code of practice for installation of septic tanks -Design Criteria & Construction                         |
| 34.     | IS: 2470 (Part 2)      | Code of practice for installation of septic tanks Secondary treatment & disposal of septic tank effluents |
| 35.     | IS : 2502              | Code of practice for bending and fixing bars for concrete Reinforcement                                   |
| 36.     | IS : 2571              | Code of practice for laying in-situ cement concrete flooring  |
| 37.     | IS : 2595              | Code of practice for radiographic testing   |
| 38.     | IS : 2751              | Code of practice for welding of mild steel bars used for reinforced concrete construction                 |
| 39.     | IS : 2974              | Code of practice for design and construction of (Part 1 to 4) machine foundations.                        |
| 40.     | IS : 3114              | Code of practice for laying of Cast iron pipes.   |
| 41.     | IS : 3370              | Code of practice for concrete structures for storage (Parts 1 to 4) of liquids                            |
| 42.     | IS : 3414              | Code of practice for design and installation of joints in buildings.                                      |
| 43.     | IS : 3558              | Code of practice for use of immersion vibrators for   |

| Sr. No. | Code or Standard | Description   |
|---------|------------------|---|
|         |                  | consolidating concrete  |
| 44.     | IS : 3935        | Code of practice for composite construction.                                  |
| 45.     | IS : 4000        | Code of practice for high strength bolts in steel structure.                  |
| 46.     | IS : 4014        | Code of practice for steel tubular scaffolding (Parts 1 & 2)                  |
| 47.     | IS : 4111        | Code of practice for ancillary structures in sewerage (Parts I to 5) system.  |
| 48.     | IS : 4127        | Code of practice for laying of glazed stoneware pipes.                        |
| 49.     | IS : 4353        | Recommendations for submerged arc welding of mild steel and low alloy steels. |
| 50.     | IS : 5329        | Code of practice for sanitary pipe work above ground for building.            |
| 51.     | IS : 5334        | Code of practice for magnetic particle flow detection of Welds                |
| 52.     | IS : 5822        | Code of practice for laying of welded steel pipes for water supply            |
| 53.     | IS: 7215         | Tolerances for fabrication of steel structures.                               |
| 54.     | IS : 9595        | Recommendation for metal arc welding of carbon and carbon manganese steels.   |
| 55.     | IS : 10005       | SI units & recommendation for the use of multiples & of certain other units.  |
| 56.     | IS: 13290        | Code of practice for earthquake resistant design & construction of buildings. |

**d) Construction Safety**

| Sr. No. | Code or Standard | Description  |
|---------|------------------|--|
| 1.      | IS : 3696        | Safety code for scaffolds and ladders. (Parts 1 & 2) |
| 2.      | IS : 3764        | Safety code for excavation work.                     |
| 3.      | IS : 7205        | Safety code for erection of structural steel work.   |

**11 Standards and specifications for Site Grading works for the Raw Water pumping station site**

To ensure that the fill has been compacted as specified, field compaction tests shall be carried out in each layer of filling until the fill to the entire height has been completed. The compaction shall comply with minimum 90% compaction by Standard Proctor Test.

**12 Standards and Specifications for Architectural finishes for Pumping Station Site**

The look and feel of office Building to be designed aesthetically and the architectural design to be approved by Employer' Engineer.



All standards, specifications, and codes of practice referred to herein shall be the latest edition including all applicable official amendments and revisions as on date of bid opening. All work shall be carried out as per the following standards & codes.

#### **Codes for Architectural and Finishes**

| <b>Sr. No.</b> | <b>Code</b>    | <b>Description</b>  |
|----------------|----------------|---|
| 1              | IS 3812, 1981  | Fly-ash for use as pozzolana and admixtures.  |
| 2              | IS 2386        | Method of test for aggregate for concrete.  |
| 3              | IS 516         | Method of test for strength of concrete   |
| 4              |                | Coarse and fine aggregate from natural sources for concrete.                                    |
| 5              | IS 1077, 1970  | Method of test for Bricks.  |
| 6              | IS 456         | Code of practice for plain and reinforced concrete.   |
| 7              | IS 1597        | Code of practice for construction of stone masonry.   |
| 8              | IS 1597 PART 1 | Code of practice for construction of rubble stone masonry.                                      |
| 9              | IS 1130        | Marble (blocks, slabs and tiles)  |
| 10             | IS 287         | Recommendation for maximum permissible moisture contents of Timber used for different purposes. |
| 11             | IS 1141        | Code of practice for seasoning of timber.   |
| 12             | IS 6313 PART 2 | Anti-termite measures in buildings, pre-constructural chemical treatment measures.              |
| 13             | IS 2571        | Code of practice for laying in situ cement concrete flooring                                    |
| 14             | IS : 226       | Structural Steel (Standard Quality)   |
| 15             | IS : 451       | Technical Supply Conditions for Wood Screws   |
| 16             | IS : 800       | Code of Practice for Use of Structural Steel in General Building Construction                   |
| 17             | IS : 806       | Code of Practice for Use of Steel Tubes in General Building Construction                        |
| 18             | IS : 813       | Scheme of Symbols for Welding   |
| 19             | IS : 814       | Covered Electrodes for Metal Arc Welding of (part I & II) Structural Steel                      |
| 20             | IS : 816       | Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel            |
| 21             | IS : 822       | Code of Practice for Inspection of Welds  |
| 22             | IS : 961       | Structural Steel (High Tensile)   |
| 23             | IS 73          | Paving bitumen.   |
| 24             | IS 702         | Industrial Bitumen  |

| Sr. No. | Code                  | Description  |
|---------|-----------------------|--|
| 25      | IS 1322               | Bitumen felts for waterproofing and damp proofing.   |
| 26      | IS 1609               | Code of practice for laying damp proof treatment using bitumen felts.  |
| 27      | IS 13711 & 13712      | Ceramic tiles  |
| 28      | IS 13630 Part 1 to 13 | Testing for Ceramic tiles  |
| 29      | IS 104                | Specification for ready mixed painted, brushing, zinc chromate priming.  |
| 30      | IS 137                | Ready mixed paint, brushing, matt or egg-shell flat, finish suitable for interior to Indian standard colour as required. |
| 31      | IS 5410               | Cement paint, colour as required.  |
| 32      | IS 6241               | Method of test for determination of stripping value of road aggregate.   |
| 33      | IS 2720               | Density test of aggregate.   |

### 13 Standards and Specifications for Topographical and contour Survey for Raw water Pumping station site and Raw Water Transmission Main alignment

#### 13.1 Pumping Station Site

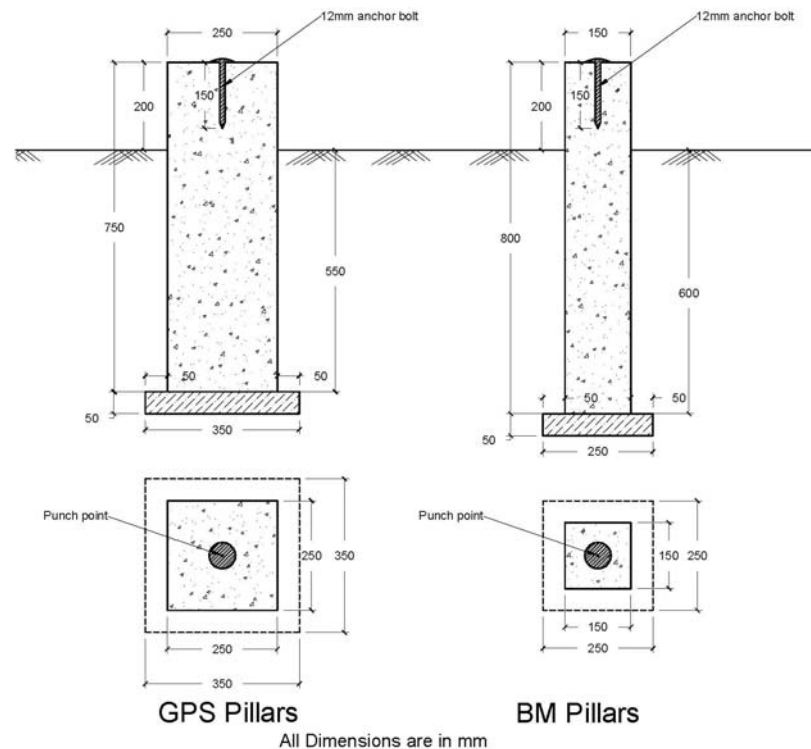
##### i) Fixation of horizontal control points using DGPS & vertical control points (Bench Marks pillars) by Digital / Auto level

Scope of Services for fixing of horizontal control with DGPS & vertical control points (Bench Marks pillars) by Digital / Auto level shall include but not limited to the following.

- Fixing of Horizontal control grid by using Differential Global Positioning System (DGPS) at every 2 km on a pair of Control Stations. Selection of Control Points and Observations shall be as detailed below:
  - The Stations selected shall be obstruction free towards sky.
  - The horizontal control station (GPS Pillars) shall be RCC (M20) pillar of size 250mm x 250mm x 750mm embedded in concrete M15 (350mm X 50 mm for the base) up to a depth of 550 mm and the balance 200 mm above the ground. Pillars shall be provided with an anchor bolts embedded in concrete with 12 mm dia. x 150 mm long. These shall be provided with punch lines & painted with anticorrosive yellow paint. All these Control Stations of GPS Survey should be provided in grid @ 2km/pair including fixing and all materials, labour, machinery, cartage, conveyance etc., complete. All Grid station and pillars shall be numbered for easy identification. & the no. should be ingrained on the pillar.
  - The control stations shall be fixed using DGPS instrument. The time of observations at Base Stations shall be observed for a minimum of 30 minutes and at Reference Stations for 15 minutes to eliminate the possible projection and time errors in the signals received from various satellites being observed at respective locations in order to ensure high accuracy in the positioning of control station within  $\pm 3$ cm.
  - Minimum of 8 satellites should be available during observation to ensure high

accuracy.

2. GPS readings in Latitude and Longitude and as well as converted into local co-ordinate system shall be submitted.
3. All the traverse stations shall be established over RCC (M20) pillars of size 150 mm x 700 mm embedded in concrete M10 (250mm X 50 mm for the base) up to a depth of 500 mm and the balance 200 mm above the ground shall be painted yellow, numbered and connected with X, Y, Z coordinates. Pillars shall be provided with an anchor bolts embedded in concrete with 12 mm dia. x 150 mm long. These shall be provided with punch lines & painted with anticorrosive yellow paint. The traverse stations should be inter visible and shall in no case the distance between two successive stations is more than 300m. These traverse stations shall be clearly shown on the AutoCAD drawing with its X, Y, Z details.



**Tentative diagram of pillars to be installed on site for survey work.**

4. The Contractor has to fix the vertical control points (BM pillars) and all levels shall be connected to the GTS bench mark over available permanent structures like parapet of culvert, plinth of building, temples etc. which are proposed to be retained in the vicinity. In the absence of such permanent structures RCC pillars of size 150mm X 150 mm X 800mm embedded in concrete M10 (50 mm all around) up to a depth of 600 mm and the balance 200 mm above the ground shall be painted yellow, numbered and connected with X,Y,Z coordinates. These BM stations shall be established at least one in every 500m intervals with double run levelling using digital/auto levels ensuring the accuracy requirements as per standards. Details of GTS bench marks shall be obtained by the Contractor from Survey of India and if necessary, assistance in obtaining the same shall be provided by the Client. Reduced Levels (RL) and BM number shall be noted. These BM stations shall be clearly

shown on the AutoCAD drawing with its X, Y, Z details and location description. Apart from the above mentioned BM pillars, the level shall also be transferred on all GPS pillars.

**ii) Detailed Topographic Survey.**

- 1 The location and details of all existing features including existing structures, utilities i.e. under-ground and over ground, trees with girth more than 0.3m, HT lines & poles, oil and gas lines, telephone lines, cart track, road crossings, railways line, natural & artificial drains, canals, water bodies, wells, bridge and culvert etc. shall be surveyed and clearly identified with respect to the existing road.
- 2 Existing ground level (spot level) to be collected at a grid interval of 50 m. Additional spot level may be taken in lesser interval if necessary to get the terrain profile.

The Contractor shall carry out;

- Fixing horizontal control points with differential Global Positioning System (DGPS).
- Running traverse with total station between horizontal control points established by DGPS.
- Fixing of vertical control points (BM Pillar) by double run levelling by connecting GTS Bench Marks available in the vicinity of the Project Road.
- Detailed topographic survey for collection of field details using total station.
- Submission of detailed Survey data (including raw data) in MS EXCEL with clear code scheme for different features; dxf; sdr or equivalent; and AUTOCAD drawings with X, Y, Z co-ordinates (This data would be used by the client at Design office for the design of horizontal alignment and vertical profile).
- All drawings prepared by the surveyors shall confirm to the Client's requirements. The survey will be verified by the Client for accuracy or missing details. In case of missing information and errors the survey will not be treated as complete and surveyor will have to comply to provide required information.

**13.2 Raw Water Transmission main from Pumping Station at Pipli to WTP at TP1**

- The Contractor shall carry out detailed topographical survey for transmission main route from Pumping station site at Pipli to WTP at TP1 of Dholera SIR.
- The Contractor needs to identify the permanent bench mark for the survey from GTS and needs to transmit along the route. The Contractor also needs to create temporary benchmarks along the route on permanent structures and need to present in the survey details.

- Existing ground levels (spot levels) to be collected at a longitudinal interval of 30 m. along the route of the pipeline covering the proposed corridor and in addition There should be 3 spot levels, one at the centre of road and other 2 at the road edges. Additional spot levels may be taken in lesser interval if necessary to get the terrain profile. Detailed topographic survey for collection of field details is to be carried out using total station after establishing GPS and completion of traverse.
- The Contractor shall submit detailed topographic survey for collection of field details using total station and with proper geo-referencing. Submission of detailed survey data in MS EXCEL with clear code scheme for different features; dxf; sdr or equivalent and AUTOCAD drawings with X,Y,Z coordinates All drawings prepared by the surveyors shall confirm to the Client's requirements.

#### **14 Standards and Specifications for Geotechnical Works at Pumping station site and Raw Water Transmission Main Route**

##### **Geotechnical Investigation:**

- The Contractor shall carryout geotechnical investigation for pumping station. The Contractor needs to present the exact location of each borehole in X and Y coordinates. The depth of each borehole shall be minimum 10 m for strong sub soil conditions ( e,g sandy strata ) and minimum 30 m for weak soil conditions (i.e. clay strata). The Contractor needs to finalise the depth of boreholes in consultation with Employer/Employer's Engineer.
- The Contractor shall carryout geotechnical investigation for Potable water transmission main alignment and at river crossings. The Contractor needs to present the exact location of each borehole in X and Y coordinates. The Contractor needs to finalise the depth of boreholes in consultation with Employer/Employer's Engineer.

- **In-situ Standard Penetration Tests**

All in-situ testing is to be carried out by personnel who have been trained and are experienced in the use of the equipment, the test methods and the recording of results. The penetration resistance may be measured using the test equipment and procedures as described in BIS 1377 or equivalent Indian Standard and used for computation of the bearing capacity of the soil. Test equipment's should be properly calibrated before being used for testing.

- **Laboratory testing**

Laboratory testing shall be in accordance with BIS-1377 or equivalent Indian Standard. The tests to be carried out on each sample shall comprise:

- Classification / particle size distribution.
- Moisture content.
- Liquid limit, plastic limit and
- Plasticity index.
- Strength parameter
- Standard tests required for stability analysis shall be done

### LABORATORY TEST

| Sr. | Test  | Equipment  | Purpose of testing  |
|-----|---|--|---|
| a)  | Grain size analysis<br>IS 2720-IV   | Coarse sieve (80 mm. 03, 37.5, 25.8 20.00, 10.0, 6.3, 4.75 mm)<br>Fine sieve (21 mm 600 micron, 425, 212, 75 micron), balance oven, stirrer, hydrometer with jars. | Indicates classification of soil and thereby getting indication of data obtained from grain size distribution curves which will be used in the design of embankment and to determine suitability of soil for road construction. |
| b)  | Atterburg limit<br>IS 2720-V  | Liquid limit device grooving tools and sieves, oven, uppal's cone penetrometer.  | Indicates properties of soils as per the IS, test not possible for nonplastic soils which are used for casing.  |
| c)  | Standard compaction<br>IS 2720-VII  | Standard compaction mould with base, collar, and rammer, soil, extractor balance 20 kg. oven 212.75 micron, balance oven, stirrer, hydrometer with jars.           | For determining the maximum density which can be attained on field optimum moisture content, with standard energy.  |
| d)  | Relative density<br>IS 2720-XIV   | Relative density apparatus, vibrator, balance 50 kg. oven.   | Similar as above but for coarse grained soil.   |
| e)  | Field density and moisture<br>IS : 2778<br>XXVII-1974<br>XXXX-1975<br>XXXIII-1971 | Core cutter and replacement kit and water replacement kit.   | To determine the placement density and monitor compaction effect. It also indicates adequacy of moisture content.   |
| f)  | Permeability<br>IS 2720-XVII-1966   | Permeability apparatus soil extractor, oven.   | To decide drainage condition under which the soil will behave in field, anticipate probable seepage and design drains.  |
| g)  | Direct shear<br>IS 2720-IV  | Direct shear apparatus soil extractor, balance 5 kg.   | To determine shear strength of soil in foundation or in embankment.   |

| <b>Sr.</b> | <b>Test</b>  | <b>Equipment</b>  | <b>Purpose of testing</b>  |
|------------|--|---|--|
| h)         | Consolidation<br>IS 2720-XV-1965                                 | Consolidate test apparatus, oven balance.   | To determine settlement rate and magnitude and to assess whether soil is normally consolidated or pre-consolidated.  |
| i)         | Moisture content<br>IS 2720-II-1973                              | Balance oven or rapid moisture meter.   | To determine degree of saturation, consistency rate of a natural strata or a compacted fill.   |
| j)         | Determination of the Consolidation properties<br>IS 2720 Part 15 | Consolidation Ring Porous Stones Consolidation Cell, Dial Gauge, Loading Device, etc. | This method for conducting one dimensional consolidation test using either fixed or the floating ring for determining the consolidation characteristics of soil. |
| k)         | Swelling pressure  | Consolidometer, Dial Gauge, oven, etc.  | The pressure which the expansive soil exerts, if the soil is not allowed to swell or the volume change of the soil is arrested.                                  |

- **Reporting**

The Contractor's geotechnical report for the site of proposed structure shall contain the borehole logs, depth of sampling, SPT test results, laboratory test results and site plans showing borehole locations. Levels for borehole logs will be given with reference to the GTS Datum.

The Contractor shall include in the geotechnical report recommendations for any additional investigations.

The Contractor shall prepare the report including the clear recommendation about the strength of the sub soil, settlement properties and foundation requirements of pipe lines and structures along the transmission line.

**Appendix D I – List of Acceptable Makes of Equipment**

(Schedule-D)

| <b>S#.</b> | <b>Equipment</b>  | <b>Acceptable manufacturer/ vender</b>  |
|------------|---|---|
| 1.         | Submersible Pumps                                       | Grundfos<br>Aqua<br>Mather Platt<br>Kirloskar Brother   |
| 2.         | Sluice Valves   | Kirloskar Brothers Ltd.<br>Indian Valve Company,<br>VAG   |
| 3.         | Non return valves                                       | Kirloskar Brothers Ltd.<br>Indian Valve Company (IVC)<br>VAG  |
| 4.         | Sluice Gates  | Jash Engineering (P) Ltd.<br>The Indian Valve Co.<br>Oriental Castings<br>Upadhaya  |
| 5.         | Cast Iron<br>Pipes & Fittings and Dismantling<br>Joints | Baroda Rollings Mills<br>The Indian Iron & Steel Company Ltd.<br>Bharat Industrial Corporation<br>Oriental Castings<br>Electro Steel Castings<br>Jindal |
| 6.         | DI pipe and specials                                    | Electro Steel Castings<br>Jindal<br>Electrotherm India Ltd<br>kalahasti   |
| 7.         | Crane   | W.H. Brady & Co. Ltd.<br>Hercules Hoists Ltd. Avon Cranes<br>Reva   |
| 8.         | Chain Pulley Block                                      | Hercules Hoists Ltd.<br>W.H. Brady & Co. Ld.  |
| 9.         | Butterfly Valves  | Fouress<br>Indian Valve Co.<br>Kirloskar<br>VAG   |



| <b>S#.</b> | <b>Equipment</b>   | <b>Acceptable manufacturer/ vender</b>  |
|------------|--|---|
| 10.        | MS pipes   | Tata Pipes<br>Jindal Pipes<br>Jadia Pipes (India) Ltd.<br>SAIL  |
| 11.        | Compressor   | KG Khosla Compressors Ltd.<br>Atlas Copco Ltd.<br>Ingersol<br>Rand  |
| 12.        | 415 V Type Tested Low Voltage Switch- gear, Control gear and Panel | Larsen & Toubro Ltd – L&T<br>Siemens Limited<br>Schneider<br>ABB  |
| 13.        | Lighting Fixtures  | Crompton Greaves Ltd.<br>Bajaj,<br>Philips,<br>Osram,<br>Wipro Ltd.   |
| 14.        | Cables / Wires   | Universal Cables<br>KEI<br>Gloster Cables<br>Grandlays<br>Finolex<br>Cable Corporation of India<br>Polycab<br>RPG |
| 15.        | Power Capacitors, APFC Relay, Detuned Filters                      | Crompton Greaves Ltd.<br>Schneider<br>EPCOS<br>Siemens<br>L&T   |
| 16.        | Dry type Transformers  | VOLTAMP Transformer Ltd.<br>Crompton Greaves Ltd.<br>ABB<br>Schneider   |
| 17.        | 11 kV Shielded Solid Switchgear Switchgear Panel                   | ABB<br>Schneider Electric<br>BHEL<br>Siemens India<br>L&T   |

| <b>S#.</b> | <b>Equipment</b>  | <b>Acceptable manufacturer/ vender</b>  |
|------------|---|---|
| 18.        | Relays (for 415 V / 11KV switchgear)                    | ABB<br>Schneider Electric<br>Siemens<br>L&T   |
| 19.        | Instrument Transformers (CT's & PT's)                   | Automatic Electric Pvt. Ltd.<br>Kappa Electricals<br>Advance Engineering Co.<br>ELMEX<br>L&T                                    |
| 20.        | Wiring Conduits   | NECBEC<br>Kalinga<br>Duraline   |
| 21.        | Automatic Power Factor Control (APFC) Panel             | Crompton<br>Larsen & Toubro Ltd.<br>Schneider<br>EPCOS  |
| 22.        | Electrical Actuators with Motor Control & Control Panel | Rotork Control (India) Ltd.<br>AUMA   |
| 23.        | PLC system  | Honey well<br>Yokogawa<br>ABB<br>Schneider  |
| 24.        | Distributed Control System (DCS)                        | Honey well<br>Yokogawa<br>Invensys<br>ABB   |
| 25.        | Gear box  | Greaves<br>Elcon<br>Alen Berry<br>Mazda   |
| 26.        | Instrument & Meters                                     | Automatic Electric Ltd.<br>Meco Instruments (P) Ltd.<br>SECURE<br>Industrial Motors Pvt. Ltd.<br>Universal Electric Ltd.<br>L&T |

| <b>S#.</b> | <b>Equipment</b>                     | <b>Acceptable manufacturer/ vender</b>   |
|------------|--------------------------------------|--|
| 27.        | Actuator                             | AUMA<br>Rotork<br>Marsh  |
| 28.        | Pressure Gauges                      | Manometers India Limited<br>H Guru Instruments Pvt. Ltd.<br>General Instruments (P) Ltd.<br>A.N. Instruments |
| 29.        | Multimeter                           | Escorp<br>Motwane<br>Megger  |
| 30.        | Online Analyser                      | Polymetron<br>ABB<br>E&H<br>Yokigawa<br>Hach<br>Forbes & Marshall  |
| 31.        | DC Power Pack                        | Siemens<br>ABB<br>L & T<br>Alstom  |
| 32.        | Mechanical Flow Meter                | Kent<br>Schlumberger<br>Capstan  |
| 33.        | Mechanical Flow Meter (Turbine Type) | Kent<br>Schlumberger<br>Capstan<br>Nivo Control<br>Sapple-Rahul  |
| 34.        | Magnetic insertion flowmeter         | Crone<br>Marshal<br>Nivo Control<br>Ultraline<br>IEPL<br>Rose Mount<br>Letrotek Crystal<br>ODNI              |

| <b>S#.</b> | <b>Equipment</b>  | <b>Acceptable manufacturer/ vender</b>   |
|------------|---|--|
| 35.        | DG Set  | Sudhir<br>Cummins<br>Sterling<br>Cater Pillar<br>Perkins   |
| 36.        | Electric Poles  | Jindal<br>Tata<br>Bajaj  |
| 37.        | VFD   | Schneider<br>Siemens<br>ABB<br>Allen Bradley<br>L&T  |
| 38.        | Flame Proof Push Button Station & Lighting Fittings   | Siemens<br>Schneider<br>BCH<br>Havells<br>Osram<br>Crompton Greaves Ltd.<br>Philips<br>Wipro Ltd.<br>FCG<br>Flexpro<br>Baliga<br>PIECO |
| 39.        | Ultra-sonic / Electromagnetic flowmeter, Ultrasonic level transmitter, Pressure transmitter | Krone Marshall<br>Endress & Hauser (India) Pvt. Ltd.<br>Siemens<br>Yokogawa  |
| 40.        | RTUs  | Siemens<br>Yokogawa<br>ABB,<br>Endress & Hauser (India) Pvt. Ltd.<br>Schneider<br>Honeywell  |
| 41.        | Motorized Control valves  | Endress & Hauser (India),<br>Yokogawa,<br>ABB  |

| <b>S#.</b> | <b>Equipment</b>            | <b>Acceptable manufacturer/ vender</b>                    |
|------------|-----------------------------|---|
| 42.        | Level Sensors/Float Switch  | FLYGT<br>SBM<br>Punetehtrol                               |
| 43.        | Sandwiched Bus duct         | ABB,<br>Legrand,<br>Schneider                             |
| 44.        | Multifunction Meter (MFM)   | Siemens,<br>Schneider,<br>ABB<br>L&T                      |
| 45.        | UPS                         | Schneider (APC),<br>Emerson,<br>EATON                     |
| 46.        | Battery                     | Standard Batteries Ltd.<br>Amco Batteries Ltd.<br>Exide   |
| 47.        | Battery Charger             | Expo Lobotek Rotromi / Chhabi<br>Gould Electronics BCH    |
| 48.        | Connectors/ Terminal Blocks | Elmex,<br>Schneider Electric,<br>Phoenix                  |
| 49.        | Timers,<br>Indicating Lamps | Siemens,<br>ABB,<br>Schneider<br>L&T                      |
| 50.        | HDPE/DWC Pipe               | Finolex,<br>Supreme<br>Duraline                           |
| 51.        | Soft Starter for motors     | Rockwell<br>Schneider<br>Siemens<br>Danfoss<br>ABB<br>L&T |

| <b>S#.</b> | <b>Equipment</b>   | <b>Acceptable manufacturer/ vender</b>                           |
|------------|--|--|
| 52.        | DOL Starters for motors  | L&T<br>Siemens<br>ABB<br>Schneider<br>C&S                        |
| 53.        | LT Variable Frequency Drive (VFD)  | Schneider<br>Danfoss<br>Siemens<br>ABB<br>L&T                    |
| 54.        | SMPS   | Pheonix<br>Schneider<br>ABB<br>Rockwell                          |
| 55.        | Cables(Power & Control)  | Havells<br>Gloster<br>KEI<br>KEC International<br>Sterlite<br>LS |
| 56.        | Intelligent MCC Panel /MPCB Panel/<br>L.T Panels / PDB Panel / LDB Panel | Schneider<br>L & T<br>Siemens<br>ABB                             |
| 57.        | Switchgear   | L & T<br>ABB<br>Siemens<br>GE                                    |
| 58.        | Control Gear   | L & T<br>ABB<br>Siemens<br>GE                                    |
| 59.        | Contactora   | L & T<br>ABB<br>Siemens<br>Schneider                             |

| <b>S#.</b> | <b>Equipment</b>                             | <b>Acceptable manufacturer/ vender</b>              |
|------------|--|---|
| 60.        | Over Load Relay                              | L & T<br>ABB<br>Siemens<br>Schneider                |
| 61.        | PUSH BUTTONS and Push Button Station         | L&T<br>Siemens                                      |
| 62.        | LT Electronic Over current/ Overload Relay   | L&T<br>ABB<br>Siemens                               |
| 63.        | MV/HT Electronic Motor Protection Relay      | L&T<br>ABB<br>Siemens                               |
| 64.        | Vacuum Circuit Breakers                      | Siemens<br>ABB<br>CGL<br>L&T                        |
| 65.        | Air Circuit Breaker                          | L&T<br>Siemens<br>Schneider                         |
| 66.        | Moulded Case Circuit Breaker (MCCB)/MCB/RCBO | L&T<br>Siemens<br>Schneider<br>ABB<br>GE<br>Legrand |
| 67.        | Street Light / Flood Light Fixtures          | CGL<br>Wipro<br>Phillips<br>Osram<br>Bajaj          |
| 68.        | Selector Switch                              | L&T<br>Leader<br>Salzer                             |
| 69.        | Air Conditioners                             | Samsung<br>LG<br>Voltas<br>Carrier                  |

| <b>S#.</b> | <b>Equipment</b>             | <b>Acceptable manufacturer/ vender</b>   |
|------------|------------------------------|--|
| 70.        | LT Capacitors                | L&T<br>ABB<br>BCH  |
| 71.        | CC TV Cameras                | Axis camera<br>Honeywell<br>Bosch<br>Cisco   |
| 72.        | ICT equipment (incl telecom) | Cisco (active devices, telephony ept etc)<br>IBM (applications / SW)<br>Lucent (for passive only)<br>Dell / HP (for servers) |
| 73.        | CPVC pipes                   | Astral<br>Finolex<br>Jain  |



## **Schedule E – Operation and Maintenance Requirements**

*(See Clause 2.1 and 14.2)*

The Contractor shall, at all times maintain the Project Works in accordance with the provision of this Agreement, Applicable Laws and Applicable Permits.

### **1. Scope of Works for O&M**

The contract includes 5 Years (60 Months) Operation & Maintenance (O&M) of Raw Water Pumping Station and Raw Water Transmission Main after successful commissioning, completion of trial run and demonstration of performance guarantee test, handover and acceptance of Raw Water Pumping station and transmission main by Employer's Engineer.. O&M shall be based on CPHEEO Manuals specified below

- a. Water supply and Treatment –Third revision-Revised & updated (May 1999)
- b. Operation and Maintenance of water supply systems (January 2005)

All spare parts and Tools & tackles as necessary for operation of the project works, for the entire O&M period, List of spare parts and Tools& tackles shall be based on CPHEEO Manual. The List of spare parts and Tools& tackles shall be approved by the Employer's Engineer before procurement. All unused spare parts and Tools & tackles will be the property of Employer at the end of the Contract Period.

### **General**

Major components and works shall include the following but not limited to:

- i. Contractor shall operate and maintain Raw water Pumping station and raw water Transmission main for 5 years on 24 hours/day basis throughout the year.
- ii. Contractor shall operate and maintain all instruments and mechanical, electrical, Instrumentation and automation equipment's in accordance with the aim and purpose of water supply up to stilling chamber of WTP at TP1 of Dholera SIR. The raw water pumping station & equipment will be totally attended to, by the Contractor including any "Troubleshooting" to ensure smooth and trouble free operation.
- iii. Contractor has to incur all the cost, taxes & duties for transportation, labours, repairing & replacing equipment, making good any part or all part of equipment, consumables, Electricity Charges, motors, pumps, gear unit, Capacitor, HT/LT Switchgear, Control Panel, valves.
- iv. The Contractor shall be responsible for procuring all spares, all tools & tackles, parts or components. Further the Contractor will plan about the requirement well in advance and procure the material from the market. Power cost would be beard by the Contractor.
- v. Contractor shall note that preparation of O&M Manual for the Raw Water Pumping station and Raw water transmission main designed and set up by them is included in Scope of Work. Contractor shall initiate and take adequate actions to ensure smooth and satisfactory performance/ running of the pumping station on a 24 hours/ round the clock basis.

- vi. The operation and maintenance service provided by the Contractor for the period specified in the Contract shall ensure the continuous operation of the raw water pumping station and that the breakdown or deterioration in performance, under normal operating conditions, of any items of pumping station and equipment and component parts thereof is kept to a minimum.
- vii. The Contractor shall carry out the Maintenance of the raw water pumping station installations in accordance with the requirements of the O & M Manual and also to the approved Maintenance Plan as mutually agreed.
- viii. The Contractor shall prepare and implement effective raw water pumping station maintenance programmed in consultation with the Employer. It is Contractor's responsibility to look after all sorts of maintenance whether preventive, Minor, Major, or break-down. The Contractor will be responsible to carry out day to day as well as periodic maintenance necessary to ensure smooth and efficient performance/running of all equipment. Contractor shall attend all the breakdown of civil, mechanical, electrical, piping and instrumentation works and maintain the raw water pumping station throughout the Contract Period.
- ix. Contractor has to keep the entire capacitor panel in working condition to maintain the power factor not less than 0.9 during No load and full load condition. Any spares required to keep capacitor panel in working condition is in the scope of the Contractor. There will be deduction from the amount if the power factor is less than 0.9. Contractor shall also record all the power failures and voltage in daily log sheet. Contractor will bring into the notice of power supply agency as well as control room and Employer's Engineer about the break down/power failure. Contractor will also get the electricity restored simultaneously. The Contractor shall follow the manufacturers' recommendations with respect to equipment maintenance, the types and grades of lubricants to be used, frequency of lubrication, adjustments to be made regularly and recommended spares to be held in store.
- x. No structure of any kind will be allowed to be constructed/ altered within the plant premises, without the approval of Employer. Nothing is to be paid by Employer for any addition if allowed. In case of damages to the building/machines and shortcoming to the machines, the same has to be made good as per original shape/good running condition by the Contractor. The decision of Employer's Engineer/ Employer in this regard shall be final and binding.
- xi. In case, the motor or any other equipment is burnt or damage due to negligence of the Contractor or due to faulty operation, it shall be sole responsibility of the Contractor to rewind/replace/repair it as per standards of the equipment free of cost. In case of any fault in operation and performance of the plant, Contractor or his staff at duty will immediately report to the Employer's Engineer about it.
- xii. The Contractor will be responsible for keeping up-to-date record of documents including History Card for equipment and maintaining every day log book relating to various analysis performed. The Contractor shall maintain and update logbook, in which details of operational parameters are recorded in every shift and at regular interval say hourly or as decided mutually. Contractor shall take the approval of the format of logbooks and records from Employer.

- xiii. The Contractor will prepare and submit daily, fortnightly and monthly reports of raw water pumping station performance and will assist the Employer in preparing the necessary documents for their purpose and records.
- xiv. Contractor shall employ appropriate and skilled manpower. The Contractor shall have to issue identity cards with photographs to all the staff employed for Operation and Maintenance. The list of the same shall be submitted to the Employer mentioning qualification & experience.
- xv. The scope of works for operation & maintenance includes the calibration of all meters e.g. pressure gauge, Ammeter, voltmeter, relay, Energy meters, temp scanners, flow meters etc. for measurement of accurate readings, 11 KV incoming line, Lighting Arrestors, D.O. fuse, earthing works, or any other maintenance required on two/four pole D P structure.
- xvi. Contractor shall be responsible for maintaining the lighting and other equipment. The premises of various works shall be provided with sodium vapor lamps LED Lamps, energy efficient industrial Indoor fixtures and also ceiling fans/exhaust fans inside the various structures. Daily on/off operation and routine cleaning of all type of electric fixtures. Replacement of lamps / Tubes / Fans in case of failure at Contractor's cost.
- xvii. Contractor shall be responsible for the maintenance of Garden, lawn, green belt etc. work shall include the watering, grass cutting, removal of shrubs, weed cutting of braches of tree/ plant, growth of garden, Plantation etc.
- xviii. Contractor shall be responsible for the maintenance of all buildings in the raw water pumping station premises. Contractor shall be responsible to keep watch on overflowing of raw water sump. If such overflow takes place the Contractor shall have to bear the damages caused to surrounding properties.
- xix. The Contractor shall carryout cement paint/ enamel paint/ white wash for exterior finish of civil units twice during in four year of O & M of the pumping station and shall also carry out painting on mechanical equipment/ above ground pipe lines/ hand railing twice in four years of O & M of the pumping station. On the expiry date of his contract operation and maintenance, the Contractor shall hand over the raw water pumping station back to employer in fully working condition. All the electrical, mechanical and instrumentation including standby shall be in perfect working condition.
- xx. The Contractor shall know all Central/State Government/ Semi-Government/Local Bodies rules regulations applicable to this contract without any excuse.
- xxi. Any dispute with the workmen shall be Contractor's responsibility as per Labour Laws/Govt. Rules and Regulations. In no way the Employer shall be responsible for the disputes between them. The Contractor shall follow the rules and regulations as per Factory Act as it is applicable.
- xxii. The Contractor shall be responsible for safety on Site during the O & M of the Works by the Contractor. Health of workers shall be protected against infectious and contagious diseases. Environmental protection shall also be given priority so as to conserve the environment.
- xxiii. The Contractor shall at his own cost provide and maintain at the Site of Works standard first aid boxes at minimum three locations as directed and approved by the

Employer for the use of his own as well as the Employer's staff on Site as stipulated by local regulations. Contractor shall arrange to train all their staff in first aid treatment within 3 months.

- xxiv. The Contractor shall provide a Notice Boards/Display Boards at appropriate locations detailing precautions to be taken by operation and maintenance personnel in work in conformity with Industries and Labour Regulations and Department of Explosives.
- xxv. All materials, works and construction operations shall conform to the Specifications for as described in CPHEEO Manuals "Water supply and Treatment –Third revision-Revised & updated (May 1999)" and "Operation and Maintenance of water supply systems (January 2005)" Where the Standards and Specifications for a work are not given, Good Industry Practice shall be adopted to the satisfaction of the Employer's Engineer

## **2. Contractor's Organization & Administration of the Contract**

- i) The Contractor shall provide experienced administrative, managerial, technical, supervisory, non-technical personnel (with CVs pre-approved by the Employer's Engineer) and labour necessary to operate and maintain the raw water pumping station properly, safely and efficiently on a continuous 24 hours basis for the full term of the O & M Contract Period. During O & M period if any expert person special persons or manpower needed, he shall have to arrange & bear pay any and all cost, charges, fare, allowances etc. for the same. The employer will not pay any cost / charges for the same.
- ii) The Contractor shall submit with his tender to the Employer the methodology for the operation and maintenance of raw water pumping station with the Schedule of 'Manpower' and 'Organization Chart showing the structure of the organization for his administration and operation of the Contract. The Contractor shall deploy a Project Manager for operation and maintenance period.
- iii) All correspondence and communication between the Employer and the Contractor including the Contractor's sub-Contractors shall be directed through the Project Manager.
- iv) Contractor shall depute the Sub Contractor only after approval of the Employer.
- v) The Contractor shall employ all the required staff immediately after the commissioning of raw water pumping station. Otherwise penalties as prescribed shall be effected
- vi) The Contractor will comply with all safety rules and regulations. The Employer will not be responsible for any accident/ injury to the staff or any person of the Contractor or loss or damage to any property. Further, the Employer will not provide any insurance or free medical facility to the staff of Contractor. Providing necessary security arrangement for safety of the raw water pumping station and Contractor's personnel will be the responsibility of Contractor.
- vii) All Central/ State Government/ Semi-Government/ Local Body's rules and regulation pertaining to this contract, all legal formalities pertaining to provident fund, factory act, and all legal formalities shall be followed and observed by the Contractor without any extra cost to the Employer. Please note that failure in complying so, all liabilities arising as per laws will be to the Contractor's account.

**3. Staffing for the operation of Raw Water Pumping station and Raw water transmission main**

The work shall be carried out on a 24 hr. basis, without intermission and the staff deployed by the Contractor shall be in accordance with this contract. The Contractor shall give or provide all necessary superintendence during the DLP and O&M period and as long thereafter as the Employer's Engineer may consider necessary. Such superintendence shall be given by a competent person having adequate knowledge of the operation and maintenance to be carried out (including the methods and techniques required), the hazards likely to be encountered and methods of preventing accident) as may be required for the satisfactory working of the pumping station

The minimum number and details of personnel to be employed by the Contractor shall be as per the table below. However the Contractor shall mention adequate number of qualified and experienced skilled staff & unskilled personnel required for O&M in his bid,

**Manpower requirement for raw water pumping station and raw water transmission main**

| <b>Man Power</b>         | <b>Pumping station and Raw Water Transmission main</b> |
|--------------------------|--|
| Manager                  | 1 in General Shift                                     |
| Pumping Station Operator | 1 in every shift                                       |
| Mechanical Fitter        | 1 in General Shift                                     |
| Electrician              | 1 in General Shift                                     |
| Helper                   | 1 in every shift                                       |
| DCS/SCADA Operator       | 1 in general shift                                     |

List of staff is to be given by the Contractor to the Employer's Engineer and advance intimation to be given before deputing/removing any staff from site during the period of contract. Not more than one of the Contractor's key staff shall be absent from the project site at any given time. In case it is necessary for more than one of the key personnel to be absent at a given time, the Contractor shall provide replacement of equivalent or better qualifications. The CVs of such replacements shall be got pre-approved from Employer in advance.

No labour below the age to 18 years shall be employed on the work. Employer's Engineer shall be authorized to direct the contracting agency to remove any or all staff employed in the pumping station if in his opinion continued presence of such staff is detrimental to safety or proper O&M of the pumping station. The Contractor shall comply with such directions & post suitable substitute(s) thereof. Whenever the Employer's Engineer has to inform the Contractor in writing that any person on the work is in his opinion unsatisfactory or/incompetent or unfaithful or dishonest untruthful or disorderly or to be otherwise unsuitable/such person shall be discharged by the Contractor from the work and shall not be employed again on it.

#### 4. Operation Schedule for Pipe lines/Raw water transmission main

- i. **Mapping and inventory of pipes and fitting:** An updated transmission system map with location of valves, flow meters, Online Analyzers and pressure transmitter is the foremost requirement of operation schedule. The valves indicated in the map should contain direction to open; number of turn to open, make of valve and date of fixing etc., the hydraulic gradient lines are to be marked to indicate the pressure in the transmission system. They can be used for identifying high pressure or problem areas with low pressure
- ii. **System pressure:** It is essential to maintain a continuous positive pressure in the transmission main at the time of transmission of water in the pipeline. Low pressure locations have to be investigated if necessary by measuring pressure with pressure gauge.
- iii. **System Surveillance:** The maintenance staff should go along the transmission line frequently so as to accomplish the following objectives.
  - To detect and correct any deterioration of the transmission system.
  - To detect if there is encroachment of transmission system failures.
  - To detect and correct if there is any unauthorized tapping of water.
  - To detect and correct if there is damage to the system by vandalism.

#### 5. Maintenance Schedule for Pipe lines/Raw water transmission main

A maintenance schedule is required to be prepared to improve the level of maintenance of water transmission system through improved co-ordination and planning of administrative and fieldwork and through the use of adequate techniques, equipment and materials for field maintenance. The schedule has to be flexible so that it can achieve team action with the available vehicles and tools. Co-ordination of activities is required for spares and fittings, quality control of materials used and services rendered. Training of maintenance staff shall, apart from the technical skills, include training to achieve better public relations with consumers.

##### a. Activities of Maintenance Schedule for Raw water transmission main

Following activities are to be included in the schedule:

- i. Develop and conduct a surveillance program for leaks in pipelines, pipe joints and valves.
- ii. Develop and conduct a water quality surveillance program.
- iii. Develop and conduct a program for locating and repairing leaks including rectifying cross connections if any, arrange for flushing, cleaning and disinfecting the mains,
- iv. Establish procedures for setting up maintenance schedules and obtain and process the information provided by the public and the maintenance teams about the pipeline leaks,
- v. Establish repair procedures for standard services and with provision for continuous training of the team members,

- vi. Procure appropriate machinery, equipment and tools for repair of leaks and replacement of pipes and valves,
- vii. Allocate suitable transport, tools and equipment to each maintenance team,
- viii. Establish time, labour and material requirement and output expected, time required and other standards for each maintenance task, and
- ix. Arrange for monitoring the productivity of each maintenance team

A preventive maintenance schedule for transmission main has to be prepared for:

- i. Maintenance of the pipelines with particulars of the tasks to be undertaken, works not completed, and works completed,
- ii. Servicing of valves, expansion joints etc.
- iii. Maintenance of all valves valve chambers,
- iv. Maintenance of DCS/SCADA and related field instruments e.g. RTUs, motorized control valves, online analyzers, pressure transmitters, electro-magnetic bulk flow meters, power cables, fiber cables, instrumentation cables etc
- v. Maintenance of record of tools, materials, labour, and
- vi. Costs required for carrying out each task.

**b. Activities for Preventive Maintenance for Raw water transmission main**

- a) **Servicing of valves:** Periodical servicing is required for valves, expansion joints flow meter and pressure gauges. Corrosion of valves is the main problem in some areas and can cause failure of bonnet and gland bolts. Leaks from spindle rods occur and bonnet separates from the body. Stainless steel bolts can be used for replacement and the valve can be wrapped in polythene wrap to prevent corrosion. Regular greasing of the gears and actuator stems are required for the motorized valves. Manufacturer's catalogues may be referred and servicing procedure should be prepared for the periodical servicing.
- b) **Servicing of RTU:** Regular cleaning inside the panel for keeping it dust free and tightening the terminals.
- c) **List of spares:** List of spares procured for the transmission system shall be prepared by the Contractor; the spares shall be procured by the Contractor and kept for use inside the pumping station premises. The spares may include check nut, spindle rods, bolt and nuts are flanged joints, gaskets for flanged joints for all sizes of valves, consumables like gland rope, grease, cotton waste, jointing materials like rubber gaskets, spun yarn, pig-lead and lead wool etc.
- d) **List of tools:** The maintenance staff shall be provided with necessary tools/equipment's for attending to the repairs in the transmission system. These tools may include key rods for operation of sluice valves, hooks for lifting manhole covers, pipe wrench, DE spanner set, ring spanner set, screw drivers, pliers, hammers, chisels, caulking tools, crow bars, spades, dewatering pumps.

## **6. Records and Reports for Maintenance of Pipelines**

- a. Updating transmission system maps with alignment plans. Longitudinal sectional plans,
- b. Record of daily readings of electro-magnetic bulk flow meter at upstream and downstream end of pipeline,
- c. Record of water level of sump at both upstream and downstream end of transmission system.
- d. Pressure reading of the transmission system.
- e. Identification of persistent low pressure location along the pipeline.
- f. Record of age of pipes.
- g. Identify pipelines to be replaced.
- h. Identify source of leaks.
- i. Record of Bulk meter/water meter reading before the delivery into WTP
- j. Record on when the pipeline leaks were repaired or pipe changed and the cost of materials and labour cost thereof.

## **7. Maintenance for Raw Water Pumping Station**

The scope of maintenance shall be limited to the installations made under the contract. The Contractor shall provide all labour and material required and shall be responsible for:

- i. To maintain power factor of 0.90, for the installed pumps failing which, the Contractor shall be liable of all type of penalties imposed by the respective power supply agency.
- ii. To maintain the raw water pumping station along with all instruments in working conditions.
- iii. Routine maintenance of the entire control system and instruments as per recommendation of the manufacturer.
- iv. Replacement of damaged control cables, and power supply cables.
- v. Repair of all instruments such as flow meters, pressure transmitters, float levels, loggers along with all other equipment.
- vi. Periodic calibration of all measuring/metering equipment, every 6 month.
- vii. To produce and submit monthly customized reports.
- viii. Repair/replacement of damaged electrical equipment / parts for proper functioning of electrical system
- ix. Routine maintenance of the pumps as per recommendation of the manufacturer.
- x. Replacement of bearings, damaged impellers and other damaged parts so that the operation of pumps ensures the guaranteed efficiencies with desired noise and vibration levels.



- xi. Breakdown maintenance of all electrical, mechanical, instrumentation equipment.

## **8. Maintenance for Raw Water Sump**

The Contractor shall provide all labour and materials required and shall carry out following maintenance work, during O & M period:

- i. Repair of damaged portions of sump
- ii. To operate and check all valves, instruments and do the required maintenance work to ensure their smooth and proper functioning.
- iii. Cleaning and bleaching of the sump once in 6 months as per direction of Employer's Engineer. The date of cleaning and bleaching shall be painted on the signboard installed near the sump
- iv. Repair of the damaged portions of the plinth protection works.
- v. To maintain the sump, its surrounding and the campus in a neat and tidy manner.

Other activities required for maintaining the sump and their surroundings in neat conditions.

## **9. Safety/Security**

The Contractor shall take all safety precautions under various Acts/Rules, under central/State Govt. from time to time and he shall be responsible for safety of its staff & material and the consequences thereof. The Contractor shall be completely responsible for the safety of the pumping station, equipment under his scope and his personnel during the O&M period.

### **Responsibility for damages**

The Contractor shall be responsible for all accidents or damages from whatever cause arising and chargeable for anything that may be stolen, removed destroyed or damaged to whomsoever belonging and also for making good all defects and damages to the said works or to any property adjoining or any cause whatever, whether such damage or defects were occasioned by the negligence of the Contractor or not or may be or might have been discovered during the progress to be known after the completion whereof or whether payment may wholly or partially have been made or the works approved as supposed to have been properly done.

Adequate safety precautions against fire, flooding, lightening, electrical shocks, accident due to moving/non-moving heavy/light equipment shall be strictly observed by the Contractor at his own cost. Suitable safety measures like gumboots, gloves, safety belts, ladders, safety lamps, insulated tools, alarms etc. shall be provided by the Contractor. Necessary medical first aid kit shall be made available all the time. In absence of observance of above safety precautions, the Contractor shall be responsible for any unforeseen loss of the equipment or persons dealing with it. Any incidence of human life or accident will be totally Contractor's responsibility.

The Contractor shall ensure that the staff employed takes all necessary precautions while carrying out the work either in shift duties or any general shift as per Indian Electricity Rules/Factory Act/CPHEEO Manual. In the event of any accident on or off site, in which the Contractor or his personnel are involved, in which an injury occurs to any

person whether directly concerned with the project or a third party, the Contractor shall inform Employer within 24 hrs. of the occurrence of the event. The pumping station will be open to local/state/central agencies for verification of safety/emission/acts compliance. Only bona-fide persons shall be allowed in the pumping station premises being a prohibited area. Smoking and drinking are prohibited in the pumping station site.

The staff engaged shall wear common uniform with name plate indicating name and designation during duty hours.

#### **10. Hazardous Waste**

The Contractor, after first notifying the Board, shall be responsible for fulfilling all requirements associated with any release of any substance into the environment (from the facility or the site) as required by Applicable law or by any Legal Entitlement including but not limit to the notification or reporting of releases / Hazardous substances or Hazardous Waste. The Contractor shall prepare a memorandum evidence such notification or reporting and provide copies thereof to the Board, along with any documents provided to the relevant regulatory agency regarding such release.

The Contractor shall process and obtain the clearance of all such agencies as required for the purpose, including all clearances during 5 years O&M period. He shall be fully responsible to comply with all requirements of Laws including hazardous substances, emission standards for air, discharge standards for effluent oil, sub-soil pollution.

The contracting agency shall not release any hazardous/toxic materials inside the premises.

#### **11. Technical Audit**

The Employer/Employer's Engineer has the right to conduct a technical audit of the Facility and to perform any analysis or inspection if deems necessary. Before any such inspection the Employer/ Employer's Engineer shall give a prior written notice of three days to the Contractor. The Contractor shall at the Contractor's sole cost and expenses provide all assistance the Employer/ Employer's Engineer requires to complete these inspections. Such audits may cover all or any of the obligations of the Contractors, including without limitation.

- (a) Verification of the system / capacity for normal wear and tear during the O&M.
- (b) Verification of the performance standards and useful life of the individual assets of the facility, for normal wear and tear during O&M.
- (c) Verification of the capacity of the facility to meet Output standards.
- (d) Measurement of various parameters of power generated.

#### **12. Reporting**

The Contractor will prepare daily / monthly reports of project performance and submit to the Employer Engineer and will assist the department in preparing the necessary documents for their purpose and record. The reports shall contain, inter-alia, the following:

- A description of the maintenance work carried out in the reporting period.
- A report on major failures, if any, their causes and remedial actions taken.

- Power consumed in the reporting period.
- An inventory of the spare parts available at the end of the reporting period.
- O&M staff deployed by the Contractor during the reporting period.
- Any major repair works, if any.

Contractor is required to maintain separate register/computerized records at all sites of following information:

- Pumping register
- Working hours register
- Electric break down register
- Maintenance register
- Staff attendance register
- Equipment breakdown, repair record and extent of repair
- Any other register, as directed by the Employer's Engineer

### **13. Site Order Book**

Site order Book shall be kept by the Employer Engineer at the pumping station site. Orders / instructions entered in this Book by the Employer Engineer or his authorized representative for the Contractor in respect of the pumping station, shall be held to have been formally communicated to the Contractor. The Employer Engineer or his authorized representative shall sign each order as it is entered and will hand over the duplicate to the Contractor or his agent, who shall sign the original in acknowledgment of having received the order.

### **14. Training for Employer staff**

Training shall be provided by the Contractor to Employer staff as per **Appendix E-IV**.

The schedule for repairs and rectifications works is given in attached **Appendix E-I**. **Appendix E-II** contains the operating details and functional Guarantees by the Contractor is covered in **Appendix E –III**. **Appendix E-IV** contains the requirements of Training for Employer staff.

**Appendix E I – Repair/Rectification of Defects and Deficiencies for Raw Water Pumping station and Raw water Transmission Main**

(Schedule E)

The Contractor shall repair and rectify the Defects and deficiencies specified in this **Appendix E-I** of Schedule-E within the time limit set forth in the table below.

**Table 16**

| Nature Of Defect Or Deficiency                   |   | Time Limit For Repair/Rectification             |
|--|---|---|
| <b>1. Raw Water Pumping station</b>              |   |   |
| (i)  | Pumps- any failure  | Within 24 hours                                 |
| (ii)   | All Other Electrical & Mechanical, Instrumentation equipment for Pumping Station what type of failure                           | As early as possible (maximum within 48 hours ) |
| (iii)  | Leakages in Water retaining Civil Units   | Within 24 hrs                                   |
| (iv)   | Paint to Water retaining Civil units  | Once in two year                                |
| (vi)   | Any fault related to Automation system including Field sensor, Automation panel, Calibrations of Sensors including PLC settings | Within 24 hours                                 |
| <b>2. Transmission Main</b>                      |   |   |
| <b>(a) Transmission mains</b>                    |   |   |
| (i)  | Bursts in the transmission mains of water supply system   | 6 hrs from occurrence                           |
| (ii)   | Flushing of transmission main   | Once in 6 months                                |
| (iii)  | Leakages in pipeline  | 8 hrs   |
| (iv)   | Major damages in pipeline or replace  | 24 hours  |
| <b>(b) Sluice Valve/Air Valve/Reflux Valve</b>   |   |   |
| (i)  | Faults and minor failures   | 6 hrs   |
| (ii)   | Faults and major failures   | 24 hrs  |
| (iii)  | Preventive maintenance for valves   | Once in 6 months                                |
| <b>I Inlet pipe, Interconnecting Piping etc.</b> |   |   |
| (i)  | Leakages in pipeline  | 2 hrs   |
| (ii)   | Faults and major failures   | 6 hrs   |
| <b>(e) Valve Chambers</b>                        |   |   |
| (i)  | Damages to valve chambers   | 24 hrs  |
| (ii)   | Overflow of valve chambers  | 2 hrs   |
| (iii)  | Cleaning of valve chambers  | Once in 3 months                                |
| <b>(f) DCS system /SCADA operating System</b>    |   |   |
| i)   | Communication failure   | 6 hrs   |
| ii)  | Power failure   | 6 hrs   |
| iii)   | RTU and related instruments failure   | 6 hrs   |
| iv)  | Preventive maintenance for all instruments including calibration  | Once in 6 months                                |
| <b>(g) CCTV Surveillance</b>                     |   |   |
| i)   | Communication failure   | 6 hrs   |
| ii)  | Power failure   | 6 hrs   |

| Nature Of Defect Or Deficiency |   | Time Limit For Repair/Rectification |
|--------------------------------|---|-------------------------------------|
| v)                             | Camera and accessories failure                    | 6 hrs                               |
| vi)                            | Preventive maintenance for camera and accessories | Once in a month                     |

**Table 17: General Preventive Maintenance Checks for Raw water pumping station and Raw water Transmission Main**

| General Preventive Maintenance Checks/Test |   |
|--|---|
| <b>(a)</b>                                 | <b>The following checks to be performed daily by the Contractor's personnel</b>   |
| (i)  | Whether there is a change in the sound of a running pump, abrupt changes in bearing temperature and seal leakage?   |
| (ii)                                       | The pump capacity, pressure, power consumption and vibration level to check if outage is required to address deterioration of specified performance values. |
| (iii)                                      | Rise in temperature of bearings in motor, in moving parts and other units, etc.   |
| (iv)                                       | Working of gauges, sensors and other flow measuring devices   |
| (v)  | Average power factor, kWh consumed  |
| (vi)                                       | Measurement of Raw Water Quality parameters (turbidity, pH, TDS)- Inlet of Raw water sump, stilling chamber of WTP etc.                                     |
| (vii)                                      | Measurement of Raw water quantity- Inlet of Raw water sump, stilling chamber of WTP etc.  |
| (x)  | Pumping Hours to be recorded  |
| (xi)                                       | Measurement of Water loss – Raw water transmission main   |
| (xii)                                      | Measurement of Pressure –Inlet to raw water sump, Raw water transmission main and at stilling chamber of WTP  |
| <b>(b)</b>                                 | <b>The following checks to be performed weekly by the Contractor's personnel</b>  |
| (i)  | Pipeline and valve leakage  |
| (ii)                                       | Functioning of non-return valve   |
| (iii)                                      | Tightness of all electrical connections of all unit panels etc.   |
| (iv)                                       | Tightness all cable connections   |
| (v)  | Temperature rise due to loose connections   |
| (vi)                                       | Operation of valves and sluice gates  |
| (vii)                                      | Current and voltages in all electrical equipment  |
| (ix)                                       | Lights on/off   |
| (x)  | Leakage current for all power distribution  |
| <b>xi)</b>                                 | <b>Visual defects for Civil, Electrical, Mechanical &amp; Instrumentation works</b>   |
| xii)                                       | Assessment of “C” value for Raw water transmission main   |
| xiii)                                      | Actuators for motorized valves  |
| <b>(c)</b>                                 | <b>The following checks to be performed monthly by the Contractor's personnel</b>   |
| (i)  | Battery voltage, battery charger, topping of distilled water, tightness of terminations etc.  |
| (ii)                                       | Gland packing   |
| (iii)                                      | Wear and tear of moving parts   |
| (iv)                                       | Adoption of Electrical energy conservation methods and energy consumption   |
| (v)  | Electrical contacts   |

|            |   |
|------------|---|
| (vi)       | Motors  |
| (vii)      | Meggering of electrical equipment   |
| (viii)     | Watering of earthen pits  |
| (ix)       | RTUs  |
| <b>(d)</b> | <b>The following checks to be performed quarterly by the' Contractor's personnel</b>  |
| (i)        | Relay testing and calibration if possible of meters, gauges, instruments  |
| (ii)       | Speed of motors   |
| (iii)      | Level gauges and flow meters signals  |
| (iv)       | Cleaning, checking/tightening of L.T. Circuit / Panel   |
| (v)        | Auxiliary DB, Capacitor bank  |
| (vi)       | Calibration of Instrumentation devices- Flow meters, Online Analyzers, transmitters etc.  |
| (vii)      | Battery and Battery charger   |
| viii)      | Asset Management-Updating of Inventory including reconciliation   |
| <b>(e)</b> | <b>The following checks to be performed bi-annually by the Contractor's personnel</b>   |
| (i)        | Free movement of stuffing box glands, gland bolts to be cleaned & lubricated and packing to be inspected to determine whether it requires replacement.  |
| (ii)       | Pump and motor alignment should be checked and corrected if necessary.  |
| (iii)      | Grease lubricated bearings should be checked to see that they contain the correct amount of grease and that it is still of suitable consistency   |
| <b>(f)</b> | <b>The following checks to be performed annually by the Contractor's personnel</b>  |
| (i)        | Vibration should be reviewed. If the pump is tending towards unacceptable vibration levels:   |
|            | <ul style="list-style-type: none"> <li>➤ The bearing should be removed, cleaned and examined for flaws and wear</li> <li>➤ The bearing housing should be carefully cleaned</li> <li>➤ Rolling element bearings should be examined for scratches and wear</li> <li>➤ Immediately after cleaning, rolling element bearings that are considered acceptable for reinstallation should be coated with grease.</li> </ul>                                       |
| (ii)       | Shaft sleeve and shaft should be examined for wear.   |
| (iii)      | When coupling halves are disconnected for an alignment check, the vertical shaft movement of a pump with sleeve (journal) bearing should be checked at both ends with packing or seals removed. Any movement exceeding the original design clearance should be investigated to determine the cause. Endplay allowed by bearings should also be checked. If it exceeds that recommended by the manufacturer, the cause should be determined and corrected. |
| (iv)       | Stuffing boxes should be repacked and the pump & motor should be realigned and reconnected  |
| (v)        | Overhauling requirement of all equipment  |
| (vi)       | Improvement required if any in operation of pumping station   |
| (vii)      | Testing and Calibration of all instruments  |
| (viii)     | Transformer cleaning, checking  |
| (viii)     | DG set cleaning, checking   |

## **Appendix E II – Operating Details**

(Schedule E)

### **Operating Details**

Contractor shall furnish the O & M Manual highlighting the following aspects but not limited to:

- Daily Maintenance
- Weekly Maintenance
- Annual Maintenance
- Tested to be carried out for preventive maintenance on Daily, Weekly and Annual basis.
- Staffing acquirements, structure and skill set for each type of staff
- Operating instructions
- Safety measures/precautions
- Replacement of spare parts, tools & tackles
- Requirement of consumables
- Standard Operating Procedures(SOP)

### Appendix E III – Contractor’s Functional Guarantees

(Schedule E)

#### 1. General

This schedule sets out the functional guarantees required for the calculation of Liquidated Damages for failing performance guarantees.

The contractor shall provide values of electrical energy for the quantity of raw water given in Schedule-D technical specifications.

#### 1.1 Raw water Output

The expected quantum of Raw water from raw water pumping station shall be as below:

| S# | Year                      | Expected raw water quantity at raw water sump of pumping station |
|----|---------------------------|--|
| 1  | O&M -1 <sup>st</sup> year | 7 MLD  |
| 2  | O&M- 2 <sup>nd</sup> year | 14 MLD   |
| 3  | O&M -3 <sup>rd</sup> year | 22 MLD   |
| 4  | O&M -4 <sup>th</sup> year | 30 MLD   |
| 5  | O&M -5 <sup>th</sup> year | 30 MLD   |

Note:

- i. The expected raw water quantity will vary depending on Dholera SIR development. The Employer may supply different quantities than mentioned above
- ii. In case of supply other than the quantities mentioned, the O&M costs will be paid on pro-rate basis with respect to supplied and expected raw water quantities.



## 2. **Functional Guarantees**

The Contractor must guarantee that the performance in the O&M period shall be as follows:

### 2.1 Loss of Water in Transmission and pumping station

The total water loss in pumping station, raw water transmission main shall not be more than 0.2% of the water input for any given month.

Pumping Station – Max. 0.05 % loss of the water input

Transmission Main – Max. 0.15% loss of the water input

### 2.2 Guaranteed 'C' Value

Guaranteed 'C' value for each section of the DI raw water transmission main under the project works shall be minimum 140.

2.3 Penalties: Due to losses or otherwise in case of reduced supply of raw water to Stilling chamber of WTP in respect of the guarantees as given above the penalties as mentioned in Schedule-M will be applicable

*Appendix E IV – Training for Employer staff*

(Schedule E)

The Contractor shall furnish here what training he proposes to provide to Employer's staff:

**1. Off the Job training**

- To provide training for the following in accordance with the Employer's requirements
- General Training for all Trainees Training for Operators
- Training for Electrical Maintenance Staff
- Training for Instrumentation staff Training for Mechanical maintenance staff

**2. On the Job training**

- On the job Training for 5 persons (Employer staff staff)

The above training will include costs for all documentation, training aids and training hand-outs etc.

Each of the courses mentioned above shall consist of 8 hours a day, 7 working days per quarter for Employer's person not exceeding 10 nos.

The training at Sl. no. 1.0 shall be carried out during the last year of O&M period and training at Sl.no 2 shall be carried out during each quarter of 5 every year of O&M period.–

## **Schedule F – Applicable Permits**

*(See Clause 3.1.5 (a))*

### **1. Applicable Permits**

The Contractor shall obtain, as required under the Applicable Laws, the following Applicable Permits:

- (a) Permission of the State Government for extraction of boulders from quarry;
- (b) Permission of Village Panchayat and Pollution Control Board for installation of crushers;
- (c) License for use of explosives;
- (d) Permission of the State Government for drawing water from river/reservoir;
- (e) License from inspector of factories or other competent authority for setting up batching plant;
- (f) Clearance of Pollution Control Board for setting up batching plant ;
- (g) Clearance of Village Panchayats and Pollution Control Board for setting up asphalt plant;
- (h) Permission of Village Panchayats and State Government for borrow earth; and
- (i) Any other permits, clearances or approvals required under Applicable Laws.
- (j) Approval from competent Govt. departments for the fuel storage in the project area.
- (k) Contractor has to coordinate with different govt. officials of all type of clearances/permissions as per requirement of the project.

1.1 Applicable permits, as required, relating to environmental protection and conservation shall have been procured by the EMPLOYER in accordance with the provisions of this Agreement.

**Schedule G - Form of Bank Guarantee**

*(See Clause 7.1.1, 7.5.3 and 19.2)*

**Annex-I**

*(See Clause 7.1.1(a))*

**Performance Security** .....

Employer.....,  
Gandhinagar, Gujarat

WHEREAS:

- (A) \_\_\_\_\_ [name and address of Contractor] (hereinafter called “the Contractor”) and [name and address of the EMPLOYER], (“**the EMPLOYER**”) have entered into an agreement (the “**Agreement**”) for “Design, Construction, Operation & Maintenance of Raw Water Pumping Station and Raw Water Transmission Main from Pipli Pumping Station (Pariyej Reservoir) to WTP at TP1 in Dholera SIR” on Engineering, Procurement and Construction (“EPC”) basis, subject to and in accordance with the provisions of the Agreement.
- (B) The Agreement requires the Contractor to furnish a Performance Security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the Construction Period and Defects Liability Period (as defined in the Agreement) in a sum of Rs. .... Crore (Rupees .... Crore) (the “Guarantee Amount”).
- (C) We, .....through our branch at ..... (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) by way of Performance Security.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful performance of the Contractor’s obligations during and under and in accordance with the Agreement, and agrees and undertakes to pay to the Employer, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the guarantee amount as the EMPLOYER shall claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall

be final, and binding on the Bank, notwithstanding any difference between the EMPLOYER and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
4. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Agreement or to extend the time or period for the compliance with, fulfillment and/or performance of all or any of the obligations of the Contractor contained in the Agreement or to postpone for any time, and from time to time, any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.
6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Agreement or for the fulfillment, compliance and/or performance of all or any of the obligations of the Contractor under the Agreement.
7. Notwithstanding anything contained herein before, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The Performance Security shall cease to be in force and effect 60 (sixty) days after the end of the Defects Liability Period as set forth in Clauses 7.1
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.

11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the end \*\*\*\* month in the year \*\*\*\*\* or until it is released earlier by the EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this ..... day of ..... 20..... at .....

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name)

(Designation)

(Code Number)

(Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

**Annex-II**

(Schedule-G)  
(See Clause 7.5.3)

**Form for Guarantee for Withdrawal of Retention Money**

.....,  
EMPLOYER,  
Gandhinagar, Gujarat

WHEREAS:

[Name and address of Contractor] (hereinafter called “the Contractor”) has executed an agreement (hereinafter called the “Agreement”) with the [name and address of the EMPLOYER], (hereinafter called “the EMPLOYER”) for the “Design, Construction, Operation & Maintenance of Raw Water Pumping Station and Raw Water Transmission Main from Pipli Pumping Station (Pariyej Reservoir) to WTP at TPI in Dholera SIR” on Engineering, Procurement and Construction (the “EPC”) basis, subject to and in accordance with the provisions of the Agreement.

- a. in accordance with the Clause 19.18 of the Agreement, whenever the amount of the retention money (hereinafter called “Retention Money”) held by the EMPLOYER exceeds 1% (one per cent) of the Contract Price, the Contractor may, at its option, withdraw the Retention Money after furnishing to the EMPLOYER a bank guarantee for an amount equal to the proposed withdrawal.
- b. We, .....through our branch at ..... (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) for the amount of Rs. .... ( ..... in words) (the “**Guarantee Amount**”).

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably undertakes to pay to the EMPLOYER, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the EMPLOYER shall claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the EMPLOYER and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.
3. In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

4. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Retention Money and any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.
6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Retention Money.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The guarantee shall cease to be in force and effect 90 (ninety) days after the end of the Defects Liability Period specified in Clauses 17.1 of the Agreement.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the end \*\*\*\* month in the year \*\*\*\*\* or until it is released earlier by the EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this ..... day of ..... 20..... at .....

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)



(Name)

(Designation)

(Code Number)

(Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

**Annex-III**

(Schedule-G)  
(See Clause 19.2)

**Form for Guarantee for Advance Payment**

.....  
.....EMPLOYER,  
Gandhinagar, Gujarat

WHEREAS:

- (A) [name and address of Contractor] (hereinafter called “the Contractor”) has executed an agreement (hereinafter called the “Agreement”) with the [name and address of the EMPLOYER], (hereinafter called “the EMPLOYER”) for the “Design, Construction, Operation & Maintenance of Raw Water Pumping Station and Raw Water Transmission Main from Pipli Pumping Station (Pariyej Reservoir) to WTP at TP1 in Dholera SIR” on Engineering, Procurement and Construction (the “EPC”) basis, subject to and in accordance with the provisions of the Agreement.
- (B) in accordance with the Clause 19.2 of the Agreement the EMPLOYER shall make to the Contractor an interest bearing advance payment (hereinafter called “Advance Payment”) equal to 10% (ten per cent) of the contract price for mobilization expenses and acquisition of equipment; and that the Advance Payment shall be made to the Contractor furnishing an irrevocable and unconditional guarantee by a scheduled bank for an amount equal to the 110% amount of advance payment to remain effective till the complete and full repayment of the Advance Payment as security for compliance with its obligations in accordance with the Agreement; and the amount of installment of the Advance Payment is Rs. \*\*\*\* cr. (Rupees \*\*\*\*\* crore) (the “Guarantee Amount”).
- (C) We, .....through our branch at ..... (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) for the Guarantee Amount.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful repayment on time of the aforesaid Advance Payment under and in accordance with the Agreement, and agrees and undertakes to pay to the EMPLOYER, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the guarantee amount as the EMPLOYER shall claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations for the repayment of the Advance Payment under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank,

notwithstanding any difference between the EMPLOYER and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
4. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Advance Payment or to extend the time or period of its repayment or to postpone for any time, and from time to time, any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.
6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Advance Payment.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The guarantee shall cease to be in force and effect 90 (ninety) days after the end of the one year from the date of payment of the Advance Payment, as set forth in Clause 19.2 of the Agreement.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.

11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the end \*\*\*\* month in the year \*\*\*\*\* or until it is released earlier by the EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this ..... day of ..... 20..... at .....

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name)

(Designation)

(Code Number)

(Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

### Schedule H - Contract Price Weightages

(See Clause 19.3)

The Contract Price for this Agreement is Rs.....

#### 1. Contract Price Weightages

1.1 Proportions of the Contract Price for construction of Raw Water Pumping station and Raw water transmission main shall be as specified below.

| S#. | Item   | Weightage in % of the Contract Prices |
|-----|--|---------------------------------------|
| 1   | Detailed Design and approval of design & drawings including carrying out Topography Survey, Soil investigation | 1.00%                                 |
| 2   | Construction of Raw Water Pumping Station  | 20.29%                                |
| 3   | Construction of Raw water transmission main  | 78.71%                                |

- The % weightage for contract price is shown in **Appendix H I**
- Milestone payment for construction works for each items are covered in **Appendix H II**

**Appendix H I – Weightage in % for Contract Price for Design and Construction Work  
(Schedule-H)**

**Weightage in % for Contract Price for Civil Construction Work**

| Sr. No   | Item  | Civil         | % age break up for Civil |
|----------|---|---------------|--------------------------|
| <b>1</b> | <b>Detailed Design Charges</b>                            | <b>0.50%</b>  |                          |
| 1.1      | Submission of Design Reports and Drawings                 |               | <b>40%</b>               |
| 1.2      | Approval of Design Reports and Drawings                   |               | <b>60%</b>               |
| <b>2</b> | <b>Raw water Pumping station at Pipli Pumping Station</b> | <b>1.40%</b>  |                          |
| a.       | Electrical Sub Station                                    |               | 3.46%                    |
| b.       | Metering Room   |               | 8.35%                    |
| c.       | Fuel Storage and D.G Set Room                             |               | 14.81%                   |
| d.       | Security Cabin  |               | 48.38%                   |
| e.       | Control Room  |               | 25.00%                   |
| <b>3</b> | <b>Raw Water Transmission main</b>                        | <b>12.56%</b> |                          |
| a.       | Civil works – Pipeline & allied works                     |               | 69%                      |
| b.       | Civil works- Canal and River Crossing for pipeline        |               | 31%                      |

**Weightage in % for Contract Price for Mechanical, Electrical & Instrumentation Work**

| Sr. No   | Item   | Mechanical, Electrical & Instrumentation work | % age break up for Civil |
|----------|--|---|--------------------------|
| <b>1</b> | <b>Detailed Design Charges</b>                               | <b>0.50%</b>                                  |                          |
| 1.1      | Submission of Design Reports and Drawings                    |   | <b>40%</b>               |
| 1.2      | Approval of Design Reports and Drawings                      |   | <b>60%</b>               |
| <b>2</b> | <b>Raw water Pumping station (for Dholera SIR ) at Pipli</b> | <b>18.89%</b>                                 |                          |
| a.       | Electrical   |   | 51.43%                   |
| b.       | Mechanical   |   | 15.85%                   |

| Sr. No   | Item                               | Mechanical, Electrical & Instrumentation work | % age break up for Civil |
|----------|------------------------------------|---|--------------------------|
| c.       | Instrumentation & control          |   | 32.72%                   |
| <b>3</b> | <b>Raw Water Transmission main</b> | <b>66.15%</b>                                 |                          |
| a.       | Electrical                         |   | 11.58%                   |
| b.       | Mechanical                         |   | 84.95%                   |
| c.       | Instrumentation & control          |   | 3.47%                    |

## **Appendix H II – Interim Milestone Payment for Construction**

(Schedule-H)

### **Preamble**

1. As mentioned in the Conditions of contract, the Contract being a lump sum type turnkey Contract, the provision of measurement will be applicable only for the assessment of value of work done for inclusion in any interim certificate for part payment to the Contractor.
2. Minimum amount payable against completion of interim milestone is INR 50 Lakhs.
3. Each item has been divided into broad components. The Contractor shall assess the value of each component as indicated in paragraph 4 herein below.
4. If the percentage breakup as indicated in the Schedule is any different from the Contractor's scheme and design then he should take this into account while quoting his lumpsum prices of items.
5. The Contractor shall, after approval of his detailed designs and drawings, furnish to the Engineer an initial bill of quantities of all major items referred to as BPQPW (Bill of principal quantities of permanent works), to be reviewed and updated periodically with the Employer's Engineer. This bill of quantity will be used for assessment of percentage process of the component at any stage, by measurement jointly taken by the Employer's Engineer and the Contractor, mutually agreed and entered in the measurement books in the form and by the method approved by the Employer's Engineer, and signed jointly by both the parties.

For interim payment purpose this schedule will be read in conjunction with Annexure I of this Schedule H.



### Interim Milestone Payment for Construction Works

**Transformer yard, 11kV panel room, MCC Room, Fuel storage and DG Room, Metering Room, ( Raw water Pumping Station site)**

| Sr. No. | Item Description                         | Percentage Payment |
|---------|--|--------------------|
| i.      | On completion of Work                    | 85%                |
| ii.     | On testing, commissioning and trial runs | 15%                |

**Control Room (Raw water Pumping Station site)**

| Sr. No. | Item Description                               | Percentage Payment |
|---------|--|--------------------|
| i.      | On completion of Column up to G.L.             | 5%                 |
| ii.     | On completion of PCC                           | 5%                 |
| iii.    | On completion of Bottom Raft/ foundation.      | 10%                |
| iv.     | On comp. of Column/Beam up to First Floor Slab | 20%                |
| v.      | On completion of First Floor Slab              | 20%                |
| vi.     | On completion of Masonry in super Structure    | 20%                |
| vii.    | On completion of Misc./Finishing Items         | 10%                |
| viii.   | On testing, commissioning and trial runs       | 10%                |

### Misc. works

| Sr. No. | Item Description                   | Percentage Payment |
|---------|------------------------------------|--------------------|
| i.      | Completion of Security Guard Cabin | 80%                |
| ii.     | On testing and Commissioning       | 20%                |

**Raw Transmission Main from Raw Water Pumping station to WTP at TP1**

| Sr. No. | Item Description   | Percentage Payment |
|---------|--|--------------------|
| i.      | On supply of tested pipes  | 40%                |
| ii.     | On completion of Excavation, laying, jointing, erecting, refilling | 25%                |
| iii.    | On completion of miscellaneous pipeline related items              | 10%                |
| iv.     | On completion of Hydraulic Test                                    | 15%                |
| v.      | On testing, commissioning and trial runs                           | 10%                |

**Raw Transmission Main from Raw Water Pumping station to WTP at TP1 ( River Crossing/Nallah Crossing)**

| Sr. No. | Item Description   | Percentage Payment |
|---------|--|--------------------|
| i.      | On supply of tested pipes  | 40%                |
| ii.     | On completion of Excavation, laying, jointing, erecting, refilling | 25%                |
| iii.    | On completion of miscellaneous pipeline related items              | 10%                |
| iv.     | On completion of Hydraulic Test                                    | 15%                |
| v.      | On testing, commissioning and trial runs                           | 10%                |

**Piping, Mechanical, Electrical & Instrumentation, Automation, DCS/SCADA system (for all components i.e. Raw Water Pumping station)**

| Sr. | Items  | % of Payment |
|-----|--|--------------|
| 1   | On supply of pumping machinery, motors ,electrical equipment ,VFD, electrical starters ,IMCC panels, pipes, specials, chain pulley block, level transmitters, Motorized sluice gates & valves, CCTV system, other accessories, instruments, instrumentation system etc. including control system and field instruments, power cables, instrumentation and communication cables, etc. complete. Including spares at site, after inspection, along with literature, drawings, Technical catalogues, operating brochures /manuals etc. as required. | 50%          |

| Sr. | Items   | % of Payment |
|-----|---|--------------|
| 2   | On erection of pumping machinery, motors ,electrical equipment , VFD, electrical starters ,IMCC panels, pipes, specials, Motorized sluice gates & valves, CCTV system , chain pulley block, level transmitters , instruments and other necessary accessories including control system and field instruments, power cabling, instrumentation and communication cabling, etc. complete. | 35%          |
| 3   | On testing, commissioning and satisfactory trial runs   | 10%          |
| 4   | After satisfactory completion of Guarantee Period.  | 5%           |

**Piping, Mechanical, Electrical & Instrumentation, Automation for all components Raw water transmission main**

| Items  | % of Payment |
|--|--------------|
| On supply of equipment, pipes, specials, valves, accessories, instruments etc. Including spares at site, after inspection, along with literature, drawings, Technical catalogues, operating brochures /manuals etc. as required. | 50%          |
| On erection of all equipment, pipes, specials, valves, instruments and necessary accessories including installation of mechanical / electrical / instrumentation system / equipment, cabling, etc. complete.                     | 25%          |
| On testing, commissioning and satisfactory trial runs  | 15%          |
| After satisfactory completion of Guarantee Period  | 10%          |
| <b>Total</b>   | <b>100%</b>  |

## **Schedule I - Drawings**

*(See Clause 10.2.4)*

### **1. Drawings**

In compliance of the obligations set forth in Clause 10.2 of this Agreement, the Contractor shall furnish to the Employer's Engineer, free of cost, all 2D drawings & 3D models in native format and PDF listed in **Appendix I-I** of this Schedule-I.

### **2. Additional Drawings**

If the Employer's Engineer determines that for discharging its duties and functions under this Agreement, it requires any drawings other than those listed in **Appendix I-I**, it may by notice require the Contractor to prepare and furnish such drawings forthwith. Upon receiving a requisition to this effect, the Contractor shall promptly prepare and furnish such drawings to the Employer's Engineer, as if such drawings formed part of **Appendix I-I** of this Schedule-I.

**Appendix I-I – List of Drawings**  
(Schedule-I)

List of drawings is given in table below:

**Table 18: List of drawings**

| <b>S. No.</b> | <b>Description</b>                                    |   |
|---------------|---|---|
| <b>1</b>      | <b>General</b>  |   |
|               | i.  | Key Plan showing location of Raw Water Pumping Station, Transmission main alignment (As per Topographical survey) and WTP             |
|               | ii.   | Layout plan with Contours for Raw water Pumping station site  |
|               | iii.  | Plan and profile for the L-section survey along the route of the raw water transmission main  |
|               | iv.   | Geotechnical Investigation Reports for the locations of Raw Water Pumping Station and along the Raw water Transmission main alignment |
| <b>3.2</b>    | <b>Mechanical Works for Raw Water Pumping station</b> |   |
|               | i.  | GA of Raw water sump and pump house   |
|               | ii.   | GA of control room  |
|               | iii.  | GA of MCC room and substation   |
|               | iv.   | Piping layout for pumping station   |
|               | v.  | GA of inter connection to inlet pipe of stilling chamber of WTP and raw water reservoir at WTP in TP1 of Dholera SIR                  |
| <b>3.3</b>    | <b>Civil Works for Raw water pumping station</b>      |   |
|               | i.  | Site grading plan for Raw Water pumping station site  |
|               | ii.   | GA of DCS operation Room /SCADA operation room  |
|               | iii.  | GA and RCC details of Office building and Control Room  |
|               | iv.   | GA of MCC Room & Substation   |
|               | v.  | GA drawing for DG and fuel storage room including foundation  |
|               | vi.   | GA of transformer yard  |
|               | vii.  | RCC Details of electrical poles   |
|               | viii.   | GA and RCC details of Raw Water sump & Pumping station  |
|               | ix.   | GA and RCC details of metering room   |
|               | x.  | Typical details of valve chambers   |
|               | xi.   | Typical details of valves   |
|               | xii.  | GA and RCC details of security cabin  |
| <b>3.4</b>    | <b>Electrical Works for raw water pumping station</b> |   |
|               | i.  | Indoor Lighting Layout for Each Building  |
|               | ii.   | Outdoor Lighting Layout   |
|               | iii.  | Cable Routing Layout  |
|               | iv.   | 11KV Single Line Diagram  |
|               | v.  | 415V Single Line Diagram  |
|               | vi.   | Cable Trench Layout   |

| S. No.     | Description  |
|------------|--|
| vii.       | GA of PMCC Room  |
| i.         | Overall Earthling Layout   |
| ii.        | GA drawing of Transformer  |
| iii.       | Transformer Foundation Drawing   |
| iv.        | Marshalling Box Drawing  |
| v.         | GA of DG space with the fuel storage tank  |
| vi.        | Switch Board GA Diagram for 11KV HT Switchgear Panel                                   |
| vii.       | Terminal Block Diagrams for 11KV HT Switchgear Panel                                   |
| viii.      | Single Line Diagram ( with Port & Metering Scheme) for 11KV HT Switchgear Panel        |
| ix.        | Switch Board GA Diagram for 415V HT Switchgear Panel                                   |
| x.         | Single Line Diagram ( with Port & Metering Scheme ) for 415V HT Switchgear Panel       |
| xi.        | Control Scheme Diagrams of various panels/feeders                                      |
| xii.       | Terminal Block Diagrams for 415V HT Switchgear Panel                                   |
| xiii.      | Switch Board GA Diagram for APFC Panel   |
| xiv.       | Single Line Diagram for APFC Panel   |
| xv.        | GA Diagram & Wiring Scheme for Local Push Button Station                               |
| xvi.       | Light pole drawing and junction box details  |
| xvii.      | Street lighting layout at raw water pumping site                                       |
| xviii.     | Light Fixture drawing  |
| <b>3.5</b> | <b>Instrumentation and Controls for Raw Water Pumping Station</b>                      |
| i.         | Process and Instrumentation Diagram (P &ID) for raw water Pumping Station              |
| ii.        | System architecture for the DCS/SCADA operation system                                 |
| iii.       | Details of DCS (Distributed Control System)/SCADA operation system                     |
| iv.        | GA of CCTV system  |
| v.         | System architecture for CCTV system  |
| <b>4</b>   | <b>Raw Water Transmission Main from Raw water pumping station to WTP</b>               |
| i.         | Plan and profile of Raw Water Transmission Main From Raw Water Pumping Station to WTP. |
| ii.        | Typical details of crossings (River/canal/NH/SH Road)                                  |
| iii.       | Typical details of valve chambers  |
| iv.        | Typical details of valves (Air Valves, Sluice /Butterfly Valves, Scour Valve, NRV)     |
| v.         | Typical details of Thrust Block  |
| vi.        | Typical details of Bulk flow water Meter Installation & chamber                        |
| vii.       | Typical details of surge protection devices  |
| viii.      | Typical details of pressure transmitter , Online Analyzer                              |
| ix.        | HV/ LV Cable Routing Layout  |
| x.         | 11KV Single Line Diagram   |
| xi.        | 415V Single Line Diagram   |
| xii.       | Cable Trench Layout  |
| xiii.      | Overall Earthling Layout, along with calculations                                      |
| xiv.       | Test certificates of all equipment   |

| <b>S. No.</b> | <b>Description</b> |   |
|---------------|--------------------|---|
|               | xv.                | Cable laying & cross section details  |
|               | xvi.               | GA drawing of Compact Substation  |
|               | xvii.              | Compact Substation Foundation and cable termination Drawing   |
|               | xviii.             | Control Scheme Diagrams of compact substation   |
|               | xix.               | GA Diagram & Wiring Scheme for Local Push Button Station  |
|               | xx.                | Motor isolation cubicle detail near the valve   |
|               | xxi.               | Light Fixture drawing. Any other drawing / calculation required but not indicated above shall be deemed to be included. |

## **Schedule J - Project Completion Schedule**

*(See Clause 10.3.2)*

### **1 Project Completion Schedule**

During Construction period, the Contractor shall comply with the requirements set forth in this Schedule-J for each of the Project Milestones and the Scheduled Completion Date. Within 15 (fifteen) days of the date of each Project Milestone, the Contractor shall notify the Employer of such compliance along with necessary particulars thereof.

### **2. Project Milestone-I**

- 2.1 Project Milestone-I shall occur on the date falling on the 180th (one hundred and Eightieth) day from the Appointed Date (the "Project Milestone-I").
- 2.2 Prior to the occurrence of Project Milestone-I, the Contractor shall have commenced construction of the project components and submitted to the Employer duly and validly prepared Stage Payment Statements for an amount not less than 10% (ten per cent) of the Contract Price.

### **3. Project Milestone-II**

- 3.1 Project Milestone-II shall occur on the date falling on the 270th (two hundred and Seventieth) day from the Appointed Date (the "Project Milestone-II").
- 3.2 Prior to the occurrence of Project Milestone-II, the Contractor shall have continued with construction of the project components and submitted to the Employer duly and validly prepared Stage Payment Statements for an amount not less than 25% (Twenty five per cent) of the Contract Price.

### **4. Project Milestone-III**

- 4.1 Project Milestone-III shall occur on the date falling on the 365<sup>th</sup> (Three Hundred and Sixty Fifth) day from the Appointed Date (the "Project Milestone-III").
- 4.2 Prior to the occurrence of Project Milestone-III, the Contractor shall have continued with construction of the project components and submitted to the Employer duly and validly prepared Stage Payment Statements for an amount not less than 50% (Fifty per cent) of the Contract Price.

### **5. Project Milestone-IV**

- 5.1 Project Milestone-IV shall occur on the date falling on the 455<sup>th</sup> (Four Hundred and Fifty Fifth) day from the Appointed Date (the "Project Milestone-IV").
- 5.2 Prior to the occurrence of Project Milestone-IV, the Contractor shall have continued with construction of the project components and submitted to the Employer duly and validly prepared Stage Payment Statements for an amount not less than 75% (Seventy Five per cent) of the Contract Price.



**6. Schedule Completion Date**

- 6.1 The Scheduled Completion Date for construction shall occur on the 545<sup>th</sup> (Five Hundred and Forty Five) day from the Appointed Date.
- 6.2 On or before the Scheduled Completion Date, the Contractor shall have completed construction in accordance with this Agreement.

**7. Extension of time**

Upon extension of any or all of the aforesaid Project Milestones or the Scheduled Completion Date, as the case may be, under and in accordance with the provisions of this Agreement, the Project Completion Schedule shall be deemed to have been amended accordingly.

## **Schedule K - Tests on Completion**

*(See Clause 12.1.2)*

### **1. General**

The Inspection and Testing of all the works carried out by the Contractor will be carried out by the Employer's Engineer. The inspection and Testing will be done at the stage of design, procurement, construction, execution and commissioning. Regular monitoring and testing of the system will be carried out during the operation and maintenance phase of the contract. The general conditions for the testing and inspection are enumerated as given.

### **2. Material and Instruments required for Testing**

The Contractor shall at his own cost arrange for all instruments, materials, required for the purpose of carrying out the tests. The Contractor will satisfy the Employer's Engineer or his Representative as to the accuracy of all the instruments used for tests and if required shall produce recent calibration tests, or otherwise have been calibrated at his own expense by an independent authority.

### **3. Test Certificates**

Test certificates for the tests carried out by the Employer's Engineer or his representative, independent agency would have to be arranged by the Contractor. In cases where further verifications are required for any of the results of testing, this would also be arranged by the Contractor. Copies of certificates of all works and tests shall be provided as detailed.

The Contractor shall obtain and submit to the Employer's Engineer and to other parties as may be direct, certificates of test of all items, certifying that they have been satisfactorily tested and describing and giving full particulars of such tests.

### **4. Schedule for Tests**

4.1 The Contractor shall, at least 30 (thirty) days prior to the likely completion of construction, notify the Employer's Engineer and the Employer of its intent to subject the project components (Civil, piping, electrical, mechanical, instrumentation & Automation items for Raw Water Pumping station and transmission main) to Tests, and not less than 10 (ten) days prior to the actual date of Tests, furnish to the Employer's Engineer and the Employer detailed inventory and particulars of all works and equipment forming part of Works.

4.2 The Contractor shall notify the Employer's Engineer of its readiness to subject the project components (civil, piping, electrical, mechanical, instrumentation items for Raw Water Pumping station, transmission etc.) to Tests at any time after 10 (ten) days from the date of such notice, and upon receipt of such notice, the Employer's Engineer shall, in consultation with the Contractor, determine the date and time for each Test and notify the same to the Employer who may designate its representative to witness the Tests. The Employer's Engineer shall thereupon conduct the Tests itself or cause any of the Tests to be conducted in accordance with Article 12: Completion Schedule and this Schedule-K.

## **5. Tests**

### **5.1 Factory tests/ manufactures works inspection test and guarantees**

All Schedules of Particulars shall be completed and the Guaranteed Particulars and the efficiencies of the equipment offered at the duties specified will be binding and may not be varied except with the consent in writing of the Employer's Engineer.

The Employer's Engineer shall be provided with the facility for inspection of all equipment and material and shall be given at least 15 days' notice when such equipment or material is ready for inspection of works test.

Full witness testing to the relevant standards and to prove guarantees given will be required for the following items:

- i. Flow measuring equipment
- ii. Pressure transmitters
- iii. Appurtenances e.g. Sluice valves, Air valves, Scour Valves, Reflux Valve etc.
- iv. Pumps
- v. DCS/ SCADA system and related all Field Instruments

In addition all other items of pipe and equipment not subject to witness testing shall be temporarily erected at the manufacturer's works and tested for satisfactory operation and shall be offered for inspection. Copies of manufacturer's test readings shall be submitted to the Engineer in Charge, all prior to packing for shipment.

Such inspection, examination, or testing, shall not release the Contractor, manufacturer or supplier of any item for many obligation under the Contract.

Certified copies of manufacturer's test readings of all items shall be submitted to the Employer's Engineer within 7 days of the satisfactory completion of the test.

Whilst the Employer's Engineer shall be provided with facilities for witness testing and / or inspection of all items of equipment at the manufacturer's works, he may at his discretion advise that the tests shall proceed in his absence. These tests shall be made as if in his presence, and duly certified copies of test readings shall be submitted.

Where items of equipment are of identical size and duty it may be required at the Employer's Engineer discretion, that a reduced number of the items be subjected to witness tests: however this shall not relieve the manufacturer from the requirement of carrying out the performance tests on all items prior to offering a witness testing.

If after inspecting, examining or testing any material or equipment, the Employer's Engineer shall decide that such items or any part thereof is defective, or not in accordance with the specification or performance requirements, he may reject the said items or part thereof, giving to the manufacturer within a reasonable time, notice in writing of such rejection, stating therein the ground upon which the said decision is based. All re-testing shall be at the Contractor's expenses.

The factory testing for some of the components are described as follows –

### 5.1.1 Main Switchboard

- i. Inspection of switchboard including wiring, electrical and mechanical connections;
- ii. Mechanical tests;
- iii. Primary and secondary injection tests to commission and calibrate all measuring, protection and control circuits and associated components;
- iv. Continuity and dielectric tests;
- v. Power frequency and pressure test;
- vi. Functional check of all control wiring.

### 5.1.2 Tests on Plates

#### A) Tensile Tests

The tensile strength, yield strength and percentage elongation of steel shall be determined from standard test pieces cut either lengthwise or crosswise from plates. The test shall be carried out on the standard test piece prepared in accordance with test edition of IS 1608 or its international equivalent standard. The tensile strength, yield strength and percentage elongation of steel should not be less than the specified values in table below:

| S. No. | Mechanical Property                                     | Value |
|--------|---|-------|
| 1.     | Tensile strength, Min, Mpa                              | 410   |
| 2.     | Yield Strength, Min, Mpa                                | 250   |
| 3.     | Bend Test (Internal dia.), as per clause 9.3 of IS 3589 | 2t    |

Only proportional test piece complying with the requirement  $L_0 = 5.65 S_0$  should be used for the tensile test, where  $L_0$  is the gauge length and  $S_0$  is the cross-sectional area of the test piece. For every 500 tonnes of finished steel, one tensile test shall be conducted.

#### B) Bend Test

The test piece shall be either lengthwise or crosswise from plates. Bend test shall be conducted in accordance with IS 1599 or its international equivalent standard. For bend test piece at room temperature shall withstand bending through  $180^\circ$  to an internal diameter not greater than specified in table in clause 5.7.1 (A), without cracking.

For every 500 tonnes of finished steel, one bend test shall be conducted.

Notes:

1. 't' is the thickness of plate
2. Test temperature shall be agreed upon between the manufacturer/ Contractor and the Engineer-in-Charge or his representative.

(a) Ultrasonic Test

All plates shall be tested by ultrasonic equipment to check for manufacturing defects such as voids, layers etc. The Contractor shall supply test certificates to this effect from manufacturer.

(b) Retest

If any one test piece first selected failed to pass any of the tests specified in the above clause two further samples shall be selected for testing in respect to each failure. If the test pieces from both these additional samples pass, the material represented by the test samples shall be deemed to comply with the requirements of that particular test. If the test piece from either of these additional sample fail the material represented by the test samples shall be discarded.

### **5.1.3 Pipe & Accessories**

Pipe shall be tested as follows:-

Each pipe shall be tested individually in accordance with the relevant IS Codes. Site conditions shall be simulated as near as possible particularly the maximum site condition. The tests shall include but not to be limited to:

- a) Continuous monitoring of dia and forming.
- b) Visual inspection of all pipes from inside and outside for permissible tolerances as per IS: 3589.
- c) On/off line ultrasonic testing of weld as per IS: 4260
- d) Radiographic testing as per IS: 4853. for 20cm length from both the ends.
- e) Each pipe shall be hydraulically tested to at the manufacturer's works to a test pressure as mentioned in IS: 3589.
- f) Mechanical tests of finished pipes as per IS 3589.

### **5.1.4 Valves**

All valve bodies shall be hydraulically tested as specified in IS Codes. Isolating valve seats shall be tested to the maximum working pressure, at which pressure they shall be drop tight.

The Contractor shall include for the necessary tests as laid down in the Specification and those required in order to comply with the relevant IS Standards.

## **5.2 Onsite inspection, tests and pre-commissioning treatment**

### **5.2.1 Visual and physical test**

The Employer's Engineer shall conduct a visual and physical check of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement.

### **5.2.2 Tanks and Level Switches**

Sides and edges of sectional tanks to be checked for distortion. The tanks shall be thoroughly cleaned with water and drained before water supply will feed in. Also before feeding of water supply, the level switch shall be simulated for the various cut-in and cut-out settings.

### **5.2.3 Pressure Switches**

The pressure transmitters to be tested shall be regarded acceptable when the pressure readings of all three gauges are the same throughout the jacking pressure range varied by applying the hand pump.

### **5.2.4 Water Tightness test for water retaining structures**

All hydraulic structures shall have to be tested for water tightness. The water tightness test shall be conducted as specified in IS: 4127- 1967.

### **5.2.5 Water Tightness test for Raw Water Sump**

The Contractor shall be fully responsible for the water tightness of the sump, The sump shall be taken as water tight if the depression in water level after filling the tank of full supply level is not more than 12.20 mm in 24 Hrs. and no leakages are observed.

### **5.2.6 Hydrostatic Tests for pipes**

All parts of the water circuit shall be filled with water before hydrostatic pressure testing, and pump running tests for verification of pressure and flow rate, are conducted. The hand jacking pump shall be applied to increase the system pressure to 2 times the working pressure or 1.5 times the working pressure plus 3.5 bar whichever is the lower but in any case not less than 7 bars. The pressure shall be maintained for a period not less than 24 hours. Where any section of pipe work or equipment is found to be unable to withstand the maximum pipe work test pressure, it shall be isolated during the pipe work test then that section of pipe work or equipment shall be made good and re-tested at the appropriate test pressure.

In every test, water used shall be left in the pipes until they are covered with earth or other trench filling material to a depth of at least 1 m over the top of pipes and until permission is given by the Employer's Engineer for the water to be released. If after the Employer's Engineer has approved the transmission main and has given permission for the trenches to be refilled the pipes become damaged and loses water from any cause and/or admit subsoil water, the Contractor shall uncover the pipes and make good the defect made good and the pipes retested as before and all at the Contractor's expense.

### **5.2.7 Cleaning, Flushing and Pre-Treatment**

Prior to start-up and hydraulic testing, the Contractor shall clean the entire installation including all fitments and pipe work and the like after installation and keep them in a new condition. All pumping systems shall be flushed and drained at least once through to get rid of contaminating materials. All pipes shall be rodded to ensure clearance of debris, cleaning and flushing shall be carried out in sections as the installation becomes completed.

All strainers shall be inspected and cleaned out or replaced.

When the entire system is reasonably clean, a pre-treatment chemical shall be introduced and circulated for at least 8 hours. Warning signs shall be provided at all outlets during pre-treatment. The pre-treatment chemical shall:

- i. Remove oil, grease and foreign residue from the pipe work and fittings;
- ii. Pre-condition the metal surfaces to resist reaction with water or air;
- iii. Establish an initial protective film;
- iv. After pre-treatment, the system shall be drained and refilled with fresh water and left until the system is put into operation.
- v. Details and procedures of the pre-treatment shall be submitted to the Employer's Engineer for approval.

### **5.2.8 Electrical Tests**

Electrical tests shall comply with the current edition of IEEE (Institute of Electronics and Electrical Engineers) regulations, Indian standards, Indian electricity act and requirements enforced by Local Authorities.

Electrical insulation tests shall apply to bus bars, isolators and other equipment and wiring where applicable.

A 500V DC instrument shall be used to check the insulation resistance. The reading shall not be less than 50 mega-ohms in all instances.

Function simulation tests shall be performed to ensure that the systems have been installed to the control requirements as described in the Specification therein.

### **5.2.9 Test on Instruments**

The Contractor shall carry out on-site re-calibration tests to demonstrate the accuracy of all level, pressure, online analysers and rate of flow instruments, the transducers, buffers, displays amplifiers, recorders, integrators and transmitters incorporated in the Works over a range of flows from the minimum anticipated design range in the plant as required by the Specification and that the accuracy obtained at the manufacturer's works tests can be obtained on site. The Contractor shall supply sets of calibration curves of weirs, flow meters, metering pumps and the like.

### **5.2.10 Pump Drives**

The direct coupling of the pump drives shall be dismantled before the pump motor control panel is energized.

The Contractor shall demonstrate to the Employer's Engineer for acceptable clearances of the coupling alignment for ensuring satisfactory power transmission.

The coupling shall not be re-mated again till the correct motor rotation has been demonstrated with power drawn from the energized pump motor control panel.

### **5.2.11 Pump Operating Test**

The Contractor shall ensure to the satisfaction of the Employer's Engineer that the installation or portion thereof which has been set to work complies with all requirements including the following:

- That the pump and apparatus shall be of robust construction and of capacity for the duty specified.

- That all valves, switches, controls and the like are properly regulated and capable of proper operation and in the case of valves are capable of being shut-off.
- That all apparatus shall be silent.
- That all instruments are correctly calibrated and read accurately.
- That all services are tested in accordance with the details of the relevant clauses of this Specification.

#### **5.2.12 Statutory Authorities' Tests and Inspections**

As and when notified in writing or instructed by the Employer's Engineer, the Contractor shall submit shop drawing and attend all tests and inspections carried out by Local Pollution Control Board Authorities, Water Authority and other Statutory Authorities, and shall forthwith execute free of charge any rectification work ordered by the Employer's Engineer as a result of such tests and inspections where these indicate non-compliance with Statutory Regulations. Some of these tests may take place after the issue of Practical Completion of the Main Contract and the Contractor shall make all allowances in this respect.

The Contractor shall be responsible for the submission of all necessary forms and shop drawings to the Statutory Authorities which shall conform in layout to the latest architectural plans submitted to and kept by these Authorities.

The submission shall comply with the requirements set forth in the current Codes of Practice and circular letters of the Statutory Authorities. The shop drawings to be submitted shall be forwarded to the Employer's Engineer for checking before submission. The Contractor shall allow for at least two submissions of complete sets of shop drawings to the Authorities, one to be made within four months after the award of the Contract but not less than six weeks before the inspection. The Employer's Engineer may at his discretion instruct the Contractor for additional submissions to the Local Authorities whenever necessary.

The Contractor shall notify the Employer's Engineer at least seven days in advance of his application for local Authority tests and inspections. On receipt of a confirmed date for test and inspection the Contractor shall inform the Employer's Engineer without delay.

#### **5.2.13 Other tests**

The Employer's Engineer may require the Contractor to carry out or cause to be carried additional tests, in accordance with Good Industry Practice, for determining the compliance of the project components (raw water Pumping station and raw water transmission main) with Standards and Specifications.

### **5.3 Environmental audit**

The Employer's Engineer shall carry out a check to determine conformity of the project components (Raw water Pumping station and raw water transmission main) with the environmental requirements set forth in Applicable Laws and Applicable Permits.

### **5.4 Safety Audit**

The Employer's Engineer shall carry out, or cause to be carried out, a safety audit to determine conformity of the project components (Raw water Pumping station and raw water transmission main) with the safety requirements and Good Industry Practice.



## **5.5 Visual and physical test**

Visual and physical test for Internal roads, boundary wall, gate, sewerage & storm water drainage system within the raw water pumping station premises ,Street lighting covering poles, luminaire, power supply, grounding, communication between luminaire to control panel and central control system.

## **6. Agency For Conducting Tests**

All Tests set forth in this Schedule-K shall be conducted by the Employer's Engineer or such other agency or person as it may specify in consultation with the Employer.

## **7. Inspection of Erection of Pipe lines & equipment**

In additional to the progressive supervision and inspection by Employer's Engineer the Contractor shall offer for inspection to Employer's Engineer, the completely Erection of pipeline/equipment or part of pipeline/ equipment on which tests are to be carried out. After such inspection by Employer's Engineer, each equipment/subsystem shall be tested by the Contractor in accordance with the applicable standards in the presence of Employer's Engineer.

## **8. Instrumentation and Control System**

Performance of the instrumentation system and function of logic control system shall be checked as per the design requirements. All automatic controls and safety devices shall be inspected and checked for service ability before the working fluid or electricity is applied to the system.

## **9. Preliminary Commissioning Checks**

On completion of erection of the equipment and before start-up, each item of the equipment shall thoroughly cleaned and then inspected jointly by the Employer's Engineer and the Contractor for correctness, completeness of installation and acceptability for start-up, leading to initial pre-commissioning tests at site. The list of pre-commissioning tests to be performed shall be as mutually agreed by the Employer's Engineer and Contractor.

## **10. Commissioning & Trial run**

When the various installations have been completed and the preliminary commissioning checks carried out, the Contractor shall set to work, regulate and calibrate all system in the entire installation. Special attention shall be paid to the following items:

- That all valves, switches, controls, etc. are regulated and capable of proper operation and in the case of isolation valves that they are capable of tight shut off.
- That all apparatus is silent in accordance with the requirements of this Specification.
- That all instruments are correctly calibrated and read accurately.
- That all services are tested in accordance with the details in the relevant clauses of this Specification.
- Operate pumps, pressure reducing sets, etc. to ensure that all control systems are functioning correctly and are properly set, sequenced or interlocked.

The equipment and pipeline shall then be commissioned and put on Trial Operation at full load when performance Guarantee Tests shall be conducted.

During the period of trial operation the Contractor shall:

- i) Operate the full works on behalf of the Employer's Engineer.
- ii) Supply the labour and materials including consumable required for the operation and maintenance of the works.
- iii) Carry out maintenance repairs of defects immediately.
- iv) Verification of the utility
  - a. The Contractor will firstly check and verify the design engineering drawings.
  - b. Ensure that the "as built" drawings are in place.
  - c. Verify the utility as per the as built drawings. This will include the checking of the following-
    - All equipment ( electrical, mechanical, instrumentation including DCS)
    - All civil units
    - Pipe Material
    - Pipe Dimensions
    - Coating and Lining
    - Invert Levels
    - Identification of all appurtenances and fitting will be done
- v) Mapping
  - a. GIS Mapping of the pumping station and pipeline would be done on ArcGIS / equivalent software and this will include all field instruments.
  - b. Locations of all the valves, chamber, tee, joints, meters would be also verified and mapped.
  - c. The GIS maps should be transferred to PMNCs/ Employer's mapping data bank.

The requirements of Inspection, testing, erection and commissioning of electrical and mechanical equipment for the pumping station are described in **Appendix K-I** attached with this Schedule K.

During the period of trial operation of working hours of the Contractors shall be 24 hours daily, 7 days week. The Contractor shall provide for the expenditure on all the consumables and water and energy required during the trial operation. All labour and cost of any other materials shall also be met fully the Contractor. The Trial Operation shall be considered successful, provided that each item of the equipment can operate continuously at the specified characteristics, for the period of Trial Operation and the Performance Guarantees are successfully met. Any special equipment, tools and tackles required for the successful completion of the performance and Guarantees Tests shall be provided by the Contractor free of cost.

The guaranteed performance figures of the equipment shall be provided by the Contractor during the Performance and Guarantee tests. Should the results of these tests show any decrease from the guaranteed values, the Contractor shall modify the equipment as required to enable them to meet the guarantees. In such case, Performance and Guarantee Tests shall be repeated within one month from the date the equipment is ready for re-test and costs for modifications including labour, materials and the cost of additional testing to prove that the equipment meets the guarantees, shall be borne by the Contractor.

#### **11. Final Acceptance Tests**

Following commissioning and inspection of the entire installation, and prior to issue of the Completion Certificate, the Contractor shall carry out final performance Test as per the approved procedure. (Flow, Power Consumption). After conduction of a successful performance guarantee test, the acceptance certificate shall be issued by the employer.

#### **12. Handing Over of Documents**

All testing and commissioning shall be done by the Contractor to the entire satisfaction of the Employer's Engineer and all testing and commissioning documents shall be handed over to the Employer's Engineer. The Contractor shall also hand over all maintenance and operation manuals, all certificates and all other documentation as per the terms of the contract to the Employer's Engineer.

#### **13. Completion Certificate**

The Works will be certified as completed for notional taking over by the Employer's Engineer only after it has successfully completed trial run for a continuous period of three (3) months.

A Completion Certificate for the project works shall not be issued unless the following documentation are duly compiled and submitted in final formats in duly bound volumes and also in accordance with the provisions of Article 12.

- i) A Completion of all shop inspection results/reports of the pipeline/machinery with due attestation that the pipeline have been manufactured to specified standards (6 copies)
- ii) All erection/construction quality control checks in appropriate approved formats for installation works with attestation that installation has been carried out as per acceptable/stipulated standard (6 copies)

#### **14. Quality Control and quality checks**

As part of the proposal the Contractor would be required to submit their Quality Plan. The plan would consist of

- Details of how the Contractor would manage the quality of works
- All the checks to be carried out
- The stages at which these checks would be done
- The complete Inspection and Test plans
- Methodology and details of execution of works
- Formats for inspection

- Compilation of all mill certificates

- List of performance test-

During Construction

During Commissioning

During Operations

The Employer's Engineer involvement should be shown at all major points in the progress of work. At all these points the Contractor will be permitted to proceed only if formal approval is made.

The procedure for this would be that the Contractor would submit the form for inspection to the Employer's Engineer or his representative at least 32 hours before the scheduled inspection. The Employer's Engineer or his representative would then go to the site of inspection at the scheduled time and date. The inspection would be carried out. All tools, materials and documents required for carrying out the inspection will be provided by the Contractor.

The Employer's Engineer would have full rights to reject or fail the inspection provided a valid reason is given. In such case the Contractor is to correct, replace, redo or remake as the case maybe and arrange for a re-inspection.

Proper certificate for proficiency should be provided for at least the supervisory level of the execution team. This includes proper license for crane operators, welding certificate for welding supervisors.

#### **15. "As Built Drawings" and "Operation and maintenance manual"**

On Completion of the Inspection and Tests for the various facilities the Contractor would be required to make the "As Built drawings" of the equipment, pipeline, appurtenances and all the components and works involved. The drawings would be on long lasting material along with tracings and blueprints. Soft copies of the same are also to be included.

Contractor shall submit the O & M Manual for approval of Employer, which may be modified, if required by Employer and this manual shall be approved from Employer prior to commissioning. The Contractor shall be modified the operation and maintenance manual as per the modification in the pumping station if any.

#### **Operation and Maintenance Manual**

- a) The Contractor shall provide six copies of draft O&M Manual to Employer, at the time of the commissioning of the project and on approval of draft, 6 copies of operation & maintenance manual shall be supplied by the Contractor.
- b) The O&M Manual shall include in elaborate detail, all operating and maintenance procedures and policies which are required, advisable and / or necessary for the Facility to achieve full compliance with the operational guarantees and to achieve maintenance and repair standard for the Facility which will ensure compliance with the maintenance specifications.
- c) Without limiting the generality of the foregoing the O&M Manual shall include descriptions, procedures, and shall comply with the requirements, set forth in the

provisions of the Bid Documents.

- d) The draft of the O&M Manual shall be subject to the review and approval of Employer, which shall have the right to make any changes and revisions to the O&M Manual as it may deem appropriate. The Contractor shall revise such draft O&M Manual prior to the commencement of the O&M period.
- e) During the DLP, the Contractor shall revise the draft O&M Manual to reflect any updates, changes or revisions it deems appropriate based inter alia on its experience and as necessary to reflect any modifications or adjustments to the pumping station. Without limiting the above, the Contractor shall annually fully review, revise, update and modify the draft O&M Manual as may be necessary or appropriate. Any revision to the draft O&M Manual shall be subject to the review and approval of DICDL. DICDL shall have the right to require revisions to the draft O&M Manual as it may deem appropriate. The Contractor shall prepare and submit to Employer, for its review and approval, 30 days prior to the proposed Date of Taking Over a revised draft O&M Manual which reflects all changes, revisions and modifications. The Contractor shall prepare the O&M Manual, as approved by the Employer, prior to the Date of Taking Over.
- f) During the term of this Agreement, the Contractor shall promptly notify Employer of any revisions, additions or modifications which he, in his professional opinion, believes should be made to the O&M Manual, whether as a result of additional experience in operating and maintaining the Facility, changes in influent quality or volume, changes or modifications to any equipment, part, component or structure incorporated in the Facility. Such notification shall set forth the reason for the proposed revision. Any proposed revision shall be subject to the approval of the Employer. In addition, during the term of this Agreement, Employer shall have the right to require relevant changes, revisions, or additions to the O&M Manual as it, shall deem appropriate to ensure full compliance with the O&M Standards.
- g) The Contractor shall submit 6 copies of the final O & M manual.

## **16. Asset Management**

The Contractor shall submit list of inventories to Employer/ Employer's Engineer quarterly. Multiple hard copies of lists of inventory will be handed over to DICDL/ Employer's Engineer for approval upon transition (post completion of operations).

## **Appendix K I – Inspection, Testing, Erection, Commissioning of Electro-Mechanical Equipment of pumping station (Part-III)**

(Schedule-K)

### **1 General**

#### **1.1 Test Instruments**

The Contractor shall satisfy the Employer's Engineer as to the accuracy of all the instruments used for tests and if required shall produce recent calibration tests, or otherwise have them calibrated at his own expense by and independent authority.

#### **1.2 Test Certificates**

Copies of certificates of all works, routine/type/ acceptance tests shall be provided as detailed.

The Contractor shall obtain and submit to the Employer's Engineer and to other parties as may be directed, certificates of test of all items, certifying that they have been satisfactorily tested and describing and giving full particulars of such tests.

#### **1.3 Manufacturer's works inspection tests and guarantees**

All Schedules of Particulars shall be completed and the Guaranteed Particulars and the efficiencies of the equipment offered at the duties specified will be binding and may not be varied except with the consent in writing of the Engineer.

The Engineer shall be provided with the facility for inspection of all equipment and material and shall be given at least 10 days 'notice when such equipment and material is ready for inspection at manufacturer or vendors workshops.

Full witness testing to the relevant standards and to prove guarantees given will be required for all items.

#### **1.4 Site Testing**

The Contractor shall arrange for the full site testing of all items of equipment and shall include provision of:

- a) All skilled and qualified operating and test staff for the testing of all equipment.
- b) Provision and disposal of all services, lubricants, and fuels other than electricity.
- c) All measuring and testing instruments to demonstrate equipment operates to the fulfilment of the works sheet.

#### **1.5 Circuits**

##### **1.5.1 Circuit Breakers and Control Gear**

- i) Routine tests including High voltage test, milli-volt drop (Ductor ) tests.

- ii) To ensure operation of the closing coil and satisfactory closing of the circuit breaker with the voltage on the coil down to 80% of its rated voltage, and that mal-operation does not occur with a voltage on the coil of 120% of its rated voltage
- iii) To ensure the satisfactory trip operation of the circuit breaker at no load conditions with the trip coil energized at 70% of its rated voltage.
- iv) Test figures for heat – run tests performed on identical panel types shall be made available.
- v) All interlocking, circuit breaker draw in & draw out operation.
- vi) All tests as recommended by the manufacture

### **1.5.2 Protection and Control Circuits**

Based on the completeness of the circuits in the final manufactured form within the manufacturer's works, the following tests shall be carried out:

- i) Primary injection tests to ensure correct operation of the current operated protection relays and direct acting coils over their full range of settings.
- ii) Balanced earth fault and differential relay stability tests by primary current injection. Care must be taken to reproduce accurately the burdens of interconnecting cables. A further test to ensure correct polarity must be made after assembly.

With different pilot wire schemes it may not be possible to apply primary injection testing. In this case the circuits shall be proved by secondary injection. Current transformer characteristics and calculations associated with the above tests shall be available for inspection by the Employer's Engineer.

- iii) Correct operation of control circuits at normal operating voltage by operating voltage by operation of local control switches, and simulation of operation from remote control positions. All controls, visuals and audible alarm test shall be carried out Automation system.

### **1.5.3 Instruments and Meters**

Tests to ensure operation of all ammeters, voltmeters and transducers and checks for correct calibration kwh meters shall be carried out to ensure that the meter is inoperative with voltage alone, if the secondary of the current transformer is left connected with the primary current interrupted.

### **1.6 Tests on Cables During Manufacture**

All cables supplied under the Contract shall be subject to routine tests in accordance with the relevant British Standard /BIS. Cables will not be accepted at Site for installation until certificates giving proof of compliance with the Specification and test certificates have been received and approved by the Employer's Engineer. A certificate shall be applicable to each drum.

The tests to be carried out on every drum at manufacturer's premises shall include:

- a) High voltage A.C insulation pressure test between cores, each core to earth metallic sheath or armour as applicable.

- b) Insulation resistance test.
- c) Core continuity and identification.
- d) Conductor resistance test.

### **1.7 Tests on Cable during Installation**

During the period of site installation the Employer's Engineer will carry out inspection of the Works to ensure the standards of workmanship meet the specification and are to his satisfaction. In the event of any part of the cabling installation failing to meet these requirements the Contractor shall remedy the deficiency to the satisfaction of the Employer's Engineer.

After completion of various parts of the installation the Contractor shall provide a test engineer, labour and materials to demonstrate to the Engineer that the cables have been correctly installed.

The Contractor shall inform the Employer's Engineer prior to the testing of cables and shall be responsible for liaison with any other Contractor to whose equipment the cables may be terminated to ensure all parties concerned are aware of the impending tests, to guarantee safety of personnel and that isolation of any particular equipment has been completed. Any special isolation or preparation required to be carried out before cable testing will be completed by the Contractor responsible for that equipment. All tests shall be carried out by the Contractor to the satisfaction of the Employer's Engineer. All tests including HT & continuity test shall be carried out as per relevant IS

### **1.8 Earthing System Tests**

The Contractor shall demonstrate to the Employer's Engineer that the resistance of the electrodes to earth and the earth conductor continuity is in accordance with the Specification and IS 3043. The tests shall be made on completion of the installation.

The test shall be performed from each major item of pumping station, by using an "Earth Muger" and auxiliary return conductor. The each earthing station shall be separately tested and value of earthing resistance shall be displaced under man hole cover.

### **1.9 Installation Inspection**

In addition to the progressive supervision and inspection by Employer's Engineer the Contractor shall offer for inspection to Employer's Engineer, the completely created pumping station/ part of pumping station on which tests are to be carried out. After such inspection by Employer, each equipment / sub system shall be tested by the Contractor in accordance with the applicable standards in the presence of Employer's Engineer. Such tests shall include but not be limited to the tests specified in following clauses.

### **1.10 Pre-commissioning Trials, Tests Of Electrical Equipment.**

On completion of erection of the equipment and before start-up, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Employer's Engineer and the Contractor for correctness, completeness of installation and acceptability for start-up, leading to initial pre- commissioning tests at site. The list of pre-commissioning tests to be performed shall be as mutually agreed by the Employer's Engineer and Contractor.



### **1.11 Commissioning**

The pumping station shall then be commissioned and put on Trial Operation at full load when Performance Guarantee Tests shall be conducted.

During the period of trial operation the Contractor shall

- i. Operate the full works on behalf of the Employer.
- ii. Supply the labour for the operation and maintenance of the works and bear the cost of electrical energy.
- iii. Carry out maintenance repairs of defects immediately.

During the period of trial operation of working hours of the Contractors shall be 24 hours daily, 7 days week.

The Contractor shall provide for the expenditure on all the consumables any energy required during the trial operation. All labour and cost of any other materials shall also be met fully by the Contractor. Water for operating the pumping station will be supplied free by the Employer.

The Trial Operation shall be considered successful, provided that each item of the equipment can operate continuously at the specified characteristics, for the period of Trial Operation and the Performance Guarantees are successfully met.

Any special equipment, tools and tackles required for the successful completion of the Performance and Guarantee Tests shall be provided by the Contractor free of cost.

The guaranteed performance figures of the equipment shall be provided by the Contractor during the Performance and Guarantee tests. Should the results of these tests show any decrease from the guaranteed values, the Contractor shall modify the equipment as required to enable them to meet the guarantees. In such case, Performance and Guarantee Tests shall be repeated within one month from the date the equipment is ready for re-test and costs for modifications including labour, materials and the cost of additional testing to prove that the equipment meets the guarantees, shall be borne by the Contractor.

Performance and Guarantee Tests shall make allowance for instrumentation errors as may.

### **1.12 Tests for Commissioning**

After all completion of installation works the Contractor shall arrange to carry out following checks/tests in the presence of Employer's Engineer.

#### **a) Tests of Motors**

##### Mechanical Completion Checks:

- i. Compare name plate details with the specification.
- ii. Check for tightness of all bolts, clamps and connecting terminals.
- iii. Check ground connection.
- iv. Bearing lubrication.
- v. Check clearance inside terminal box.

- vi. Muggger testing of motor winding and cables.
- vii. Motor winding, control and power cables continuity checks.
- viii. Resistance of motor winding.
- ix. Check / calibration if RTDs, BTDS, flow switches (in case of water cooled motors) and if any other instrument mounted.

Commissioning Tests:

- i. Controls and interlocks.
- ii. Ready test and settings.
- iii. Phase sequence and rotation.
- iv. Starting and no load currents.
- v. No load operation (observe variation, noise level, temperature of bearing and windings of motor, check speed of motor) for 8 hours.
- vi. On load operation, starting and running currents operation (observe variations, noise level, temperature of bearing and windings of motor, check speed of motors).
- vii. In case of closed loop arrangement for cooling the windings of motor, inlet and outlet temperature of the cooling air / water.

**b) Tests on Control Panels and Switchboards**

Mechanical Completion Tests:

- i. Check name plate details of every associated equipment according to specification.
- ii. Check for physical damage.
- iii. Check for tightness of all bolts, clamps and connecting terminals.
- iv. Check earthing.
- v. Switch developments.
- vi. Each wire shall be traced by continuity tests and it should be made sure that the wiring is as per relevant drawings. All interconnections between panels/equipment shall be similarly checked.
- vii. All the wires should be meggered to earth.

Commissioning Tests:

- i. Checks on relays.
- ii. Checks on motors.
- iii. Setting of relays, other alarm, tripping devices and interlocks as per scheme.
- iv. Phase angle checks, measurement of magnitude and phase angle of current transformer secondary currents and potential transformer secondary voltage.

- v. Functional checking of all power and control circuits e.g. closing, tripping, control, interlock, supervision and arm circuits including proper functioning of the components equipment.

**c) Test of Relays**

Mechanical Completion Checks:

- i. Check name plate details according to specification.
- ii. Check for any physical damage.
- iii. Check internal wiring.
- iv. Megger all terminals to body.
- v. Megger AC to DC terminals.

Commissioning Checks:

- i. Check operating characteristics over the entire range by secondary injection.
- ii. Check minimum pick up voltage.
- iii. Check operation of electrical / Mechanical targets.
- iv. Relay settings.

**d) Tests for Meters**

Mechanical Completion Tests:

- i. Check name plate details according to specification.
- ii. Check for any physical damage.

Commissioning Checks:

- i. Check calibration.
- ii. Megger all insulated portions.
- iii. Check CT and VT connection with particular reference to their polarities for relevant meters.

**e) Tests for Circuit Breakers:**

Mechanical Completion Checks:

- i. Check name plate details according to specification.
- ii. Check for any physical damage.
- iii. Check for tightness of all bolts, clamps and connecting terminals.
- iv. Check oil level, air pressure and leakage (wherever applicable ).
- v. Check earth connection

- vi. Check cleanliness of insulators and bushings.
- vii. Check all moving parts are properly lubricated.
- viii. Check heaters provided.
- ix. Check alignment of breaker trucks for free movement, check operation of shutters.

Commissioning Test:

- i. Check control wiring for correctness of connections, continuity and IR values.
- ii. Manual operation of breaker.
- iii. Power closing / operating manually and electrically.
- iv. Breaker tripping and closing time.
- v. Trip free and anti-pumping operation.
- vi. IR values, resistance and minimum pick up voltage.
- vii. Contact resistance.
- viii. Simultaneous closing and mechanical interlocks provided.
- ix. Check electrical and mechanical interlocks provided.
- x. Checks on spring charging motor, correct operation of limit switch and time of charging.
- xi. Checks on CTs.
- xii. All functional tests.

**f) Tests for Dry Type transformers**

Mechanical Completion Tests:

- i. Check name plate details.
- ii. Check for any physical damage.
- iii. Check cleanliness of insulators and bushings.
- iv. Check for tightness of all bolts, clamps and connecting terminals.
- v. Check earthing connections.
- vi. Check that the transformer is correctly installed with reference to its phasing.

Commissioning Tests:

- i. Meggar test between windings, winding terminals and body.
- ii. Check for damage & tight connection prior to energizing the transformer.
- iii. Polarity test.

- iv. Check for primary & secondary voltage.
- v. Ratio identification, all ratios with primary injection of current.
- vi. Magnetizing characteristics, secondary winding resistance
- vii. Capacitance and Star delta test.

**g) Tests for Potential Transformers (PT)**

Mechanical Completion Tests:

- i. Check name plate details.
- ii. Check for any physical damage.
- iii. Check cleanliness of insulators.
- iv. Check for tightness of all bolts, clamps and connecting terminals.
- v. Check earthing connections.

Commissioning Tests:

- i. Insulation resistance test.
- ii. Polarity test.
- iii. Ratio test on all cores.
- iv. Line connections are per connection diagram.
- v. Open delta test with low voltage, wherever required.
- vi. Measure core loss from LT side.

**h) Tests for Current Transformer**

Mechanical Completion Tests:

- i. Check name plate details according to specification.
- ii. Check for any physical damage.
- iii. Check cleanliness of insulators and bushings.
- iv. Check for tightness of all bolts, clamps and connecting terminals.
- v. Check for oil level and leakage.
- vi. Check connections.

Commissioning Tests:

- i. Megger between windings, winding terminals and body.
- ii. Polarity test.

- iii. Ratio identification checking of all ratios on all cores by primary injection of current. Magnetisation characteristics, secondary winding resistance.
- iv. Capacitance and tan delta test.

**i) Test for Isolators**

Mechanical Completion Tests:

- i. Check name plate details according to specification.
- ii. Check for any physical damage.
- iii. Check cleanliness of insulators.
- iv. Check for tightness of all bolts, clamps and connecting terminal.
- v. Insulation resistance of each pole.

Commissioning Tests:

- i. Manual and electric operation and interlocks.
- ii. Correctness of connections, continuity and insulation resistance values of control circuits.
- iii. Contact resistance of each pole / gap between male and female contacts.
- iv. Earth connections of structures and operating handle.
- v. Clearance in open and closed position.
- vi. Simultaneous closing of all phases.

**j) Test for Cables**

Mechanical Completion Checks:

- i. Check name plate details according to specification
- ii. Check for any physical damage
- iii. Megger test between each core and armour/sheet
- iv. Continuity check
- v. Connections.

**k) Tests for Battery**

Mechanical Completion Checks:

- i. Check name plate details according to specification.
- ii. Check for any physical damage.
- iii. Dimensional check of plates (before assembly).

Commissioning Checks:

- i. Cell voltage test.
- ii. Capacity test.
- iii. Initial charging cycle.

**l) Tests for Battery Charger**

Mechanical Completion Checks:

- i. Check name plate details according to specification.
- ii. Check for any physical damage.
- iii. Check Connections.

Commissioning Checks:

- i. Functional check of auxiliary devices, such as alarms, indicating lamp etc.
- ii. Insulation test of all circuits.
- iii. Measurement of voltage regulation.
- iv. No load current and voltage (AC) and voltage and current both AC and DC) at different points.
- v. Voltage at tap cell (While boost charging ).

**m) Tests for DG set**

Test on DG set shall be performed as mentioned in Central public works department (CPWD) and as per relevant IS code

**n) Test on complete control system**

On completion, the functioning of the complete system shall be tested to demonstrate its correct operation in accordance with the Specification.

For control system testing, the Contractor may provide temporary means to simulate operating conditions, but the system will not be finally accepted until correct operation has been demonstrated to the satisfaction of the Engineer when all the pumps are operating.

The system shall be shown to operate correctly whatever the selection of duty and standby equipment may be.

Conditions to be tested shall include:

- Normal automatic operation.
- Normal manual operation
- Emergency manual operation

Commissioning Tests:

Correct operation of controllers shall be verified by observing that the final control element moves in the proper direction to correct the process variable as compared to the set point. All logic sequences shall be verified to operate in accordance with the specifications.

All defects and malfunctions disclosed by test shall be corrected immediately. New parts and materials shall be used as required and approved and tests shall be repeated.

A report certifying completion of validation of each instrument system indicating calibration values, verification that the system performs as per requirements and any provisional settings made to devices shall be provided. A format for commissioning checklist to be provided for approval before performing the commissioning tests.

Final Operational Testing and Acceptance:

Upon completion of instrument calibration and system validation, all systems shall be tested under process conditions.

The testing shall include, but not limited to all specified operational modes, taking process variables to their limits (simulated or process) to verify all alarms, failures, interlocks and operational interlocks between systems and/ or mechanical equipment.

Any defects or malfunctions shall be immediately corrected using approved methods and materials and the tests shall then be repeated.

Upon completion of final operational testing, a report shall be submitted, indicating that the total control system provided meets all the functional requirements specified herein. This report shall be made in the format approved by the Engineer. The Engineer shall certify this report and it shall constitute final acceptance of the control.

**o) Tests for Electrical Installations**

Mechanical Completion Tests:

- i. Check all closing, tripping, supervision and interlock of control devices.
- ii. Check operation of all alarm circuits.
- iii. Earthing :
  - Measure resistance of each earth electrode by isolating the same from station grid as well as from other earth electrodes.
  - Check continuity of grid conductors and wires.

Commissioning Test:

- i. Cable Testing.
- ii. All, 11 KV cables to be high voltage tested.
- iii. In addition to above, any other tests specified by manufacturer shall be carried out as per manufacturer's instruction.



- iv. Measure voltage across bearing pedestal insulation and between rotor shaft and bearing.

**p) Miscellaneous**

Mechanical completion checks and commissioning tests on items not covered above, shall be carried out by the Contractor as per the instructions of employer representative.

**q) Completion Taking Over**

- i. The Works will be certified as completed for taking over by the Employer only after it has successfully completed trial operation for a continuous period of one month.
- ii. A Completion Certificate for pumping station shall not be issued unless the following documentation are dully compiled and submitted in final formats in duly bound volumes.
- iii. A Completion of all shop inspection results/ reports of the machinery with due attestation that the plants have been manufactured to specified standards (6 copies).
- iv. All erection/construction quality control checks in appropriate approved formats for installation works with attestation that installation has been carried out as per acceptable / stipulated standards (6 copies).

**r) Maintenance**

During the O&M, the Contractor shall station one experienced engineer with sufficient staff round the clock, who will service /maintain all the equipment supplied under the contract and attend to any notified defects. In regard to the rectification of faults and defects and wear and tear (including replacements) of major nature which arise during normal operation of the pumping station during the DLP the Contractor shall be responsible for all costs thereto.

**s) Inspection, Testing and commissioning for DCS/SCADA system.**

**A. Factory Acceptance Test (FAT)**

- 1. The Contractor shall provide, as specified under "Quality Assurance" and "Submittals", a factory test procedure, for review and approval by the Engineer. The test shall be conducted at the Manufacturer's facility and be witnessed by the Engineer and or Employer. The test shall be not less than 40 working hours in duration. It shall cover all operations of the System which may be technically feasible to evaluate. Upon agreement of an appropriate time, this test shall be conducted prior to shipment. Passing this test, as judged by the Engineer/ Employer, shall constitute approval for shipping. Travel and boarding costs for the Engineer/Employer staff ( minimum people of 3 ) shall be paid by the Contractor itself.
- 2. Following criteria must be met prior to start of factory test:
  - a. All submittals must be complete and approved and any attendant disputes resolved.
  - b. All hardware which is to be supplied is fully operational.
  - c. Test procedure has been submitted and approved.

- d. Test date has been set which is agreeable to all.
3. Purpose of test is to demonstrate fully integrated system being used under simulated conditions similar to those for which system was designed. All hardware and software supplied under this Contract shall be tested including basic software and project specific software.
4. The integrated system demonstration test will be conducted by Supplier.
5. Test shall be completed when Engineer has issued a formal concurrence that all equipment and software supplied is in conformance with Specifications and any remaining discrepancies have been resolved. Upon completion of factory test, system may be shipped.
6. Each point (input and output) shall be checked from the element location on the DCS to the respective process graphic on workstations.
7. Provide a simulation panel to facilitate the test. The simulation panel will be used to test continuous and sequential control(s) during the test. The simulation panel shall include: lights to indicate run state, switches to change state, potentiometer to generate signals, and current meter. The simulation panel shall accommodate a minimum of 16 analog control loops and 48 discrete signals.

B. Training:

1. General:

- a. All instructors shall be full time, professional instructors, skilled in the discipline which they are responsible for teaching. For maintenance training, the instructors shall have had practical hands-on experience with the installation and troubleshooting of the system. Engineering instructors shall have formal education and experience in the design and implementation of DCS projects.
- b. The System Supplier shall provide a portion of the required training for selected people at the Employer's facility if instructed by the Engineer. The Employer shall provide necessary tables, chairs and power in a suitable room for this training. All equipment necessary to perform the training shall be provided by the Contractor. All training shall be accomplished during weekdays, excluding legal holidays. Training sessions shall include up to 50 percent laboratory exercises. Lab time shall include formal lab exercises. All courses shall incorporate effective use of audio visual aids in the classroom. Contractor shall submit all audio visual information for approval by the Engineer.
- c. The System Supplier shall also provide regularly scheduled courses at their training facility. These classes shall also include lab time of no less than 50 percent. The Contractor shall cover the costs of all transportation, food and lodging expenses for all Employer employed trainees, for all training sessions that take place at the System Supplier's Facilities. Wherever possible, training at the manufacturer's facility shall utilize simulation equipment which emulates the treatment process.
- d. All trainees shall be provided with formal educational material which is separate from the manufacturer's instructional manuals. Additionally, a formal, professionally video-taped introductory course shall be provided which includes

software for the lab exercises as well as training manuals for multiple students. The Contractor shall submit video tapes for review by the Engineer.

- e. The training shall include generic, measurement and control theory training and basic instrumentation training. The Training shall be comprehensive such that they are fully confident of operation and maintenance of the Instruments and Controls.
- f. At the End of each training course the trainees shall be given course certificates mentioning the type of course which they have undergone.

2. Training Plan:

- a. The overall goal for training shall be to prepare Employer personnel for the proper operation and the necessary upkeep and maintenance of the DCS. The Contractor shall provide instructors, facilities, equipment and materials as required to meet the overall goal. As a minimum, training shall comprise the courses and sessions for the number and background of attendees as indicated in Table 1. The Contractor to fill the table as required and submit to the Engineer for approval.
- b. The Contractor shall submit a Training Plan as part of the Project Overview submittal.
- c. The Training Plan shall include a schedule of all courses in a format similar to Table 36. The schedule shall show, at a minimum, the following information:
  - (1) Course title.
  - (2) Date of course.
  - (3) Date of significant construction milestones that impact the timing of each course, in relation to the course date
  - (4) Number of students per class, by title
  - (5) Course duration
  - (6) Course location
- d. The training Plan shall also contain detailed lesson plans for each course, including the learning objectives, samples of handouts to be provided, a description of any equipment provided and the portion of classroom time versus lab time. Resumes of all instructors shall also be included in the Training Plan. No training shall be conducted until the Training Plan is approved by the Engineer.
- e. One (1) copy of all handouts to be utilized during any training session shall be submitted to the Engineer at least one week prior to any session in addition to the copies distributed during the session.

**Table 19: Training Plan Schedule**

| No: | Date of course | Course title(s) | No: of students per class | Student Profile | Coursed duration/Location         |
|-----|----------------|-----------------|---------------------------|-----------------|-----------------------------------|
| 1   |                |                 | 25                        | Operators       | 10 working days, 8 hours each day |
| 2   |                |                 | 15                        | Supervisors     | 15 working day, 8 hours per day   |
| 3   |                |                 | 15                        | Engineers       | 15 working days 8 hours per day   |
| 4   |                |                 | 5                         | Managers        | 15 working days 8 hours per day   |

3. Course Objectives:

a. The objectives for each course indicated in Table 36 shall be as listed below. The Training Plan shall provide the specific details indicating how the Contractor-provided training will implement these objectives. The objectives indicated below are meant to be guidelines. Topics may be substituted at the discretion of the Engineer, as long as the same total number of session days is provided.

(1) System Overview:

- (a) Emphasis on functional characteristics of the major system components (hardware and software).
- (b) Preliminary introduction to hands-on use of operator interface.

(2) Preliminary Operator Interface Training:

- (a) Hands-on training in capabilities of Operator Interface.
- (b) Ability to design displays and reports specific to this project.

(3) Preliminary Archive Interface Training:

- (a) Knowledge of capabilities of Archival System for long term storage, retrieval and utilization of plant data.
- (b) Ability to design displays and reports specific to projects related to historical database.

(4) Configuration:

- (a) Understanding of all configuration tools.
- (b) Hands-on training in the creation and modification of displays and reports, and of alarm handling procedures.

- (5) Archival System Configuration:
  - (a) Understanding of all configuration tools.
  - (b) Hands-on training in creation and modification of databases, displays and reports from database.
- (6) System Maintenance:
  - (a) Thorough understanding of system architecture.
  - (b) Ability to identify and use system diagnostics to troubleshoot all system components.
  - (c) Demonstrate proper removal and replacement procedures.
  - (d) Demonstrate software installation procedures.
  - (e) Operation of control configurator.
  - (f) Use software to perform loop checkout.
- (7) Console Maintenance:
  - (a) Working knowledge of all console components (drives, modules, screens, keyboards, etc.) and their functions.
  - (b) Hands-on use of systems diagnostics; ability to troubleshoot and identify faulty components.
  - (c) Demonstration of repair/replace procedures; basic understanding of requirements to accomplish repairs (personnel, equipment/tools, time, cost).
- (8) Archival System Maintenance:
  - (a) Working knowledge of all hardware components of Historical Data Computer and Optical Disks, Tape Back-up Unit and System Terminal.
  - (b) Hands-on use of systems diagnostics; ability to troubleshoot and identify faulty components.
  - (c) Demonstration of repair/replace procedures; basic understanding of requirements to accomplish repairs (personnel, equipment/tools, time, cost).
- (9) Customized Operation Training I:
  - (a) Demonstrate use of all displays and reports specific to Owls Head.
- (10) Customized Operator Training II:
  - (a) Hands-on demonstration of displays, reports, and alarm handling on system installed at Owls Head.
  - (b) Hands-on demonstration of manual entry and use of lab data.

- (11) UPS:
  - (a) Operation and maintenance.
- (12) Automated Process Control Overview:
  - (a) Thorough background in control devices (transmitters, controllers, valves, etc.).
  - (b) Basic understanding of control loop (feed-forward and feedback).
- (13) Process Control Using Plant Computer:
  - (a) Design/implementation of process control databases and strategies.
  - (b) Utilization of continuous ladder and sequential control.
- (14) Customized Operator Training III:
  - (a) Review of displays, reports, alarm handling.
  - (b) Review of manual data input.
  - (c) Review of creating and modifying displays and reports.
  - (d) Review of all updated system documentation including I/O lists, system architecture and manufacturer's manuals.

C. Installed System Test( Site Acceptance Test, SAT):

- 1. Commissioning shall commence after completion of system installation phase and checkout of basic system software. Supplier shall supply all labor and materials necessary to conduct these activities. Test shall verify that system meets all requirements of Specification. The test shall be not less than 80 working hours in duration. Included in the test are the following sections.
- 2. I/O Checkout:
  - a. Schedule of how Supplier intends to perform I/O checkout effort shall be submitted for approval to Engineer. This schedule shall identify site by order in which the checkout will be performed and anticipated date of completion of each site.
  - b. I/O check of a given process area shall be performed only after completion of all field terminations. Supplier shall coordinate his work with other Contractors, to accommodate this requirement and shall notify Engineer of conflicts.
  - c. I/O check shall be performed only upon completion of system delivery and installation.
  - d. Each point (input and output) shall be checked from the end field element to respective process graphic on area operator station and central control center. Where possible final control element shall be motion checked to verify correct interface to device. Where it is not possible to motion check final control element, it shall be simulated at final control element location.

Engineer shall receive a field copy of all field test reports at time each test is completed.

- e. Document all points checked providing point name, termination information, applicable loop drawing references, field device name, tests performed, diagnosis of problem, and date tested. These findings shall be submitted to Engineer.
  - f. The Control Loops shall be checked individually and confirm the functioning as required. The complete control loop shall be tested for total functionality as required by the Plant process parameters and checked.
3. Following conditions shall be met prior to start of installed system tests:
- a. In factory test problem lists shall have been resolved.
  - b. Installed system test procedure shall have been submitted to and approved by Engineer.
  - c. All documentation shall be on-site and in corrected form.
  - d. All test equipment and spare parts shall be on-site, labeled, and properly stored.
  - e. All instrumentation supplied under this and other contracts shall be an operational part of system.
  - f. Immediately prior to start of installed system test, all software shall be rebuilt from supplied source code and shall be loaded into system and made operational.
  - g. A list of programs residing in system shall be generated and compared with documentation supplied. All discrepancies shall be resolved prior to start of test.
4. Conduct of Test:
- a. A detailed step-by-step test procedure for Installed System Test shall be submitted to Engineer for approval at least 3 weeks in advance of test. Submit six copies.
  - b. Supplier shall supervise and conduct test. Supplier shall provide assistance upon request at no additional cost or time extension.
  - c. Engineer shall determine sequence in which portions of test procedure will be performed and which portions may be performed simultaneously.

**Schedule L - Provisional Certificate**

*(See Clause 12.2 and 12.4)*

1. I, ..... (Name of the EMPLOYER’s Engineer), acting as EMPLOYER’s Engineer, under and in accordance with the Agreement dated ..... (the “**Agreement**”), for “Design, Construction, Operation & Maintenance of Raw Water Pumping Station and Raw Water Transmission Main from Pipli Pumping Station (Pariyej Reservoir) to WTP at TP1 in Dholera SIR” in the State of Gujarat through Engineering, Procurement & Construction (EPC) Basis Contract through ..... (Name of Contractor), hereby certify that the Tests in accordance with Article 12 of the Agreement have been undertaken to determine compliance of the Project ..... with the provisions of the Agreement.
2. Construction Works that are incomplete on account of Time Extension have been specified in the Punch List appended hereto, and the Contractor has agreed and accepted that it shall complete all such works in the time and manner set forth in the Agreement. In addition, certain minor works are incomplete and these are not likely to cause material inconvenience to the users of the Project ..... or other their safety. The Contractor has agreed and accepted that as a condition of this Provisional Certificate, it shall complete such minor works within 30 (thirty) days hereof. These minor works have also been specified in the aforesaid punch list.
3. In view of the foregoing, I am satisfied that that Project ..... can be safely and reliably placed in service of the users thereof, and in terms of the Agreement, the Project ..... is hereby provisionally declared fit for entry into operation on this the .....day of .....20 .....

ACCEPTED, SIGNED, SEALED  
AND DELIVERED

SIGNED, SEALED AND DELIVERED

For and on behalf of

For and on behalf of

CONTRACTOR by

EMPLOYER’s Engineer by:

(Signature)

(Signature)



### COMPLETION CERTIFICATE

1. I, ..... (Name of the EMPLOYER's Engineer), acting as EMPLOYER's Engineer, under and in accordance with the Agreement dated ..... (the "**Agreement**"), for "Design, Construction, Operation & Maintenance of Raw Water Pumping Station and Raw Water Transmission Main from Pipli Pumping Station (Pariyej Reservoir) to WTP at TP1 in Dholera SIR" in the State of Gujarat under through Engineering, Procurement & Construction (EPC) Basis through ..... (Name of Contractor), hereby certify that the Tests in accordance with Article 12 of the Agreement have been successfully undertaken to determine compliance of the Project ..... with the provisions of the Agreement, and I am satisfied that the Project ..... can be safely and reliably placed in service of the Users thereof..
2. It is certified that, in terms of the aforesaid Agreement, all works forming part of Project Works have been completed, and the Project Works is hereby declared fit for entry into operation on this the .....day of .....20 .....

SIGNED, SEALED AND DELIVERED

For and on behalf of

EMPLOYER's Engineer by:

(Signature)

(Name)

(Designation)

(Address)

### Schedule M - Payment Reduction for Non-Compliance

*(See Clauses 14.6., 15.2 and 19.7)*

#### **1 Payment reduction for non-compliance with the Operation & Maintenance Requirements**

- 1.1 Monthly lump sum payments for operation and maintenance shall be reduced in the case of non-compliance with the Operation & Maintenance Requirements set forth in Schedule-E.
- 1.2 Any deduction made on account of non-compliance with the operation & maintenance requirements shall not be paid even after compliance subsequently. The deduction shall continue to be made every month until compliance is done.
- 1.3 The Employer's Engineer shall calculate the amount of payment reduction on the basis of weightage in percentage assigned to non-conforming items as given in Paragraph 2.

#### **2 Percentage reductions in lump sum payments**

- 2.1 The following weightages/percentages shall govern the payment reduction:

**Table 20: Percentage reductions for Works (on monthly basis)**

| Sr. No.  | Item/Defect/Deficiency  | % ( of the monthly O&M amount) |
|----------|---|--------------------------------|
| <b>1</b> | <b>Raw Water Pumping Station</b>  | <b>65%</b>                     |
| 1.1      | If the operational hours of the pumping station is less than 24 hrs. as per Schedule E  | 20%                            |
| 1.2      | If the output raw water quantity is less than the quantity as specified in Schedule E   | 20%                            |
| 1.3      | If the general repair and rectification of defects as per Schedule E not addressed in time for the Civil units on any defect/deficiency   | 10%                            |
| 1.4      | If the general repair and rectification of defects(as per Schedule E not addressed in time for the Electrical, Mechanical or Instrumentation Units (including DCS /SCADA system) on any defect/deficiency | 15%                            |
| <b>2</b> | <b>Raw Water Transmission Main from Pumping Station to WTP (of the applicable monthly maintenance amount)</b>   | <b>30%</b>                     |
| 2.1      | If the C value of the raw water transmission main is more than the C value specified in Schedule E.   | 5%                             |
| 2.2      | If the loss of water in the raw water transmission main is more than the loss specified in Schedule E   | 10%                            |
| 2.3      | If the general repair and rectification of defects as per Schedule E not addressed in time for the Civil units on any defect/deficiency   | 7.5%                           |

| Sr. No. | Item/Defect/Deficiency   | % ( of the monthly O&M amount) |
|---------|--|--------------------------------|
| 2.4     | If the general repair and rectification of defects as per Schedule E not addressed in time for the Electrical, Mechanical or Instrumentation Units (including DCS system) on any defect/deficiency | 7.5%                           |
| 3       | <b>Project facilities (, Drainage, Sewage collection system, Water Supply system, Miscellaneous Items)</b>   | <b>5%</b>                      |
| (ii)    | Defects in Project Facilities  | 5%                             |

### 3. Payment adjustment for variable water supply during O&M Period

If the Employer requires less/more raw water supply than expected water quantity for each of the years that specified in Appendix E-III, then the applicable monthly O&M cost for any of the months will be adjusted as follows:

- **30% of the applicable monthly O&M cost will be paid as fixed cost**
- **The remaining 70% applicable monthly O&M Cost will be paid on pro-rata basis of the water quantity supplied (with respect to the expected quantities)**

## **Schedule N - Selection of Employer's Engineer**

*(See Clause 18.1.1)*

### **1. Selection of EMPLOYER's Engineer**

- 1.1 The provisions of the Model Request for Proposal for Selection of Technical Consultants, issued by the Ministry of Finance in May 2009, or any substitute thereof shall apply for selection of an experienced firm to discharge the functions and duties of an EMPLOYER's Engineer.
- 1.2 In the event of termination of the Technical Consultants appointed in accordance with the provisions of Paragraph 1.1, the EMPLOYER shall appoint another firm of Technical Consultants forthwith and may engage a government-owned entity in accordance with the provisions of Paragraph 3 of this Schedule-N.

### **2. Terms of Reference**

The Terms of Reference for the EMPLOYER's Engineer (the "TOR") shall substantially conform with Annex 1 to this Schedule N.

### **3. Appointment of Government entity as EMPLOYER's Engineer**

Notwithstanding anything to the contrary contained in this Schedule, the EMPLOYER may in its discretion appoint a government-owned entity as the EMPLOYER's Engineer; provided that such entity shall be a body corporate having as one of its primary functions the provision of consulting, advisory and supervisory services for engineering projects; provided further that a government-owned entity which is owned or controlled by the EMPLOYER shall not be eligible for appointment as EMPLOYER's Engineer.

**Annex – I**

(Schedule - N)

**Terms of Reference for Employer’s Engineer**

**1. Scope**

1.1 These Terms of Reference (the “**TOR**”) for the EMPLOYER’s Engineer are being specified pursuant to the EPC Agreement dated ..... (the “**Agreement**”), which has been entered into between the .....Name of EMPLOYER (the “EMPLOYER”) and ..... (the “**Contractor**”) for “Design, Construction, Operation & Maintenance of Raw Water Pumping Station and Raw Water Transmission Main from Pipli Pumping Station (Pariyej Reservoir) to WTP at TP1 in Dholera SIR on Engineering, Procurement & Construction (EPC)” Basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this TOR.

1.2 The TOR shall apply to design, construction, operation and maintenance of the Project .....

**2. Definitions and interpretation**

2.1 The words and expressions beginning with or in capital letters and not defined herein but defined in the Agreement shall have, unless repugnant to the context, the meaning respectively assigned to them in the Agreement.

2.2 References to Articles, Clauses and Schedules in this TOR shall, except where the context otherwise requires, be deemed to be references to the Articles, Clauses and Schedules of the Agreement, and references to Paragraphs shall be deemed to be references to Paragraphs of this TOR.

2.3 The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Agreement shall apply, *mutatis mutandis*, to this TOR.

**3. General**

3.1 The EMPLOYER’s Engineer shall discharge its duties in a fair, impartial and efficient manner, consistent with the highest standards of professional integrity and Good Industry Practice.

3.2 The EMPLOYER’s Engineer shall perform the duties and exercise the authority in accordance with the provisions of this Agreement, but subject to obtaining prior written approval of the EMPLOYER/ PMNC before determining:

- (a) Any Time extension;
- (b) Any additional cost to be paid by the EMPLOYER to the Contractor;
- (c) The Termination Payment; or
- (d) any other matter which is not specified in (a), (b) or (c) above and which creates an obligation or liability on either Party for a sum exceeding Rs.5,000,000 (Rs. fifty lakh).

3.3 The EMPLOYER’s Engineer shall submit regular periodic reports, at least once every month, to the EMPLOYER/ PMNC in respect of its duties and functions under this Agreement. Such reports shall be submitted by the EMPLOYER’s Engineer within 10 (ten) days of the beginning of every month.

- 3.4 The EMPLOYER's Engineer shall inform the Contractor of any delegation of its duties and responsibilities to its suitably qualified and experienced personnel provided, however, that it shall not delegate the authority to refer any matter for the EMPLOYER's prior approval in accordance with the provisions of Clause 18.2.
- 3.5 The EMPLOYER's Engineer shall aid and advise the EMPLOYER on any proposal for Change of Scope under Article 13.
- 3.6 In the event of any disagreement between the Parties regarding the meaning, scope and nature of Good Industry Practice, as set forth in any provision of the Agreement, the EMPLOYER's Engineer shall specify such meaning, scope and nature by issuing a reasoned written statement relying on good industry practice and authentic literature.

#### **4. Construction Period**

- 4.1 During the Construction Period, the EMPLOYER's Engineer shall review the Reports, Designs and Drawings furnished by the Contractor along with supporting data, including the geo-technical characteristics of materials from borrow areas and quarry sites, topographical surveys, and the recommendations of the Safety Consultant in accordance with the provisions of Clause 10.1.6. The EMPLOYER's Engineer shall complete such review and send its observations to the EMPLOYER/ PMNC and the Contractor within 15 (fifteen) days of receipt of such Drawings; provided, however that in case of a Structure, the aforesaid period of 15 (fifteen) days may be extended up to 30 (thirty) days. In particular, such comments shall specify the conformity or otherwise of such Drawings with the Scope of the Project and Specifications and Standards.
- 4.2 The EMPLOYER's Engineer shall review any revised Reports, Designs and Drawings sent to it by the Contractor and furnish its comments within 10 (ten) days of receiving such Drawings.
- 4.3 The EMPLOYER's Engineer shall review the (a) Quality Assurance Plan (b) Health, Safety and Environmental Management Plan submitted by the Contractor and shall convey its comments to the Contractor within a period of 21 (twenty-one) days stating the modifications, if any, required thereto. The Employer's Engineer shall ensure the Contractor's Project Management requirements, BIM and CAD requirements regularly on a monthly basis to the Employer/ PMNC
- 4.4 The EMPLOYER's Engineer shall complete the review of the methodology proposed to be adopted by the Contractor for executing the Works, and convey its comments to the Contractor within a period of 10 (ten) days from the date of receipt of the proposed methodology from the Contractor.
- 4.5 Deleted.
- 4.6 The EMPLOYER's Engineer shall review the monthly progress report furnished by the Contractor and send its comments thereon to the EMPLOYER/ PMNC and the Contractor within 7 (seven) days of receipt of such report.
- 4.7 The EMPLOYER's Engineer shall inspect the Construction Works and the Project Components and shall submit a monthly Inspection Report bringing out the results of

- inspections and the remedial action taken by the Contractor in respect of Defects or deficiencies.
- 4.8 The EMPLOYER's Engineer shall conduct the pre-construction review of manufacturer's test reports and standard samples of manufactured Materials, and such other Materials as the EMPLOYER's Engineer may require.
- 4.9 For determining that the Works conform to Specifications and Standards, the, EMPLOYER's Engineer shall require the Contractor to carry out, or cause to be carried out, tests at such time and frequency and in such manner as specified in the Agreement and in accordance with Good Industry Practice for quality assurance. For purposes of this Paragraph 4.9, the tests specified in the relevant Codes for Design, Construction, Operation and Maintenance ..... and the Specifications for Design, Construction, Operation and Maintenance ..... or any modification/substitution thereof and standards for (to be developed for project specific requirement) shall be deemed to be tests conforming to Good Industry Practice for quality assurance.
- 4.10 The EMPLOYER's Engineer shall test check at least 20 (twenty) percent of the quantity or number of tests prescribed for each category or type of test for quality control by the Contractor.
- 4.11 The timing of tests referred to in Paragraph 4.9, and the criteria for acceptance/ rejection of their results shall be determined by the EMPLOYER's Engineer in accordance with the Quality Control Manuals and/or the relevant Codes and Standards... ..... The tests shall be undertaken on a random sample basis and shall be in addition to, and independent of, the tests that may be carried out by the Contractor for its own quality assurance in accordance with Good Industry Practice.
- 4.12 In the event that results of any tests conducted under Clause 11.10 establish any Defects or deficiencies in the Works, the EMPLOYER's Engineer shall require the Contractor to carry out remedial measures.
- 4.13 The EMPLOYER's Engineer may instruct the Contractor to execute any work which is urgently required for the safety of the Project Works, whether because of an accident, unforeseeable event or otherwise; provided that incase of any work required on account of a Force Majeure Event, the provisions of Clause 21.6 shall apply.
- 4.14 In the event that the Contractor fails to achieve any of the Project Milestones, the EMPLOYER's Engineer shall undertake a review of the progress of construction and identify potential delays, if any. If the EMPLOYER's Engineer shall determine that completion of the Project Works is not feasible within the time specified in the Agreement, it shall require the Contractor to indicate within 15 (fifteen) days the steps proposed to be taken to expedite progress, and the period within which the Project Completion Date shall be achieved. Upon receipt of a report from the Contractor, the EMPLOYER's Engineer shall review the same and send its comments to the EMPLOYER/ PMNC and the Contractor forthwith.
- 4.15 The EMPLOYER's Engineer shall obtain from the Contractor two copies of all the Contractor's quality control records and documents before the Completion Certificate is issued pursuant to Clause 12.4.

- 4.16 EMPLOYER's Engineer may recommend to the EMPLOYER/PMNC suspension of the whole or part of the Works if the work threatens the safety of the. After the Contractor has carried out remedial measure, the EMPLOYER's Engineer shall inspect such remedial measures forthwith and make a report to the EMPLOYER recommending whether or not the suspension hereunder may be revoked.
- 4.17 In the event that the Contractor carries out any remedial measures to secure the safety of suspended works and Users, and requires the EMPLOYER's Engineer to inspect such works, the EMPLOYER's Engineer shall inspect the suspended works within 3 (three) days of receiving such notice, and make a report to the EMPLOYER/ PMNC forthwith, recommending whether or not such suspension may be revoked by the EMPLOYER.
- 4.18 The EMPLOYER's Engineer shall carry out, or cause to be carried out, all the Tests specified in Schedule-K and issue a Completion Certificate or Provisional Certificate, as the case may be. For carrying out its functions under this Paragraph 4.18 and all matters incidental thereto, the EMPLOYER's Engineer shall act under and in accordance with the provisions of Article 12 and Schedule-K.

## **5. Operation and Maintenance Period**

- 5.1 The EMPLOYER's Engineer shall aid and advise the Contractor in the preparation of its monthly Operation and Maintenance Programme and for this purpose carry out a joint monthly inspection with the Contractor.
- 5.2 The EMPLOYER's Engineer shall undertake regular inspections, at least once every month, to evaluate compliance with the Operation and Maintenance Requirements and submit an Operation and Maintenance Inspection Report to the EMPLOYER/ PMNC and the Contractor.
- 5.3 The EMPLOYER's Engineer shall specify the tests, if any, that the Contractor shall carry out, or cause to be carried out, for the purpose of determining that the Project Works is in conformity with the Operation and Maintenance Requirements. It shall monitor and review the results of such tests and the remedial measures, if any, taken by the Contractor in this behalf.
- 5.4 In respect of any defect or deficiency referred to in Paragraph 3 of Schedule-E, the EMPLOYER's Engineer shall, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Specifications and Standards and shall also specify the time limit for repair or rectification of any deviation or deterioration beyond the permissible limit.
- 5.5 The EMPLOYER's Engineer shall examine the request of the Contractor for closure of Services for undertaking maintenance/repair thereof, and shall grant permission with such modifications, as it may deem necessary, within 5 (five) days of receiving a request from the Contractor. Upon expiry of the permitted period of closure, the EMPLOYER's Engineer shall monitor the reopening of such lane(s), and in case of delay, determine the Damages payable by the Contractor to the EMPLOYER under Clause 14.5.

## **6. Determination of costs and time**

- 6.1 The EMPLOYER's Engineer shall determine the costs, and/or their reasonableness, that are required to be determined by it under the Agreement.



6.2 The EMPLOYER's Engineer shall determine the period of Time Extension that is required to be determined by it under the Agreement.

6.3 The EMPLOYER's Engineer shall consult each Party in every case of determination in accordance with the provisions of Clause 18.5.

## **7. Payments**

7.1 The EMPLOYER's Engineer shall withhold payments for the affected works for which the Contractor fails to revise and resubmit the Drawings to the EMPLOYER's Engineer in accordance with the provisions of Clause 10.2.4 (d).

7.2 EMPLOYER's Engineer shall -

(a) within 10 (ten) days of receipt of the Stage Payment Statement from the Contractor pursuant to Clause 19.4, determine the amount due to the Contractor and recommend the release of 90 (ninety) percent of the amount so determined as part payment, pending issue of the Interim Payment Certificate; and

(b) within 15 (fifteen) days of the receipt of the Stage Payment Statement referred to in Clause 19.4, deliver to the EMPLOYER/ PMNC and the Contractor an Interim Payment Certificate certifying the amount due and payable to the Contractor, after adjustments in accordance with the provisions of Clause 19.10.

7.3 The EMPLOYER's Engineer shall, within 15 (fifteen) days of receipt of the Monthly Operation and Maintenance Statement from the Contractor pursuant to Clause 19.6, verify the Contractor's monthly statement and certify the amount to be paid to the Contractor in accordance with the provisions of the Agreement.

7.4 The EMPLOYER's Engineer shall certify final payment within 30 (thirty) days of the receipt of the final payment statement of Operation and Maintenance in accordance with the provisions of Clause 19.16.

## **8. Other duties and functions**

The EMPLOYER's Engineer shall perform all other duties and functions as specified in the Agreement.

## **9. Miscellaneous**

9.1 A copy of all communications, comments, instructions, Drawings or Documents sent by the EMPLOYER's Engineer to the Contractor pursuant to this TOR, and a copy of all the test results with comments of the EMPLOYER's Engineer thereon, shall be furnished by the EMPLOYER's Engineer to the EMPLOYER/PMNC forthwith.

9.2 The EMPLOYER's Engineer shall retain at least one copy each of all Drawings and Documents received by it, including 'as-built' Drawings, and keep them in its safe custody.

9.3 Within 90 (ninety) days of the Project Completion Date, the EMPLOYER's Engineer shall obtain a complete set of as-built Drawings, in 2 (two) hard copies and in micro film form or in

such other medium as may be acceptable to the EMPLOYER, reflecting the Project ..... as actually designed, engineered and constructed, including an as-built survey illustrating the layout of the Project Works and setback lines, if any, of the buildings and structures forming part of Project Facilities; and shall hand them over to the EMPLOYER against receipt thereof.

- 9.4 The EMPLOYER's Engineer, if called upon by the EMPLOYER/PMNC or the Contractor or both, shall mediate and assist the Parties in arriving at an amicable settlement of any Dispute between the Parties.
- 9.5 The EMPLOYER's Engineer shall inform the EMPLOYER/PMNC and the Contractor of any event of Contractor's Default within one week of its occurrence.
- 9.6 The Employer's Engineer, if called upon by the Employer/ PMNC, shall attend the meetings on Project reviews, discussions to be held at Employer/ PMNC office with required reports and presentations.

## **Schedule O - Forms of Payment Statements**

*(See Clauses 19.4.1, 19.6.1, and 19.8.1)*

### **1. Stage Payment Statement for Works**

The Stage Payment Statement for Works shall state:

- (a) The estimated amount for the Works executed in accordance with Clause 19.3.1 subsequent to the last claim;
- (b) Amounts reflecting adjustments in price for the aforesaid claim;
- (c) The estimated amount of each Change of Scope Order executed subsequent to the last claim;
- (d) Amounts reflecting adjustment in price, if any, for (c) above in accordance with the provisions of Clause 13.2.3 (a);
- (e) Total of (a), (b), (c) and (d) above;
- (f) Deductions:
  - (i) Any amount to be deducted in accordance with the provisions of the Agreement except taxes;
  - (ii) Any amount towards deduction of taxes; and
  - (iii) Total of (i) and (ii) above.
- (g) Net claim: (e) – (f) (iii);
- (h) The amounts received by the Contractor up to the last claim:
  - (i) For the Works executed (excluding Change of Scope orders);
  - (ii) For Change of Scope Orders, and
  - (iii) Any deductions
  - (iv) Taxes deducted

### **2. Monthly Operation and Maintenance Payment Statement**

The monthly Statement for Operation and Maintenance Payment shall state:

- (a) the monthly payment admissible in accordance with the provisions of the agreement;
- (b) the deductions for operation and maintenance work not done;
- (c) net payment for operation and maintenance due, (a) minus (b);
- (d) amounts reflecting adjustments in price under Clause 19.12; and
- (e) amount towards deduction of taxes

### **3. Contractor's claim for Damages**

**Note:** The Contractor shall submit its claims in a form acceptable to the EMPLOYER/ PMNC.

## **Schedule P - Insurance**

*(See Clause 20.1)*

### **1. Insurance during Construction Period**

1.1. The Contractor shall effect and maintain at its own cost, from the Appointed Date till the date of issue of the last Completion Certificate, the following insurances for any loss or damage occurring on account of Non Political Event of Force Majeure, malicious act, accidental damage, explosion, fire and terrorism:

(a) insurance of Works and Materials and an additional sum of [15 (fifteen)] per cent of such replacement cost to cover any additional costs of and incidental to the rectification of loss or damage including professional fees and the cost of demolishing and removing any part of the Works and of removing debris of whatsoever nature; and

(b) Insurance for the Contractor's equipment and Documents brought onto the Site by the Contractor, for a sum sufficient to provide for their replacement at the Site.

1.2 The insurance under paragraph 1.1 (a) and (b) above shall cover the EMPLOYER and the Contractor against all loss or damage from whatsoever cause arising under paragraph 1.1 other than risks which are not insurable at commercial terms.

### **2. Insurance for Contractor's Defects Liability**

The Contractor shall effect and maintain insurance cover for the works from the date of issue of the Completion Certificate until the end of the Defects Liability Period for any loss or damage for which the Contractor is liable and arises from a cause occurring prior to the issue of Completion Certificate. The Contractor shall also maintain other insurances for maximum sums as may be required under the Applicable Laws and in accordance with Good Industry Practice.

### **3. Insurance against injury to persons and damage to property**

3.1 The Contractor shall insure against each Party's liability for any loss, damage, death or bodily injury which may occur to any physical property (except things insured under Paragraph 1 and 2 of this Schedule or to any person (except persons insured under Clause 20.9), which may arise out of the Contractor's performance of this agreement and occurring before the issue of the Performance Certificate. This insurance shall be for a limit per occurrence of not less than the amount stated below with no limit on the number of occurrences.

The insurance cover shall be not less than: Rs. 10 Lakhs.

3.2 The insurance shall be extended to cover liability for all loss and damage to the EMPLOYER's property arising out of the Contractor's performance of this Agreement excluding:

(a) the EMPLOYER's right to have the construction works executed on, over, under, in or through any land, and to occupy this land for the Works; and

(b) Damage which is and unavoidable result of the Contractor's obligations to execute the Works.

**4. Insurance to be in joint names**

The insurance under paragraphs 1 to 3 above shall be in the joint names of the Contractor and the EMPLOYER.

## **Schedule Q - BIM and CAD Requirements**

*(See Clause 3.1.7 K)*

### **1. Objective**

- 1.1. The Employer mandates the use Building Information Modelling (BIM) and Geographic Information Systems (GIS) for the detailed planning, design, engineering, construction and operation of the DSIR to allow simulation, visualization and engineering analysis of all transportation, utility, building, civil works and geospatial infrastructures.
- 1.2. This includes an aggregate dynamic Building Information Modelling (BIM) in 3D for the city infrastructure systems involves civil, landscape, treatment plants and underground and aboveground utilities systems participating.
- 1.3. Building Information Modelling (BIM) and Geographic Information Systems (GIS) technology shall be used to develop and produce project models and simulations (e.g. in case of natural calamity etc.) as required for submittals.
- 1.4. The BIM infrastructure information models are to be used throughout the design, construction and operational life-cycle of the asset, including but not limited to for system collision detection, materials quantification, construction sequencing and carbon impact analysis.
- 1.5. BIM and GIS models use shall be maximized for project reviews, decision support, design analysis, and quality assurance during all phases and asset integration architectural plan for ICT systems and their city wide uses.

### **2. Scope**

- 2.1. All infrastructures, networks and facilities designed by the Contractors as part of this assignment shall be consolidated as part of a spatial database preferably using MS-SQL Server Spatial or Oracle Spatial or other systems. The Contractor shall coordinate with the Employer/Employer's Engineer on the design of data scheme of the spatial database beforehand. Both the 2D and 3D spatial data shall be stored in project spatial database for mapping, modelling and analysis.
- 2.2. To successfully implement Building Information Modelling (BIM) and Geographic Information Systems (GIS) the Contractors shall develop detailed project BIM Execution Plan, defines uses for BIM and GIS on the project, asset information's details and asset supply chain approach for city wide ICT integrations.
- 2.3. To effectively introduce BIM into the project delivery process, the Contractors shall outlines the overall vision along with implementation details for the team to follow throughout the project but not limited to project information, BIM goal & uses, project member's roles, staffing and competency, BIM process and strategy, BIM exchange protocol and submittal format, BIM data requirement, collaboration procedures and method to handle shared models, BIM design and drawings quality checklist, technology use, asset information's spreadsheet for facility management, BIM & GIS international best practices followed during implementations, and asset information tagging and integration approach for ICT. Refer to Appendix Q I – BIM Project Execution Plan template.

- 2.4. The Contractor shall be responsible to prepare detailed construction project schedule plan including but not limited to BIM Execution Plan (BEP), Master Document Register (MDR), Site Layout Plan, Project Folder Information Structure Hierarchy, 3D designs and drawings, Level of Development (LOD), construction and operation asset information spreadsheet and BIM & GIS spatial database, etc.
- 2.5. The Contractor shall provide structured BIM approach to the production of all required design and as-built data and information for these works under the Contract, modelled on BS1192 collaborative production of architectural, engineering and construction information; Code of practice, including BIM quality checklist. Refer to Appendix Q I – BIM Project Execution Plan template.
- 2.6. The Contractor shall provide all native and design models list through MDR which shall be part of BIM Execution Plan (BEP) and Monthly Progress Report (MPR) but not limited to 2D Drawings, 3D models, PDF's, native software files, calculation data sheets and reports, etc.
- 2.7. The Contractor shall be responsible for development of Master Document Register (MDR), Site Layout Plan in a form of 2D/3D and drawing sheet name plate, in consultation with Employer's Representative, at the start of the works that shall list all the 'file identifiers' and information details of the assets with their delivery dates and intermediate milestones. The following metadata shall be included but not limited to Program ID, Contract No, Originator Code, Discipline Code, Type, Zone, Level, Description/Title, and Delivery Date. Refer to Annexure-II of CAD Guideline.
- 2.8. The Contractor shall prepare and share available existing data sets in a form of 2D/3D models for reference and liable for validating the models before utilizing/enhancing further. Data sets with distinct owners, e.g. DP, TP1, TP2, etc. shall be referenced into the model.
- 2.9. 3D Models, 2D CAD drawing files shall have original plot composition files containing all extractions, CAD drawings shall have a corresponding PDF's provenance shown on the plot, i.e. the references, extractions, model revision used to generate plot. Drawing title block shall be consistent with setup by the Employer/ Employer's Engineer for the Contractor to use for the project.
- 2.10. The PMIS or Common Data Environment (CDE) setup by the Employer/Employer's Engineer are mandated for the Contractors to use, to collect, manage and disseminate all relevant approved project documents. The Contractor shall develop project folder information structure hierarchy that is consistent with the principles of the CDE for all models and drawings. Refer to Schedule-H.
- 2.11. The Contractor shall outline a uniform and interoperable software/hardware platform across the entire Work Package, in that any software used shall be consistent with the principles of the sharing of multi-disciplinary object data in a CDE; That data shall include geometry and object attributes.
- 2.12. The coordinate system and unit convention for Design and drawings shall be consistent with completed/ongoing projects at Dholera SIR and geo reference details will be provided by the Employer. Vertical datum values/details will be provided by the Employer. DSIR falls in WGS84 UTM43N.
- 2.13. Document Management setups by Employer are mandated for the Contractor shall require follow and prepare asset (Level of Development-LOD) spreadsheet as part of

- 2.14. BIM Execution Plan (BEP) document. For effective and quality information, the Contractor shall represent Level of Detail i.e. Size, Volume, Shape, Height and Orientation for graphical data and non-graphic data.
- 2.15. The Contractor shall be responsible to clearly outline the technology to be used for design and drawings production and software native outcomes in their BIM Execution Plan (BEP), in consultation with Employer/ Employer's Engineer and ICT Consultant.
- 2.16. The Contractor shall be responsible for preparation of construction-operations information exchange standard spreadsheet, and tag asset information within the infrastructure models but not limited to asset name, code, quantity, manufacturer, model no, serial no, etc. which controls the transition of As-Built data for operations and maintenance.
- 2.17. For seamless coordination and integration of drawing packages within BIM environment, the Contractor shall reference each models to other discipline models in timely manner and clash detection software routines shall be run on the multi-discipline model. The reports of which will be included with transmittals during project delivery and on request of the Employer/ Employer's Engineer.
- 2.18. The Contractor shall also be responsible to develop GIS (Geographical Information System) spatial database with level of details; extractions of vectors data from CAD and design models of each infrastructure component.
- 2.19. The Contractor shall carry out transfer of digital model files in mutually agreed conditions with the Employer as per the project management requirement.
- 2.20. The Contractor shall provide a pre-construction Still or Ariel video tape and photographs in DVD format or open format with Monthly Progress Report (MPR), documenting the condition of the Project area prior to commencement of any construction work.
- 2.21. The Contractor shall provide Still or Ariel video during construction and post construction periods. The contractor shall also provide pre-construction and during construction time lapse progress in Still and Aerial video tape in DVD format or open format.
- 2.22. The photographs and video (color) shall be in high resolution digital format with date stamped.
- 2.23. The Contractor shall coordinate with Competent Authorities i.e. Ministry of Defence, DGCA, Ministry of Environment and Forest, District Magistrate, Local Police Authority etc., and shall get the approvals/permissions for Aerial Photography/Videography before the commencement of work.



### 3. Schedule of Deliverables

Project Information Model (PIM) and Asset Information Model (AIM) shall be submitted in commonly accessible electronic formats as per the details given below;

| <b>Deliverables</b>  | <b>Timeline</b>                                      |
|--|--|
| BIM Execution Plan (BEP)   | Within 4 months of appointed date                    |
| Master Document Register (MDR)   | Within 4 months of appointed date                    |
| BIM Design and Drawings Quality Checklist Plan   | Within 4 months of appointed date                    |
| Designs and Drawings (Plan & Profile, design files, models, calculation sheets, Reports, all native files etc.) and Asset details in approved format | Along with submission of Designs and Drawings        |
| As-Built   | As per Project Schedule                              |
| Pre-Construction Still or Aerial Images and Videos   | Within 3 Months of Appointed date                    |
| Construction Time Lapse Still or Aerial Videos and Images.   | Every 6 Months                                       |
| Post Construction Still or Aerial Images and Videos  | Within 3 months of completion of Construction period |

## **Appendix Q I – BIM Project Execution Plan (Sample Format)**

*(Schedule-Q)*

### **Section A: BIM Project Execution Plan Overview**

To successfully implement Building Information Modeling (BIM) on a project, the project team has developed this detailed BIM Project Execution Plan. The BIM Project Execution Plan defines uses for BIM on the project (e.g. design authoring, cost estimating, and design coordination), along with a detailed design of the process for executing BIM throughout the project lifecycle.

[INSERT ADDITIONAL INFORMATION HERE IF APPLICABLE. FOR EXAMPLE: BIM MISSION STATEMENT This is the location to provide additional BIM overview information. Additional detailed information can be included as an attachment to this document.

Please note: Instructions and examples to assist with the completion of this guide are currently in grey. The text can and should be modified to suit the needs of the organization filling out the template. If modified, the format of the text should be changed to match the rest of the document. This can be completed, in most cases, by selecting the normal style in the template styles.

**Section B: Project Information**

This section defines basic project reference information and determined project milestones.

**PROJECT OWNER:**

**PROJECT NAME:**

**PROJECT LOCATION AND ADDRESS:**

**CONTRACT TYPE / DELIVERY METHOD:**

**BRIEF PROJECT DESCRIPTION:** [NUMBER OF FACILITIES, GENERAL SIZE, ETC]

**ADDITIONAL PROJECT INFORMATION:** [UNIQUE BIM PROJECT CHARACTERISTICS AND REQUIREMENTS]

**PROJECT NUMBERS:**

| PROJECT INFORMATION | NUMBER |
|---------------------|--------|
| CONTRACT NUMBER:    |        |
| TASK ORDER:         |        |
| PROJECT NUMBER:     |        |
|                     |        |
|                     |        |
|                     |        |

**PROJECT SCHEDULE / PHASES / MILESTONES:**

Include BIM milestones, pre-design activities, major design reviews, stakeholder reviews, and any other major events which occur during the project lifecycle.

| PROJECT PHASE / MILESTONE | ESTIMATED START DATE | ESTIMATED COMPLETION DATE | PROJECT STAKEHOLDERS INVOLVED |
|---------------------------|----------------------|---------------------------|-------------------------------|
| PRELIMINARY PLANNING      |                      |                           |                               |
| DESIGN DOCUMENTS          |                      |                           |                               |
| CONSTRUCTION DOCUMENTS    |                      |                           |                               |
| CONSTRUCTION              |                      |                           |                               |
|                           |                      |                           |                               |

**Section C: Key Project Contacts**

List of lead BIM contacts for each organization on the project. Additional contacts can be included later in the document.

| <b>ROLE</b>         | <b>ORGANIZATION</b> | <b>CONTACT NAME</b> | <b>LOCATION</b> | <b>E-MAIL</b> | <b>PHONE</b> |
|---------------------|---------------------|---------------------|-----------------|---------------|--------------|
| Project Manager(s)  |                     |                     |                 |               |              |
| BIM Manager(s)      |                     |                     |                 |               |              |
| Discipline Leads    |                     |                     |                 |               |              |
| Other Project Roles |                     |                     |                 |               |              |
|                     |                     |                     |                 |               |              |

**Section D: Project Goals / BIM Uses**

Describe how the BIM Model and Facility Data are leveraged to maximize project value (e.g. design alternatives, life-cycle analysis, scheduling, estimating, material selection, pre-fabrication opportunities, site placement, etc.) Reference [www.engr.psu.edu/bim/download](http://www.engr.psu.edu/bim/download) for BIM Goal & Use Analysis Worksheet.

**1. MAJOR BIM GOALS / OBJECTIVES:**

State Major BIM Goals and Objectives

| PRIORITY<br>(HIGH/<br>MED/<br>LOW) | GOAL DESCRIPTION | POTENTIAL BIM<br>USES |
|------------------------------------|------------------|-----------------------|
|                                    |                  |                       |
|                                    |                  |                       |
|                                    |                  |                       |
|                                    |                  |                       |
|                                    |                  |                       |

**2. BIM USE ANALYSIS WORKSHEET: ATTACHMENT 1**

Reference [www.engr.psu.edu/bim/download](http://www.engr.psu.edu/bim/download) for BIM Goal & Use Analysis Worksheet. Attach BIM Use analysis Worksheet as Attachment 1.

**3. BIM USES:**

Highlight and place an X next to the additional BIM Uses to be developed by the use of the BIM model as selected by the project team using the BIM Goal & Use Analysis Worksheet. See BIM Project Execution Planning Guide at [www.engr.psu.edu/BIM/BIM\\_Uses](http://www.engr.psu.edu/BIM/BIM_Uses) for Use descriptions. Include additional BIM Uses as applicable in empty cells.

| X | PLAN                         | X | DESIGN                           | X | CONSTRUCT                    | X | OPERATE                         |
|---|------------------------------|---|----------------------------------|---|------------------------------|---|---------------------------------|
|   | PROGRAMMING                  |   | DESIGN AUTHORIZING               |   | SITE UTILIZATION PLANNING    |   | BUILDING MAINTENANCE SCHEDULING |
|   | SITE ANALYSIS                |   | DESIGN REVIEWS                   |   | CONSTRUCTION SYSTEM DESIGN   |   | BUILDING SYSTEM ANALYSIS        |
|   |                              |   | 3D COORDINATION                  |   | 3D COORDINATION              |   | ASSET MANAGEMENT                |
|   |                              |   | STRUCTURAL ANALYSIS              |   | DIGITAL FABRICATION          |   | SPACE MANAGEMENT / TRACKING     |
|   |                              |   | LIGHTING ANALYSIS                |   | 3D CONTROL AND PLANNING      |   | DISASTER PLANNING               |
|   |                              |   | ENERGY ANALYSIS                  |   | RECORD MODELING              |   | RECORD MODELING                 |
|   |                              |   | MECHANICAL ANALYSIS              |   |                              |   |                                 |
|   |                              |   | OTHER ENG. ANALYSIS              |   |                              |   |                                 |
|   |                              |   | SUSTAINABILITY (LEED) EVALUATION |   |                              |   |                                 |
|   |                              |   | CODE VALIDATION                  |   |                              |   |                                 |
|   | PHASE PLANNING (4D MODELING) |   | PHASE PLANNING (4D MODELING)     |   | PHASE PLANNING (4D MODELING) |   | PHASE PLANNING (4D MODELING)    |
|   | COST ESTIMATION              |   | COST ESTIMATION                  |   | COST ESTIMATION              |   | COST ESTIMATION                 |
|   | EXISTING CONDITIONS MODELING |   | EXISTING CONDITIONS MODELING     |   | EXISTING CONDITIONS MODELING |   | EXISTING CONDITIONS MODELING    |

**Section E: Organizational Roles / Staffing**

Determine the project’s BIM Roles/Responsibilities and BIM Use Staffing

**1. BIM ROLES AND RESPONSIBILITIES:**

Describe BIM roles and responsibilities such as BIM Managers, Project Managers, Draftspersons, etc.

**2. BIM USE STAFFING:**

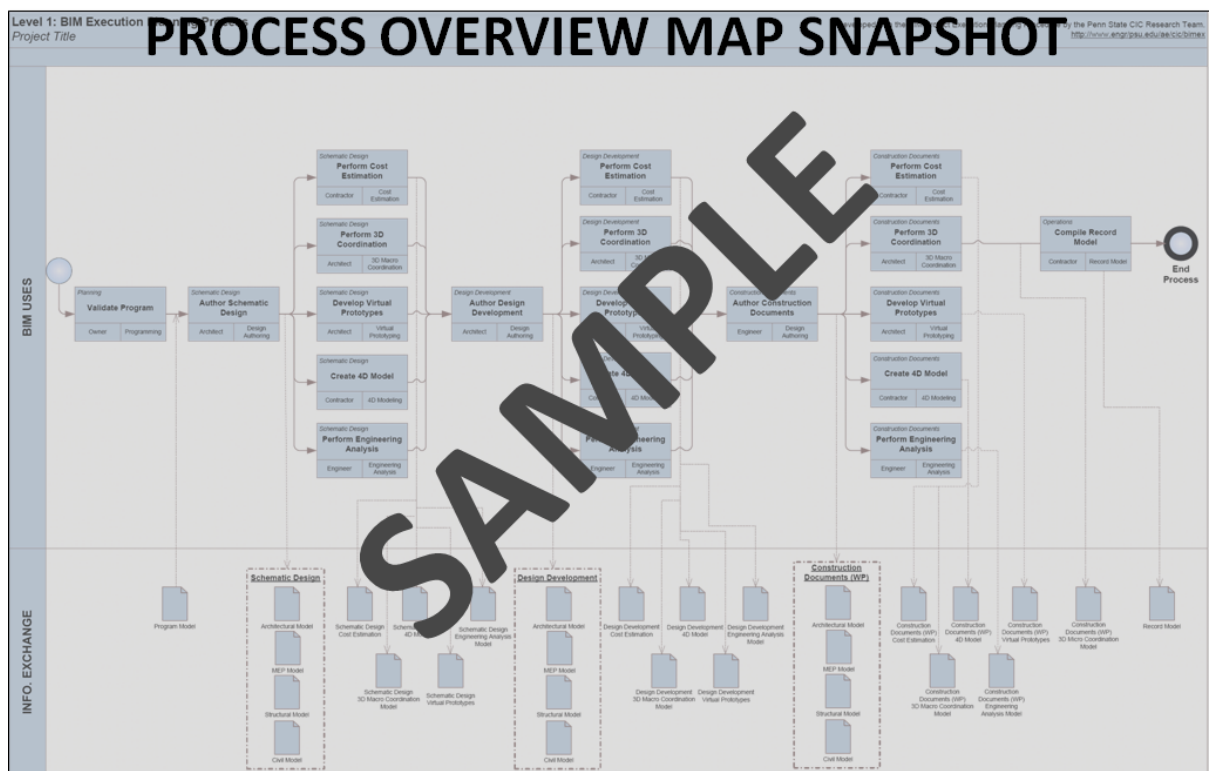
For each BIM Use selected, identify the team within the organization (or organizations) who will staff and perform that Use and estimate the personal time required.

| BIM USE         | ORGANIZATION | NUMBER OF TOTAL STAFF FOR BIM USE | ESTIMATED WORKER HOURS | LOCATION(S) | LEAD CONTACT |
|-----------------|--------------|-----------------------------------|------------------------|-------------|--------------|
| 3D coordination | Contractor A |                                   |                        |             |              |
|                 | B            |                                   |                        |             |              |
|                 | C            |                                   |                        |             |              |
|                 |              |                                   |                        |             |              |

## Section F: BIM Process Design and Level of development (LOD)

Provide process maps & Level of Detail (LOD) for each BIM Use selected in section D: Project Goals/BIM Objectives. These process maps provide a detailed plan for execution of each BIM Use. They also define the specific Information Exchanges for each activity, building the foundation for the entire execution plan. The plan includes the Overview Map (Level 1) of the BIM Uses, a Detailed Map of each BIM Use (Level 2), and a description of elements on each map, as appropriate. Level 1 and 2 sample maps are available for download at [www.engr.psu.edu/BIM/download](http://www.engr.psu.edu/BIM/download). (Please note that these are sample maps and should be modified based on project specific information and requirements). Please reference Chapter Three: Designing BIM Project Execution Process in the BIM Project Execution Planning Guide found at [www.engr.psu.edu/BIM/PxP](http://www.engr.psu.edu/BIM/PxP)

### 1. LEVEL ONE PROCESS OVERVIEW MAP: ATTACHMENT 2



### 2. LIST OF LEVEL TWO – DETAILED BIM USE PROCESS MAP(S): ATTACHMENT 3

The following are examples. Modify for specific project. Some Process Maps may need to be removed, while some process maps may need to be added.

- Existing Conditions Modeling
- Cost Estimation
- Phase Planning (4D Modeling)
- Programming
- Site Analysis
- Design Reviews
- Design Authoring
- Energy Analysis
- Structural Analysis
- Lighting Analysis
- 3D Coordination

- l. Site Utilization Planning
  - m. 3D Control and Planning
  - n. Record Modeling
  - o. Maintenance Scheduling
  - p. Building System Analysis
- [Delete unused or add additional process maps from list]

**3. BIM MODELING SCOPE / ELEMENTS / LEVEL OF DEVELOPMENT (LOD)**

Model elements by discipline, level of development, and any specific attributes important to the project are documented using information exchange worksheet. Each Party shall be responsible for any Contribution that it makes to a model or that arises from that party's access to that model. Management of BIM must be clearly stated throughout the process and in accordance with the BEP, since such is not always the responsibility of the Architect.



### Section G: BIM Information Exchanges

Model elements by discipline, level of detail, and any specific attributes important to the project are documented using information exchange worksheet. See Chapter Four: Defining the Requirements for Information Exchanges in the BIM Project Execution Planning Guide for details on completing this template.

#### 1. LIST OF INFORMATION EXCHANGE WORKSHEET(S): ATTACHMENT 4

The following are examples. Modify for specific project. Some Information Exchanges may need to be removed, while some Information Exchanges may need to be added.

- Existing Conditions Modeling
- Cost Estimation
- Phase Planning (4D Modeling)
- Programming
- Site Analysis
- Design Reviews
- Design Authoring
- Energy Analysis
- Structural Analysis
- Lighting Analysis
- 3D Coordination
- Site Utilization Planning
- 3D Control and Planning
- Record Modeling
- Maintenance Scheduling
- Building System Analysis
- [Delete unused information exchanges from list]

| INFORMATION EXCHANGE (IE)  |                   | Programming |            | Design Authoring       |      | Existing Conditions Modeling |                        | Cost Estimation |            | 3D Coordination        |      | Design Reviews |                        |
|--|-------------------|-------------|------------|------------------------|------|------------------------------|------------------------|-----------------|------------|------------------------|------|----------------|------------------------|
| Information  | Responsible Party | Info        | Resp Party | Additional Information | Info | Resp Party                   | Additional Information | Info            | Resp Party | Additional Information | Info | Resp Party     | Additional Information |
| <b>BIM Use Title</b><br>Project Phase: Planning<br>Time of Exchange [SD, DD, CD, Construction]: Design<br>Responsible Party (Information Receiver)<br>Recipient File Format<br>Application & Version<br><b>A. SUBSTRUCTURE</b><br>Foundations<br>Standard Foundations<br>Special Foundations<br>Slab on Grade<br>Basement Construction<br>Basement Excavation<br>Basement Walls<br><b>B. SHELL</b><br>Superstructure<br>Floor Construction<br>Roof Construction<br>Exterior Enclosure<br>Exterior Walls<br>Exterior Windows<br>Exterior Doors<br>Roofing<br>Roof Coverings<br>Roof Overhangs<br><b>C. INTERIORS</b><br>Interior Construction<br>Partitions<br>Interior Doors<br>Finishes<br>Stairs<br>Stair Construction<br>Stair Finishes<br>Interior Finishes<br>Wall Finishes<br>Floor Finishes<br>Ceiling Finishes<br><b>D. SERVICES</b><br>Covering Systems<br>Elevators & Lifts<br>Escalators & Moving Walks<br>Other Mechanical Systems |                   |             |            |                        |      |                              |                        |                 |            |                        |      |                |                        |

#### 2. MODEL DEFINITION WORKSHEET: ATTACHMENT 5

(Attach Model Definition Worksheet)

| MODEL DEFINITION (MOD)   |                   | Planning |            |                        | Design |            |                        | Construction |            |                        | Operations |            |                        |
|--|-------------------|----------|------------|------------------------|--------|------------|------------------------|--------------|------------|------------------------|------------|------------|------------------------|
| Information  | Responsible Party | Info     | Resp Party | Additional Information | Info   | Resp Party | Additional Information | Info         | Resp Party | Additional Information | Info       | Resp Party | Additional Information |
| <b>Project Phase Deliverable</b><br>Author File Format (if varies, specify in notes)<br>Application & Version<br><b>Model Element Breakdown</b><br><b>A. SUBSTRUCTURE</b><br>Foundations<br>Standard Foundations<br>Special Foundations<br>Slab on Grade<br>Basement Construction<br>Basement Excavation<br>Basement Walls<br><b>B. SHELL</b><br>Superstructure<br>Floor Construction<br>Roof Construction<br>Green Roof<br>Exterior Enclosure<br>Exterior Walls<br>Exterior Windows - Glass Panels<br>Exterior Doors<br>Roofing<br>Roof Coverings<br>Roof Overhangs<br><b>C. INTERIORS</b><br>Interior Construction<br>Partitions<br>Interior Doors<br>Finishes<br>Stairs<br>Stair Construction<br>Stair Finishes<br>Interior Finishes<br>Wall Finishes<br>Floor Finishes<br>Ceiling Finishes<br>Ceiling Grid<br>Grid Ceiling<br>Ceiling Finishes<br><b>D. SERVICES</b><br>Covering Systems |                   |          |            |                        |        |            |                        |              |            |                        |            |            |                        |

## **Section H: BIM and Facility Data Requirements**

The section should include the employer BIM requirements. It is important that the employers's requirements for BIM be considered so that they can be incorporated into the project's BIM process.

## Section I: Collaboration Procedures

### 1. COLLABORATION STRATEGY:

Describe how the project team will collaborate. Include items such as communication methods, document management and transfer, and record storage, etc.

### 2. MEETING PROCEDURES:

The following are examples of meetings that should be considered.

| MEETING TYPE   | PROJECT STAGE | FREQUENCY | PARTICIPANTS | LOCATION |
|--|---------------|-----------|--------------|----------|
| BIM REQUIREMENTS KICK-OFF                                |               |           |              |          |
| BIM EXECUTION PLAN DEMONSTRATION                         |               |           |              |          |
| DESIGN COORDINATION                                      |               |           |              |          |
| CONSTRUCTION OVER-THE-SHOULDER PROGRESS REVIEWS          |               |           |              |          |
| ANY OTHER BIM MEETINGS THAT OCCURS WITH MULTIPLE PARTIES |               |           |              |          |
|  |               |           |              |          |

### 3. MODEL DELIVERY SCHEDULE OF INFORMATION EXCHANGE FOR SUBMISSION AND APPROVAL:

Document the information exchanges and file transfers that will occur on the project.

| INFORMATION EXCHANGE                 | FILE SENDER         | FILE RECEIVER                  | ONE-TIME or FREQUENCY | DUE DATE or START DATE | MODEL FILE | MODEL SOFTWARE | NATIVE FILE TYPE | FILE EXCHANGE TYPE |
|--------------------------------------|---------------------|--------------------------------|-----------------------|------------------------|------------|----------------|------------------|--------------------|
| DESIGN AUTHORIZING – 3D COORDINATION | STRUCTURAL ENGINEER | (FTP POST) (COORDINATION LEAD) | WEEKLY                | [DATE]                 | STRUCT     | DESIGN APP     | .XYZ             | .XYZ<br>.ABC       |
|                                      | MECHANICAL ENGINEER | (FTP POST) (COORDINATION LEAD) | WEEKLY                | [DATE]                 | MECH       | DESIGN APP     | .XYZ             | .XYZ<br>.ABC       |
|                                      |                     |                                |                       |                        |            |                |                  |                    |

### 4. INTERACTIVE WORKSPACE

The project team should consider the physical environment it will need throughout the lifecycle of the project to accommodate the necessary collaboration, communication, and reviews that will improve the BIM Plan decision making process. Describe how the project team will be located. Consider questions like “will the team be collocated?” If so, where is the location and what will be in that space? Will there be a BIM Trailer? If yes, where will it be located and what will be in the space such as computers, projectors, tables, table configuration? Include any additional information necessary information about workspaces on the project.

**5. ELECTRONIC COMMUNICATION PROCEDURES:**

(Note: File Naming and Folder Structure will be discussed in Section L: Model Structure). The following document management issues should be resolved and a procedure should be defined for each: Permissions / access, File Locations, FTP Site Location(s), File Transfer Protocol, File / Folder Maintenance, etc.

| FILE LOCATION   | FILE STRUCTURE / NAME | FILE TYPE | PASSWORD PROTECT | FILE MAINTAINER | UPDATED |
|---|-----------------------|-----------|------------------|-----------------|---------|
| FTP SITE:<br><u>ftp://ftp.****.com/****/*</u><br>***  | ROOT PROJECT FOLDER   | FOLDER    | YES<br>*****     | PW/PMIS         | ONCE    |
|   | ARCH ROOT FOLDER      | FOLDER    |                  |                 | ONCE    |
|   | ARCH-11111-BL001.xyz  | .xyz      |                  |                 | DAILY   |
| NETWORK drive @<br>PSU<br>F:\PROJECT\BIM              | ROOT PROJECT FOLDER   | FOLDER    | NO               | PW/PMIS         | ONCE    |
| Project Management<br>Software<br><u>www.****.com</u> |                       |           |                  |                 |         |
|   |                       |           |                  |                 |         |
|   |                       |           |                  |                 |         |

**Section J: Quality Control**

**1. OVERALL STRATEGY FOR QUALITY CONTROL:**

Describe the strategy to control the quality of the model.

**2. QUALITY CONTROL CHECKS:**

The following checks should be performed to assure quality.

| CHECKS                 | DEFINITION  | RESPONSIBLE PARTY | SOFTWARE PROGRAM(S) | FREQUENCY |
|------------------------|---|-------------------|---------------------|-----------|
| VISUAL CHECK           | Ensure there are no unintended model components and the design intent has been followed   |                   |                     |           |
| INTERFERENCE CHECK     | Detect problems in the model where two building components are clashing including soft and hard   |                   |                     |           |
| STANDARDS CHECK        | Ensure that the BIM and AEC CADD Standard have been followed (fonts, dimensions, line styles, levels/layers, etc)   |                   |                     |           |
| MODEL INTEGRITY CHECKS | Describe the QC validation process used to ensure that the Project Facility Data set has no undefined, incorrectly defined or duplicated elements and the reporting process on non-compliant elements and corrective action plans |                   |                     |           |
|                        |   |                   |                     |           |

**3. MODEL ACCURACY AND TOLERANCES:**

Models should include all appropriate dimensioning as needed for design intent, analysis, and construction. Level of detail and included model elements are provided in the Information Exchange Worksheet.

| PHASE            | DISCIPLINE      | TOLERANCE   |
|------------------|-----------------|---|
| DESIGN DOCUMENTS | ARCH            | ACCURATE TO +/- [ # ] OF ACTUAL SIZE AND LOCATION |
| SHOP DRAWINGS    | MECH CONTRACTOR | ACCURATE TO +/- [ # ] OF ACTUAL SIZE AND LOCATION |
|                  |                 |   |

**4. BIM QUALITY CHECKLIST:**

The section will cover the proposed BIM quality checklist.

**Section K: Technological Infrastructure Needs**

**1. SOFTWARE:**

List software used to deliver BIM. Remove software that is not applicable.

| BIM USE            | DISCIPLINE (if applicable) | SOFTWARE               | VERSION         |
|--------------------|----------------------------|------------------------|-----------------|
| DESIGN AUTHORIZING | ARCH                       | XYZ DESIGN APPLICATION | VER. X.X (YEAR) |
|                    |                            |                        |                 |
|                    |                            |                        |                 |

**2. COMPUTERS / HARDWARE:**

Understand hardware specification becomes valuable once information begins to be shared between several disciplines or organizations. It also becomes valuable to ensure that the downstream hardware is not less powerful than the hardware used to create the information. In order to ensure that this does not happen, choose the hardware that is in the highest demand and most appropriate for the majority of BIM Uses.

| BIM USE            | HARDWARE            | EMPLOYER OF HARDWARE | SPECIFICATIONS  |
|--------------------|---------------------|----------------------|---|
| DESIGN AUTHORIZING | XXX COMPUTER SYSTEM | ARCHITECT X          | PROCESSOR, OPERATING SYSTEM, MEMORY STORAGE, GRAPHICS, NETWORK CARD, ETC. |
|                    |                     |                      |   |
|                    |                     |                      |   |

**3. MODELING CONTENT AND REFERENCE INFORMATION**

Identify items such as families, workspaces, and databases.

| BIM USE            | DISCIPLINE (if applicable) | MODELING CONTENT / REFERENCE INFORMATION | VERSION          |
|--------------------|----------------------------|--|------------------|
| DESIGN AUTHORIZING | ARCH                       | XYZ APP FAMILIES                         | VER. X.X. (YEAR) |
| ESTIMATING         | CONTRACTOR                 | PROPRIETARY DATABASE                     | VER. X.X (YEAR)  |
|                    |                            |  |                  |

## Section L: Model Structure

### 1. FILE NAMING STRUCTURE:

Determine and list the structure for model file names.

| <b>FILE NAMES FOR MODELS SHOULD BE FORMATTED AS:</b>                              |         |
|---|---------|
| DISCIPLINE – PROJECT NUMBER – BUILDING NUMBER.XYZ (example: ARCH-11111-BL001.xyz) |         |
| <b>ARCHITECTURAL MODEL</b>  | ARCH-   |
| <b>CIVIL MODEL</b>  | CIVIL-  |
| <b>MECHANICAL MODEL</b>   | MECH-   |
| <b>PLUMBING MODEL</b>   | PLUMB-  |
| <b>ELECTRICAL MODEL</b>   | ELEC-   |
| <b>INSTRUMENTATION MODEL</b>  | INST-   |
| <b>STRUCTURAL MODEL</b>   | STRUCT- |
| <b>ENERGY MODEL</b>   | ENERGY- |
| <b>CONSTRUCTION MODEL</b>   | CONST-  |
| <b>COORDINATION MODEL</b>   | COORD-  |

### 2. MODEL STRUCTURE:

Describe and diagram how the Model is separated, e.g., by building, by floors, by zone, by areas, and/or discipline.

### 3. MEASUREMENT AND COORDINATE SYSTEMS:

Describe the measurement system (Imperial or Metric) and coordinate system (geo-referenced) used.

### 4. BIM AND CAD STANDARDS:

Identify items such as the BIM and CAD standards, content reference information, and the version of IFC, etc.

| <b>STANDARD</b> | <b>VERSION</b> | <b>BIM USES APPLICABLE</b> | <b>ORGANIZATIONS APPLICABLE</b> |
|-----------------|----------------|----------------------------|---------------------------------|
| CAD STANDARD    |                | DESIGN AUTHORIZING         | ARCHITECT                       |
| IFC             | VERSION/MVD(s) | RECORD MODELING            | CONSTRUCTION MANAGER            |
|                 |                |                            |                                 |

**Section M: Project Deliverables**

In this section, list the BIM deliverables for the project and the format in which the information will be delivered.

| <b>BIM SUBMITTAL ITEM</b> | <b>STAGE</b>           | <b>APPROXIMATE DUE DATE</b> | <b>FORMAT</b> | <b>NOTES</b>   |
|---------------------------|------------------------|-----------------------------|---------------|--|
|                           | Design Development     |                             |               |  |
|                           | Construction Documents |                             |               |  |
|                           | Construction           |                             |               |  |
| Record Model              | Close out              |                             | (.xyz)        | See Record Model Information Exchange to ensure that the proper information is contained in this model |
|                           |                        |                             |               |  |



## **Section N: Delivery Strategy / Contract**

### **1. DELIVERY AND CONTRACTING STRATEGY FOR THE PROJECT:**

What additional measures need to be taken to successfully use BIM with the selected delivery method and contract type?

### **2. TEAM SELECTION PROCEDURE:**

How will you select future team members in regards to the above delivery strategy and contract type?

### **3. BIM CONTRACTING PROCEDURE:**

How should BIM be written into the future contracts? (If documents / contracts are developed, please attach as attachment 6)

### **4. AGREEMENT FOR TRANSFER OF DIGITAL MODEL FILES**

How the Contractor proposes to transfer and use digital model files.

**Section O: Attachments**

1. **BIM USE SELECTION WORKSHEET** [FROM SECTION D]
2. **LEVEL 1 PROCESS OVERVIEW MAP** [FROM SECTION F]
3. **LEVEL 2 DETAILED BIM USE PROCESS MAP(S)** [FROM SECTION F]
4. **INFORMATION EXCHANGE REQUIREMENT WORKSHEET(S)** [FROM SECTION G]
5. **MODEL DEFINITION WORKSHEET** [FROM SECTION G]
6. **DEVELOPED DOCUMENTS / CONTRACTS** [FROM SECTION H]
7. **BIM QUALITY CHECKLIST** (FROM SECTION J)
8. **DELIVERY STRATEGY / CONTRACTS** (FROM SECTION N)

**Schedule R – Guideline for Health, Safety and Environment Plan**

*(See Clause 3.1.7 (l))*

The Contractor shall prepare and submit a project specific Health, Safety and Environment plan based on the Manual for Construction Procedures within 30 days of the Appointed Date.

## Schedule S - Project Management Requirements

(See Clause 3.1.7 (m))

### PROJECT CONTROL / MANAGEMENT - TERMS OF REFERENCE

The Contractor shall perform all the Project Management activities necessary for proper planning, management and control of the work. Below are some of the typical tasks that are required to be performed by contractor:

1. Participate in the project kick-off workshop with project stakeholders designated by Employer/ PMNC. The kick-off workshop shall accomplish the following objectives:
  - Common understanding of the project goals and objectives
  - Define respective roles and responsibilities and
  - Agree on the methods of communication and reporting throughout the project duration.
2. Participate in monthly project status review meetings and present the project progress update in the meeting. The frequency of project status review meetings may change based on actual requirements.
3. **Schedule:** The Contractor shall submit a Level 3 schedule that cover's the full scope of Contractor's work within 30 calendar days of date of appointment. This will be reviewed within 15 calendar days by Employer /PMNC. The Contractor shall incorporate the comments and resubmit the schedule no later than 15 calendar days after receiving the comments from Employer/ PMNC. Upon approval the level 3 schedule will become the baseline schedule for all the future monitoring and tracking.

The Contractor should keep to the following guidelines

- i. Develop and incorporate a detailed Work Breakdown Structure (WBS) for all project schedules that are submitted.
- ii. All schedules shall be created, maintained and submitted to Employer /PMNC in the latest version of Oracle Primavera P6 or equivalent in an electronic format.
- iii. All schedules shall follow the Critical Path Method (CPM) of scheduling and shall have meaningful and realistic logical ties and relationships between activities.
- iv. The use of negative lags is not permitted in the baseline and all other versions of the schedule.
- v. The schedule must contain all the long lead procurement items identified.
- vi. Shall exercise reasonableness while assigning constraints in schedule and milestones
- vii. Upon approval, the copy of the Baseline schedule will become the first Current Schedule.
- viii. The Current schedule shall be actively updated and maintained by the Contractor every month.

- ix. The updated Primavera P6 or equivalent schedule file should be submitted every month along with Monthly progress report in electronic format. A pdf copy of the updated schedule with all activities also needs to be submitted
  - x. A schedule narrative document shall accompany the updated electronic schedule describing the work performed in the reporting period.
  - xi. The contractor should also submit a level 4 schedule within 60 calendar days from approval of baseline level 3 schedules.
  - xii. In the level 4 schedule activity durations should be reasonable (typically no more than 15 days duration except for project management tasks, procurement activities for long lead items or any other activity that obviously needs to be of longer duration).
4. **Cash Flow:** Prepare project cash flow at the start of the project. Prepare monthly statements to show the actual versus plan spending; update the cost periodically
  5. **Lessons Learned Database:** The Contractor shall develop and actively maintain a “lessons learned” database on a monthly basis (to be included in the monthly project report) and submit it to Employer/ PMNC at the end of the project during closeout.
  6. **Risk Register:** Maintain an active risk register addressing the risks and mitigation measures (could be in excel format) that lists the project risks related to their Scope of Work.
  7. **Inter-Project Links:** Identify potential inter-project links, inter-dependencies or conflicts/interference to work or work areas and narrate them in the monthly progress report.
  8. **Monthly Progress Report:** Prepare and submit a monthly progress report (standard format and template will be provided by Employer /PMNC at a later date). Items 3 to 7 mentioned above shall be the minimum information that will need to be included in the monthly progress report.
  9. For better collaboration, Contractor shall use the Programme and Document Management system that will be provided by Employer/PMNC at a later date and pay for the cost of procuring licenses to use the system.

Monthly payments are subject to timely submission of monthly progress report and the monthly updated electronic schedule file in the required and acceptable format.