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**JICA ASSISTED DELHI WATER SUPPLY IMPROVEMENT PROJECT IN CHANDRAWAL WTP COMMAND AREA (LOAN NO. ID-P225)**

**NIT NO. 02(2019-20)/EE (Project) W-II**

# VOLUME : III / V

# BIDDING DOCUMENTS

**(Part 2 : WORKS REQUIREMENTS)**

## DRAFT TENDER DOCUMENT

**FOR**

## PACKAGE – 2 ( West )

**Improvement of Water Supply System including Operation and maintenance of Transmission & Distribution Pipes, Pumping Stations, Service Connections and Consumer Meters with DMA formation and NRW Reduction in Chandrawal WTP Command Area (West Zone)**

**ON**
**INTERNATIONAL COMPETITIVE BIDDING**

**May 2019**

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# SUB-SECTION 1. PROJECT DESCRIPTION

## 1.1 Project and the Loan

The Delhi Water Supply Improvement Project (DWSIP), JICA Loan No. ID-P225, has been envisaged with the following main objective.

> To achieve equitable and continuous water distribution in the Chandrawal Water Treatment Plant Command Area by improving the water supply network including service network to customers thereby contributing in upgrading citizen's standards.

The DWSIP project in Chandrawal Command area (hereafter referred to as 'the project') pertains to achieving the above objective in the command area of Chandrawal Water Treatment Plant.

The project is mainly based on the JICA funded "Study on Improvement of Water Supply System in Delhi" carried out by Tokyo Engineering Consultants Co. Ltd. (TEC) and Oriental Consultants Co. Ltd. The Master Plan (MP) and Feasibility Study (FS) Reports prepared under the Study were finalized in September 2011. The Minutes of Discussion (MOD) were signed on 19 Dec 2011 between JICA, Ministry of Urban Development (MoUD), and Government of National Capital Territory of Delhi (GNCTD), wherein Delhi Jal Board (DJB) was named as the Executing Agency. Subsequently, the Loan Agreement, ID-P 225, was finalized on 29 October 2012, the signatories were JICA, Department of Economic Affairs, Government of India (DEA), MoUD and GNCTD.

In order to assist DJB in the implementation of the project, DJB has appointed M/s Tokyo Engineering Consultants Co., Ltd. (Consortium) as the Project Monitoring and Supervision Consultants (PMSC).

## 1.2 Location and Area

Delhi is located in northern India between the latitudes of 28°24' and 28°53' North and longitudes of 76°50' and 77°20' East. Delhi shares its border with the States of Uttar Pradesh and Haryana. Delhi has an area of 1483 sq. km. Its maximum length is 51.90 km and greatest width is 48.48 km. Delhi lies at the periphery of Gangetic planes. River Yamuna passes through Delhi from north to south. The core areas of old and New Delhi are on the right bank of river Yamuna. Delhi is categorized under the seismic zone IV.

Delhi is fed by several Water Treatment Plants (WTP) viz. Wazirabad, Chandrawal, Haiderpur, Bhagirathi, Sonia Vihar, Okhla and Nangloi.

This project is pertaining to the Chandrawal Water Treatment Plant Command area only. It is bound in the North by Najafgarh Drain, GT road and in the East by Ring Road. The Southern boundary is defined by Palam Marg, Africa Avenue and Western boundary by Najafgarh Drain & Jaipur Railway line. The project area lies in the northern and central parts of Delhi and covers an area of 67.10 sq.km. (Excluding NDMC area)

## 1.3 Existing Water Supply System

There are two treatment plants in Chandrawal at present; they were constructed in two phases

in 1930s (called as Chandrawal-I for 159 MLD) and 1960s (called as Chandrawal-II for 250 MLD). In addition, there is another 36 MLD capacity recycling plant constructed recently to capture and treat process effluent from the above two WTPs. Hence, the total existing installed capacity of Chandrawal waterworks is 445MLD.

The raw water to Chandrawal WTPs is received from Wazirabad raw water pump house which used to offtake water from the River Yamuna at Wazirabad barrage. However, in recent past the raw water is received to the pump house through a closed conduit from the Western Yamuna Canal.

At present, the Chandrawal WTPs supply water to areas on its south. These include Civil lines, walled city, parts of NDMC area, special zone, Karol Bagh, Patel Nagar, Bapa Nagar, R. K. Puram, Naraina and Delhi Cantonment. Some of these areas also receive water from other WTPs.

## 1.4 Proposed Scope of the Project

The current per capita water supply in Delhi is about 200 lpcd (Litre per capita per day). However, the actual water received by the people is about 132 lpcd only, less than the target set by MoUD, due to high rate of leakage (more than 40%). That is why the water supply in Delhi is intermittent (2 to 6 hours per day). The intermittent supply causes degradation of water quality and deterioration of pipes. In addition to the intermittent water supply, equitable water supply is not achieved within any command area because of the increase in the population of the command beyond the WTP production capacity.

Therefore, the main objective of the project is set to achieve equitable and continuous water distribution in the Chandrawal WTP command area by rehabilitating the existing water supply facilities. In order to achieve these objectives, the entire scope of works proposed under this project is divided into five main contract packages as follows.

### 1.4.1 Package 1: Water Treatment Plant at Chandrawal Campus

Since both the Chandrawal I and II water treatment plants have outlived their design life and most of the units are in dilapidated state with no automated operation and control systems, it is envisaged to renovate and construct a new water treatment plant with a capacity of 477 MLD under this contract. The 477 MLD capacity has been derived from a raw water allocation of 486 MLD allowing for an average of 9 MLD daily losses at the plant.

The scope of works includes Design, Construction, Installation, Testing, Commissioning, and Automation with 2 year DNP and 14 years O&M of 477 MLD Chandrawal Water Treatment Plant including Upgradation and Integration of part Existing Units.

The scope of works also includes a Central Water Management Centre (CWMC), which will acquire information from both the WTP SCADA and distribution SCADA. The SCADA system will control the flow from transmission pumps of the Chandrawal WTP to each UGR as per the instructions given by the Employer.

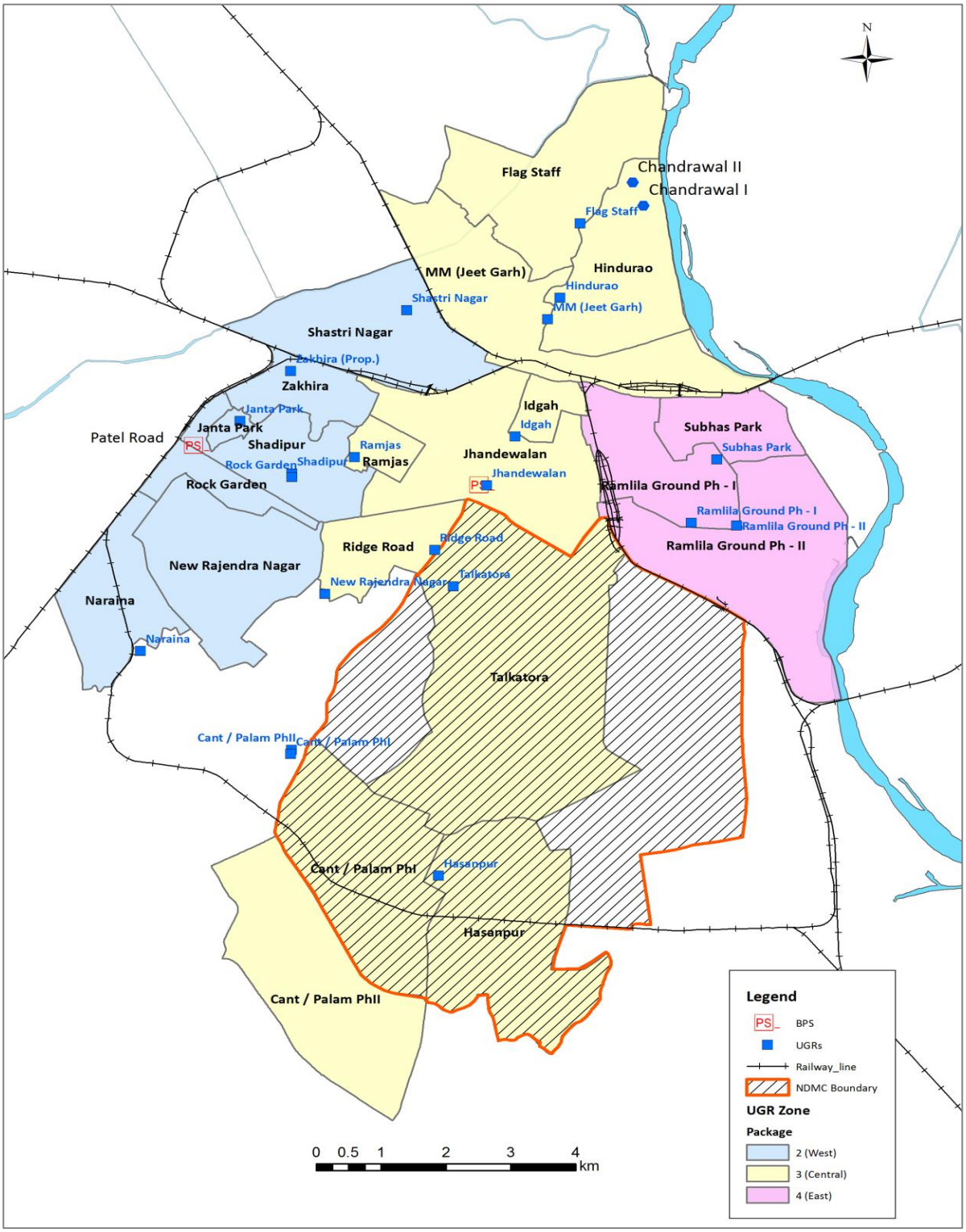



**Figure:** Project area boundary showing Package 2-4 areas and location of Chandrawal WTP I and II

### 1.4.2 Transmission/Distribution Networks in 3 Zones (West, Central and East)

The Population and number of service connections in all three zones are estimated as follows.

| Sl. No. | Zone | Population 2011 | Estimated Population 2021 | Estimated No. of Service Connections 2021 |
|---|---|---|---|---|
| 1 | West (Pkg 2) | 571,756 | 683,291 | 84,563 |
| 2 | Central (Pkg 3) | 1,029,209 | 1,155,915 | 110,052 |
| 3 | East (Pkg 4) | 342,604 | 355,437 | 42,910 |
| | **Total** | **1,943,569** | **2,194,643** | **237,525** |

Package wise scope of work as per DPR of Package 2 and design details of other packages (in-progress) is tabulated below for tentative understanding of the bidders.

| Sl. No. | Work Items | Pkg 2 (West) | Pkg 3 (Central) | Pkg 4 (East) |
|---|---|---|---|---|
| 1 | **Transmission Mains:**<br>Treated Water Transmission Mains (Replacement of existing Mains by New laying, dia 300 to 1400 mm). The mains are of DI/MS. | 16.8 Km | 20.9 Km | 0.96 Km |
| 2 | **UGR:**<br>a) Construction of New UGRs (capacity 1.7 ML to 21.6 ML)<br>b) Rehabilitation of UGRs | 4<br>4 | 8 (2 for NDMC)<br>3 (1 for NDMC) | --<br>2 |
| 3 | **BPS:**<br>a) Construction of new Pumping Stations<br>b) Rehabilitation of Pumping Stations<br>c) Installation of Booster Pumps for Distribution Systems and Transmission BPS | 4<br>3<br>41 (27 KW to 315 KW) | 3<br>2<br>24 (3 KW to 200 KW) | -<br>3<br>15 (18 KW to 315 KW) |
| 4 | **Distribution System:**<br>a) Secondary Mains (New DI/MS Mains)<br>b) Distribution Pipes (New DI mains (100 to 400 mm) &<br>c) Existing Distribution Pipes/Mains (MS / CI / DI) connecting to proposed networks | 26 Km (Dia 200 to 1000)<br>274 Km<br>84 Km (Dia 100 to 300) | 52 Km (dia 100 to 1000)<br>508 Km<br>159 Km (dia 100 to 600) | 5 Km (dia 200 to 900)<br>140 Km<br>61 Km (dia 100 to 900) |

| | | | | |
|---|---|---|---|---|
| | d) Estimated Service connections (Yr 2021) | 84,563 | 110,052 | 42,910 |
| 5 | Creation of DMAs and NRW Reduction works | 46 (UGR Areas 7) | 78 (UGR Areas 8) | 23 (UGR Areas 3) |

**Note:** The above scope of works is subject to change during the actual execution of works as per the site conditions.

### 1.4.3 Package 5 - Strengthening of GIS Mapping

Scope of this Package includes the following:

- Survey and GIS mapping of WTPs, UGRs and BPSs in Delhi (except Chandrawal WTP, Nangloi WTP, Malviya Nagar UGR, and Vasant Vihar DMA command areas)
- Preparation of the Long Term Asset Management Plan

### 1.4.4 Package 6 - Public Outreach Program

Scope of this Package includes the following:

- Baseline survey to finalize program with Consultant to be hired
- Public Outreach Campaign
- Media Intervention

The details given above are tentative and are subject to change when the DPRs for these packages are finalised.

# SUB-SECTION 2. SCOPE OF WORKS- GENERAL

## 2.1 General

The main works to be provided under this contract includes Improvement of Water Supply System by Construction/ Rehabilitation, Supply, Laying, Installation, Testing, Commissioning of Transmission and Distribution Pipes with Appurtenances, Pumping Stations, Under Ground Reservoir, SCADA system, DMA formation and NRW Reduction in the West Zone of the Chandrawal WTP Command Area in a Project Period of 5-years Construction (along with 4.5 years O&M of existing and newly constructed facilities within that) plus 5-years O&M after Construction.

The Contractor's scope includes but not limited to the site survey and investigations, pipe condition assessment, demolition & disposal, detailed design (for specified components of work), supply, delivery, construction / erection, renovation, testing, commissioning, operation & maintenance for 4.5 years during construction and 5 years after construction phase.

## 2.2 Main Components of Physical Works

Followings are the main components of the works involved under this contract:

| Sl. No. | Work Items | Quantity | Size/ Capacity |
|---|---|---|---|
| 1 | **Transmission Mains:**<br>Treated Water Transmission Mains (New Pipelines). The mains are of DI/MS. | 16.8 Km | Dia.400 to 1400 mm |
| 2 | **UGR:**<br>a) Construction of New UGRs<br>b) Rehabilitation of existing UGRs | 4 Nos.<br>4 Nos. | 4.81 ML to 10.70 ML |
| 3 | **BPS:**<br>a) Construction of new Pumping Stations<br>b) Rehabilitation of Pumping Stations<br>c) Installation of Booster Pumps for Distribution Systems<br>d) Installation of Booster Pumps for Transmission to UGRs | 4 Nos.<br>3 Nos.<br>38 Nos.<br>3 Nos. | (27 KW to 315 KW) |
| 4 | **Distribution System:**<br>a) Secondary Mains (New DI/MS Mains)<br>b) Distribution Pipes New DI mains<br>c) Existing Distribution Pipes/Mains retaining and connecting to new CI/DI networks<br>d) Estimated Service connections (Yr 2021) to be given | 26 Km<br>274 Km<br>84 Km<br>84,563 | Dia 200 to 1000 mm<br>Dia 100 to 400 mm<br>Dia 100 to 300 mm |

| | | | |
|---|---|---|---|
| 5 | Creation of DMAs and NRW Reduction works | 46 DMAs | UGR Areas 7 nos. |
| 6 | SCADA System- One central SCADA at Than Singh nagar BPS and distribution SCADA | 1 Lot | |
| 7 | Field investigation and survey works including topograpic survey, pipe condition, test pits, customer survey, and so on | 1 Lot | West Zone |

## 2.3 Summary on Scope of works, Activities and Services to be provided under the Contract

The Contractor shall carry out and provide services as necessary to do the works in accordance with the approved design, drawings and specification, which includes the following. The contractor is also required to do the investigation and detailed design works for certain components, namely Distribution SCADA & Instrumentation works, as specified.

### 2.3.1 Survey, Investigation and Design Confirmation works

1. Topographic survey of the pipeline alignment and the sites for structures wherever required.

2. Geo-technical investigations along the Transmission and Distribution Mains/Pipes and at UGR and BPS sites as required.

3. Taking Trial Pits across the road width, wherever required, for the identification/ confirmation of underground utilities, their depth and alignments. Review and modification of working drawings of pipelines to be laid, as required.

4. Re-confirmatory survey on the pipeline identification crossing across the UGR/DMA boundaries especially for the isolation of Zone/DMA purposes.

5. Condition assessment of existing pipelines: Condition assessment of the existing pipelines that are to be retained as it is (not to be replaced) on the matters of pipe material, diameter and internal encrustation (on sample basis) status which are to be required for confirmatory hydraulic modelling and pipe replacements.

6. Conditions assessment of the existing UGRs and BPSs proposed for Rehabilitation in view of design and construction methodologies to be prepared for the rehabilitation works.

7. SCADA and Instrumentation works: All kinds of Analysis, Design and Drawings preparation for SCADA and Telemetry Systems including General arrangement, System architecture, Functional Design Specification (FDS), P&ID etc.

8. House Survey and updation of GIS maps supplied by the Employer.

9. Revalidation of Hydraulic models and DMA boundaries based on the latest site information.

10. Assessment of water loss level for monitoring the progress of construction works.

### 2.3.2 Detailed Design works

The following components of work are to be executed under Design and Build basis. The contractor has to prepare all required detailed design, engineering, drawings and construction methodologies based on the requirements given in the scope of works and technical specifications. For rehabilitation of the existing systems/structures, the design shall be based on the conditions assessment.

1. Reservoirs (UGRs): New Construction and Rehabilitation of Existing Reservoirs.

2. Pumping Stations (BPSs): New Construction and rehabilitation of existing Pump Stations or Booster Pumping Stations- all Civil and E/M works including Pumps.

3. SCADA and Instrumentation: Central SCADA centre and field stations (PLCs/RTUs) including all hardware and software.

### 2.3.3 Construction Activities (include supply, delivery, installation/erection, testing and commissioning as applicable)

**1. Pipeline Works:**

a. Laying of new Pipelines for the Transmission mains and Distribution systems including pipe supply, delivery, laying, joining/ installation, testing and commissioning works along with all necessary valves, flow meters, pressure gauge/transmitter, anchor/thrust blocks, chambers and appurtenances etc. This also includes pipe laying at Culverts/Bridges, crossing of River/Drainage/Canals and Road/railway crossings etc.

   Laying/Installation works includes all kinds of earthworks in excavation, disposal of excess earth, strutting, shoring and shuttering, bailing out of water, erection of safety and caution boards/enclosure walls, lighting and traffic diversion arrangements and filling of the trench with selected material.

b. Removal/ Realignment of old pipelines with the new pipelines at certain interconnection points. The work includes all kinds of earthworks in excavation, disposal of excess earth, strutting, shoring and shuttering, bailing out of water, cutting and removing of the pipelines including conveyance and storage at the designated places. Laying of pipeline includes all works as specified in (1.a) above including jointing with the existing pipes as per approved methodologies.

c. Laying of pipeline by trenchless technologies (no-dig method) as specified or wherever required as per site condition during the execution period.

d. Construction of requisite support structures for pipe laying/crossing at Culverts, Bridges, Canals, Drains, Rivers, Road crossings, Railway crossings etc.

e. Supply, installation, testing and commissioning of house service connection and customer water meters. The work includes new house service connections for all existing connections as well as new customers.

f. DMA creation and boundary isolation works as per designed hydraulic network which may involve disconnection and reconnection of pipes, end capping etc.

**2. Booster Pump Station (BPS)**

a. Rehabilitation and/or construction of buildings for Booster Pump Stations including associated works of roads, drainage, landscaping, fencing, building services and lighting of the site area.

b. Rehabilitation of Existing BPSs including supply, delivery, installation/ erection, testing, commissioning of Pumps and all accessories as per approved design, drawing and construction methodologies including all associated civil, piping, mechanical and electrical works viz. Sub-station and Transformers, standby generator & fuel tanks and surge suppression devices. Further works may include the bye-pass or alternative arrangement for operation of BPS during rehabilitation works as per detailed scope of works and specifications.

c. Construction of new BPSs including supply, delivery, installation/erection, testing, commissioning of Pumps and all accessories as per approved design, drawing and construction methodologies including all associated civil, piping, mechanical and electrical works viz. Sub-station and Transformers, standby generator & fuel tanks and surge suppression devices.

d. Pump duty parameter:

The contractor is suggested to design and select the pumps based on the following hydraulic data.

| **Year →** | **2051** | | **2036** | | **2026** | | **Daily Variation** |
|---|---|---|---|---|---|---|---|
| **Duty Point →** | **Q (LPS)** | **H (m)** | **Q (LPS)** | **H (m)** | **Q (LPS)** | **H (m)** | |
| **Shastri Nagar** | 1194 | 33 | 1061 | 35 | 946 | 37 | Peak |
| | 478 | 42 | 424 | 42 | 378 | 43 | Average |
| | 143 | 44 | 127 | 44 | 114 | 44 | Lean |
| **Zakhira-1** | 255 | 41 | 225 | 44 | 199 | 46 | Peak |
| | 102 | 51 | 90 | 52 | 80 | 52 | Average |
| | 31 | 53 | 27 | 53 | 23 | 53 | Lean |
| **Zakhira - 2** | 226 | 26 | 202 | 28 | 181 | 29 | Peak |
| | 90 | 34 | 81 | 35 | 73 | 35 | Average |
| | 27 | 36 | 24 | 36 | 22 | 36 | Lean |
| **Shadipur** | 342 | 20 | 303 | 21 | 270 | 23 | Peak |
| | 137 | 26 | 121 | 26 | 108 | 26 | Average |
| | 41 | 27 | 36 | 27 | 32 | 27 | Lean |
| **Janta Park** | 305 | 26 | 271 | 28 | 241 | 29 | Peak |
| | 122 | 33 | 108 | 34 | 96 | 34 | Average |
| | 37 | 35 | 33 | 35 | 29 | 35 | Lean |
| **New Rajendra Nagar** | 418 | 24 | 377 | 25 | 341 | 27 | Peak |
| | 167 | 31 | 151 | 31 | 137 | 31 | Average |
| | 50 | 32 | 45 | 32 | 41 | 32 | Lean |

| **Year →** | **2051** | | **2036** | | **2026** | | **Daily Variation** |
|---|---|---|---|---|---|---|---|
| **Duty Point →** | **Q (LPS)** | **H (m)** | **Q (LPS)** | **H (m)** | **Q (LPS)** | **H (m)** | |
| **Naraina-1** | 736 | 15 | 654 | 16 | 582 | 17 | Peak |
| | 294 | 19 | 261 | 19 | 233 | 20 | Average |
| | 88 | 20 | 78 | 20 | 70 | 20 | Lean |
| **Naraina-2** | 108 | 20 | 96 | 21 | 85 | 22 | Peak |
| | 43 | 26 | 38 | 26 | 34 | 26 | Average |
| | 13 | 27 | 11 | 27 | 10 | 27 | Lean |

Guaranteed performance figures shall be based on this condition, as entered in the Technical Schedules.

**3. Underground Reservoir Works (UGR)**

a. Rehabilitation of Existing UGRs including all materials and workmanship as per approved design, drawing and construction methodologies including all associated piping and instrumentation works. This also includes associated works of roads, drainage, landscaping, fencing and lighting at the site area. Further works may include bypass or alternative arrangement for operation of reservoirs during rehabilitation works as per approved methodology, detailed scope of works and specifications.

b. Construction of New UGRs including all materials and workmanship as per approved design, drawing and construction methodologies including all associated piping and instrumentation works. This also includes associated works of roads, drainage, landscaping, fencing and lighting at the site area.

c. UGR & BPS :

The following UGR & BPS are included under this contract for Construction or Rehabilitation Purposes. In addition to these, there are a number of existing UGRs and BPSs currently operating in the command area. Those are to be continued operation and maintenance until the completion of the new system. The details are as given in O&M sections.

| **Name of UGR** | **Existing** | | **Proposed System** | |
|---|---|---|---|---|
| | **UGR** | **BPS** | **UGR** | **BPS** |
| Shastri Nagar | Yes | Yes | Yes (rehab) | Yes (rehab) |
| Zakhira | Not operational | Not operational | Yes (new) | Yes (new) |
| Than Singh Nagar | Yes | Yes | Yes (rehab & extension) to work as balancing reservoir | Yes (rehab) |
| Janta Park | Yes | Yes | Yes (rehab) | Yes (rehab) |
| Shadipur-1 | Yes | None | Yes (new). To be made as Rock Garden Gravity | None |

| Name of UGR | Existing | | Proposed System | |
|---|---|---|---|---|
| | UGR | BPS | UGR | BPS |
| Shadipur-2 | Yes | None | Yes (new). To be made as Shadipur Gravity | None |
| Rock Garden | Yes | None | Yes (rehab). To be made as Shadipur Pumping | None<br>For Shadipur : Pumping |
| New Rajendra Nagar | Yes | Yes | Yes (new) | Yes (new) |
| Naraina | Yes | Yes | Yes (new) | Yes (new) |

**4. SCADA and Instrumentation Works**

a. SCADA and Automation Works: Investigation, design, supply, erection/installation, testing and commissioning of Distribution SCADA and associated Instrumentation works that includes:

i. Construction of telemetry outstation near field plants/devices (e.g. motor operated valves, Flow meters, Pressure meters, chlorine analyser, Level measuring equipment at reservoirs etc.) that has to relay the signal to West Distribution SCADA system/centre. The works may consist of supply and erection of all kinds of instruments including casing box, RTU/ PLC, cabling works, communication and power systems etc.
ii. Distribution SCADA system for the entire zone with all necessary Hardware (Panels, Servers, PC, Printers etc.) and Software (System, Configuration, Communication, Application etc.) including power back up arrangement and building services (raised flooring, furniture, air-conditioning etc.).
iii. Configuration and Synchronization of Distribution SCADA with the Central Water Management Centre (CWMC) for performing specified monitoring and control functions.
iv. Various Application Software as specified in the specification.

b. Providing flow meters, on-line measurement of chlorine, and other instrumentation as required in DMAs.

### 2.3.4 Commissioning and Trial Run

The Contractor shall run the entire components of works for a specified period of commissioning and trial run to demonstrate the satisfactory performance to the Engineer prior to issuance of taking over certificate by the Employer. The cost towards it along with cost of electricity power, tools, spare parts and consumables shall be borne by the Contractor.

### 2.3.5 Operation & Maintenance Activities

Operation and Maintenance (O&M) of the entire West Zone for 9.5 years (4.5 years during the construction phase and 5 years after the construction phase) complying with the specified Service Level Benchmarks (SLB) and Key Performance Indicators (KPI).

1. O&M of Existing System: Operation and Maintenance of existing distribution system for

9.5 years starting after six months of work award i.e. preparatory period. However, the O&M of the Booster Pump Station is required only till the new BPS is constructed and commissioned.

Names of the existing UGR and BPS currently under operation in the Package 2 command area are provided below for Contractor's reference purposes only. There could be more also and this list wouldn't relieve the contractor's responsibility to do the O&M if any more are available in the command area. The O&M activities shall be carried out till the new proposed systems are put in place.

| Sl. No. | Name of UGR/BPS | Sl. No. | Name of UGR/BPS | Sl. No. | Name of UGR/BPS |
|---|---|---|---|---|---|
| 1 | Gali No. 8 Baljeet Nagar | 17 | Jullahana Mahola, Naraina Village | 33 | Pragati Appt. 356 Flats |
| 2 | Gali No. 6 Prem Nagar | 18 | I Block Naraina Vihar | 34 | Kharra Market |
| 3 | 35 Block West Patel Nagar | 19 | H- Block Naraina Vihar | 35 | Patel Nagar Online BPS |
| 4 | Shiv Charan Ranjeet Nagar | 20 | Inder Puri | 36 | Sarai Basti BPS |
| 5 | C1 Block Ranjeet Nagar (No existence) | 21 | Toda Pur | 37 | Shahzada Bagh BPS |
| 6 | Khanna Market | 22 | Rajender Park Old Rajender Nagar (not in use) | 38 | Inder Lok BPS |
| 7 | C Block Ranjeet Nagar | 23 | Rajender Nagar | 39 | Gulabi Bagh BPS/ Shastri Nagar |
| 8 | O Block West Patel Nagar | 24 | Near Dispansary, Naraina Village | 40 | Vivekanandpuri BPS |
| 9 | 28 Block West Patel Nagar | 25 | (online BPS) | 41 | Daria Nala BPS |
| 10 | Old Farid Puri | 26 | Tikone Park Naraina Village | 42 | Than Singh Nagar BPS |
| 11 | New Farid Puri | 27 | Pandu Nagar | 43 | Bapa Nagar BPS |
| 12 | D Block Karam Pura | 28 | Naraina | 44 | Sarai Rehilla BPS |
| 13 | Nehru Nagar (online BPS) | 29 | Naraina Village (online BPS) | 45 | Zakhira |
| 14 | Durga Park (online BPS) | 30 | Shadi Pur | | |
| 15 | Dusghara Village (online BPS) | 31 | Rock garden | | |
| 16 | Dusghara Village | 32 | Janta Park | | |

2. <u>O&M of constructed facilities during Construction Phase</u>: Operation and maintenance of all works constructed under the contract from the date of completion (taking over) till the end of 5 years Construction Phase. For this purpose, 3-4 reservoir command areas (i.e. consisting of distribution system) shall be clubbed into a cluster and a cluster shall be taken over at once. Hence, there will be 3 taking over dates (based on sectional completion targets) and O&M will start correspondingly.

The names of UGRs/BPSs are mentioned in the preceding clause.

3. O&M of constructed facilities after Construction Phase: Operation and maintenance of all constructed works/facilities for 5 years after the Construction phase i.e. from 6th year to 10th year of the contract period. For Cluster 3 and SCADA & Instrumentation work's DNP will also fall under this period for which only operation cost shall be included in the contract by the bidders.

For O&M Period (6th to 10th year), the Employer shall pay for the electricity power charges within the guaranteed power consumption.

The names of UGRs/BPSs are mentioned in the preceding clause.

### 2.3.6 NRW reduction and Customer Services

1. Carrying out all kinds of activities required for reducing the Water loss to 15% level (total in Transmission, Reservoir and distribution system) after completion of construction and rehabilitation works at the end of construction phase and then to maintain the same during the entire O&M period.

2. Provide the Customer services during the entire 9.5 years of O&M period which will include, but not limiting to the following:

   - New house service connections,
   - New water meter installations
   - Replacements of damaged/not working meters
   - Leak detection and rectification of the same
   - Attending all the visible leaks irrespective of the water loss level in the system
   - Investigation of water contamination and remedy for the same.
   - Replacement of all the damaged/leaking appurtenances such as sluice valves, air valves etc.
   - Testing of 5% of existing consumer meters at accredited lab for accuracy
   - Meter reading, generation of bills and integrating with DJB's Revenue Management System (RMS)

3. Design and supply of Software based Complaint Redressal System (CRS), receiving and redressing the customer complaints

### 2.3.7 Miscellaneous works and services

1. Supplying and set up of a Laboratory with requisite instruments and appliances required for analysis of water quality parameters specified under the contract.

2. Preparation of Specified Design & Drawings, Monthly progress reports, As-built/As-laid drawings and Operation &Maintenance Manuals in 6 sets (hardcopies) and 2 sets of Softcopies.

3. Provision of all kinds of inspection and testing as required from the approved laboratories/agencies for the raw materials, equipment and constructed products so as to ensure the quality.

4. Liaising works with external agencies for getting all required permissions, approvals, licenses and registrations of plant and facilities as required for completing the project. The Employer shall not accept any delay on account of delay in obtaining basic data and/or approvals.

5. Compliance with all statutory environmental and safety regulations and the Environmental Management Plan (EMP).

6. Establishing and maintaining a Quality Control System.

7. Liaison and interfacing with contractors of package 1, 3 and 4.

8. Obtaining permits and clearances required for the project works.

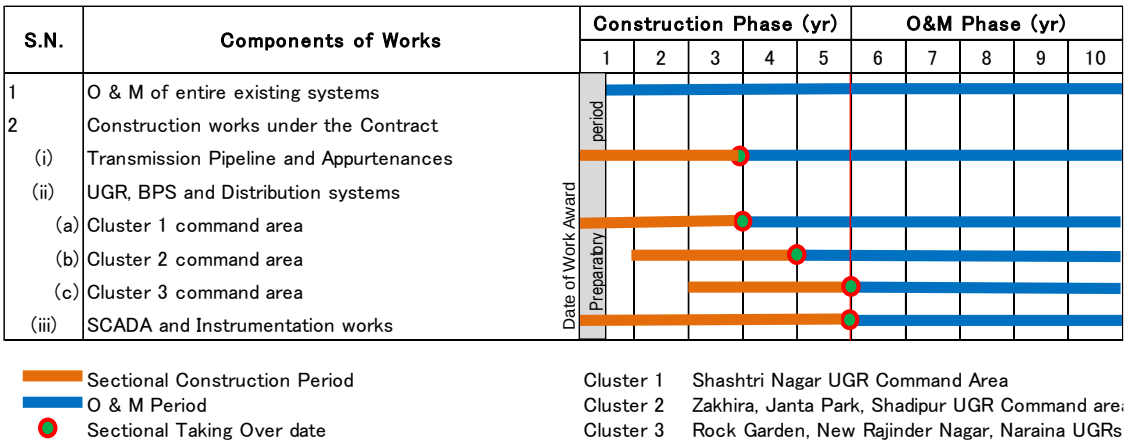
## 2.4 Implementation Schedule and Contract Period

### 2.4.1 Implementation Schedule

The entire service area has been divided into 3 Clusters comprising of the following UGR and their command areas.

Cluster 1 = Shastri Nagar UGR Command area
Cluster 2 = Zakhira + Janta Park UGR + Shadipur UGR Command areas
Cluster 3 = Rock Garden + New Rajendra Nagar + Naraina UGR Command area

The Start and Completion of new construction/rehabilitation works shall be done on the Cluster-wise basis as shown in the bar chart below.




Note: There will be one year DNP for the capital works from the respective Taking Over dates

For the O&M of the existing system, there will be six month's preparatory period during which the Contractor and DJB will jointly make all the documentation required for transferring the O&M activities to the Contractor. Then after, the contractor shall undertake the O&M activity of the entire existing water supply system covered under this Package. In addition, newly constructed works shall also be added up gradually for the O&M activities from 4th year onwards.

### 2.4.2 Contract Period and Details

The overall construction period for the entire works shall be 5 years with a sectional completion targets/periods. The Taking Over and start of DNP for the respective part shall also be done based on sectional completion. The DNP shall be one (1) year. Some other details are given in Table below.

| Sl. No. | Particulars | Conditions |
|---|---|---|
| **1** | **Construction Phase** | |
| **1.1** | **Construction/Rehabilitation Activities** | |
| | Overall Construction Period | 5 years |
| | Sectional Completion Periods | |
| | Transmission Pipeline and Appurtenances | 3 years of work award |
| | UGR, BPS and Distribution Systems-Cluster 1 | 3 years of work award |
| | UGR, BPS and Distribution Systems-Cluster 2 | 4 years of work award |
| | UGR, BPS and Distribution Systems-Cluster 3 | 5 years of work award |
| | SCADA and Instrumentation works for the entire Contract | 5 years of work award |
| | Basis of issuing Taking Over Certificate | As per Sectional Completion |
| | Defects Notification Period | 1 year for the respective works based on Sectional Completion |
| **1.2** | **O&M during Construction Phase** | |
| | Preparatory Period for O&M of existing systems | 6 months from the date of work award |
| | O&M of Existing Systems | For 4 years and 6 months after the Preparatory Period |
| | O&M of newly constructed / rehabilitated and Taken Over works | Included after Taking Over |
| | Payment terms | Fixed Cost basis as per BoQ and Quoted Amount |
| **2** | **O&M (Post-Construction) Phase** | |
| | O&M Period | 5 years |
| | Components of Works | All new and old works |
| | Payment terms | Fixed and Performance-based (60:40 ratio) |
| | Grace Period for Performance on KPIs | 6 month during which no deduction will be applied on performance-based payment portion |

# SUB-SECTION 3. PIPELINE WORKS

## 3.1 General

Scope of work under this contract package is spread over 7 UGR command areas with 46 newly proposed DMAs within those UGR command areas. Demarcation of boundaries of proposed UGR Command areas and the associated DMAs are marked in the respective overall UGR drawings and the DMA wise drawings prepared for distribution network improvements.

It shall be noted that the proposed command areas under the project differ significantly from the existing operational zones of DJB. Therefore, certain interlinks prevailing at the current operational zones should be discontinued with the new design proposals. Most importantly the current O&M scenarios prevailing at present are not in line with the proposed DMA concept and therefore the existing distribution mains with their sizes & alignments could have certain deviation with the new design scenario of establishment of DMAs. As a whole establishment of clear demarcation of the new operational boundaries for UGR command areas would be paramount as a basic scope. Similarly, the boundaries of proposed DMAs should have clear and firm demarcation after implementation of the proposed systems.

In general, DMAs will have approximately 500 to 5000 service connections depending upon the locality and density. In order to achieve reasonably equitable flows & allowable residual pressures while optimizing the capital and O&M costs, the DMA boundaries were decided keeping in those limitations at service connections. At the designs of UGRs & DMAs command area, interlinks were only permitted among them to suit the requirement for water transfer in emergency situations where technically feasible. Hence further interlinks shall not be created other than for justifying the same.

In general, UGR and DMA boundaries have been decided keeping in view physical boundaries like drains, major roads, colony boundaries etc. They shall be unique and shall not be overlapping or duplicating. As a whole, limited flexibility is granted to change the physical boundaries of the proposed UGR and allied DMAs during its establishment unless there is a proven & justifiable reason to do so in the perspectives of hydraulic, technical or ground reality.

In a broad summary the principal scope of work under the distribution improvement in Package-02 could be outlined as for following key activities.

### 3.1.1 Transmission Pipelines/Mains

This includes supply & laying of transmission mains up to UGR including flow control, pressure monitoring and data transmittal under the proposed SCADA system. The length of pipeline is approx. 16.8 km. The mains up to 600 mm are DI pipes and beyond MS pipes. The existing mains may be of non-standard size, therefore, allowance for the same should be considered while linking/de-linking to the new system.

**Proposed Transmission Pipe Line:**

| Sl. No. | Pipe Dia. (mm) | MOC | Proposed Length (m) |
|---|---|---|---|
| 1 | 1400 | MS | 6925 |

| | | | |
|---|---|---|---|
| 2 | 1200 | MS | 1782 |
| 3 | 1000 | MS | 2632 |
| 4 | 700 | MS | 4256 |
| 5 | 600 | DI | 509 |
| 6 | 400 | DI | 709 |
| | **Total** | | **16,813** |

**Supply & Installation of Valves:**

**Isolation Valve**

| Sl. No. | Valve dia. (mm) | Quantity (Nos.) | Type of Valve |
|---|---|---|---|
| 1 | 1000 | 1 | BFV |
| 2 | 800 | 3 | BFV |
| 3 | 500 | 1 | BFV |
| | **Total** | **5** | |

**Scour Valve**

| Sl. No. | Valve dia. (mm) | Quantity (Nos.) | Type of Valve |
|---|---|---|---|
| 1 | 800 | 4 | SV |
| 2 | 500 | 1 | SV |
| 3 | 400 | 2 | SV |
| | **Total** | **7** | |

**Air Valve**

| Sl. No. | Air Valve dia. (mm) | Quantity (Nos.) | Type of Valve |
|---|---|---|---|
| 1 | 200 | 8 | DAV |
| 2 | 150 | 2 | DAV |
| | **Total** | **10** | |

## Locations of trenchless pipe sections:

6 locations identified for trenchless railway/road/highway crossings along the pipeline route for this transmission system. The crossings shall be considered individually on case by case basis and prior approval shall be obtained before planning of such crossings. The scope of trenchless or no-dig pipe laying should be done in accordance with the standard technical guidelines developed by the "Indian Society for Trenchless Technology" and as per the specifications. The following Table indicates on the locations and basic details of the proposed trenchless road crossings.

| Trenchless Indicative Road Crossing for Transmission main | | | | |
|---|---|---|---|---|
| **Sl. No.** | **Transmission Main Pipe dia (mm)** | **Length (m)** | **Location** | **Remarks** |
| 1 | 1400 | 56 | Mahatma Ghandhi Marg in front of Railway Tribunal Principal Bench | Highway crossing |
| 2 | 1400 | 56 | Railway Line crossing near Sabji Mandi Railway Station | Railway Line crossing |
| 3 | 1400 | 29 | Veer Banda Bairagi Marg Near Gulabi Bagh Police Station | Road crossing below Elevated Metro line |
| 4 | 1400 | 125 | Railway Line crossing near Sarai Rohilla Railway Station | Railway Line crossing |
| 5 | 1400 | 28 | New Rohtak Road near Sarai Rohilla Railway Station | Road crossing |
| 6 | 1000 | 35 | Patel Road near Patel Nagar Metro Station | Road crossing below Elevated Metro line |

### 3.1.2 Distribution Pipelines from UGR to inlet of DMAs- Secondary Mains

This includes Supply & laying of Secondary mains from UGR to DMA boundaries (inlet of DMAs) including supply and installation of DMA meter and associated equipment for flow control, pressure monitoring and data transmittal under the proposed SCADA system. Approximate length of these pipelines is 26 km in new.

In general, all Secondary mains would be with socketed DI/MS pipes and fittings and diameter would be in the range of 200 mm to 1000 mm. Flanged pipes and fittings shall only be used for above ground sections, at special crossings like canal crossings and also for fixing of valves as per the standard details. The existing pipes are not recommended for use as Secondary mains. However, some of the higher size mains (700 to 1000 mm) are MS. In most of the UGR command areas one secondary main has been designed to feed few other DMAs as well. In some cases one DMA will be fed from two to three entry points either with the same Secondary main or from others. That design scenario of multiple entry points is to provide more flexibility in operation of intermediate sub-zones within the DMA, with a better facility in emergency situations.

Each DMA inlet point must have a flow meter with a motor operated flow control valve and pressure transmitter. Control panel of the SCADA system and the electrically controls of actuators shall be installed at a suitable ground location where power supply from the grid is accessible but should be at a reasonable distance from the DMA flow meter and valve to optimize the costs of cables and operational flexibility. DMA flow meter and the valve with the pipe accessories could be installed in an underground chamber as per the tentative locations suggested at the DMA pipe outline drawings. The DMA meter & control valve chamber shall be a water proof RC chamber with necessary protection against flood or storm water. In addition, each DMA must have pressure measurement points at the tentative locations indicated in the DMA drawings. Those pressure measurement points shall have link to SCADA system in order to indicate the minimum residual pressure at the distribution network within the DMA. Furthermore, there shall be a pipe tapping facility for site pressure measurements at the average pressure points, in line with the final hydraulic model results. Online water quality measuring points at each DMA shall be linked with the proposed SCADA system to monitor the selected water quality parameters including residual chlorine level.

### 3.1.3 Distribution Pipes within the DMA pipe networks- Distribution Pipes

This includes supply and laying of **Distribution pipes** as the feeder mains to the service lines to the customers. Those are tertiary elements of the overall distribution network of the DMA and as branches from Distribution mains or as interlinks. Approximate length of these pipelines is 274 km as new and 84 km as existing. The existing mains may be of non-standard size, therefore, allowance for the same should be considered while linking/de-linking to the new system.

The minimum diameter of those distribution pipes would be 100 mm and in most of the DMA networks it will be in the range of 100 mm to 400 mm depending upon the area and density of demand pockets. In order to minimize the number of road crossings while giving the service connections, rider mains are also proposed and marked in the DMA drawings as another element within the distribution pipe category. Wherever technically feasible and the primary condition assessment was up to the satisfaction, some of the existing CI and DI pipes have been recommended for further use as network element. Those pipes are clearly marked in the DMA drawings with a separate identity. However, the accuracy of the information on pipe alignment, their proposed cutting ends, re-jointing locations to the proposed network etc. shall be verified prior to the execution of work. Also, the condition assessment of pipes, hydraulic properties etc. shall be further evaluated under the scope of work in similar way as stated above for the existing distribution mains. Since those distribution pipes significantly contribute to the NRW, it is an essential scope of work to re-assess the feasibility and technicality of use of such proposed pipe sections. In this respect, technical report shall be produced as a pre-construction submission covering the feasibility & approach of connecting those pipes to the proposed distribution network. That document should also cover the alternative arrangements proposed for continuation of water supply to the existing service connections with minimum interruption during the construction period. It shall be noted that the cleaning & disinfection are some of the mandatory requirements prior to hooking up of those selected existing distribution pipes to the proposed network and the overall commissioning should be with the entire proposed network.

Further it shall be noted that the majority of the distribution pipes are to be laid in narrow congested roads wherein other utilities like sewer, electrical, gas, storm drainage etc. are also present. Hence the pre-determination of possible pipe alignments is critically important to cause minimum interference with those utilities. There should be a pre-construction plan for immediate repair of those utilities and to restore such services within an acceptable target time to satisfy the line agencies and their customers. Likely Environmental hazards due to the damages of those utilities during the construction shall be taken into account seriously and the mitigate plans shall be clearly spelled out in the EMP. Besides the construction activities may cause severe disturbances to the residences and occupants in those narrow roads or allies if there is no possibility to detour the daytime traffic and closing of the sections of the road for pipe laying. In such cases, night work shall be required and the contractor shall pre-plan for the same as an alternative measure.

### 3.1.4 Service lines & Service Connections within DMAs

This includes improvements to **Service Connections** (including Bulk Supplies) by replacement of service lines with MDPE pipes and replacement of defective consumer water meters.

There is an absolute need to improve the existing service connections as a project policy to

reduce the prevailing NRW. Majority of the service lines are in deteriorated condition and are leaking from the taping points to the existing distribution mains and also along the service line up to the water meter. Besides, bunch of long service lines, mostly above ground, are in existence which are contributing to the NRW in addition to the illicit or unauthorized tapings. Substantial numbers of defective meters are also prevailing. Most of the consumer water meters do not have sufficient protective measures and the meters installed at some locations have incompatibilities with the standard or acceptable norms. All those factors shall be strictly considered under the scope of improvements to the service connections. Underground sections of the Service lines shall be with PE 80 grade MDPE pipe and the above ground portions should be with GI pipe of medium class. However, the bulk water supply connections where service line diameter is greater than 63mm shall be made with DI pipe. Only the saddle connections are permitted at the tapping points to the distribution pipes and the more details of the types of service connections are given in the specifications/ drawings.

### 3.1.5 Special Crossings within the Distribution Networks

There is one bridge crossing above canal, for which the basic structural details are given in the associated drawing. Lengths of crossings are around 24 m and the above ground pipe sections along the pipe bridges shall be MS pipes. There should not be any cross links or disturbance to the adjoining road bridges when erecting the pipe bridges at those locations.

In addition to above, there are 11 locations identified for trenchless road crossings within the project area of this package. It shall be considered individually on case by case basis and prior approval shall be obtained before planning of such crossings. The scope of trenchless or no-dig pipe laying should be done in accordance with the standard technical guidelines developed by the "Indian Society for Trenchless Technology" and as per the specifications. The following Table indicates on the locations and basic details of the proposed trenchless road crossings.

**Trenchless Indicative Crossings of Roads for Distribution Pipelines**

| Sl. No. | DMA | Road Name | Dia of Pipe (mm) | Pipe Length (Crossing) (m) | Line Type |
|---|---|---|---|---|---|
| **SHASTRI NAGAR** | | | | | |
| 1 | B-01-07 | Swami Narayan Marg | 600 | 25 | Secondary Main DI |
| 2 | B-01-05 | Swami Narayan Marg | 900 | 30 | Secondary Main MS |
| 3 | B-01-06 | Junction at Veer Banda Bairagi Marg & Swami Narayan Marg | 800 | 59 | Secondary Main MS |
| 4 | B-01-11 | Swami Narayan Marg | 250 | 19 | Secondary Main DI |
| 5 | B-01-07 | Swami Narayan Marg | 300 | 19 | Secondary Main DI |
| **ROCK GARDEN** | | | | | |
| 1 | B-09-01 | Patel Road | 350 | 30 | Secondary Main DI |

| | | | | | |
|---|---|---|---|---|---|
| 2 | B-09-01 | Girdhari Lal Chowk | 500 | 29 | Secondary Main DI |
| **NEW RAJINDER NAGAR** | | | | | |
| 1 | B-05-01 | Dev Prakash Shastri Marg, in front of ICAR | 600 | 28 | Secondary Main DI |
| 2 | B-05-03 | Dev Prakash Shastri Marg (near Ratnapuri Chowk) | 400 | 35 | Secondary Main DI |
| **NARAINA** | | | | | |
| 1 | B-04-04 | Choudhary Girdhari Lal Marg | 400 | 25 | Secondary Main DI |
| **Trenchless Indicative Crossings of Railway Tracks for Distribution Pipelines** | | | | | |
| **Sl. No.** | **DMA** | **Road Name** | **Dia of Pipe (mm)** | **Pipe Length (Crossing) (m)** | **Line Type** |
| **ZAKHIRA** | | | | | |
| 1 | B-07-05 | Railway Tracks Crossing near Zakhira UGR Complex | 250 | 24 | Secondary Main DI |
| Note: - Invert level up the trenchless section should be decided after carryout utility mapping & details soil investigation along the trenchless route. | | | | | |

### 3.1.6 Specific Features of Installation of Valves and associated fittings

The Valve sizes in three categories of Sluice Valves, Scour Valves & Air Valves have been used in the works as shown in Specification, drawings and BOQ with respect to different diameters of DI pipes in the proposed distribution networks. Besides, when sizing the components, the availability of the DI Fittings in accordance with the IS 9523 has been taken into consideration in order to avoid unnecessary losses with application of multiple fittings. Those guiding principles shall be followed for the supply & laying of valves and fittings.

All distribution networks other than gravity operating systems should have Double orifice Air Valves (DAV) for its Secondary mains and Distribution mains. The gravity operated networks shall have single orifice air valve (SAV) for its Distribution Mains and Distribution pipes but for Secondary mains where dia > 350 mm should have DAVs.

### 3.1.7 Rehabilitation of Distribution Pipe

The project aims at replacing the following distribution pipes, among others;

- all AC, PVC, PSC, and GI pipe material
- the sections found hydraulically insufficient
- the sections which have outlived their useful life (older than 30~40 years)
- the sections in a bad shape due to external or internal corrosion
- the sections showing severe encrustation
- the sections having history of frequent leakage and breakdown

Since 100% replacement of distribution pipe is not feasible from both economic point of view

and time required, newer pipe sections and sections inferred to be in good conditions will be used.

### 3.1.8 Maintenance of Public Stand Post and Community Taps

The following works are required to be done for Public Stand Posts and Community Taps.

(a) Maintaining the water service (flow, pressure etc.) of Public Stand Posts and Community Taps (including Cistern Stand Posts) as at current level or gradual phasing out in accordance of the policies & consent of DJB.
(b) Installation of water meters for all Public Stand Posts and Community Taps with the renovation of service lines where necessary during the construction phase and GIS mapping of those locations with the details of number of taps and the approximate number of consumers.
(c) Inclusion of meter reading of those facilities to the billing cycles and take into account for computation of NRW.
(d) Replacement of defective meters, repairs to service lines etc. if any during the contract period.
(e) Prompt action on controlling wastage from those facilities by way of information received from Public complaints, regular inspection of mobile units etc.

## 3.2 Quantities of Pipeline and Valve works to be carried out for distribution system

### 3.2.1 Supply of Pipes &Valves

The following Tables indicate UGR-wise major quantities of supply of pipes which will be involved under the scope of work. Indicative quantities of associated fittings are given in the respective sections of BOQs based on the standard details of junctions, tentative alignment of pipe routes and in accordance with the STD for fixing of above categories of valves. Also the pipe fittings required for connecting existing CI/DI pipe lines to the proposed distribution networks, where specified, have been taken into consideration. Similarly, the pipe fittings required for disconnection of existing pipes & fittings have been considered to formulate the proposed network as per the design details (since the existing pipe network details at most of the areas have uncertainties as per the available as-built details, the given quantities in the BOQs could vary significantly during the execution). Those quantities are indicative ones and can have deviations according to the ground reality which should be ascertained with more specific details during the construction phase. However, the contractor is required to convey such deviations to the Engineer timely and prior to planning for the execution and necessary prior approval shall be obtained accordingly. Contractor to note that the existing mains may be of non-standard size, therefore, allowance for the same should be considered while linking/delinking to the new system. Contractor to keep this in consideration.

**(1) UGR wise indicative Distribution Pipe Length**

| Proposed Dist. Pipes | | UGR Command Area wise Pipe Length (Km) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Diameter of pipe (mm) | MOC | Shastri Nagar | Zakhira | Shadipur | Rock Garden | Janta Park | New Rajinder Nagar | Naraina | Total |
| 100 | DI | 48.44 | 33.05 | 40.59 | 22.12 | 13.65 | 5.34 | 35.13 | 198.32 |
| 150 | | 11.26 | 4.89 | 6.21 | 3.71 | 1.04 | 1.94 | 9.05 | 38.09 |

| Proposed Dist. Pipes | | UGR Command Area wise Pipe Length (Km) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Diameter of pipe (mm)** | **MOC** | **Shastri Nagar** | **Zakhira** | **Shadipur** | **Rock Garden** | **Janta Park** | **New Rajinder Nagar** | **Naraina** | **Total** |
| 200 | | 3.09 | 2.99 | 2.94 | 2.44 | 0.65 | 0.35 | 3.25 | 15.71 |
| 250 | | 4.48 | 1.72 | 1.58 | 1.27 | 0.40 | 1.75 | 2.79 | 13.99 |
| 300 | | 2.05 | 0.47 | 0.88 | 0.30 | 0.44 | 0.31 | 0.78 | 5.23 |
| 350 | | 3.52 | 1.04 | 1.76 | 0.40 | 0 | 1.36 | 0.93 | 9.00 |
| 400 | | 0.83 | 0.51 | 0.41 | 0.31 | 0.36 | 2.02 | 0.80 | 5.23 |
| 500 | | 2.06 | 0.32 | 2.72 | 1.51 | 0 | 1.36 | 0.99 | 8.97 |
| 600 | | 0.15 | 0 | 0.85 | 0.72 | 0 | 0.36 | 2.25 | 4.33 |
| 800 | | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.01 |
| 1000 | | 0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 |
| **Sub-Total (DI Pipes)** | | **75.90** | **44.99** | **57.94** | **32.78** | **16.54** | **14.79** | **55.98** | **298.90** |
| 800 | MS | 0.63 | 0 | 0 | 0 | 0 | 0 | 0 | 0.63 |
| 900 | | 0.16 | 0 | 0 | 0 | 0 | 0 | 0 | 0.16 |
| **Total MS Pipe** | | **0.79** | **0** | **0** | **0** | **0** | **0** | **0** | **0.79** |
| **Grand Total** | | **76.69** | **44.99** | **57.94** | **32.78** | **16.54** | **14.79** | **55.98** | **299.69** |

**(2) Supply & Installation of Valves:**

| Proposed Valves | UGR Command Area wise Valves (Nos.) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Diameter (mm)/ Type** | **Shastri Nagar** | **Zakhira** | **Shadipur** | **Rock Garden** | **Janta Park** | **New Rajender Nagar** | **Naraina** |
| **3.1 Sluice Valves** | | | | | | | |
| 100 to 300 dia (Without chambers) | 137 | 123 | 156 | 56 | 46 | 20 | 130 |
| Above 300 (with chamber) | 06 | | | 01 | | 01 | 01 |
| **3.2 Air Valves** | | | | | | | |
| SAVs | | | 21 | 16 | | | |
| DAVs | 51 | 30 | 14 | 02 | 14 | 09 | 25 |
| **3.3 Wash out Valves** | | | | | | | |
| 80mm to 200mm | 59 | 33 | 35 | 19 | 13 | 07 | 30 |

| Proposed Valves | UGR Command Area wise Valves (Nos.) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Diameter (mm)/ Type** | **Shastri Nagar** | **Zakhira** | **Shadipur** | **Rock Garden** | **Janta Park** | **New Rajender Nagar** | **Naraina** |
| 200 mm and above | 02 | 0 | | 01 | 0 | 01 | 01 |

**(3) Material and Rating of pipes to be supplied**

- **DI Pipe:** DI pipe shall be of K9 & K7 rating shall be used for Transmission/Secondary & Distribution pipes respectively, and fittings in K12 rating as per IS 8329; 2000. Pipe shall be internally lined with cement mortar and externally with metallic Zinc coating or Bitumen coating.

- **MS pipe:** MS pipe shall be fabricated out of grade Fe 410 (IS 3589:2001) and below specified minimum thickness of plates/coils. Pipes shall be internally lined with cement mortar of specified thickness and externally with coal tar coating and wrapping as per IS code.

| **Minimum plate thickness for MS pipe** | | | | **Internal Lining Thickness** | | |
|---|---|---|---|---|---|---|
| **Sl. No.** | **Pipe dia. (mm)** | **Min. Plate thickness (mm)** | | **Sl. No.** | **Pipe dia. (mm)** | **Mini. Lining thickness (mm)** |
| 1 | 350 - 500 | 6 | | 1 | 150 - 300 | 6 |
| 2 | 600 – 800 | 8 | | 2 | 350 - 600 | 7 |
| 3 | 900 – 1100 | 10 | | 3 | 700 - 1100 | 9 |
| 4 | 1200 – 1500 | 12 | | 4 | 1200 - 2500 | 12 |
| 5 | 1600 - 1800 | 16 | | | | |

### 3.2.2 House Service Connections

The following Table summarises the requirements for improvement of the service connections. This work comprises of replacement of existing service connections and connecting to new distribution pipe, replacement of service connections from the existing distribution pipe but changing from ferrule based connection system to saddle based connection system, new service connections for new customers either from new or old distribution pipe, preparing as-built drawings in GIS compatible format showing exact location of tapping point and route of service connection from tapping point to consumer meter and so on. The following table summarizes the activity requirements for improvement to the service connections with the quantities as per BOQ in VOL. V.

The scope of the work under installation of Consumer meter includes providing and fixing of consumer meters on unmetered consumer connections, replacing defective consumer meters with new meters, and testing of working consumer meters for accuracy check.

| Sl. No. | Description | Unit | Quantity |
|---|---|---|---|
| **1.0** | **House Service Connection** | | |

| | | | |
|---|---|---|---|
| 1.1 | Providing of house service connections from old and new distribution main (100 to 200mm DI/CI distribution pipes, 15 mm connections) | Nos. | 80,665 |
| 1.2 | -Do- above for 20 mm service connections | Nos | 3,401 |
| 1.3 | -Do- above for 25 mm service connections | Nos | 851 |
| 1.4 | -Do- above for bulk connections (40 mm and above) | Nos | 12 |
| **2.0** | **Consumer Meter** | | |
| 2.1 | Providing Class B meters along with fixing accessories for size below | | |
| | 15 mm | Nos. | 48,896 |
| | 20 mm | Nos. | 2,073 |
| | 25 mm | Nos. | 519 |
| | 40 mm | Nos. | 10 |
| | 50 mm | Nos. | 2 |
| | 80 mm | Nos. | 4 |
| | 100 mm | Nos. | 9 |
| | 150 mm | Nos. | 2 |
| | 200 mm | Nos. | 8 |
| **3.0** | **Testing of existing consumer meter** | | |
| 3.1 | Testing of existing meter for accuracy check in DJB approved lab. Including removing and re-installation of tested meters as per detailed specification. | | |
| | 15 mm | Nos. | 7,885 |
| | 20 mm | Nos. | 332 |
| | 25 mm | Nos. | 83 |
| | 40 mm and above | Nos. | 31 |

# SUB-SECTION 4. SCOPE OF WORKS- NRW AND CUSTOMER SERVICES

## 4.1 General

This package covers for around 85,000 service connections in an area of 28.11 Sq. Km. The actual area where the Operator is required to execute the works is 20.00 Sq. Km. The distribution system improvement works and water loss program in the Military area and Pusa campus are taken care by respective departments and are not in the scope of this contract.

Non-Revenue Water (NRW) is the difference between the water put into the system (water supplied) minus billed consumption. In this contract and especially for contractor's KPI purposes, 'Water Loss' would be measured and monitored. NRW is the sum of 'Water Loss' and 'Unbilled Authorised Consumption'.

The scope of works under Water Loss reduction & control and customer services includes the following main tasks.

1. Consumer survey and mapping
2. District Meter Areas (DMAs) formation and implementation
3. Replacement of house service connection on existing main and providing new service connections from newly laid distribution pipe
4. Consumer metering
5. Leak detection and repair
6. Replacement of distribution pipe (included in the scope of Pipeline works)
7. 
8. Preparation of detailed as-built network map
9. Preparation/up-dation of consumer database
10. Preparation of DMA file and operation manual
11. Providing new house service connections
12. Identification of unauthorized connections
13. Training of DJB Staff
14. Calculation of Water Loss
15. Monitoring and Control of Water Loss Levels during Construction Period
16. Monitoring and Control of Water Loss Levels during Post-construction O&M Period
17. Miscellaneous works
18. Reporting

The detailed scope of works and methodologies of work for each of the above tasks are described in following sub-sections.

## 4.2 Customer Survey and Mapping

The Contractor (also called as the Operator hereafter) shall undertake door to door surveys to confirm the Meter details and functionality, illegal connections and consumption (source), etc. in accordance to the contract requirements. During the survey, the operator shall also collect the population details. Scope of survey is as given below:

1. Conducting door-to-door survey of each household (regardless of connection status with DJB piped water supply) within the project area.
2. GIS mapping of consumer meter location for each metered connection

3. GIS mapping of house entry point for all unmetered connections
4. GIS mapping of unconnected households showing as a point which shall fall within the building polygon on GSDL or google map,
5. Collection of the details of population
6. Preparation of database and report of the survey.

### 4.3 District Meter Areas (DMAs) formation and implementation

#### 4.3.1 District Meter Areas (DMAs)

The contract area is divided into 46 District Meter Areas (DMAs) based on good industry practice, taking into consideration of the water distribution system configuration, continuity of adequate supplies to all consumers, ease of establishment and maintenance. Number of connections in the DMAs vary between 400 to 5000 service connections. The DMA boundaries were finalized based on existing topographical boundaries such as major drains, railways, major roads, etc., as well as the ease of creating hydraulic boundaries within the existing distribution network in consultation with DJB. However, in exceptionally unavoidable circumstances, changes to DMA boundary shall be reviewed during the implementation period.

O&M Zone and revenue zone boundaries of DJB are currently different. For future technical and operational reasons, the O&M Zone and revenue zone boundaries can be progressively adjusted to coincide with each other considering the hydraulic boundaries of the new DMAs as they are developed and implemented.

#### 4.3.2 DMA Formation

While executing the physical works such as pipe laying, fixing of boundary valves, installation of district meters, etc. thrust should be given to isolate the DMA boundaries on priority to make sure that the DMAs are hydraulically discrete. Priority should be given to fix boundary valves and execute the pipeline works to isolate the DMA wherever possible without affecting the supply conditions. This will enable to understand the water loss level in the DMAs thereby initiation can be taken to reduce if the water loss is more than the expected target level.

#### 4.3.3 Installation of DMA meters

The operator should fix the district meters (DM) which is of full bore electromagnetic flow meter at designated locations to measure the DMA inflow and outflow (if any). The pressure shall also be monitored by pressure transducers at the flow monitoring point. The pressure data shall be recorded by the integral loggers. All the flow and pressure data shall be captured and transmitted to the SCADA as per the requirement.

#### 4.3.4 Conducting Pressure Zero test

Once the DMA boundary has been identified, a PZT shall be carried out in accordance with the procedure detailed below to prove that the DMA is isolated fully from the rest of the pressurized distribution system. This involves closing the supply to the DMA and checking that the pressure drops towards zero. All boundary valves should be sounded to check whether the valves are water tight. If faulty valves are found, those should be rectified and the PZT to be repeated.

In order to undertake the Pressure Zero Tests sufficient pressure logging points shall be

installed to verify that the mains pressure has dropped to zero across all parts of the DMA during the test. Suitable locations for pressure monitoring shall also be identified and pressure loggers shall be installed to monitor regularly.

A typical procedure for a PZT will be as follows:

1. PZT to be undertaken once the pipe laying works are completed in the DMAs and boundaries are froze with DMA receives continuous water supply. If continuous supply is not possible before this test, then arrangement should be made with DJB to make sure that the DMA and adjoining DMAs/areas have continuous supply during the PZT.
2. Identify the boundary valves and mark them for easy identifications.
3. Arrange for the test to take place between 01.00 and 05.00. Inform customers with special needs (hospitals, dialysis patients etc.) in advance.
4. Ensure that the staff has maps indicating the DMA boundary, boundary valves, and the DMA inlet valve.
5. Deploy pressure loggers on the pressure monitoring points (PMT) and set to 5 minute intervals.
6. Close boundary valves and DMA inlet valve/s in order to isolate the DMA.
7. The pressure on the loggers, as read on-site, should fall as soon as the supply and boundary valves are closed. If the pressure falls to zero excluding static head, or reduces but will remain steady for more than one hour, this will be accepted as a successful PZT.
8. If PZT is not successful, check and sound each supply and boundary valve in turn to identify passing valve if any. Passing valves should be fully closed, where possible, and the PZT repeated.
9. If the PZT is not successful, the Contractor shall organise further investigations to find the cause of the failure and then repeat the PZT.
10. On successful completion of the PZT, open the supply valve(s) and make sure that supplies have been restored in the DMA. Loggers deployed under shall be left in place for few days to confirm the impact of the new boundary on local pressures. Customer contact shall be monitored and reviewed over this period also and any necessary action to rectify supply problems shall be taken by the Contractor in consultation with the DJB.
11. All the relevant records shall be completed before leaving site.
12. PZT Completion Report shall be prepared and submitted to DJB.

### 4.3.5 Development of Pressure Monitoring Points

Suitable locations for pressure monitoring shall be identified and pressure loggers shall be installed to monitor regularly. These regularly monitoring points are Average Zonal Pressure (AZP) points and Critical Pressure Point (CPP) in each DMA. This will enable to ascertain the supply of water with adequate pressure for the DMA.

### 4.3.6 Critical Pressure Point (CPP)

The critical pressure point in the DMA is the point which represents the minimum pressure or critical pressure which influences downstream supply, therefore, it is required to maintain the same for supply with adequate pressure. CPP point to be monitored permanently through SCADA system.

### 4.3.7 Average Zonal Pressure Point (AZP)

The average pressure point is identified based on the design which represents average pressure of that particular DMA. It is intended to establish two AZP in each DMA for monitoring purpose to ascertain the functioning of the DMA. AZP points shall be monitored through the pressure data loggers fixed at that locations which will record the data at 15 minutes interval. On weekly basis this data will be downloaded for review and record.

### 4.3.8 Developing Water Quality Sampling Point

The objective is to assess the quality of water supplied in the distribution system. Sample must be taken from the locations which are representative of the distribution system. While selecting sampling points, general criteria considered are; representative of the different inlets; representative of the DMA in terms of low pressure and far end of the distribution system. Operator is required to establish this pre-identified location suitable for sample collection. A tapping (same as house service connection) on the distribution line shall be taken and housed in a post mounting MS cabinet enclosure with stopcock to collect the sample.

The enclosure shall be constructed from galvanised steel which is at least 3 mm thick. The enclosure shall have a hinged access door. The enclosure shall be mounted on a concrete plinth. A duct shall pass through the plinth to enable the pipe from the distribution line to enter the enclosure. A label showing details of the Employer's name and the unique reference number shall be fixed to the external face of the access door.

### 4.3.9 Preparing Water Loss Reports

#### (i) DMA wise Water Loss report

Water Loss for a DMA will be defined as:

$$\text{Water Loss (\%)} = \frac{X - (A + B + C + D)}{X} \times 100\ \%,$$

Where:
X = Water input to the system (DMA) during the period (typically 1 billing period)
A = Water billed during the period
B = Water legally supplied but not billed (including slum and stand post consumption) during the period
C = Operational use (scouring, jetting, dust suppression, etc.) during the period
D = Tankers metered and billed/unbilled during the period

Operator should use the downloaded data from the flow meter to calculate the inflow to the DMA. The billed consumption is the actual consumption taken for the billing period. In case of water legally supplied but not billed (including slum and stand post consumption) during the period, operator can measure the flows to Slums and stand post consumption. Operational use can be measured or estimated based on site conditions.

#### (ii) Cluster wise Water Loss

For Cluster wise water loss, the above-mentioned formula for DMA water loss shall be used but for the inflow, quantity of water entering the reservoirs shall be considered. For billed consumption, legally supplied but not billed and other components, the cumulative of all the

DMAs in the Cluster shall be considered. This package has three clusters and the details of the cluster with reservoirs and command area are as given below:

- Cluster 1: Shastri Nagar UGR command areas.
- Cluster 2: Shadipur, Zakhira & Janta Park UGR command areas.
- Cluster 3: Rock Garden, New Rajinder Nagar and Naraina UGR command areas.

**(iii) Transmission Water Loss**

Water loss in transmission system shall be the difference between the quantity of water measured at the outlet of the WTP and inlet of all the service reservoirs coming under that transmission system and divided by the quantity of water measure at the outlet of WTP.

Transmission Water Loss (%) = ((Y-Z)/Y) × 100%

Where:
Y = Water measure at output of the WTP during the period (typically 1 billing period)
Z = Water measure at inlets to the reservoirs during the period (typically 1 billing period)

**(iv) Contract wise Water Loss**

For this, the transmission as well as distribution losses shall be added to obtain the total loss for the Contract area. For distribution losses, the formula given for DMA water loss shall be used but the water into the system shall be the total cumulative inflow measured at the inlets of all reservoirs in the Contract area for the billing cycle. Similarly, other components like billed consumption, legally supplied but not billed etc. shall be total cumulative of all the DMAs for the billing cycle.

### 4.3.10 Approach for Reducing Water Loss

The water loss can be divided into two types namely, Physical Losses (Real Losses) and Non-physical losses (Apparent Losses/commercial). Real Losses in the System are due to Leaks and can be measured using Minimum Flow Method (MNF). Where there is a problem of 24 hours of water supply for a minimum period of about 7 days to conduct MNF test, top down approach can be adopted. In this case the difference between water into the system minus authorized consumption can be taken as Water Losses.

Apparent losses are due to unauthorized (illegal) consumptions & Metering errors. There are no direct measurements to estimate apparent losses.

**A. Approach for reducing real losses**

As per International Water Association best practice guideline, the four basic methods of reducing real losses are (i) Pipeline and asset management – selection, installation, maintenance, renewal, and replacement, (ii) Speed and quality of repair, (iii) Active leakage control, and (iv) Pressure management.

Provisions shall be made in the contract such that all the above methods will be employed to reduce real loss in the project area (working).

**(i) Pipeline and asset management** – selection, installation, maintenance, renewal, and replacement

- All Asbestos Cement pipes, PVC pipes and most of the aged CI pipes in the distribution network will be replaced by internally lined DI pipes.
- The pipe material of house connections in Delhi is GI. This material gets corroded quickly giving rise to leakage. All these house connections will be replaced with Polyethylene (PE) pipe which is recognized as a suitable material for house service connection. However, the exposed part of the HSCs shall be replaced with Class-B GI pipes. Appropriate adaptor shall be used to change from PE to GI and GI to PE pipes.
- House connection tapping points are often the weak points leading to water leakage. Traditionally only a ferrule is used for house connection in Delhi. All the existing connections shall be replaced with PE pipe and saddle trap. Even all the new house connections will be given using PE pipe and saddle trap. This will significantly reduce the chances of leakage from tappings.
- As-built drawings with details of pipes and fittings will be prepared in GIS or GIS compatible formats such as AutoCAD. This will be a valuable tool for pipe asset management in future.
- An Asset Management module has been prescribed for inclusion in SCADA software. The Operator / DJB should prepare and implement an Asset Management Plan in line with the guidelines given under JICA's Technical Assistance program.
- The scrap value of MS, DI and CI pipes, fittings and specials shall be Rs.16/kg. The scrap value of old serviceable bricks and stone soling shall be Rs.1300 per 1000 bricks and Rs.500 per cum respectively.
- The scrap value is the net rate of recovery/deduction to be made from the contractor's bill after considering the cost of removal and transportation of the existing pipes to be incurred by the contractor.

**(ii) Speed and quality of repair**

- Under current intermittent supply system where the supply duration is about 2-4 hours per day, speed of repair may not be a critical variable for leakage reduction. But once the supply system becomes 24 by 7, speed of repair will be crucial for reducing leakage. Performance target in terms of response time for leak repair will be set in O&M contract.
- Repair method and quality of materials will be specified so that minimum required standard is maintained.
- Enough stock of leak repair materials will be maintained.

**(iii) Active leakage control**

- Proactive program of leak detection and repair will be prepared and implemented in the established DMAs. DMAs will be screened for leakage levels and prioritized for leak detection surveys. Step tests will be conducted to further narrow down the higher leakage sections. Leak detection and location methods appropriate to the condition of project area will be identified and applied. The probable methods to be deployed for leak detection are; acoustic methods using acoustic equipment if the pressures are good (more than 10 m) in the system, if not gas tracer (helium/hydrogen gas) method to detect invisible leaks which plays major role in physical losses. Even geophone may be used for leak detection.

**(iv) Pressure management**

- Water pressure and leakage rates are directly proportional though the exact relationship varies depending upon the type of pipe material and nature of leak. Flexible non-metallic pipes tend to be more affected by pressure than rigid metallic pipe. Similarly, leakage from pipe surface cracks varies more with pressure than the leakage from joints or pin holes.
- Higher pressure differential increases scope of pressure management particularly when the ground profile is undulating or when the ground elevation variation within a project area is large. But these are not the cases in this project area. Thus, the scope of pressure management is limited.
- However, pressure management is a natural consequence of automating pump operation to respond to demand variation. By this process, pumping rate is varied by means of VFDs and hence high pressures are avoided at night time, when demand is low.
- However, at some locations, pressure reducing devices may be deployed to control the pressure if required.

## B. Approach for reducing apparent losses

Apparent losses are mainly related to metering and billing. IWA best practice guideline has identified the following four components of active apparent loss management program; (i) Reduction of meter error by testing, sizing, replacement, (ii) Reduction of human error by training, standardizing, reporting, auditing, (iii) Reduction of computer error by auditing, checking, routine analysis, upgrade, and (iv) Reduction of illegal use/theft by education, legal action, other measures.

The contract will have provisions to address the above-mentioned issues either by the contractor himself or through DJB.

### (i) Reduction of meter error

- All productions and distribution will be metered. Flow meters will be installed at outlets of WTP, and inlets and outlets of UGR. This will allow assessing water loss from transmission mains and from UGRs. Provision for meter accuracy checking and calibration as per internationally accepted practice will be made.
- All un-metered consumer connections will be metered. All public stand-posts will be metered. Water supply through tankers will be measured.
- All defective consumer meters will be replaced.
- Suspicious meters (showing abnormal readings) will be tested and replaced as required.
- About 5% of randomly selected functional meters representing all categories and age (DMA wise) will be tested at certified test benches to understand the meter accuracy of the existing meters to estimate the meter losses. A decision can be taken based on outcome of the accuracy test. During the maintenance period or after completion works, each year about 5% meters from DMAs shall be selected based on the criteria mentioned above and tested for accuracy to keep a tab on meter accuracy losses.
- Bulk meters are sized according to expected flow range and manufacturer's recommended range to keep the error at minimum.
- Meter replacement age will be defined based on total volume passed or service year. All meters reaching these criteria will be replaced. Replacement shall be done based on volume of water (9999 Kl) passed through the meter or age (8 years) of the meters whichever occurs earlier.

- Meters intended for horizontal installation will not be allowed to be installed in vertical position.

**(ii) Reduction of human error**

- DJB has introduced hand held devices. This system is expected to gradually replace the old error-prone meter reader diary system. Chances of human error while transferring meter reading from one to another paper based records will be minimized.
- Bill generation is now managed by computerized Revenue Management System (RMS). Chances of human error are reduced.
- Water bills have printed barcode which reduces the time taken for collection of revenue and chances of mishandling the cash.

**(iii) Reduction of computer error**

- DJB hired a private agency to develop the RMS. The same agency is currently managing the system. In future also, it is likely that DJB will get the services of private agencies for this work. Required checks and balances, auditing, routine analysis, and upgrade of hardware/ software should be the integral part of the contract with such agencies so that apparent loss due to computer errors is minimized.

**(iv) Reduction of illegal use/ water theft**

- Unaccounted connections (missing consumers) are the major source of apparent loss in the project area. The project aims at replacing all house connections. Majority of distribution pipe from which the house connections are given will also be replaced. This process will greatly help identifying missing customers and illegal connections. Since the house connections will be given from new distribution pipe and old pipe will be disconnected from the system, the existing illegal connections from the old distribution pipe will automatically be disconnected. In case where the existing distribution pipes are to be retained all the house service connections will be replaced, this will eliminate or reduces to some extent the illegal connections in those mains.
- Another cause of apparent loss is reading manipulation by meter reader-customer collusion. This becomes possible when the meter readers are assigned fixed area and they continue reading meters there for years. This problem will be reduced by introducing GIS based “Meter Reading Route” system and rotation of meter readers. Once the MR route is established there will be no problem locating each customer/meter and any meter reader can do the reading.
- Since the entire distribution system will be restructured and customer database cleaned, it will be easier to correctly identify and monitor bulk consumers.

In Metro City like Delhi, there are pocket of economically weaker section settlements in which neither pipeline can be laid nor provide house service connections due to constraint of lane width. In addition, there are notified/identified Slums wherein also laying of pipelines may not be possible due to space constraints. Under these circumstances, DJB may consider fixing of bulk meters (similar to district meters) at the entry point for measurement of supply to those areas. This will help in understanding the quantity of water supply to those areas and facilitate NRW calculations.

### 4.3.11 The Scope of DMA establishment work for each DMA

The following are the list of works to be undertaken in each DMA as per specifications but not limited to:

- Conduct pressure zero test until it is successful (repeat if PZT fails with investigations till it is successful) and establish the DMAs as hydraulically discrete,
- Supply and install sluice valves to isolate DMAs hydraulically at boundaries between the DMAs/service stations,
- Construct inflow District Meter chambers, complete with the installation of all pipework; including supply of all required pipes, materials, fittings and equipment,
- Supply and install DMA meters (electromagnetic flow meters),
- Supply and install motorized (SCADA compatible) control valves,
- Identify pressure monitoring (AZP & CPP) locations in each DMA, construct chambers for installation of pressure transducers at these locations; including supply of all required pipes, materials, fittings and equipment,
- Supply and install dual channel pressure and flow data logger at the inflow points, pressure data logger at pressure monitoring locations, set up data transfer to zonal control and Central Water Management Centre (CWMC); supply and install respective software,
- Execute any other civil, mechanical, installation or plumbing works, including supply of all required pipes, materials, fittings and equipment for DMA establishment, as per the specifications,
- Prepare as-built drawings for all works executed on GIS / AutoCAD formats.
- All the DMs, pressure loggers, transducers etc. shall transmit the data to Contractor office as well as to Central Water Management Centre (CWMC) using the modem as per contract requirement.

The scope will also include the following as per the relevant specifications under chapter C1 – Civil works.

(i) Measuring and monitoring water loss level at DMA level
(ii) Replacement of house service connection on existing main and providing new service connections from newly laid distribution pipe

### 4.4 Metering

The scope of work includes the following:

(a) Providing and installing new meters on all unmetered domestic connections
(b) Providing and replacing all visibly defunct meters
(c) Providing and installing new meters on all unmetered bulk connections (industrial, commercial, institutional)
(d) Providing and replacing with new meters on all bulk connections (industrial, commercial, institutional) having visibly defunct meters
(e) Providing and installing meters on public taps and on community toilets/urinals.

#### 4.4.1 Consumer meters

The project aims at universal metering. To this effect, new meters will be installed in all unmetered connections and all non-working meters will be replaced. All new/old connections will be metered. Reference will be made to RMS data/ DJB water bill for identifying non-working meters. In addition, any meter showing abnormal reading during the preceding meter reading cycle shall be checked for accuracy and if found to have error +- 5% at normal flow

rate, shall be considered a candidate for replacement.

The proposed UGR command area wise distribution of bulk connections is summarized in the table here under. The connections are existing and included in metering status and the sizing is as per hydraulic analysis.

**NUMBER AND SIZE OF BULK CONNECTIONS IN PKG 2 AREA**

| Pipe or meter size (mm) | UGR Command Area | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Shastri Nagar | Shadipur | Naraina | New Rajendra Nagar | Zakhira | Rock Garden | |
| 20 | 2 | 8 | 3 | 2 | | 3 | 18 |
| 25 | 2 | 2 | | 1 | | | 5 |
| 32 | | 1 | 1 | 1 | 1 | 2 | 6 |
| 40 | 1 | | 1 | 2 | | | 4 |
| 50 | 1 | 1 | | | | | 2 |
| 80 | 3 | 1 | | | | | 4 |
| 100 | 2 | | 1 | 2 | 4 | | 9 |
| 150 | | | | | 1 | | 1 |
| 200 | 2 | 1 | | | | | 3 |
| 250 | | 1 | | 1 | | | 2 |
| **Sub-total** | **13** | **15** | **6** | **10** | **5** | **5** | **54** |

As a rule, water meters should be installed in a location which is closest to the road boundary within the customer's premises, where meter-reading, inspection, and replacement work can be undertaken easily. In addition, the location should be secure against damage from vandalism. The meter should preferably be installed within 1 m from the public-private boundary.

In case water meters are installed underground, they should be placed in meter boxes with cast iron covers and with mechanism to prevent flooding. In addition, prevention of contamination by back water should be taken into consideration when removing the meter.

In case of highly congested areas like Anand Parbat, Zakhira, Thansingh etc. enough space may not be available to install water meters on the ground. In such cases, as it is commonly practiced, water meters may be installed on side walls of the building.

The meters should be protected with existing meter boxes wherever they may be installed. Depending upon the configuration of HSC near the meter, water meters may be installed as shown in the following figures. Consideration should always be given to the followings:

- to make sure that meters are installed horizontally (except the particular types of meters intended for vertical installation),
- to the provision of enough lighting for meter reading,
- securing of space for replacement work,
- securing of specified straight pipe distances before and after the meter depending on the type of meter,
- for back-flow prevention a check valve is recommended to be installed just before water meter, and
- it is not allowed to make any connection from the service connection line before the water meter.

### 4.4.2 Meter on Public Taps

As a matter of principle, water distribution through public taps shall be discouraged. But it may not be possible to eliminate public taps altogether. In such a situation, they shall be metered. Community approach shall be followed for metering public taps in which a caretaker committee shall be formed for each tap. These committees will be given responsibility of protecting meter and reporting leakage or misuse of water. Suitable secure location shall be identified in consultation with the committee for meter installation and the meter shall be protected with a meter box.

### 4.4.3 Meters on Community and Public Toilets

Total number of community and public toilets for Delhi was obtained from literature with further details available from the MoUD website.

**SERVICE CONNECTION AND METERING NEEDS FOR COMMUNITY AND PUBLIC TOILETS**

| Description | Urban Delhi excluding NDMC and Cant. | Pkg 2 |
|---|---|---|
| **2011 Population** | 15,632,591 | 571,824 |
| **Number of CTC complex (Nos.)** | 788$ | 29 |
| **Number of Public Toilet (Urinal Blocks) (Nos.)** | 1,931$ | 71 |
| **Total water connections (Nos.)** | | 100 |
| **Total metering (Nos.)** | | 100 |

*Note: $ - Numbers as of Oct 2015, excluding NDMC and Cant. areas*

### 4.4.4 DMA Meters

The DMA establishment work will start after completion of the above-mentioned distribution pipe replacement, house connection replacement, and consumer meter replacement works or in parallel to these works. There are 7 UGRs and 46 DMAs under this Package.

The following Table lists the DMAs to be established. Other pertinent information such as number of inlets / outlets and requirement of DMA meters in each DMA is also presented in the Table below.

**LIST AND FEATURE OF DMAS**

| UGR Command Area | Number of DMAs | Inlet / outlet pipe | | DMA meter | |
|---|---|---|---|---|---|
| | | Size (mm) | Nos. | Size (mm) | Nos. |
| **Shastri Nagar** | 16 | 250 | 7 | 150 | 7 |
| | | 300 | 3 | 200 | 3 |
| | | 350 | 4 | 250 | 4 |
| | | 400 | 2 | 300 | 2 |
| Sub-total | **16** | | **16** | | **16** |
| **Shadipur** | 10 | 200 | 2 | | |

| UGR Command Area | Number of DMAs | Inlet / outlet pipe | | DMA meter | |
|---|---|---|---|---|---|
| | | Size (mm) | Nos. | Size (mm) | Nos. |
| | | 250 | 2 | 150 | 4 |
| | | 300 | 1 | 200 | 1 |
| | | 350 | 4 | 250 | 4 |
| | | 400 | 1 | 300 | 1 |
| | | 500 | 1 | 350 | 1 |
| Sub-total | **10** | | **11** | | **11** |
| **Naraina** | 6 | 200 | 1 | 150 | 1 |
| | | 350 | 1 | 250 | 1 |
| | | 400 | 3 | 300 | 3 |
| | | 500 | 1 | 350 | 1 |
| Sub-total | **6** | | **6** | | **6** |
| **New Rajinder Nagar** | 3 | 300 | 1 | 200 | 1 |
| | | 400 | 1 | 300 | 1 |
| | | 500 | 1 | 350 | 1 |
| Sub-total | **3** | | **3** | | **3** |
| **Zakhira** | 6 | 250 | 3 | 150 | 3 |
| | | 350 | 1 | 250 | 1 |
| | | 400 | 2 | 300 | 2 |
| Sub-total | **6** | | **6** | | **6** |
| **Janta Park** | 2 | 400 | 1 | 300 | 1 |
| | | 500 | 1 | 350 | 1 |
| Sub-total | **2** | | **2** | | **2** |
| **Rock Garden** | 3 | 300 | 1 | 200 | 1 |
| | | 350 | 1 | 250 | 1 |
| | | 400 | 1 | 300 | 1 |
| Sub-total | **3** | | **3** | | **3** |
| **Grand-total** | **46** | | **47** | | **47** |

### 4.4.5 Meter Testing

- The operator should attend to all the consumer complaints and reports from DJB pertaining to the performance of the consumer meters. If required, the operator to undertake testing of the meter and/or replace malfunction/damaged meters and same to be undertaken for the non-performing operator investigated meters.
- Operator to test minimum 5% of the water meters (selected on random basis) installed by himself to ascertain the accuracy levels of the meters installed under the Contract.
- Wherever illegal connections are identified, the Contractor shall immediately report to the Engineer with details. The Engineer in turn will inform to the O&M Division of DJB to formalize or disconnect the connection.

## 4.5 Leak Detection and Repair

Leak detection (during post-construction O&M period) shall be covered by the performance payment to the contractor and hence no separate payment shall be made. Leak repair shall be paid as per BOQ and approved schedule of rates. The Operator shall start leak detection and rectifications as soon as the DMAs are established and execution of physical works are completed in the Contract area. The priority can be given to those DMAs where the water loss level is more than 14%.

### 4.6 Replacement of distribution pipelines (included in the scope of distribution improvement)

The pipeline condition assessment report was prepared by JICA under the technical cooperation project for DJB in which 251 pipe samples were taken and studied to ascertain; a) pipe structure, b) soil condition affecting pipe corrosion externally and c) pipe encrustation inside of pipe. Based on outcome of the study and the experience of the DJB, pipeline replacement proposals are prepared. Total number of pipe samples used for criteria (a) & (b) were 251 and for criteria (c) it is 51 from among the 251 numbers. The outcome of the study is that due to encrustation of the pipelines, carrying capacities were reduced considerably. Moreover, the internal conditions of the pipelines were dirty due to which maintaining the chlorine level would have been difficult.

- All secondary mains from reservoirs shall be of new DI/MS mains. This decision was taken due to too many tapings on the existing secondary mains, due to which it is difficult to ascertain the number of inlets to DMA.
- Based on outcome of the study, the pipelines which are old were identified and considered for replacement. While doing so, leakage history of the pipelines was also referred and the mains which have frequent leakage history were also considered for replacement.
- Replacement of distribution pipe which are PSC, AC, GI, and PVC.
- Distribution pipelines which are less than 100 mm dia were also considered for replacement, as the minimum stipulated size is 100 mm as per CPHEEO manual for 'Urban/Metro Cities' Water Supply Systems.
- The sections found hydraulically insufficient,
- The sections having history of frequent leakage and breakdown.

Since 100% replacement of distribution pipe is not feasible from both economic point of view and time required, newer pipe sections and sections inferred to be in good conditions will be retained for use.

### 4.7 Rehabilitation of Water Mains

In case of DMAs where the existing mains retained are substantial in length and suspected that they are leaking due to which the water loss level is more than 14%, then the operator is required to carry out the detailed investigations which shall provide a comprehensive overview in terms of interruption to supply due to leakage and condition of pipeline. Specifically, the investigations should be based on burst history/interruptions to supply, leakage and physical pipe condition, degree of corrosion, tuberculation, etc. The Operator can take few samples (length could be around 0.45m) in the DMAs and study the physical conditions of pipe, degree of corrosion, tuberculation, etc. and submit the report with cost benefit analysis to DJB for review and recommendations.

Investigative methods to be employed by the Contractor shall include, but not be limited to,

collation and interpretation of historical data and complaints, corrosion surveys, pipe sampling results and leakage surveys. The criteria shall be subject to review and refinement as data is captured. Contractor shall utilize the data from SCADA System developed under the contract for analysis and reporting.

### 4.8 Preparation of detailed as-built network map

All the details of distribution system and house connections shall be captured and presented in GIS map or GIS compatible AutoCAD format as as-built drawings. The GIS maps shall be geo-referenced and contain all important attributes such as diameter, material type and installation year of pipe, valve, house service connection and appurtenances. If the drawings are prepared in AutoCAD they shall be prepared in such a way that it will allow transfer of attributes from AutoCAD to GIS format.

### 4.9 Preparation/ Update of Consumer database

GPS coordinates of each consumer meter, either new installation or replaced, shall be recorded and marked on a map. Location of any consumers that use large quantities of water in relation to the rest of the DMA (bulk consumer) or use high flow rates at specific times of the day or week shall be specifically identified and marked. Similarly, location of sensitive consumers and location of all public stand-posts shall also be recorded and marked. All pertinent data of newly added consumer or rectified illegal connections shall be updated on daily or weekly basis.

### 4.10 Preparation of DMA file and operation manual

Separate comprehensive files shall be prepared for each DMA to serve as a reference document and to assist future teams in managing NRW. The files will contain accurate details of all assets in the DMA and will have the record of historical development of the DMA, its features, results achieved, flows and leakage levels, trends, etc. The DMA files shall be up-dated regularly as work is undertaken in each DMA. The DMA files shall contain the information on the following:

- Boundary/limit of the DMA
- Location and detail of boundary valves
- Location and detail of DMA meters
- Location and operating schedule valves for step-testing
- Flow and pressure graphs
- Pressure monitoring points
- Leakage step tests data
- Leak locations
- Illegal connection locations
- Legitimate night flow (LNF) measurement data
- Night-Day correction factor data

Operation manual shall be prepared incorporating the above data and considering the operational sequences.

### 4.11 Providing new connections

The process of new connection shall be as laid out in the latest version of “Delhi Water &

Sewer (Tariff and Metering) Regulations, 2012". DJB shall receive the application for and complete the statutory process and intimate to the Contractor. The Contractor shall make the connection as per agreed specification and BOQ within the time frame defined under the Performance Guarantee. The Contractor shall be paid as per the agreed rates in the Contract.

### 4.12 Identification of unauthorized connections

The Contractor shall make all efforts to identify unauthorized connections within the project area. If the Contractor suspects any case of unauthorized connection it shall report the case to DJB in prescribed format with supporting documents and photographs to prove the case. DJB shall take necessary measures including confirmatory survey and site investigation and decide the case within 1 calendar month of the receipt of such request from the Contractor.

If the case is confirmed as 'authorized connection' but missing in DJB billing record, the consumer shall be added to the DJB's record and its consumption shall be calculated from 3 months prior to the date of report by the Contractor. Daily average consumption of the connection shall be derived from annual average of similar category of connections within the cluster. For the purpose of Contractor's performance payment, the calculated volume of consumption shall be added to the succeeding billing cycle.

If the case is confirmed as 'unauthorized connection' then DJB shall act as per the prevailing laws / rules to either regularize the connection or disconnect and take necessary legal actions. Its consumption shall be calculated from 6 months prior to the date of report by the Contractor. Daily average consumption of the connection shall be derived from the annual average of similar category of connections within the cluster. For the purpose of Contractor's performance payment, the calculated volume of consumption shall be added to the succeeding billing cycle. For each confirmed 'unauthorized case' the Contractor shall be paid an incentive as agreed under the provision of Performance Fees.

### 4.13 Training of DJB staff

The DJB staff will be trained sufficiently by Operator so that the board staff shall be capable of undertaking all the activities involved in planning and undertaking water loss reduction and control. The training shall be a mix of on-the-job and classroom training and shall cover, but not be limited to, the following topics:

- Overview of water loss reduction and control (including pressure management as a leakage control tool)
- Design of water supply system including network modelling
- District Meter Areas design
- Planning and conducting of PZTs
- Planning and implementation of reduction of water loss level.
- Data logging
- Use of leak detection equipment
  - Acoustic leak sounding techniques
  - Use of Leak noise loggers and other equipment
  - Leak correlation
  - Leak detection by gas tracer method etc.
- Step testing
- Water meters – DMA, bulk and revenue meters including testing and repair
- Leak repair techniques and materials

- Quality control
- Use of GIS including up-dation of new information
- Operation and maintenance of SCADA

For selected DJB staff directly involved in water loss activities, study visits to leading Indian water utilities or private water networks, as well as regional water utilities, where water loss reduction and control and distribution network rehabilitation has been successfully implemented may be included in the training programme. The Contractor shall develop a detailed Training Plan. This shall be reviewed and approved by the Engineer. Training Report shall be prepared in both hard and soft copies describing the training delivered.

## 4.14 Miscellaneous Works

### 4.14.1 Mutation

The process of mutation shall be as laid out in the latest version of "Delhi Water & Sewer (Tariff and Metering) Regulations, 2012". DJB shall receive the application for and complete the statutory process and intimate to the Contractor. The Contractor shall update the consumer record.

### 4.14.2 Disconnection

The process of disconnection shall be as laid out in the latest version of "Delhi Water & Sewer (Tariff and Metering) Regulations, 2012". DJB shall receive the application for and complete the statutory process and intimate to the Contractor. The Contractor shall disconnect and update the consumer record. The Contractor shall be paid as per the agreed rates in the Contract.

## 4.15 Reporting

The Contractor shall prepare and submit the reports including but not limited to the followings in relation to Water Loss and Control:

(a) DMA report – every two months after beginning of the Construction period. The content of the report shall be as described in 'Preparation of DMA file and operation manual' section above.
(b) Water loss report – every billing period (currently bi-monthly) after end of 24 months from the beginning of Contract period. The report to include current and target Water Loss levels, including a detailed action plan to achieve the target level.
(c) Key Performance Indicator report – every billing period (currently bi-monthly) starting from the 1st billing cycle of post-construction O&M period.

# SUB-SECTION 5. SCOPE OF UGR AND BPS CIVIL WORKS

The entire Civil works at BPS and UGR complex are to be executed on Design and Build basis by the Contractor based on the scope of works, technical specifications and drawings provided in the Bid documents.

The requirements including quantity, number, sizing, capacity etc. given below are indicative only. The Contractor is required to ascertain them based on the field conditions and hydraulic design and data provided.

## 5.1 General

The main components of works include the following:

- Construction and/or rehabilitation of Underground Reservoirs including associated works of Piping, Valves, Drains, Ladders/Stairs, Lightning Arrester, Landscaping etc.
- Construction and/or rehabilitation of Pump Houses adequate to house the number pumps designed and installed including spaces and provisions for EOT, Electrical Panels, Piping works etc.
- Ancillary houses/structures for housing Generator, Electrical panels, Transformers, Solar Systems, Instruments for SCADA etc.
- Roads, Drains, Street Lightings, Landscaping, Gates, etc.

The works covers for the construction and/or rehabilitation of pumping stations and underground reservoirs as per Table Below.

| Sl. No | PS/UGR Site | Pumping Station (PS) | | Under Ground Reservoir (UGR) | | Remarks |
|---|---|---|---|---|---|---|
| | | New | Rehab | New | Rehab. | |
| 1 | Shastri Nagar | | √ | | √ | |
| 2 | Shadipur | √ | | √ | | |
| 3 | Janta Park | | √ | | √ | |
| 4 | Narayana | √ | | √ | | |
| 5 | New Rajinder Nagar | √ | | √ | | |
| 6 | Rock Garden | | | | √ | |
| 7 | Than Singh | | √ | | √ | |
| 8 | Zakhira | √ | | √ | | |

## 5.2 Detailed Scope of Works

Detailed scope of work for each underground reservoir & pumping station shall be as follows:

### 5.2.1 Shastri Nagar UGR & BPS

Rehabilitation of existing UGR at Shastri Nagar is proposed to enhance the life span of structure.

To confirm the exact condition of existing structure, non-destructive testing shall be carried out and accordingly proposal for remedial measures shall be prepared. Existing UGR consists of two compartments. One of the compartment has to be rehabilitated by continuing existing water supply with the other compartment as per the methodology given in specification and elsewhere in the document. Current level of supply including the tanker supply shall be maintained.

Under rehabilitation work, corroded reinforcement in the reservoir (UGR), shall be replaced/rectified with epoxy primer or epoxy mortar as required. Guniting/shotcrete of minimum 75mm thickness shall be provided over the walls and roof slab of reservoir. Food grade epoxy paints shall be used on inside face of walls/roof slab after completion of rehabilitation work. Screed with necessary slope shall be provided on base of reservoir.

Ventilators provided over the roof of the reservoir shall be inspected and rehabilitated since some of them are in deteriorated condition. Waterproofing needs to be provided over roof slab of reservoir. Once completing & commissioning of rehabilitation of one compartment is over & water supply commences from this compartment, rehabilitation of the other compartment shall be started.

Rehabilitation of pumping station (BPS) is also proposed. This includes grouting in common wall of pumping station & UGR. Water proofing of roof slab of pumping station is also proposed. The scope covers dismantling of existing pump's foundation with the construction of new foundation. Painting on the internal & external surface of pumping station shall also be done. Minor rehabilitation work like replacement of doors, windows, repair of flooring shall also be done.

Reference drawing: P-225-223-L-UGR-SHN-001

Associated works of road, drainage, landscaping, street lighting etc. at the UGR complex shall also be included in the scope of works.

### 5.2.2 Naraina UGR & BPS

The existing Naraina UGR is at structurally unstable & vulnerable state and with severe leaks. Hence it is proposed to construct a new UGR as per the specification and approved methodology given in the documents. Capacity of the UGR shall be as per the table given in this section. Existing UGR consists of a single compartment and it is proposed to construct a small tank adjoining to existing UGR so as to continue existing water supply during the period of construction. Once small tank is constructed, existing inlet/outlet pipes shall be connected with this tank to continue the water supply (details as per E&M section). This small tank shall be constructed in such a manner that it becomes a part of new reservoir on its completion. Required number of ventilators needs to be provided over roof of reservoir. Proper approach shall be provided inside and top of the reservoir.

Once existing supply is restored from this new UGR, External & internal walls, columns and roof of existing reservoir have to be demolished/ dismantled. As a basic O&M need two compartments shall be constructed for the proposed UGR. Size of sump shall be as per the O&M requirement for maintaining the water supply. Floor of the existing reservoir can be used as base for new construction where ever possible & 100 mm thick PCC shall be laid

and footing shall be casted over this. Circular columns are proposed inside the reservoir to support the flat slab. Water proofing shall be provided over the roof of proposed UGR. Required number of ventilators needs to be provided over roof of reservoir. Proper approach shall be provided inside and top of the reservoir.

A new Pumping station is proposed along with this new UGR. Minimum size of Pumping Station is indicated in arrangement drawing which is based on the E&M requirements.

Reference drawing: P-225-223-L-UGR-NAR-001

Associated works of road, drainage, landscaping, street lighting etc. at the UGR complex shall also be included in the scope of works.

### 5.2.3 Shadipur UGR & BPS and Rock Garden UGR

This existing UGR consists of two compartments. Out of them, one compartment is bigger than other. (Pl refer GA drawings under E&M section). Smaller compartment of UGR shall be constructed first and for continuous maintenance of water supply bigger compartment shall be kept under service.

Two external walls of small compartment shall be dismantled and two other existing walls can be used as formwork for construction part of new walls where ever possible. Internal walls and roof slab shall also be dismantled. 100 thick PCC Shall be provided over the base slab where ever possible. New RCC walls with foundation and floor on ground shall be constructed as per the design requirements. (This compartment will be later converted as Rock Garden – 'gravity supply' UGR). Once smaller part of reservoir is completed & water supply is commissioned from this, other portion will also be constructed as per approved Design & Construction Methodologies.

New pumping station with a sump shall be constructed as per the design requirement. It shall be noted that the existing Rock Garden UGR will be converted as the Shadipur UGR in order to fulfil the water requirement of the part of Shadipur Command area.

The bigger compartment of existing Shadipur UGR will be constructed as a new UGR and converted as a gravity supply facility for Shadipur command area. (Since the existing Shadipur & Rock Garden UGRs are at the same premises but at different elevations; such switching over is suggested to optimally use the ground topography for both command areas of Shadipur & Rock Garden). Finally, Shadipur will have two UGRs dedicated with separate supply provisions by pumping and by gravity as per the hydraulic requirement.

Floor of the existing reservoir can be used as base for new construction where ever possible & 100 mm thick PCC shall be laid and footing shall be casted over this. Existing walls can be used as formwork for construction part of new walls where ever possible. Circular columns are proposed inside the reservoir to support the flat slab. Water proofing shall be provided over the roof of proposed UGR. Required number of ventilators needs to be provided over roof of reservoir. Proper approach shall be provided inside and top of the reservoir.

The condition of existing reservoir of Rock Garden is good with a better appearance. However non Destructive testing shall be carried out on the structure to confirm the exact condition and required remedial measures shall be taken to enhance the life of this structure. This UGR shall be connected to sump provided in new pumping station. After

improvements in this UGR it will be dedicated as the UGR for Shadipur pumping portion of the command area.

Reference drawing: P-225-223-L-UGR-SP-001

Associated works of road, drainage, landscaping, street lighting etc. at the UGR complex shall also be included in the scope of works.

### 5.2.4 Janta Park UGR & BPS

The condition of existing reservoir is good with a better appearance. However non Destructive testing shall be carried out on the structure to confirm the exact condition and required remedial measures shall be taken to enhance the life of this structure.

Existing UGR consists of two compartments. One of the compartment has to be rehabilitated by continuing existing water supply with the other compartment as per the methodology given in specification and elsewhere in the document. This UGR shall be rehabilitated as per the specification and methodology given in these documents. It is required to carry out the hydraulic test of this UGR. If any leakage is found in the wall/slab of the reservoir then same shall be rectified with grouting. Wherever reinforcement is corroded in the reservoir, same needs to be repaired with epoxy mortar. Food grade epoxy paints shall be provided over the walls/Roof slab inside face of UGR after completing of rehabilitation work.

Rehabilitation of pumping station (BPS) is also proposed. This includes grouting in common wall of pumping station & UGR. Water proofing of roof slab of pumping station is also proposed. The scope covers dismantling of existing pump's foundation with the construction of new foundation. Painting on the internal & external surface of pumping station shall also be done. Minor rehabilitation work like replacement of doors, windows, repair of flooring shall also be done.

Reference drawing: P-225-223-L-UGR-JP-001

Associated works of road, drainage, landscaping, street lighting etc. at the UGR complex shall also be included in the scope of works.

### 5.2.5 New Rajinder Nagar UGR & BPS

The existing New Rajendra Nagar UGR is at structurally unstable & vulnerable state. Hence it is proposed to construct a new UGR as per the specification and approved methodology given in the documents. Capacity of the UGR shall be as per the table given in this section.

Existing UGR consists of two compartments. One of the compartment has to be constructed by continuing existing water supply with the other compartment as per the methodology given in specification and elsewhere in the document. Ventilators in required number needs to be provided over roof of reservoir. Proper approach shall be provided inside and top of the reservoir.

Similarly the existing pump house is also in a bad state and a new Pumping Station is proposed. Minimum size of Pumping Station is indicated in arrangement drawing which is based on the E&M requirements.
Reference drawing: P-225-223-L-UGR-NRN-001

Associated works of road, drainage, landscaping, street lighting etc. at the UGR complex shall also be included in the scope of works.

### 5.2.6 Zakhira UGR & BPS

The existing Zakira UGR is in defunct state and is being used as a garbage dumping yard by the surrounding community.

New UGR & BPS is proposed at Zakhira within the DJB premises. New UGR is proposed as per the specification and approved methodology given in the documents. Capacity of the UGR shall be as per the table given in this section. 100 mm thick PCC shall be provided and footing/base slab of the proposed structure shall be casted over PCC. Circular RCC column with RCC flat slab shall be provided inside the reservoir.

Water proofing shall be provided over the roof of proposed UGR. Required number of ventilators needs to be provided over roof of reservoir. Proper approach shall be provided inside and top of the reservoir.

Size of pumping station shall be as per electrical & mechanical requirement. Minimum size of Pumping Station is indicated in arrangement drawing which is based on the E&M requirements.

Reference drawing: P-225-223-L-UGR-ZH-001

Associated works of road, drainage, landscaping, street lighting etc. at the UGR complex shall also be included in the scope of works.

### 5.2.7 Than singh UGR & BPS

Existing UGR consist of single compartment and hence to rehabilitate this UGR, a small tank of required capacity (As per hydraulic requirement) shall be constructed. Once this tank is constructed and water supply is restored with that sump, the rehabilitation of existing UGR shall be started. Rehabilitation of existing UGR is proposed so as to enhance the life of structure.

Non Destructive testing shall be carried out on the structure to know the exact condition of existing structure and accordingly remedial measures shall be taken. Existing UGR consist of single compartment. It is proposed to provide partition wall inside the reservoir to make two equal compartments. Proposed rehabilitation works includes replacement of reinforcement with epoxy mortar, shotcrete/guniting over the walls and slab of structure and epoxy paint over the walls and roof slab of structure. Ventilators are proposed over the roof of structure along with proper approach to both the compartments and floor slab of UGR. Water proofing is proposed over the roof of structure.

It shall be noted that the Thansingh UGR & BPS will be hydraulically required as a transit basin to feed the UGRS, namely Naraina, Shadipur, Rock Garden, Janta Park & New Rajinder Nagar. It will not have its own command area. As such it will be necessary to transfer the existing service provision from this UGR to Jhandewalan & Zakira as per the hydraulic design requirement, before commissioning of the new system.

Reference drawing: P-225-223-L-UGR-TSN-001

Associated works of road, drainage, landscaping, street lighting etc. at the UGR complex shall also be included in the scope of works.

## Proposed size & capacity of UGRs

| Sl. No. | Proposed UGR | UGR Size (m) | | | | Proposed Minimum Water Level (MWL) (Mandatory) | Top Water Level (TWL) | Minimum Effective Capacity (ML) |
|---|---|---|---|---|---|---|---|---|
| | | Compartment 1 | | Compartment 2 | | | | |
| | | L | B | L | B | | | |
| 1 | Zakhira | 36 | 25 | 36 | 25 | 225.50 | 228.70 | 5.60 |
| 2 | Shadipur (Gravity) | 38 | 43 | | | 245.20 | 249.40 | 6.8 |
| 3 | Rock Garden (Gravity) | 38 | 35 | | | 245.20 | 249.40 | 5.5 |
| 4 | New Rajendra Nagar | 34 | 18.8 | 34 | 18.8 | 246.26 | 250.16 | 4.90 |
| 5 | Narayana | 43 | 26 | 43 | 26 | 237.40 | 241.90 | 9.95 |
| 6 | Than Singh Nagar (Extension) | 17 | 5.5 | | | 220.50 | 225.50 | 0.45 |

# SUB-SECTION 6. SCOPE OF ELECTRICAL WORKS

The entire Electrical works at Booster Pumping Station and UGR complex are to be executed on Design and Build basis by the Contractor based on the scope of works, technical specifications, P&I and other drawings provided in the Bid documents. The quantity, number, sizing, capacity of the goods and equipment/instrumentation required are given below which are indicative only. The Contractor is required to ascertain them based on the field conditions and hydraulic design and data provided.

## 6.1 General

These Scope of works shall include for the electrical works for Pumping Stations.

The Contract shall include the Supply, Installation, Testing and Commissioning of Electrical Equipment required for successful operation of plant including but not limited to:-

- High voltage switchboards;
- Compact Sub Station;
- Dry Type transformers;
- Low voltage switchboards and motor control centers, motor starters;
- Variable Frequency Drive
- Battery and Battery Charger
- Reactor power compensation equipment;
- Power and control cabling;
- Earthing and lightning protection.
- Solar Panel generation and its proper utilization.
- Lighting system.
- Ventilation System

The electrical equipment shall be supplied and installed as per standards and the following clauses herein. Where the drawings, standard specification and the particular specification differ, the latter shall take precedence.

## 6.2 Estimated Power Requirements

(a) The Tenderer shall submit estimated installed and running loads for each load centre.

(b) The Contractor shall update the preliminary load schedule, finalize plant ratings and submit all calculations and drawings to the DJB for approval. If DJB requires any further details during detail engineering, the Contractor shall provide the same.

## 6.3 Liaison with NDPL/BSES

The Contractor shall be responsible for:

(a) Confirming short-circuit and earth fault current data.
(b) Establishing any special NDPL/BSES requirements.
(c) Responsibility of co-ordination with NDPL/BSES.
(d) Liaison with the NDPL/BSES shall be via the DJB.

### 6.4 Clearance from Statutory Authorities

The Contractor shall be responsible for obtaining statutory clearances from all the relevant bodies (such as electrical inspector, factory inspector explosive authorities etc.). Payment in respect of fees, deposit, etc., of such bodies is required to be made by contractor; supporting documents, if any required, shall be given by DJB.

### 6.5 Details of Work

Proposed scope of work is covered in the respective single line diagrams enclosed with these documents and is also being briefed here under.

#### 6.5.1 Shastri Nagar Pumping Station

The DJB will provide 11 KV, 50 Hz, 3 phase electrical power up to electrical meter within the premises through two incomers through two different sources, however Contractor has to do the liasining for the same with electricity department. Bidder has to feed 11 KV supply from metering unit to 11 KV indoor switch board (2 I/C, 1 B/C and 2 O/G) through HT, XLPE cable. From 11 KV HT panel, 11 KV supply will be fed to 11 / 0.433 KV, indoor cast resin dry type transformer for step down the voltage. From transformer to Main LT panel, 415 V supply will be fed through Bus duct. Main LT Panel will also be connected with Solar System and DG set through bus coupler and required interlocking between all incomers. From Main LT panel supply will be fed to Motors, lighting system, battery charger, dewatering pump, actuators, and auxiliary load of pumping station. Following are the items which Bidder has to supply install, testing and commissioning.

Refer SLD: P-225-224-E-SLD-SHN-001.

(a) 11 KV indoor HT, VCB switchgear panel having 2 incomers, 1 bus-coupler and 2 outgoing feeders as per specification and SLD.
(b) 11 / 0.433 KV, Cast Resin Dry Type transformer with OLTC tap changer and all required accessories as per specification. (Transformer shall be supplied with 100 % redundancy).
(c) DG Set with AMF Panel.
(d) Solar system complete for feeding supply to system load and for supply to Grid as per specification.
(e) 415 V LT switchgear panel for feeding supply to motors, valve DB, lighting DB, exhaust fan DB, battery and battery charger, dewatering Pump, PLC/SCADA System, Chlorination System, Welding Socket, other auxiliary load of pumping stations.
(f) Variable Frequency Drive as per motors rating and specification.
(g) HT and LT XLPE cable, control cable, NPSBD, cable tray, angle support, lugs, gland, termination, cable marking as per specification.
(h) Indoor and Outdoor, energy efficient lighting (LED fittings), lighting poles, cable, wiring, conduit, lighting DB, switchboard, switches and sockets, fans, exhaust fans, AC, as per specification.
(i) Earthing and Lightning Protection System as per specification.
(j) Battery and Battery Charger (Float cum Boost Charger)
(k) Safety Kit and tools, Spare Items, Safety Chart, Sand Bucket, Rubber Mat and Gloves, Spares etc.
(l) Dismantling and deposit to DJB existing Transformer, HT panels, Starters, LT Panels, Changeover switches, APFC panels, cables, earthing etc.

(m) Miscellaneous items which are not mentioned above but required for commissioning of complete plant.

### 6.5.2 Zakhira Pumping Station

The DJB will provide 11 KV, 50 Hz, 3 phase electrical power up to electrical meter within the premises through two incomers from two different sources, however Contractor has to do the liasining for the same with electricity department. Bidder has to feed 11 KV supply from metering unit to 11 KV Compact Substation (comprise of VCB breaker, transformer and LT MCCB) through HT, XLPE cable. From compact sub stations, after step down the voltage, power will be fed to main LT panel. Main LT Panel will also be connected with Solar System and DG set through bus coupler and required interlocking between all incomers. From Main LT panel supply will be fed to Motors, lighting system, dewatering pump, actuators, and auxiliary load of pumping station. Following are the items which Bidder has to supply install, testing and commissioning.

Refer SLD: P-225-224-E-SLD-ZH-001.

(a) 11 KV Compact Substation having RMU (VCB), dry type transformer and MCCB breaker as per specification and SLD.
(b) DG Set with AMF Panel.
(c) Solar system complete for feeding supply to system load and for supply to Grid as per specification.
(d) Main 415 V LT switchgear panel for feeding supply to motors, valve DB, lighting DB, exhaust fan DB, dewatering Pump, PLC / SCADA, welding socket, other auxiliary load of pumping stations.
(e) Variable Frequency Drive as per motors rating and specification shall be installed in LT panel.
(f) HT and LT XLPE cable, Control Cable, cable tray and angle support, lugs, gland, termination, marking as per specification.
(g) Indoor and Outdoor, energy efficient lighting (LED fittings), lighting poles, cable, wiring, conduiting, lighting DB, switchboard, switches and sockets, fans, exhaust fans, AC, as per specification.
(h) Earthing and Lightning protection system as per specification.
(i) Safety Kit and tools, Spare Items, Safety Chart, Sand Bucket, Rubber Mat and Gloves, Spares etc.
(j) Miscellaneous items which are not mentioned above but required for commissioning of complete plant.

### 6.5.3 Than Singh Pumping Station

The DJB will provide 11 KV, 50 Hz, 3 phase electrical power up to electrical meter within the premises through two incomers through two different sources, however Contractor has to do the liaising for the same with electricity department. Bidder has to feed 11 KV supply from metering unit to 11 KV indoor switch board (2 I/C, 1 B/C and 2 O/G) through HT, XLPE cable. From 11 KV HT panel, 11 KV supply will be fed to 11 / 0.433 KV, indoor cast resin dry type transformer for step down the voltage. From transformer to Main LT panel, 415 V supply will be fed through Bus duct. Main LT Panel will also be connected with Solar System and DG set through bus coupler and required interlocking between all incomers. From Main LT panel supply will be fed to Motors, lighting system, battery charger, dewatering pump, actuators, and auxiliary load of pumping station. Following are the items which Bidder has to

supply install, testing and commissioning.

Refer SLD: P-225-224-E-SLD-TSN-001.

(a) 11 KV indoor HT, VCB switchgear panel having 2 incomers, 1 bus-coupler and 2 outgoing feeders as per specification and SLD.
(b) 11 / 0.433 KV, Cast Resin Dry Type transformer with OLTC tap changer and all required accessories as per specification. (Transformer shall be supplied with 100 % redundancy).
(c) DG Set with AMF Panel.
(d) Solar system complete for feeding supply to system load and for supply to Grid as per specification.
(e) 415 V LT switchgear panel for feeding supply to motors through Soft Starters, valve DB, lighting DB, exhaust fan DB, battery and battery charger, dewatering Pump, PLC / SCADA System, Chlorination System, Welding Socket, other auxiliary load of pumping stations.
(f) HT and LT XLPE cable, control cable, NPSBD, cable tray, angle support, lugs, gland, termination, cable marking as per specification.
(g) Indoor and Outdoor, energy efficient lighting (LED fittings), lighting poles, cable, wiring, conduit, lighting DB, switchboard, switches and sockets, fans, exhaust fans, AC, as per specification.
(h) Earthing and Lightning Protection System as per specification.
(i) Battery and Battery Charger (Float cum Boost Charger)
(j) Safety Kit and tools, Spare Items, Safety Chart, Sand Bucket, Rubber Mat and Gloves, Spares etc.
(k) Dismantling and deposit to DJB existing Transformer, HT panels, Starters, LT Panels, Changeover switches, APFC panels, cables, earthing etc.
(l) Miscellaneous items which are not mentioned above but required for commissioning of complete plant.

### 6.5.4 Shadipur Pumping Station

The DJB will provide 11 KV, 50 Hz, 3 phase electrical power up to electrical meter within the premises through two incomers from two different sources, however Contractor has to do the liaising for the same with electricity department. Bidder has to feed 11 KV supply from metering unit to 11 KV Compact Substation (comprise of VCB breaker, transformer and LT MCCB) through HT, XLPE cable. From compact sub stations, after step down the voltage, power will be fed to main LT panel. Main LT Panel will also be connected with Solar System and DG set through bus coupler and required interlocking between all incomers. From Main LT panel supply will be fed to Motors, lighting system, dewatering pump, actuators, and auxiliary load of pumping station. Following are the items which Bidder has to supply install, testing and commissioning.

Refer SLD: P-225-224-E-SLD-SP-001.

(a) 11 KV Compact Substation having RMU (VCB), dry type transformer and MCCB breaker as per specification and SLD.
(b) DG Set with AMF Panel.
(c) Solar system complete for feeding supply to system load and for supply to Grid as per specification.

(d) Main 415 V LT switchgear panel for feeding supply to motors, valve DB, lighting DB, exhaust fan DB, dewatering Pump, PLC / SCADA, welding socket, other auxiliary load of pumping stations.
(e) Variable Frequency Drive as per motors rating and specification shall be installed in LT panel.
(f) HT and LT XLPE cable, Control Cable, cable tray and angle support, lugs, gland, termination, marking as per specification.
(g) Indoor and Outdoor, energy efficient lighting (LED fittings), lighting poles, cable, wiring, conduiting, lighting DB, switchboard, switches and sockets, fans, exhaust fans, AC, as per specification.
(h) Earthing and Lightning protection system as per specification.
(i) Safety Kit and tools, Spare Items, Safety Chart, Sand Bucket, Rubber Mat and Gloves, Spares etc.
(j) Miscellaneous items which are not mentioned above but required for commissioning of complete plant.

### 6.5.5 Janta Park Pumping Station

The DJB will provide 11 KV, 50 Hz, 3 phase electrical power up to electrical meter within the premises through two incomers from two different sources, however Contractor has to do the liaising for the same with electricity department. Bidder has to feed 11 KV supply from metering unit to 11 KV Compact Substation (comprise of VCB breaker, transformer and LT MCCB) through HT, XLPE cable. From compact sub stations, after step down the voltage, power will be fed to main LT panel. Main LT Panel will also be connected with Solar System and DG set through bus coupler and required interlocking between all incomers. From Main LT panel supply will be fed to Motors, lighting system, dewatering pump, actuators, and auxiliary load of pumping station. Following are the items which Bidder has to supply install, testing and commissioning.

Refer SLD: P-225-224-E-SLD-JP-001.

(a) 11 KV Compact Substation having RMU (VCB), dry type transformer and MCCB breaker as per specification and SLD.
(b) DG Set with AMF Panel.
(c) Solar system complete for feeding supply to system load and for supply to Grid as per specification.
(d) Main 415 V LT switchgear panel for feeding supply to motors, valve DB, lighting DB, exhaust fan DB, dewatering Pump, PLC / SCADA, welding socket, other auxiliary load of pumping stations.
(e) Variable Frequency Drive as per motors rating and specification shall be installed in LT panel.
(f) HT and LT XLPE cable, Control Cable, cable tray and angle support, lugs, gland, termination, marking as per specification.
(g) Indoor and Outdoor, energy efficient lighting (LED fittings), lighting poles, cable, wiring, conduiting, lighting DB, switchboard, switches and sockets, fans, exhaust fans, AC, as per specification.
(h) Earthing and Lightning protection system as per specification.
(i) Safety Kit and tools, Spare Items, Safety Chart, Sand Bucket, Rubber Mat and Gloves, Spares etc.
(j) Dismantling and deposit to DJB existing electrical equipments.

(k) Miscellaneous items which are not mentioned above but required for commissioning of complete plant.

### 6.5.6 New Rajendra Nagar Pumping Station

The DJB will provide 11 KV, 50 Hz, 3 phase electrical power up to electrical meter within the premises through two incomers from two different sources, however Contractor has to do the liaising for the same with electricity department. Bidder has to feed 11 KV supply from metering unit to 11 KV Compact Substation (comprise of VCB breaker, transformer and LT MCCB) through HT, XLPE cable. From compact sub stations, after step down the voltage, power will be fed to main LT panel. Main LT Panel will also be connected with Solar System and DG set through bus coupler and required interlocking between all incomers. From Main LT panel supply will be fed to Motors, lighting system, dewatering pump, actuators, and auxiliary load of pumping station. Following are the items which Bidder has to supply install, testing and commissioning.

Refer SLD: P-225-224-E-SLD-NRN-001.

(a) 11 KV Compact Substation having RMU (VCB), dry type transformer and MCCB breaker as per specification and SLD.
(b) DG Set with AMF Panel.
(c) Solar system complete for feeding supply to system load and for supply to Grid as per specification.
(d) Main 415 V LT switchgear panel for feeding supply to motors, valve DB, lighting DB, exhaust fan DB, dewatering Pump, PLC / SCADA, welding socket, other auxiliary load of pumping stations.
(e) Variable Frequency Drive as per motors rating and specification shall be installed in LT panel.
(f) HT and LT XLPE cable, Control Cable, cable tray and angle support, lugs, gland, termination, marking as per specification.
(g) Indoor and Outdoor, energy efficient lighting (LED fittings), lighting poles, cable, wiring, conduiting, lighting DB, switchboard, switches and sockets, fans, exhaust fans, AC, as per specification.
(h) Earthing and Lightning protection system as per specification.
(i) Safety Kit and tools, Spare Items, Safety Chart, Sand Bucket, Rubber Mat and Gloves, Spares etc.
(j) Dismantling and deposit to DJB existing electrical equipments.
(k) Miscellaneous items which are not mentioned above but required for commissioning of complete plant.

### 6.5.7 Naraina Pumping Stations

The DJB will provide 11 KV, 50 Hz, 3 phase electrical power up to electrical meter within the premises through two incomers from two different sources, however Contractor has to do the liaising for the same with electricity department. Bidder has to feed 11 KV supply from metering unit to 11 KV Compact Substation (comprise of VCB breaker, transformer and LT MCCB) through HT, XLPE cable. From compact sub stations, after step down the voltage, power will be fed to main LT panel. Main LT Panel will also be connected with Solar System and DG set through bus coupler and required interlocking between all incomers. From Main LT panel supply will be fed to Motors, lighting system, dewatering pump, actuators, and auxiliary load of pumping station. Following are the items which Bidder has to supply install,

testing and commissioning.

Refer SLD: P-225-224-E-SLD-NAR-001.

(a) 11 KV Compact Substation having RMU (VCB), dry type transformer and MCCB breaker as per specification and SLD.
(b) DG Set with AMF Panel.
(c) Solar system complete for feeding supply to system load and for supply to Grid as per specification.
(d) Main 415 V LT switchgear panel for feeding supply to motors, valve DB, lighting DB, exhaust fan DB, dewatering Pump, PLC / SCADA, welding socket, other auxiliary load of pumping stations.
(e) Variable Frequency Drive as per motors rating and specification shall be installed in LT panel.
(f) HT and LT XLPE cable, Control Cable, cable tray and angle support, lugs, gland, termination, marking as per specification.
(g) Indoor and Outdoor, energy efficient lighting (LED fittings), lighting poles, cable, wiring, conduiting, lighting DB, switchboard, switches and sockets, fans, exhaust fans, AC, as per specification.
(h) Earthing and Lightning protection system as per specification.
(i) Safety Kit and tools, Spare Items, Safety Chart, Sand Bucket, Rubber Mat and Gloves, Spares etc.
(j) Dismantling and deposit to DJB existing electrical equipments.
(k) Miscellaneous items which are not mentioned above but required for commissioning of complete plant.

# SUB-SECTION 7. SCOPE OF MECHANICAL WORKS

The entire Mechanical works of Booster Pumping Stations and UGR complex including Supply and Installation of Pumps are to be executed on Design and Build basis by the Contractor based on the scope of works, technical specifications, P&I and other drawings provided in the Bid documents. The quantity, number, sizing, capacity of the goods and equipment/instrumentation required are given below which are indicative only. The Contractor is required to ascertain them based on the field conditions and hydraulic data provided.

## 7.1 Shastri Nagar Reservoir

Reference drawing:

Survey drawing no. IE/TEC/SN/DW/B1

| **Data on Existing Components** | |
|---|---|
| Storage capacity | 21.79 ML |
| Land area available | 11659.48 $m^2$ |
| Built-up area | 5121.36 $m^2$ |
| No. of compartments | 2 Nos. (An inlet sump is provided within the reservoir compartments). |
| I.L. of UGR (m) | 211.323 |
| T.L. of slab (m) | 215.847 |
| Dimensions of each compartment (m x m) | 93.65 x 55.00 |
| Details of existing incoming pipes (mm) | |
| Pipe 1 | 750 dia |
| Pipe 2 | 750 dia |
| Details of existing outgoing pipes (mm) | |
| Pipe 1 | 1000 dia |
| Pipe 2 | 700 dia |
| **Details of existing Pumping Units** | |
| Pump – 1 | 41 mld @ 35.5 mwc (225kW) |
| Pump – 2 | 41 mld @ 35.5 mwc (225kW) |
| Pump – 3 | 41 mld @ 35.5 mwc (225kW) |
| Pump – 4 | 41 mld @ 35.5 mwc (225kW) |

| Sl. No. | Valve Size (mm) | Qty. and Location |
|---|---|---|
| 1 | 600 | 14 Nos. (7 Nos. at Suction side of Pumps, 7 Nos. at discharge side of Pumps) |
| 2 | 700 | 1 No. (outlet to Delhi Prasaran Metro) |
| 3 | 750 | 3 Nos. (Inlet of UGR) |
| 4 | 1000 | 3 Nos. (at Pumps header main) |

*Proposed Project Bid Purpose drawings:*

- Layout drawing no. P-225-223-L-UGR-SHN-001
- Process and Instrumentation Diagram no. P-225-212-P-UGR-SHN-001

*Proposed Recommendations:*

- UGR command area 'water demand' is planned from Shastri Nagar reservoir of capacity 41.33 MLD.
- Inlet to the reservoir will be replaced by new pipe lines, valves and associated fittings.
- For valve replacement, temporary bypass arrangement shall be proposed.
- A flow control valve is proposed at the inlet of the UGR.
- Proposed arrangement will have electromagnetic flow meters at the inlet and outlet.
- Portable Dewatering pumps for annual cleaning of reservoirs and chambers should be provided.
- Depending on the flow and head finalized the augmentation requirements are proposed. However, the space available for 3 additional pumps will be utilized for Set -1 of the new pumps.
- Sequential/progressive replacement of existing pumps with Set -2 of new pumps needs to be considered without disturbing the current operation.
- Since the proposed system will be 24x7 potable water supply scenario, it will be required to install VFD driven pumps to take care of lean flows for both sets of pumps.
- The delivery side arrangement inside the Pump house needs modification to have flexibility in operation and ease of maintenance.
- Once the new proposed system is commissioned, all the existing arrangement including pipes, valves and fittings etc. shall be dismantled and new UGR shall be connected to the Transmission & Distribution networks as per the design details. Until the commissioning of the new UGR, bypass arrangement shall be made to maintain the supply from existing units or as appropriate.
- The pumping station shall be fully equipped with all necessary and required mechanical items as following:
  a. Electrically operated handling system
  b. Firefighting equipment
  c. Dewatering and Drain Pumps
  d. Ventilation system
  e. Vacuum pump
- Any other item required shall be taken care by the contractor and no extra payment shall be made.

**Proposed Components for Shastri Nagar Command Area**

| Year | Projected Demand (MLD) | |
|---|---|---|
| 2021 | 32.74 | |
| 2036 | 36.71 | |
| 2051 | 41.33 | |
| Details of proposed pump sets (tentative) | Duty point condition | Qty. (W + S) |

| | | |
|---|---|---|
| Set – 1 | 2150 $m^3$/hr @ 37 mwc | 2W + 1S |
| Set – 2 | 520 $m^3$/hr @ 44 mwc | 1W + 1S |
| Details of proposed incoming pipes | 600 mm | |
| Details of proposed outgoing pipes | 1000 mm | |

- Refer attached proposed GA drawing for more details.
- Refer tentative Bill of quantities (for approximate pipes & fittings quantities).

## 7.2 Zakhira Reservoir

Reference drawing:

Survey drawing no. IE/TEC/ZH/DW/UGR

| Data on Existing Components | |
|---|---|
| Land area available | 16224.85 $m^2$ |
| Built-up area | 2745.99 $m^2$ |
| No. of compartments | 1 |
| T.L. of slab (m) | 238.39 |
| Dimensions of each compartment (m x m ) | 38.99 x 70.41 |

*Proposed Project Bid Purpose drawings:*

- Layout drawing no. P-225-223-L-UGR-ZH-001
- Process and Instrumentation Diagram no. P-225-212-P-UGR-ZH-001

*Proposed Recommendations:*

- UGR command area 'water demand' is planned from Zakhira reservoir of capacity 16.63MLD.
- A new UGR with a new Pump house catering to the Zakhira DMA is proposed.
- A flow control valve is proposed at the inlet of the UGR.
- Proposed arrangement will have electromagnetic flow meters at the inlet and outlet.
- Portable Dewatering pumps for annual cleaning of reservoirs and chambers should be provided.
- Since the proposed system will be 24x7 potable water supply scenario, it will be required to install VFD driven pumps to take care of lean flows for both sets of pumps.
- The pumping station shall be fully equipped with all necessary and required mechanical items as following:
  a. Electrically operated handling system
  b. Firefighting equipment
  c. Dewatering and Drain Pumps
  d. Ventilation system
- Any other item required shall be taken care by the contractor and no extra cost shall be considered.

**Proposed Components for Zakhira Command Area**

| Year | Projected Demand (MLD) | |
|---|---|---|
| 2021 | 13.18 | |
| 2036 | 14.78 | |
| 2051 | 16.63 | |
| Details of proposed pump sets (tentative) | Duty point condition | Qty (W + S) |
| Set – 1 | 500 $m^3$/hr @ 45 mwc | 2W + 1S |
| Set – 2 | 100 $m^3$/hr @ 53 mwc | 1W + 1S |
| Set – 3 | 400 $m^3$/hr @ 30 mwc | 2W + 1S |
| Set – 4 | 100 $m^3$/hr @ 36 mwc | 1W + 1S |
| Details of proposed incoming pipes | 1000 mm | |
| Details of proposed outgoing pipes | 2 pipes of 400 mm dia. Each & 1 pipe of 500 mm dia. | |

- Refer attached proposed GA drawing for more details and as a guide for further improvements

Refer tentative Bill of Quantities as per the preliminary design features.

### 7.3 Than Singh Nagar Reservoir

Reference drawing:

Survey drawing no. IE/TEC/TSN/DW/BPS

| Data on Existing Components | |
|---|---|
| Storage capacity | 0.45 ML |
| Year of construction / commissioning | 1984 |
| Land area available | 1265 $m^2$ |
| Built-up area | 475 $m^2$ |
| No. of compartments | 1 No. |
| I.L. of UGR (m) | 220.522 |
| Scour level (m) | 220.759 |
| Overflow level (m) | 225.607 |
| T.L. of slab (m) | 226.240 |
| Dimensions of each compartment (m x m) | 17.5 x 27.0 |
| Details of existing incoming pipes (mm) | |
| Pipe 1 | 200 dia |
| Pipe 2 | 300 dia |
| Details of existing outgoing pipes (mm) | |
| Pipe 1 | 200 dia (Pumped Main) |
| Pipe 2 | 300 dia (Pumped Main) |

| | |
|---|---|
| Pipe 3 | 450 dia (Pumped Main) |
| Details of existing Pumping Units | |
| Pump – 1 | 100 hp |
| Pump – 2 | 100 hp |
| Pump – 3 | 100 hp |
| Pump – 4 | 100 hp |
| Pump – 5 | 50 hp |
| Pump – 6 | 50 hp |

| Sl. No. | Valve Size (mm) | Qty. |
|---|---|---|
| 1 | 150 | 4 Nos. (2 Nos. SV and NRV each at Discharge of P5 & P6) |
| 2 | 200 | 3 Nos. (1 No. at inlet to UGR, 2 Nos. SV at Suction of P5 & P6) |
| 3 | 250 | 13 Nos. (1 No. Scour Valve, 4 Nos. SV each at Suction & Discharge of P1 to P4, 4 Nos. NRV at Discharge of P1 to P4) |
| 4 | 300 | 1 No. (inlet of UGR) |

*Proposed Project Bid Purpose drawings:*

- Layout drawing no. P-225-323-L-UGR-TSN-001
- Process and Instrumentation Diagram no. P-225-212-P-UGR-TSN-001

P*roposed Recommendations:*

- As per the transmission network design, Than Singh Nagar UGR is planned to work as balancing UGR for the following UGRs
  a. Janta Park
  b. Shadipur
  c. Rock garden
  d. New Rajendra Nagar
  e. Naraiana
- In order to meet the command area requirements, three new Pumps are proposed in place of the four existing 100 HP pumps for transmission to the above said UGRs.
- A flow control valve is proposed at the inlet of the UGR.
- The existing pumps shall be planned for replacement in such a way that the existing supply to the areas currently being catered to does not get disturbed. This replacement exercise shall be carried out one after another and also a new suction header shall be considered.
- For electrical requirements existing electrical rooms and facilities shall be utilized as feasible.
- Since the pumping system is going to boost for 5 UGRs, it is very important that it works smoothly. Hence it is recommended to go for 100% standby pumps. At any point of time, it is recommended to have 3 numbers of pumps installed (2W + 1S) and another pump with motor and accessories to be supplied and kept in store for ready installation.

- The pumping station shall be fully equipped with all necessary and required mechanical items as following:
  a. Electrically operated handling system
  b. Firefighting equipment
  c. Dewatering and Drain Pumps
  d. Ventilation system
  e. Vacuum Pump
- Any other item required shall be taken care by the contractor and no extra cost shall be considered.

**Proposed Components for Than Singh Nagar**

| Details of proposed pump sets (tentative) | Duty point condition | Qty. (W + S) |
|---|---|---|
| Set – 1 | 2100 $m^3$/hr @ 33 mwc | 2W + 1S |
| Details of proposed incoming pipes | 1000 mm dia | |
| Details of proposed outgoing pipes | 1000 mm dia | |

- Refer attached proposed GA drawing for details
- Refer tentative Bill of Quantities as per the preliminary design features

## 7.4 Janta Park Reservoir

Reference drawing:

Survey drawing no. IE/TEC/JP/DW/UGR

| Data on Existing Components | |
|---|---|
| Storage capacity | 3.5 ML |
| Land area available | 2776.74 $m^2$ |
| Built-up area | 844.07 $m^2$ |
| No. of compartments | 2 Nos. |
| I.L. of UGR (m) | 239.56 |
| Overflow level (m) | 245.217, 245.478 |
| T.L. of slab (m) | 246.21 |
| Dimensions of each compartment (m x m) | 14.40 x 44.07 |
| Details of existing incoming pipes (mm) | |
| Pipe 1 | 350 dia |
| Pipe 2 | 350 dia |
| Details of existing outgoing pipes | |
| Pipe 1 | 400 dia (main line) |
| Pipe 2 | 400 dia (main line) |
| Pipe 3 | 300 dia (main line) |
| Details of existing Pumping Units | |
| Pump – 1 | 723 $m^3$/hr @ 30 mwc (90 kW) |

| | |
|---|---|
| Pump – 2 | 723 $m^3$/hr @ 30 mwc (90 kW) |
| Pump – 3 | 723 $m^3$/hr @ 30 mwc (90 kW) |
| Pump – 4 | 531 $m^3$/hr @ 15 mwc (37 kW) |
| Pump – 5 | 531 $m^3$/hr @ 15 mwc (37 kW) |
| Pump – 6 | 531 $m^3$/hr @ 15 mwc (37 kW) |

| Sl. No. | Valve Size (mm) | Quantity and Location |
|---|---|---|
| 1 | 300 | 2 Nos. (Outlet to Punjabi Basti) |
| 2 | 350 | 8 Nos. (2 Nos. Suction Gate valve at inlet to reservoir, 3 Nos. at inlet pipe of Pump P1, P2 & P3, 3 Nos. at outlet pipe of Pump P1, P2 & P3) |
| 3 | 400 | 10 Nos. (3 Nos. at inlet pipe of Pump P4, P5 & P6, 3 Nos. at outlet pipe of Pump P4, P5 & P6, 1 No. at outlet to Hill Marg, 3 Nos. at outlet to road no. 20) |
| 4 | 500 | 2 Nos. (Gate valve at main inlet to reservoir) |
| 5 | 700 | 1 No. (Gate Valve at interconnecting pipe) |

*Proposed Project Bid Purpose drawings:*

- Layout drawing no. P-225-223-L-UGR-JP-001
- Process and Instrumentation Diagram no. P-225-212-P-UGR-JP-001

*Proposed Recommendations:*

- UGR command area 'water demand' is planned from Janta Park reservoir of capacity 10.51 MLD.
- Inlet to the reservoir will be replaced by new pipe lines, valves and associated fittings.
- For valve, replacement temporary bypass arrangement shall be proposed.
- A flow control valve is proposed at the inlet of the UGR.
- Proposed arrangement will have electromagnetic flow meters at the inlet and outlet.
- Portable Dewatering pumps for annual cleaning of reservoirs and chambers should be provided.
- Depending on the flow and head finalized the augmentation requirements are proposed.
- Sequential/progressive replacement of existing pumps with Set of new pumps, needs to be considered without disturbing the current operation.
- Since the proposed system will be 24x7 potable water supply scenario, it will be required to install VFD driven pumps to take care of lean flows for both sets of pumps.
- The delivery side arrangement inside the Pump house needs modification to have flexibility in operation and ease of maintenance.
- Once the proposed system is commissioned, all the existing arrangement including pipes, valves and fittings etc. shall be dismantled and new UGR shall be connected to the Transmission & Distribution networks as per the design details. Until the

commissioning of the new UGR, bypass arrangement shall be made to maintain the supply from existing units or as appropriate.

- The pumping station shall be fully equipped with all necessary and required mechanical items as following:
  a. Electrically operated handling system
  b. Firefighting equipment
  c. Dewatering and Drain Pumps
  d. Ventilation system
  e. Vacuum Pump
- Any other item required shall be taken care by the contractor and no extra payment shall be made.

**Proposed Components for Janta Park Command Area**

| Year | Projected Demand (MLD) | |
|---|---|---|
| 2021 | 7.73 | |
| 2036 | 9.34 | |
| 2051 | 10.51 | |
| Details of proposed pump sets (tentative) | Duty point condition | Qty. (W + S) |
| Set – 1 | 550 $m^3$/hr @ 31 mwc | 2W + 1S |
| Set – 2 | 140 $m^3$/hr @ 40 mwc | 1W + 1S |
| Details of proposed incoming pipes | 400 mm | |
| Details of proposed outgoing pipes | 500 mm | |

- Refer attached proposed GA drawing for details

Refer tentative Bill of Quantities as per the preliminary design features

## 7.5 Shadipur and Rock Garden Reservoir

Reference drawing:

Survey drawing no. IE/TEC/SP/DW/B2

| Data on Existing Components | | |
|---|---|---|
| | **Shadipur 1 & 2 (Two adjoining Reservoirs)** | **Rock Garden** |
| Storage capacity | 12.71 ML (Total) | 4.54 ML |
| Land area available | 17599.84 $m^2$ | |
| Built-up area | 2101.91 $m^2$ | |
| No. of compartments | 2 Nos. reservoirs each single compartment | 1 reservoir with single compartment |
| I.L. of UGR (m) | 247.449 | 244.590 |
| Scour level (m) | 244.327 | - |

| **Data on Existing Components** | | |
|---|---|---|
| Overflow level (m) | 246.719 | - |
| T.L. of slab (m) | 250.225<br>250.299 | |
| Dimensions of each compartment (m x m) | 39.88 x 38.88 | 27 x 26.71 |
| Details of existing incoming pipes (mm) | | |
| Pipe 1 | 600 dia | 450 dia |
| Pipe 2 | 600 dia | |
| Pipe 3 | 450 dia | |
| Details of existing outgoing pipes (mm) | | |
| Pipe 1 | 450 dia | 400 dia |
| Pipe 2 | 600 dia | 200 dia |
| Pipe 3 | 100 dia | |
| Pipe 4 | 450 dia | |
| Pipe 5 | 300 dia | |
| Pipe 6 | 450 dia overflow | |

| Sl. No. | Valve Size (mm) | Quantity |
|---|---|---|
| **Shadipur – 1** | | |
| 1 | 300 | 2 Nos. Scour Valves |
| 2 | 300 | 1 No. Outlet to Faridpur |
| 3 | 450 | 6 Nos. (2 Nos. at Outlet to West Patel Nagar, 1 no. at East Patel Nagar, 2 Nos. at Inlet connection from Patel Nagar & 1 No. at overflow) |
| 4 | 600 | 2 Nos. at Inlet line from Jhandewalan |
| **Shadipur – 2** | | |
| 1 | 300 | 1 No. Scour Valve |
| 2 | 450 | Interconnection line of UGR 1&2 |
| 3 | 600 | 2 Nos. (1 No. at Outlet line connected to main outlet to east Patel Nagar & 1 No. at Inlet line tap off from UGR-1 inlet line) |
| **Rock Garden** | | |
| 1 | 200 | 2 Nos. (1 No. Scour Valve & 1 No. at outlet connected to Faridpur area) |
| 2 | 400 | Scour Valve |
| 3 | 450 | 1 No. at Tap off inlet line from Shadipur-1 |

*Proposed Project Bid Purpose drawings:*

- Layout drawing no. P-225-223-L-UGR-SP-001

- Process and Instrumentation Diagram no. P-225-212-P-UGR-SP-001

*Proposed Recommendations:*

- UGR command area 'water demand' is planned for Shadipur-1 as gravity, Shadipur-2 as pumping and Rock garden as gravity reservoirs with capacities of 20.30 MLD, 11.83 MLD and 13.13 MLD respectively.
- For Shadipur pumping area, a new sump & new pump house is proposed for the pumping and the same will be located in between the existing quarters and existing rock garden reservoir.
- It is proposed to install new incoming and outgoing pipelines with valves, and the existing arrangement shall be dispensed with.
- For valve replacement temporary bypass arrangement shall be provided
- A flow control valve is proposed at the inlet of the UGR.
- Proposed arrangement will have electromagnetic flow meters at the inlet and outlet.
- Portable Dewatering pumps for annual cleaning of reservoirs and chambers should be provided.
- Since the proposed system will be 24x7 potable water supply scenario, it will be required to install VFD driven pumps to take care of lean flows for both sets of pumps.
- Once the proposed system is commissioned, all the existing arrangement including pipes, valves and fittings etc. shall be dismantled and the UGRs shall be connected to the Transmission & Distribution networks as per the design details. Until the commissioning of the new UGR, bypass arrangement shall be made to maintain the supply from existing units or as appropriate.
- The pumping station shall be fully equipped with all necessary and required mechanical items as following:
  a. Electrically operated handling system
  b. Firefighting equipment
  c. Dewatering and Drain Pumps
  d. Ventilation system
  e. Vacuum Pump
- Any other item required shall be taken care by the contractor and no extra payment shall be made.

**Proposed Components for Shadipur & Rock Garden Command Area**

| Year | Projected Demand (MLD) | | |
|---|---|---|---|
| | **Shadipur (Gravity)** | **Shadipur (Pumping)** | **Rock garden (Gravity)** |
| 2021 | 16.73 | 9.33 | 10.36 |
| 2036 | 18.38 | 10.45 | 11.62 |
| 2051 | 20.30 | 11.83 | 13.13 |
| Details of proposed pump sets for Shadipur (pumping) pump house | Duty point condition for Shadipur (pumping) only. | | Qty. (W + S) |
| Set – 1 | 625m$^3$/hr @ 23 mwc | | 2W + 1S |
| Set – 2 | 150m$^3$/hr @ 27 mwc | | 1W + 1S |

| Year | Projected Demand (MLD) | | |
|---|---|---|---|
| | **Shadipur (Gravity)** | **Shadipur (Pumping)** | **Rock garden (Gravity)** |
| Details of proposed incoming pipes (mm) | 500 | 500 | 500 |
| Details of proposed outgoing pipes (mm) | 600 and 500 | 600 and 200 | 600 |

- Refer attached proposed GA drawing for details
- Refer tentative Bill of Quantities as per the preliminary design features

### 7.6 New Rajendra Nagar Reservoir

Reference drawings:

Survey drawing no. IE/TEC/NRN/DW/B5

| Data on Existing Components | |
|---|---|
| Storage capacity | 5.45 ML |
| Land area available | 7987.50 $m^2$ |
| Built-up area | 1365.56 $m^2$ |
| No. of compartments | 1 No. |
| I.L. of UGR (m) | 245.36 |
| Scour level (m) | 244.42 |
| Overflow level (m) | 247.04 |
| T.L. of slab (m) | 250.87 |
| Dimensions of each compartment (m x m) | 35.21 x 38.85 |
| Details of existing incoming pipes (mm) | |
| Pipe 1 | 600 dia |
| Pipe 2 | 400 dia |
| Details of existing outgoing pipes (mm) | |
| Pipe 1 | 300 dia, part – 1 |
| Pipe 2 | 600 dia, part – 2 |
| Details of existing Pumping Units | |
| Pump – 1 | 260 $m^3$/hr @ 26 mwc (37 kW) |
| Pump – 2 | 260 $m^3$/hr @ 26 mwc (37 kW) |
| Pump – 3 | 260 $m^3$/hr @ 26 mwc (37 kW) |
| Pump – 4 | 260 $m^3$/hr @ 26 mwc (37 kW) |
| Pump – 5 | --- $m^3$/hr @ 26 mwc (22 kW) |
| Pump – 6 | --- $m^3$/hr @ 26 mwc (22 kW) |

| Sl. No. | Valve Size (mm) | Quantity |
|---|---|---|
| 1 | 100 | 4 Nos. (2 Nos. discharge Gate valve at pump P5 & P6, 2 Nos. NRV at discharge pipe of pump P5 & P6) |
| 2 | 150 | 15 Nos. (4 Nos. discharge gate valve at Pump P1 to P4, 2 Nos. at |

| Sl. No. | Valve Size (mm) | Quantity |
|---|---|---|
| | | suction gate valve at Pump P5 & P6, 3 Nos. at outlet branch pipe to Rajendra nagar, 2 Nos. NRV at discharge pipe of pump P4 & P2, 3 Nos. at outlet pipe to NPL, and 1 No. of gate valve connecting pipe). |
| 3 | 200 | 5 Nos. (4 Nos. Gate valve suction pipe of Pump P1 to P4, 1 No. Suction Gate valve at outlet to NPL) |
| 4 | 300 | 5 Nos. (3 Nos. gate valve at Scour line, 1 No. at outlet from UGR, 1 No. gate valve at branch pipe from ) |
| 5 | 400 | 1 No. (gate valve at inlet to reservoir) |
| 6 | 450 | 1 No. (gate valve at outlet to New Rajendra Nagar) |
| 7 | 600 | 2 Nos. (1 No. gate valve at inlet from Jhandewalan, 1 No. gate valve at outlet from reservoir) |

*Proposed Project Bid Purpose drawings:*

- Layout drawing no. P-225-223-L-UGR-NRN-001
- Process and Instrumentation Diagram no. P-225-212-P-UGR-NRN-001

*Proposed Recommendations:*

- UGR command area 'water demand' is planned from New Rajendra Nagar reservoir of capacity 14.45 MLD.
- Due to increase in the pumping requirement and limited space available in the existing pump house, a new pump house with sump is proposed at entrance towards the left of the existing Pumping Station premises.
- This new pump house will have 5 numbers of pumps to cater the demand under the New Rajendra Nagar UGR.
- A flow control valve is proposed at the inlet of the UGR.
- Proposed arrangement will have electromagnetic flow meters at the inlet and outlet.
- Portable Dewatering pumps for annual cleaning of reservoirs and chambers should be provided.
- Since the proposed system will be 24x7 potable water supply scenario, it will be required to install VFD driven pumps in order to take care of lean flows for both sets of pumps.
- Online Electro-chlorination system is proposed to cater the reduced amount of Chlorine in DMAs
- The pumping station shall be fully equipped with all necessary and required mechanical items as following:
  a. Electrically operated handling system
  b. Firefighting equipment
  c. Dewatering and Drain Pumps
  d. Ventilation system
- Any other item required shall be taken care by the contractor and no extra payment shall be made.

**Proposed Components for New Rajender Nagar Command Area**

| Year | Projected Demand (MLD) | |
|---|---|---|
| 2021 | 11.79 | |
| 2036 | 13.02 | |
| 2051 | 14.45 | |
| Details of proposed pump sets (tentative) | Duty point condition | Qty. (W + S) |
| Set – 1 | 760 $m^3$/hr @ 29 mwc | 2W + 1S |
| Set – 2 | 180 $m^3$/hr @ 38 mwc | 1W + 1S |
| Details of proposed incoming pipes (mm) | 700 dia. | |
| Details of proposed outgoing pipes (mm) | 600 dia. | |

- Refer attached proposed GA drawing for details

Refer tentative Bill of Quantities as per the preliminary design features

**7.7 Naraina Reservoir**

Reference drawing:

Survey drawing no. IE/TEC/NAR/DW/B4

| Data on Existing Components | |
|---|---|
| Storage capacity | 9.08 ML |
| Year of construction / commissioning | 1935 |
| Land area available | 5187.20 $m^2$ |
| Built-up area | 1602.13 $m^2$ |
| No. of compartments | 1 No. |
| I.L. of UGR (m) | 236.395 |
| Scour level (m) | 237.289 |
| Overflow level (m) | 242.120 |
| T.L. of slab (m) | 242.749 |
| Dimensions of each compartment (m x m) | 40 x 40 |
| Details of existing incoming pipes | |
| Pipe 1 | 400 dia |
| Pipe 2 | 600 dia |
| Pipe 3 | 800 dia (closed) |
| Details of existing outgoing pipes | |
| Pipe 1 | 100 dia |
| Pipe 2 | 250 dia |
| Pipe 3 | 300 dia |
| Pipe 4 | 400 dia |
| Pipe 5 | 600 dia |

| Data on Existing Components | |
|---|---|
| Pipe 6 | 750 dia |
| Details of Existing Pumps | |
| Pump – 1 | HSC, 3.2 MGD @ 35m, 125 HP |
| Pump – 2 | HSC, 5 MGD @ 16m, 125 HP |
| Pump – 3 | HSC, 5 MGD @ 16m, 125 HP |
| Pump – 4 | HSC, 2.8 MGD @ 18m, 60 HP |
| Pump – 5 | HSC, 2.8 MGD @ 18m, 60 HP |

| Sl. No. | Valve Size (mm) | Quantity |
|---|---|---|
| 1 | 250 | 2 Nos. (1 No. outlet to Todapur & 1 No. outlet to KrishiKunj) |
| 2 | 300 | 13 Nos. (2 Nos. SV at suction of Pump -4 & 5, 2 Nos. SV & NRV each at discharge of Pump -4 & 5, 1 No. outlet to Todapur, 1 No. outlet to Naraiana Vihar C Block, 1 No. outlet to Valmiki Colony, 2 Nos. outlet to Inderpuri, 2 Nos. at inlet to UGR) |
| 3 | 400 | 9 Nos. (3 Nos. at outlet to Pump – 1 to 3, 2 Nos. outlet to Palam, 1 No. at inlet to UGR, 3 Nos. at suction of Pump – 1 to 3) |
| 4 | 600 | 7 Nos. (2 Nos. at inlet from Patel road, 1 No. at outlet to MES, 1 No. at branch to Patel road, 2 Nos. at outlet to Naraina gaon, 1 No. at outlet to MES) |
| 5 | 750 | 2 Nos. (outlet to Mayapuri) |
| 6 | 800 | 1 No. (inlet to UGR from khyala haiderpur) |

*Proposed Project Bid Purpose drawings:*

- Layout drawing no. P-225-223-L-UGR-NAR-001
- Process and Instrumentation Diagram no. P-225-212-P-UGR-NAR-001

*Proposed Recommendations:*

- UGR command area ‘water demand’ is planned for Naraina with a capacity of 29.19 MLD.
- A new UGR shall be constructed for the Naraina command area.
- The new pump house is proposed at front, on to right side of entry gate along with the new UGR at the existing space. The new Pump house will house two sets of pumps catering to two areas by means of two separate system (header & rising main).
- The proposed new reservoir will be constructed in a staged manner, the sequence of planned construction activity is elaborated in the General Arrangement drawing.
- It is proposed to install new incoming and outgoing pipelines with valves, and the existing arrangement will be dispensed with.
- For valve replacement, temporary bypass arrangement shall be proposed.
- A flow control valve is proposed at the inlet of the UGR.
- Proposed arrangement will have electromagnetic flow meters at the inlet and outlet.
- Portable Dewatering pumps for annual cleaning of reservoirs and chambers should be provided.

- Since the proposed system will be 24x7 potable water supply scenario, it will be required to install VFD driven pumps to take care of lean flows for both sets of pumps.
- Online Electro-chlorination system is proposed to cater the reduced amount of Chlorine in DMAs
- Once the new proposed system is commissioned, all the existing arrangement including pipes, valves and fittings etc. shall be dismantled and new UGR shall be connected to the Transmission & Distribution networks as per the design details. Until the commissioning of the new UGR, bypass arrangement shall be made to maintain the supply from existing units or as appropriate.
- The pumping station shall be fully equipped with all necessary and required mechanical items as following:
  a. Electrically operated handling system
  b. Firefighting equipment
  c. Dewatering and Drain Pumps
  d. Ventilation system
- Any other item required shall be taken care by the contractor and no extra payment shall be made.

**Proposed Components for Naraina Command Area**

| Year | Projected Demand (MLD) | |
|---|---|---|
| 2021 | 21.48 | |
| 2036 | 25.93 | |
| 2051 | 29.19 | |
| Details of proposed pump sets (tentative) | Duty point condition | Qty. (W + S) |
| Set – 1 | 1325 $m^3$/hr @ 17mwc | 2W + 1S |
| Set – 2 | 320 $m^3$/hr @ 22 mwc | 1W + 1S |
| Set – 3 | 400 $m^3$/hr @ 20 mwc | 1W + 1S |
| Details of proposed incoming pipes (mm) | 700 dia. | |
| Details of proposed outgoing pipes (mm) | 800 dia. and 300 dia. | |

- Refer attached proposed GA drawing for more details
- Refer tentative Bill of Quantities as per the preliminary design features

# SUB-SECTION 8. SCOPE OF SCADA AND INSTRUMENTATION WORKS

The entire works of SCADA and Instrumentation (including RTU and PLC) at West Zone SCADA Control Room as well as in the field area are to be executed on Design and Build basis based on the scope of works, technical specifications and P&I drawings as per following indicative quantities.

## 8.1 Equipment to be installed under SCADA and Automation works

| Sl. No. | Name of UGR | Component | No. of Units | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Main Eqp. Qty. | Mag flow meter | Level Transmitter | Level Switch | Level Gauge | Drain Pit Level Controller | Pr. Transmitter | Dual Bar Graph Indicator | Pr. Switch | Pr. Gauge | Portable Temp. measuring instrument | Portable Vibration measuring instrument | Wireless Fire & Intruder Alarm | CCTV & Intruder Monitoring System | Residual Chlorine Analysers | Turbidity Analysers | Power and Instrument Cables (m) | LCP | RTU | UPS |
| 1 | Than Singh Nagar | UGR | 2 | | 2 | 2 | 2 | | | 1 | | | | | | | | | 2000 | 1 | 1 | 1 |
| | | Sump | 0 | | | | | | | | | | | | | | | | | | | |
| | | Pump Set | 3 | | | | | | 3 | 3 | | 6 | | | 1 | 1 | | | | | | |
| | | Inlets to UGR (1000 mm) | 1 | 1 | | | | | 1 | 1 | | 1 | | | | | | | | | | |
| | | Common Outlet (1000 mm) | 1 | 1 | | | | | 1 | 1 | 1 | 1 | | | | | 1 | 1 | | | | |
| | | Drain Pit | 1 | | | | | 1 | | | | | | | | | | | | | | |
| 2 | Naraina | UGR | 2 | | 2 | 2 | 2 | | | 1 | | | | | | | | | 2000 | 1 | 1 | 1 |
| | | Sump | 2 | | | 2 | | | | | | | | | | | | | | | | |
| | | Pump Set | 7 | | | | | | 7 | 4 | | 14 | | | 1 | 1 | | | | | | |
| | | Inlets to UGR (700 mm) | 1 | 1 | | | | | 1 | 1 | | 1 | | | | | | | | | | |
| | | Common Outlet (800 & 300 mm) | 2 | 2 | | | | | 2 | 1 | 2 | 2 | | | | | 2 | 2 | | | | |
| | | Drain Pit | 1 | | | | | 1 | | | | | | | | | | | | | | |
| 3 | Shastri Nagar | UGR | 2 | | 2 | 2 | 2 | | | 1 | | | | | | | | | | 1 | 1 | 1 |

| Sl. No. | Name of UGR | Component | No. of Units | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Main Eqp. Qty. | Mag flow meter | Level Transmitter | Level Switch | Level Gauge | Drain Pit Level Controller | Pr. Transmitter | Dual Bar Graph Indicator | Pr. Switch | Pr. Gauge | Portable Temp. measuring instrument | Portable Vibration measuring instrument | Wireless Fire & Intruder Alarm | CCTV & Intruder Monitoring System | Residual Chlorine Analysers | Turbidity Analysers | Power and Instrument Cables (m) | LCP | RTU | UPS |
| | | Sump | 1 | | | 1 | | | | | | | | | | | | | | | | |
| | | Pump Set | 5 | | | | | | 5 | 3 | | 10 | | | 1 | 1 | | | 2000 | | | |
| | | Inlets to UGR (600mm) | 1 | 1 | | | | | | | | | | | | | | | | | | |
| | | Common Outlet (1000 mm) | 1 | 1 | | | | | | | 1 | 1 | | | | | 1 | 1 | | | | |
| | | Drain Pit | 1 | | | | | 1 | | | | | | | | | | | | | | |
| 4 | Shadipur (Pumping) | UGR | 1 | | 1 | 1 | 1 | | | 1 | | | | | | | | | | 1 | 1 | 1 |
| | | Sump | 1 | | | | 1 | | | | | | | | | | | | | | | |
| | | Pump set | 5 | | | | | | 5 | 3 | | 10 | | | 1 | 1 | | | 2000 | | | |
| | | Inlet to UGR (500 mm) | 1 | 1 | | | | | 1 | 1 | | 1 | | | | | | | | | | |
| | | Common Outlet (600 mm) | 1 | 1 | | | | | 1 | 1 | 1 | 1 | | | | | 1 | 1 | | | | |
| | | Drain Pit | 1 | | | | | 1 | | | | | | | | | | | | | | |
| 5 | Shadipur (Gravity) | UGR | 1 | | 1 | 1 | 1 | | | 1 | | | | | | | | | | | | |
| | | Sump | | | | | | | | | | | | | | | | | | | | |
| | | Pump set | | | | | | | | | | | | | | | | | 500 | | | |
| | | Inlet to UGR (500 mm) | 1 | 1 | | | | | 1 | 1 | | 1 | | | 1 | 1 | | | | | | |
| | | Common Outlet (500 & 600 mm) | 2 | 2 | | | | | 2 | 1 | 2 | | | | | | 1 | 1 | | | | |
| | | Drain Pit | | | | | | 1 | | | | | | | | | | | | | | |
| 6 | Rock Garden (Gravity) | UGR | 1 | | 1 | 1 | 1 | | | 1 | | | | | | | | | | 1 | 1 | 1 |
| | | Sump | | | | | | | | | | | | | | | | | 500 | | | |
| | | Pump set | | | | | | | | | | | | | | | | | | | | |
| | | Inlets to UGR (500 mm) | 1 | 1 | | | | | 1 | 1 | | 1 | | | 1 | 1 | | | | | | |
| | | Common Outlet (600 mm) | 1 | 1 | | | | | 1 | 1 | 1 | | | | | | 1 | 1 | | | | |

| Sl. No. | Name of UGR | Component | No. of Units | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Main Eqp. Qty. | Mag flow meter | Level Transmitter | Level Switch | Level Gauge | Drain Pit Level Controller | Pr. Transmitter | Dual Bar Graph Indicator | Pr. Switch | Pr. Gauge | Portable Temp. measuring instrument | Portable Vibration measuring instrument | Wireless Fire & Intruder Alarm | CCTV & Intruder Monitoring System | Residual Chlorine Analysers | Turbidity Analysers | Power and Instrument Cables (m) | LCP | RTU | UPS |
| | | Drain Pit | | | | | | | | | | | | | | | | | | | | |
| 7 | Janta Park | UGR | 2 | | 2 | 2 | 2 | | | 1 | | | | | | | | | 2000 | 1 | 1 | 1 |
| | | Sump | 1 | | | 1 | | | | | | | | | | | | | | | | |
| | | Pump set | 5 | | | | | | 5 | 5 | | 10 | | | 1 | 1 | | | | | | |
| | | Inlet (400 mm) | 1 | 1 | | | | | 1 | 1 | | 1 | | | | | 1 | 1 | | | | |
| | | Outlet (500 mm) | 1 | 1 | | | | | 1 | 1 | 1 | 1 | | | | | | | | | | |
| | | Drain Pit | 1 | | | | | 1 | | | | | | | | | | | | | | |
| 8 | New Rajendra Nagar | UGR | 2 | | 2 | 2 | 2 | | | 1 | | | | | | | | | | 1 | 1 | 1 |
| | | Sump | 2 | | | 2 | | | | | | | | | | | | | | | | |
| | | Pump set | 5 | | | | | | 5 | 5 | | 10 | | | 1 | 1 | | | 2000 | | | |
| | | Inlet (700 mm) | 1 | 1 | | | | | 1 | 1 | | 1 | | | | | | | | | | |
| | | Outlet (600 mm) | 1 | 1 | | | | | 1 | 1 | 1 | 1 | | | | | 1 | 1 | | | | |
| | | Drain Pit | 1 | | | | | 1 | | | | | | | | | | | | | | |
| 9 | Zakhira | UGR | 2 | | 2 | 2 | 2 | | | 1 | | | | | | | | | | 1 | 1 | 1 |
| | | Sump | 2 | | | 2 | | | | | | | | | | | | | | | | |
| | | Pump set | 10 | | | | | | 10 | 5 | | 20 | | | 1 | 1 | | | 2000 | | | |
| | | Inlet (1000 mm) | 1 | 1 | | | | | 1 | 1 | | 1 | | | | | | | | | | |
| | | Outlet (2 nos. 400 mm & 1 No. 500 mm) | 3 | 3 | | | | | 3 | 1 | 3 | 3 | | | | | 2 | 2 | | | | |
| | | Drain Pit | 1 | | | | | 1 | | | | | | | | | | | | | | |
| **TOTAL QUANTITY** | | | | **22** | **15** | **24** | **15** | **8** | **61** | **55** | **13** | **99** | **2** | **2** | **9** | **9** | **11** | **11** | **15000** | **8** | **8** | **8** |

**Notes:**

1. As Analyzers are specialized items and need periodic servicing from experienced & trained personnel, 5 years AMC for all Analyzers are to be provided by OEM supplier only.
2. A local SCADA system is required at each UGR/BPS and full SCADA at Zonal SCADA (West) with a Large VDU
3. CCTV monitoring is required at all UGRs/BPS and at each LCP of DMAs
4. Float type Level switch at each under-ground Chamber for flooding alarm of that chamber.
5. SCADA system shall have the Disaster Recovery and Business Continuity Plan
6. Fire and Intruder Alarm System in all UGR/BPS with adequate numbers of sensors / detectors.

## 8.2 Equipment Details for DMA's (Quantities)

For DMAs, all the flowmeters shall be Electro-magnetic Flowmeters and the Valves as Motorized Operating Valves (MOVs). A tentative details of other equipment and DMAs are given in the Table below.

| Sl. No. | Name of UGR | No. of DMAs | No. of Inlets in DMA | Pressure Gauge | Pressure Gauge at lowest Pressure Point | Pressure Transmitter | Pressure Transmitter at Lowest Pressure Pt. | Online Residual Chlorine analyser at lowest pressure Point | Level Switch for Chamber Flooding Alarm | Instrument & Power cables @ 50m per DMA |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Than Singh Nagar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Naraina | 6 | 6 | 12 | 6 | 12 | 6 | 6 | 6 | 300 |
| 3 | Shastri Nagar | 16 | 16 | 32 | 16 | 32 | 16 | 16 | 16 | 800 |
| 4 | Shadipur | 10 | 11 | 22 | 10 | 22 | 10 | 10 | 11 | 550 |
| 5 | Rock Garden | 3 | 3 | 6 | 3 | 6 | 3 | 3 | 3 | 150 |
| 6 | Janta Park | 2 | 2 | 4 | 2 | 4 | 2 | 2 | 2 | 100 |
| 7 | New Rajendra Nagar | 3 | 3 | 6 | 3 | 6 | 3 | 3 | 3 | 150 |
| 8 | Zakhira | 6 | 6 | 12 | 6 | 12 | 6 | 6 | 6 | 300 |
| | **Total Qty.** | **46** | **47** | **94** | **46** | **94** | **46** | **46** | **47** | **2350** |

## 8.3 Equipment Details for SCADA SYSTEM;

Given below is a tentative detail of SCADA related equipment with 1 Zonal SCADA (West) Control Room, 8 UGRs, 7 BPS and 46 DMAs as per Drg. No. P-225-225-S-SD-001.

| Sl. No. | Description | Quantity |
|---|---|---|
| **A** | **Zonal SCADA (West) Control Room Hardware** | |
| 1.1 | Redundant Server-Router system<br>SCADA Redundant Server Grade<br>HDD: 1TB, 4 GB RAM, DVD R/W, 2 serial and 1 parallel, 4-USB port. Windows 2008/2012 or latest with standard Keyboard and Optical mouse along with Antivirus software, MS Office latest version with 32" screen along with webserver with three client and built in historian and OPC server. | 2 |
| 1.2 | Redundant Data Storage System | 2 |
| 1.3 | Web Router | 1 |
| 1.4 | Complete Ethernet LAN installation for the Zonal SCADA (West) | As required |
| 1.5 | Central Location GPRS modem (TCP/IP)/Modbus ) - 1 | 1 |
| 1.6 | Workstations<br>Central Programming & Configuration PC(ES-1)<br>For PLC/RTU & SCADA system<br>32" screen,, i3-Core , RAM: 4GB, HDD:750GB, DVD R/W, 4-USB,port. Windows 7 (32Bit) with standard Keyboard and optical mouse along with Antivirus software, MS office software latest version<br>Workstations PC (OS Client1, 2)<br>32" screen,, i3-Core , RAM: 4GB, HDD:750GB, DVD R/W, 4-USB,port. Windows 7 (32Bit) with standard Keyboard and optical mouse along with Antivirus software ,MS office software latest version | 3 |
| 1.7 | Additional workstation outside SCADA centre comprising web router and UPS for 10 web clients | 1 |

| Sl. No. | Description | Quantity |
|---|---|---|
| 1.8 | Alarm/Event printer | 1 |
| 1.9 | A3 colour laser printer with scanner | 1 |
| 1.10 | A4 laser printer with scanner | 1 |
| 1.11 | Programmer notebook comprising software-<br>Service Laptop for programming and configuration of PLC and RTU. | 1 |
| 1.12 | Office MAN/WAN router | 1 |
| 1.13 | MAN/WAN Firewall | 11 |
| 1.14 | Network Managed Switches (24 port) for Central Server | 4 |
| 1.15 | Network Managed Switches (8 port) for UGRs | 16 |
| 1.16 | Large LED screen 67" | 1 |
| | SCADA Centre PLC/RTU | 1 |
| 1.17 | PLC / RTU considered to receive all signals from various RTUs | |
| 1.18 | 230V AC Redundent UPS for the Zonal SCADA (West) of required capacity with 4 hour backup | 2 |
| **B** | **UGRs & BPS Hardware** | |
| 1.19 | UGRs + BPS<br>Redundant PLC DNP3 & Modbus Communication enabled with Control Panels Duly wired IP 54 & Accessories. | 7 |
| 1.20 | **UGRs with BPS**: Local SCADA System with Workstations PC<br>32" screen, i3-Core, RAM: 4GB, HDD: 750GB, DVD R/W, 4-USB port. Windows 7 (32Bit) with standard Keyboard and optical mouse along with Antivirus software ,MS office software latest version, A4 Printer, Switch Firewall and other items as required for System Complete ness | 7 |
| 1.21 | UGRs : Telemetry RTU with PLC, DNP3 & Modbus Communication or equivalent enabled with Panels & Accessories | 1 |
| 1.22 | GPRS modem (TCP/IP)/Modbus | 8 |
| 1.23 | UGRs : 10" Colour Panel HMI with Touch Screen along with its Software | 1 |
| 1.24 | UGR/BPS -Local Control Panels | 8 |
| 1.25 | 230V AC Redundent UPS for UGRs and BPS of required capacity with 4 hour backup | 7 |
| 1.26 | A4 laser printer with Scanner | 7 |

| Sl. No. | Description | Quantity |
|---|---|---|
| 1.27 | 3 +- 0.5 kVA, 230V AC Redundant UPS of required capacity with 1 hour backup | 1 |
| **C** | **DMAs HARDWARE** | |
| 1.28 | Telemetry RTU with PLC and Dual SIM ROUTERS with DNP3 & Modbus Communication enabled with Panels & Accessories with 7"' Colour HMI Screen, its software and UPS of required capacity with 2 hour backup | 93 |
| 1.229 | 230V AC UPS for each DMA Panel of required capacity with 4 hour backup | 93 |
| 1.30 | Local Control Panel(LCP) with CCTV monitor | 93 |
| **D** | **ITEMS COMMON TO ALL THE ABOVE A, B & C** | |
| 1.31 | Complete data and power cabling - supply and state-of-the-art installation in channels etc. | As required |
| 1.32 | Complete power supply and power distribution equipment for the SCADA centre | As required |
| 1.33 | Dual Data & Voice Communication Networks Hardware required between Zonal SCADA (West) Control Room and all BPS/UGRs/DMAs of Package-2. | As Required |
| **E** | **SOFTWARE**<br>All the required SOFTWARE and Licences for all the HARDWARE/Equipment supplied namely PLCs, MODEMs, RTUs, PCs, Data Storage, Pumps Operations etc. along with its customization with CWMC of Package-1 and the special software packages with licences. | As Required |

## 8.4 CCTV, Fire & Intruder Alarm Systems (Hardware and Software)

| Sl. No. | Description | Quantity |
|---|---|---|
| 1 | SITC of 1/3" CCD/CMOS sensor 2 MP IP bullet IR UL listed Box/Bullet camera with dual streaming H 264 at HD 1080p/30 FPS, VF lens 2.8 – 10 mm | 32 |
| 2 | VGA Flat screen TFT 17" high resolution monitor with power supply complete with key board & mouse | 08 |

| | | |
|---|---|---|
| 3 | VGA Flat screen TFT 42" high resolution monitor with power supply complete with key board & mouse | 02 |
| 4 | Power supply with input 230V AC output, 12V, load regulation & line regulation less than 0.1%, Electronic protection against overload & short circuit, cut out ripple less than 1 millivolt RMS with redundancy mode | 04 |
| 5 | Network video recorder cum Management software | 08 |
| 6 | Video Management Software with camera license | 01 |
| 7 | Client workstation for live monitoring | 01 |
| 8 | 8 Port network switch POE | 08 |
| 9 | 8 Port Managed Network switch POE | 01 |
| 10 | CAT 6 capable PVC conduit for camera | As required |
| 11 | 2 core power cable PVC insulated & sheathed cable in conduit | As required |
| 12 | Intruder Alarm System for UGRs/BPSs | 08 |
| 13 | Fire Alarm System for BPSs (Cold Wire Technology) | 07 |

## 8.5 Laboratory Testing Equipments

| Sl. No. | Description | Quantity |
|---|---|---|
| 1 | Laboratory Testing Equipments | 01 Lot |
| 2 | Lovibond comparators for Chlorine & required furniture for Lab | 01 Lot |

# B. General Requirements

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# SUB-SECTION 1. GENERAL

## 1.1 Languages

All the reports, drawings, instructions, signs, notices, name-plates, etc. for use in the design, construction, operation and maintenance of the Works shall be in English. All site boards and warning signs shall be in Hindi and English.

## 1.2 Standards

Except where otherwise specified, all Plant, Equipment, Materials and Workmanship shall comply with the requirements of Central Public Works Department (CPWD), relevant Indian Standards (hereinafter referred to as IS) issued by the Bureau of Indian Standards (BIS) or such other Code of practices or Manuals issued by the Relevant State/Central Government agencies of India for that purpose.

In the absence of any Indian Standard or Specification, International Standards and Specifications such as those issued by International Organization for Standardization (ISO), British Standards (BS or BS EN), European Standards (EN), American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), Japanese Industrial Standards (JIS), International Electro-Technical Commission (IEC) or any other International Standards, Specification or manual may be followed or proposed by the Contractor at the Sole discretion of the Engineer or as may have been agreed in the Contract.

All Standards and Specifications, whether national or international, applied and used shall be with the latest edition (revision, amendments or correction slips) as available up to the date of submission of Bid.

In the event of conflict between any of these Specifications and the Codes referred, such specifications shall be defined, prepared by the contractor and submitted to the Engineer for approval. The decision of the Engineer in such case shall be final and binding on the Contractor.

In referring to the Standards, Code of Practices (CP) or Manuals, the following abbreviations are used to indicate the publishing organisations.

| | |
|---|---|
| ACI | American Concrete Institute |
| AGMA | American Gear Manufacturer's Association |
| ANSI | American National Standards Institute |
| API | American Petroleum Institute |
| ASA | American Standards Association |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| AWS | American Welding Society |
| AWWA | American Water Works Association |
| BIS | Bureau of Indian Standards |
| BS | British Standards Institution |

| | |
|---|---|
| CP | British Standards Institution (Code of Practice) |
| DIN | German Industrial Standards |
| EN | European Committee for Standardization |
| HMSO | Her Majesty's Stationery Office |
| IEC | International Electro-technical Association |
| IEE | Institute of Electrical Engineers |
| IEEE | Institute of Electrical and Electronic Engineers |
| IS | Indian Standards (by BIS) |
| ISO | International Organisation for Standardisation |
| JIS | Japanese Industrial Standards |
| JWWA | Japan Water Works Association |
| MORTH | Ministry of Road, Transport and Highways |
| NEMA | National Electrical Manufacturers Association |
| SI | International System of Units |
| SIS | Swedish Standards Commission |
| WHO | World Health Organisation |

Standards are referred to in the text of the Specification in abbreviated form e.g. IS 456.

### 1.3 Materials, Manufacturing and Manufacturers: general requirements

The term materials shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

The Contractor shall as far as possible use materials available in India for the completion of the Works, subject to compliance with the Specification.

Substances and products used in the Works which may be applied to or introduced into water which is to be supplied for drinking, washing or cooking shall not contain any matter which could impart taste, odour, colour or toxicity to the water or otherwise be objectionable on health grounds. Only substances and products which have been approved by a national or international regulatory body shall be used.

In case the documentary evidence as required in the clauses 1.3.1 to 1.3.3 is in a language other than English, the Bidder shall also submit the translation of such document from other language to English duly authenticated by the Indian Embassy in the respective country. In case the documents pertain to a project executed in a country other than India / supply of items from or to a country other than India / any other activity carried out in a country other than India, the Bidder shall submit documents duly attested by the Indian Embassy in the relevant country.

The qualification criteria for the manufacturers of various plants/equipment/products/materials shall be as follows.

### 1.3.1 Major Plant and equipment to be evaluated along with the Bid:

- Nil

### 1.3.2 Specified Equipment/Goods/Products

The materials and products and their Makes shall be proposed by the Contractor prior to the execution. The following general criteria for evaluation and requirements on selection of Makes shall apply at the time of design / datasheet approval.

(i) The general qualification criteria shall be as per the Table below. The bidder/contractor shall furnish documentary evidence that the Goods offered have been in production for at least 'X' years and that a minimum of 'Y' units of similar capacity have been sold. The bidder / Contractor shall furnish end user certificate of satisfactory performance of at least 5 units from each type of equipment listed in the following table. The certificates for each type of equipment should be from at least 3 end users.

| S.N. | Goods | Manufacturer's Experience Criteria | | |
|---|---|---|---|---|
| | | Minimum No. of years the goods offered are in production (X) | Minimum quantity of similar capacity goods sold (Y) (in 'X' No of years as in col 3 preceding the due date of tender) | No. of years in satisfactory operation to the end users (Z) |
| 1 | 2 | 3 | 4 | 5 |
| 1 | Pumps | 10 | 50 units | 5 |
| 2 | Electrical Equipment | 10 | 20 units | 5 |
| 3 | Valves | 10 | 50 units | 5 |
| 4 | Pipes | | | |
| 4.1 | Mild Steel | 10 | 2 times of total length required or 20 Km whichever is higher | 5 |
| 4.2 | Ductile Iron | 10 | 2 times of total length required or 80 km whichever is higher | 5 |
| 4.3 | All Other Pipes | 10 | 2 times of total length required or 100 km whichever is higher | 5 |
| 5 | Electronic and ICA equipment | 5 | 50 units | 5 |
| 6 | Bulk Flow Meters | 5 | 50 units | 5 |

Note:

(1) Documentary evidence in support of X-Criteria i.e. "Year of production." After production of any product by manufacturer, he has to supply to any client. The proof of supply of the product to client shall be treated as year of production.

(2) Documentary evidence in support of Y-Criteria i.e. "Units produced."

The Purchase order and goods dispatch letter from the manufacturer to the client shall be considered for counting the number of units sold as evidence.

(3) Documentary evidence in support of Z-Criteria i.e. "User satisfaction"
The Letter from the client (Govt./Semi-Govt./PSU) certifying the number of years of satisfactory performance shall be considered for end user satisfaction.

(4) Similar capacity means the size or capacity of minimum 80% of the size or capacity required/used in the contract works to be executed

(5) In addition to above, the goods shall also meet the following criteria:

- Suitable for Indian condition for Voltage and Frequency
- Manufacturer shall supply spares for entire period of O&M
- All the suppliers and manufacturing companies must have a valid ISO 9001 Certificate. The companies shall need to have continuous ISO 9001 Certification up to the end of 5 years Construction Phase
- The Manufacturer shall not have poor performance record in DJB. The equipment shall also not have poor performance record in DJB

(ii) For each Equipment/Goods/Products, the Contractor shall offer/propose at least 3 Makes and can choose any one of them at the implementation stage subject to the Engineer's approval. The BOQ rate/quality shall not be changed in any result from this procedure.

### 1.3.3 All other Goods/products/materials

For all other goods not covered under clause 1.3.1 and 1.3.2 above, the qualification criteria (X, Y, and Z criteria) shall be as per the Table below. The bidder/contractor shall furnish documentary evidence that the Goods offered have been in production for at least 'X' years and that a minimum of 'Y' units of similar capacity have been sold. The bidder / Contractor shall furnish end user certificate of satisfactory performance of at least 5 units from each type of equipment listed in the following table. The certificates for each type of equipment should be from at least 3 end users.

| S.N | Goods | Manufacturer's Experience Criteria | | |
|---|---|---|---|---|
| | | Minimum No. of years the goods offered are in production (X) | Minimum quantity of similar capacity goods sold (Y) (in 'X' No of years as in col 3 preceding the due date of tender) | No. of years in satisfactory operation to the end users (Z) |
| 1 | 2 | 3 | 4 | 5 |
| 1 | Any goods not specified under Clauses 1.3.1 and 1.3.2 above | 10 | 2 times of total quantity required in the contract | 5 |

The notes (1) to (5) given above for Clause 1.3.2 shall also be applicable to this sub-clause.
The bidder shall specify / propose 3 makes along with the bids. The evaluation and approval can be given at the time of design / data sheet approval.

### 1.3.4 Miscellaneous

The contractor shall furnish guarantees from manufacturers for all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage or other failure. The manufacturers guarantee shall be in addition to the warranty that shall be furnished by the contractor, as applicable. Under this guarantee the contractor agrees to replace, correct without delay and at no expense to the employer any such fault including the failure of any equipment or any part thereof to successfully perform within the limits of the specification and conditions of contract and further shall make good any damage caused by such failure. The contractor will be held liable for all expenses incurred by the Employer in replacing or getting the defects remedied and for all other losses.

All equipment shall be designed, fabricated, assembled, and installed in accordance with the best modern engineering and shop practice. Individual parts shall be manufactured to standard size and gauges so that spare parts, furnished at any time can be installed in the field.

Facilities and labour for the handling and inspection of all materials and equipment shall be provided by the contractor. If the Engineer requires, either prior to beginning or during the progress of the work, the contractor shall submit samples of materials for such special tests to demonstrate that they conform to the specification. Such samples shall be furnished stored and tested as directed at the contractor's expense.

The contractor shall submit details of material to be procured sufficiently early and in any case not less than twenty one (21) days prior to placing of orders, required data to permit considerations and approval by Engineer in consultation with Employer before materials are ordered. Any delay of approval resulting from the contractor's failure to submit samples or data timely shall not be used as basis of a claim against the Employer

## 1.4 Plant to be safe in use

The Contractor shall ensure that the Plant is safe in use, and that any safety regulations imposed by law or by any authorised body empowered to make such regulations are complied with.

## 1.5 Design life

"Design life" means the period for which an item is designed to operate at full design output without major overhaul involving extensive dismantling, serious corrosion or necessity for substantial renewal of any anti corrosion system, reduction of efficiency in excess of 5%, or replacement of major components essential to the functioning of the item etc except for consumables and for any limited-life components explicitly agreed at the time of the Contract award.

Unless otherwise specified, the Design life of works shall normally comply with the manuals on Water Supply, Sewage and other aspects of water supply systems published by the Central Public Health and Environmental Engineering Organisation (CPHEEO) of Ministry of Urban Development, Government of India. In case of other Civil works, Electro-mechanical and Instrumentation works, similar guidelines issued by other Departments/Agencies of Government of India should be followed. If no guideline exists, international practices shall be

adopted.

All items and systems shall be designed to allow replacement or major overhaul at the end of the design life without requiring major work or dismantling of other items and systems which interrupt operation of independent items and systems.

## 1.6 Interfaces with other contracts

This Contract **"Improvement of Water Supply System including Transmission and Distribution Pipes with Appurtenances, Pumping Stations, Underground Reservoirs, SCADA System, DMA formation and NRW Reduction in Chandrawal WTP Command Area with 5-years Construction and O&M and 4.5-years O&M after Construction- Package 2 (West Zone)"** forms part of a water supply improvement project for Chandrawal Water Treatment Plant Command area. The Employer is procuring works under separate contracts for:

(a) Design, Construction, Installation, Testing, Commissioning, and Automation with 2 years DNP and 14 years O & M of 477 MLD Chandrawal Water Treatment Plant including Upgradation and Integration of part Existing Units and Central Water Management Centre- Contract Package 1

(b) Improvement of Water Supply System including Transmission and Distribution Pipes with Appurtenances, Pumping Stations, Underground Reservoirs, SCADA Systems, DMA formation and NRW Reduction in Chandrawal WTP Command Area with 5-years Construction and O&M and 4.5-years O&M after Construction- Package 3 (Central Zone)

(c) Improvement of Water Supply System including Transmission and Distribution Pipes with Appurtenances, Pumping Stations, Underground Reservoirs, SCADA System, DMA formation and NRW Reduction in Chandrawal WTP Command Area with 4-years Construction and O&M and 4.5-years O&M after Construction- Package 4 (East Zone)

The Works under this Contract will interface with the Contract under other Packages.

In addition to above, the DJB might undertake some works separately as part of their regular O&M works within the Chandrawal WTP command area.

The Engineer shall arrange a meeting between himself, the Contractor and the contractor for other packages and DJB's other regular works, to agree on a programme for the interfacing works.

# SUB-SECTION 2. CONTRACT ADMINISTRATION

## 2.1 Contractor's organisation and administration of the Contract

The Contractor shall submit to the Engineer a diagram showing the structure of the contractor's organisation for administration of the Contract. A Contractor's Representative shall be appointed. The duties of the Contractor's Representative shall include responsibility for programming, progressing and co-ordinating on:

- Submission of all the Contractor's designs, drawings, catalogues, manuals, quality test reports etc. as applicable under the scope of works, including those of his subcontractors;
- Manufacture, erection, testing and commissioning of all the plants as per design, drawing and specifications;
- Construction, testing and commissioning of all the civil works as per design, drawing and specifications;
- Compliance with Quality, Health, Safety and Environmental standards/ regulations
- Submission of Work Programmes, Progress reports and photographs, As-built drawings, Operation and Maintenance Manuals
- All the works required during O&M (during construction and after construction) period
- Correspondences and attendance in the meetings with the Engineer/Employer

The Contractor's representative shall also be responsible for ensuring that all codes, standards, specifications and any other technical requirements of the Contract are complied with by the contractor including subcontractors, if any.

All correspondence and communication between the Engineer and the Contractor (including the Contractor's subcontractors, if any) shall be directed through the Contractor's representative.

Designs, drawings and documents that are required to be submitted to the Engineer for approval shall be considered as bona fide by the Engineer only if they have been submitted by the Contractor's representative or a person authorized by him/her. Prior to submission to the Engineer, the Contractor's representative shall have reviewed the design, drawing or document, whether initiated by the Contractor himself or by one of his subcontractors.

## 2.2 Programme of Work (Work schedule)

In preparing the programme required to be furnished, the Contractor shall take into account any restrictions on possession of the Site or of Temporary Working Areas imposed by the Contract. The Contractor shall also take account of the availability dates for the different portions of the site.

The programme shall be in the form of a Critical Path Network, PERT/CPM, using appropriate software like MS Projects, Primavera etc. together with bar charts. Alternatively, the Contractor may employ Project Management Software (described in next clause below) to prepare the schedule of works, if such features are available. Particulars to be shown on the programme shall include:

- Submission of designs, drawings and documents.
- Engineer's approval procedures/review procedures
- Re-submission of drawings etc as necessary and review
- Civil construction of each major structure
- Placing of orders for Plant
- Plant manufacture
- Plant tests at place of manufacture
- Plant deliveries to Site
- Plant erection
- Plant tests at Site
- Tests on completion (commissioning tests)

Any work programme, either component-wise or overall, submitted by the contractor shall be supported by the requisite resource plan viz. manpower, equipment, cash flow available with the contractor, without which the Engineer wouldn't be bound to approve or accept the work programme.

The programme shall make reasonable allowance for any work to be carried out by other contractors employed by the Employer. The Time for Completion of the Works and Sections thereof shall correspond to the periods prescribed in the Contract.

Approval of the Contractor's programme by the Engineer shall not relieve the Contractor of his duties and responsibilities under the Contract.

The programme shall be updated monthly and when requested by the Engineer to show actual progress and any revisions necessary to achieve completion.

## 2.3 Project Management

The Contractor shall use a project monitoring software based project management system to prepare the Project Progress (Physical and Financial) and other kinds reports (resource input and component-wise progress) as necessary for the various levels of management information. The Application should be made web-based and user id and passwords shall be provided to the Engineer and Employer's staff also so as to view the project status and print out the reports as necessary. All required data should be fed by the contractor in the day to day basis so that the Physical and Financial progress status viewed remains updated.

The Project monitoring software should have the minimum following capabilities:

- Setting up in sufficient detail the original project and the scheduled development of the project parameters from the beginning of the project up to the completion
- Processing of monthly progress data and ad hoc events for each individual project component
- Monitoring and controlling/auditing of the past "historic" and actual progress of the project components.
- Analysis of project development against the original scheduled developments (past and future) of the project parameters to identify and anticipate problem areas and bottlenecks, and the need of management action.

- Managing of special events (e.g. cost changes, variations, claims, contingency management) and deviations from scheduled developments.
- Preparing and supporting management decisions through "what if" analysis and scenarios, forecasting and analysis of the consequences of alternative management action on the project parameters.
- After management decisions, setting up of updated current projects (with revised updated financial and physical parameters) as a whole and the individual project components, by appending the revised expected development of the parameters to the "historic" project.
- Reporting comprehensively on the
  a. "Historic" progress of the project parameters,
  b. Variance to the original schedule,
  c. Actual position of the individual project components,
  d. Consolidated positions,
  e. Expected future development,
  f. Expected consequences on the completed project,
  g. Disbursement schedules,
  h. Cash flow forecasting

## 2.4 Method statements

The Contractor shall prepare and submit to the Engineer detailed method statements for aspects of his work which may affect the operations of the Employer, the activities of others outside the site, the work of other contractors on the Site or other potentially hazardous activities. The method statements shall be submitted for review by the Engineer at least 21 days before the work covered by the method statement is programmed to start. Aspects of work for which method statements are required include:

- work which may affect access to the Works;
- work which may affect the electricity supply system to the existing waterworks or new systems installed as part of the Works;
- work which may have an effect on the operation of the existing waterworks;
- work which involves filling any part of the Works with water or passing water through any part of the Works as part of testing, commissioning, and setting to work;
- works to be carried out at Night time
- work which involves any other aspect of the Contractor's operations, as may be requested by the Engineer;
- Communication mechanism with the Consumers and General public at the working areas
- any work which might in the opinion of the Engineer be potentially hazardous.

Each method statement shall comprise a step-by-step schedule of specific operations and activities with descriptions, dates, times and durations for each step. It shall highlight specific points in the programme, and include contingency plans for emergency reinstatement of works including "point of no return" and "earliest start time" of modified or new plan. The statement shall clearly state who and what organisation will carry out work and precisely when and what support or provisions are to be made by others outside the Contract. The statement shall include all supportive detail to enable a clear understanding of the method and significance of each step of the operation. The statement shall provide details of the Health and Safety measures to be

taken in carrying out the proposed activities.

No work which affects the operation of existing waterworks or the work of other contractors or which may be deemed by the Engineer as presenting a significant hazard, shall be carried out until the method statement has been agreed by the Engineer.

The Contractor shall revise the method statement as necessary if the Engineer requests it.

No agreement by the Engineer of the Contractor's method statement shall relieve the Contractor of his obligation to do the Works safely and in accordance with the Specification.

## 2.5 Quality Control / Quality assurance

### 2.5.1 Policy

The Contractor shall apply the formal requirements of Quality Control/ Quality Assurance to the design, supply, construction, testing and maintenance of the works. This shall be achieved through the implementation of a Quality System Compliant through BS 5750 or other International Standards such as EN 29000 or ISO 9000.

Positive commitment to Quality Control/Quality Assurance shall be expressed in a formal policy statement given in the Contractor's Quality Manual.

### 2.5.2 Quality System

The Quality System shall be fully integrated for all of the Works. This system will be defined by the organizational structure, responsibilities, activities, resources, and events that together demonstrate the capability of the Contractor to meet the stated quality requirements.

The Contractor shall supply to the Engineer such evidence as is necessary to demonstrate the effective implementation of a quality system.

The quality system of the Contractor will be subject to periodic audits undertaken by the Engineer. On a day-to-day basis the Contractor shall afford reasonably availability of staff and documentation for the Engineer to assess the implementation of the quality system. The Contractor shall ensure that all relevant personnel and documentation are available for such audits.

The Contractor shall establish a site laboratory for testing of materials used in construction during entire construction period. The lab shall be well equipped with equipment/instruments required for testing of construction materials e.g. weigh balance, sieve of requires sizes for gradation, vicat's apparatus for test setting time of cement, UTM for compressive strength testing, Water meter testing facility etc.

Quality assurance system should also include but not limited to the preparation and use of following as per the proforma approved by the Engineer:

- Daily progress report
- Bar bending schedule
- Concrete Pour Card
- Reinforcement Inspection check list
- Post concreting check ups
- Formwork check up
- Slump test register
- Inspection slip for plastering works
- Tests on materials
- Compaction tests for the earthwork in filling/backfilling
- Hydrostatic Pressure/ Leakage tests for Pipelines
- Holiday test for Pipes
- Tests for Welding of MS Pipes

### 2.5.3 Quality Assurance Plan

The implementation of the quality system shall be through the establishment of a comprehensive quality plan issued to and approved by the Engineer. The document procedures shall include but not be limited to:

(i) Management procedures;
(ii) Design;
(iii) Supply/procurement;
(iv) Construction;
(v) Putting to work/commissioning/reliability trial/performance test;
(vi) Operator training and maintenance;
(vii) Interface control.

### 2.5.4 Quality Assurance of the Works on Site

The Contractor shall provide an assurance system to ensure quality assurance by phased inspection as follows:

(i) Preparatory phase inspection: A construction risk workshop should be arranged before construction commences to evaluate the risk and develop measures to mitigate those risks.

(ii) Perform inspections prior to commencement of each part of the Works which shall be a review of requirements with the supervisors directly responsible for that part of the Works.
- Such review shall be in the form of written statements of the processes to be followed and critical characteristics, tests and similar evaluations which will be a part of inspection procedures.
- Verify that products incorporated with that part of the Works which have been tested and applicable submissions have been made for control testing.
- Verify that proceeding work has been completed and approved.
- Verify products incorporated with that part of the Works confirm to submission

data and Contract requirements and that necessary materials and equipment are easily and readily available.

The contractor shall provide labour, instruments, testing devices, facilities and required shelter at the site for following:

- To determine ambient and material temperature by thermometers with Celsius scale
- To determine relative humidity of air and moisture content of materials
- To facilitate inspection and tests
- For obtaining and handling of samples at site and plant

### 2.5.5 Quality Assurance of Off-site Works

The Contractor shall impose quality assurance methods at the location of manufacture fabrication and assembly of items to be incorporated in the Works to ensure that they conform to requirements of the Contract documents.

The Contractor's quality assurance representative off-site shall be responsible for the release of items for transit to the job site. In addition, the Contractor shall provide notice to the Engineer in writing at least 2 weeks in advance of packing of every batch of product components or assemblies so that the Employer or the Engineer may have opportunity at his/ their choice of inspecting any such product components or assemblies prior to transportation at the cost of the Contractor.

The products requiring factory, shops, suppliers or sub-contractors inspection are identified in relevant specification in the specific codes.

The Engineer's acceptance of product components or assemblies prior to transportation shall not imply final acceptance under the Contract. Final acceptance of product components or assemblies by Engineer shall be approved in accordance with the Contract only after successful erection, testing and commissioning have been completed.

### 2.5.6 Schedule of Quality Assurance Operations

The Contractor shall provide the Engineer with three copies of a schedule of quality assurance operations, both on-site and off-site to outline the procedures, instructions and reports which will be used, as follows:

(i) Quality assurance organization.
(ii) Qualifications of quality assurance personnel
(iii) Authority and responsibilities of each quality assurance person
(iv) Schedule of inspections and tests with personnel assigned to each task and duration of each task.
(v) Schedule of required services to be provided by inspection and testing firms.
(vi) Coordination required in order that quality assurance is integrated
(vii) Test methods which will be utilized.
(viii) Methods of performing and documenting quality assurance operations.

### 2.5.7 Quality Control and Quality Assurance obligation of the Contractor

Progress on a project is not at all the expense of quality of finished product. Quality control is, therefore, an important concern for the Contract.

The Contractor's quality control and quality assurance plan and activities shall include, but not limited to, the following.

- The quality control system of the complete project is made during design and planning stage. Quality control during construction/ Installation will largely consist of ensuring conformance to original design and planning decisions.
- All material and equipment intended to be used in the project comply with specifications;
- Personnel employed shall comply with applicable professional standards in achieving the quality of finished product.
- Submit details of quality assurance tests and methods inclusive of the specification.
- Provision of inspection and testing instruments and devices and facilities required to ensure proper performance of Quality Assurance at the job site.
- The contractor shall engage, at no extra cost to the employer, third party independent professionals or firms or testing laboratories for inspection if required as per the applicable codes or specifications. All such engagements shall require prior approval of the Engineer.
- All the field and site laboratory tests shall be carried out as per CPWD specifications. Minimum 10% of these field tests shall be got done from approved laboratory and a testing charges shall be borne by the contractor.
- All required test certificates and reports, are supplied with, in a timely manner.
- Maintain continuity of quality assurance surveillance throughout fabrication of products and execution of work
- Perform inspection and testing of all works in accordance with the relevant standards or as otherwise approved by the Engineer.
- Certification by producer/ manufacturer that specified products meet requirement of standard as specified in applicable codes/ specification.
- Calibrate measuring and testing devices periodically against certified standard equipment. Calibration shall be verified by the Engineer.

### 2.5.8 Quality Control/ Assurance Reports

Reports shall be in an approved format and shall certify off-site item produced correctly, as applicable. Similarly the report shall certify items that are defective with a statement of records on corrective measures taken. The Contractor shall:

(i) Document each test and inspection on a report and submit the report in triplicate to the Engineer.
(ii) Include on each report the purpose of the inspection or test, a description of methods used observations made and personnel involved.
(iii) Maintain in the approved format a log book of all tests performed which shall include the date of test, type of test and the results of the test.

If inspection and testing procedures are assigned to an approved inspection and testing firm, only copies of test reports signed by the approved inspection and testing firm will be acceptable.

### 2.5.9 Quality Performance, Monitoring and Review

There shall be procedures to control transmission across all interfaces both internally (that is, within the Contractor's quality system) and externally. Those of the latter shall include all statutory bodies, authorities and the Engineer.

Formal assessment of any non-compliance with the quality plan shall be achieved through periodic reviews. All deficiencies shall be recorded and appropriate corrective measures shall be assessed, implemented and reviewed.

## 2.6 Samples

Where the Contract requires the submission of samples, they shall be submitted by and at the expense of the Contractor not less than 20 working days excluding weekends and public holidays prior to the time that the materials represented by such samples are needed for incorporation into any work. Samples shall be subject to approval by the Engineer and material represented by such samples shall not be manufactured, delivered to the site nor incorporated into any work without such approval.

Where samples, including samples of materials and workmanship constructed on the Site, are submitted as a reference for materials and workmanship to be provided as part of the Permanent Works, they shall, after being approved by the Engineer, be carefully preserved for this purpose on site by the Contractor to the satisfaction of the Engineer until permission is given by the Engineer for their disposal.

## 2.7 Manufacturers' and Contractor's certificates

Where certificates are required by the Specification or relevant Standard, the original and one copy of each such certificate shall be provided by the Contractor, unless otherwise specified. The original and copy certificates shall be submitted to the Engineer.

Certificates shall be clearly identified by serial or reference number where possible to the material being certified and shall include information required by the relevant Standard or Specification clause.

Unless otherwise specified, the timing for submittal of certificates shall be as follows:

(a) Manufacturer's and supplier's test certificates shall be submitted as soon as the tests have been completed and in any case not less than seven calendar days prior to the time that the materials represented by such certificates are needed for incorporation into the Permanent Works.

(b) Certificates of tests carried out during the installation of plant and equipment or on completion of parts of the Permanent Works shall be submitted within 7 days of the completion of the test.

## 2.8 Progress reports and meetings

Each month the Contractor shall submit to the Engineer six hard copies and two soft copies of a written detailed progress report showing the stage reached in the execution of the Works. The report shall show progress to the end of the preceding month with respect to the approved Work Programme. The reports shall be accompanied by such additional information in approved form as may be required by the Engineer. The reports shall be forwarded promptly so that on receipt the content is not more than seven days out of date.

The report shall show all activities required by the Contract such as design, drawings, procurement, manufacture, works tests, delivery, erection, testing and commissioning of all items of plant.

Delays shall be detailed by the Contractor, with the proposed action to overcome it.

The Engineer may call meetings in his office, at the Contractor's office, or at the Site, to review the progress of the Contract. The Contractor's representative shall attend such meetings.

## 2.9 Progress photographs

Progress of work on Site shall be recorded monthly in six hard print copies of colour photographs of size not less than 175 mm by 125 mm. The hard copy printed photographs shall be suitably mounted, captioned and bound into a set as directed and approved by the Engineer. A suitable typed caption shall be affixed to each photograph (prints and those on disc) describing the detail and date taken. In addition two further sets of photographs shall be provided in digital/soft file formats. The bound set of colour photographs shall be submitted to the Engineer with the Contractor's monthly progress report. The camera and photographic papers shall be of types to the approval of the Engineer.

The photographs shall be the property of the Employer and no files or prints from these may be supplied to any person or persons except with the authority of the Employer. The Contractor shall also ensure that no unauthorised photography is allowed on the Site.

# SUB-SECTION 3. DRAWINGS AND DOCUMENTATION

## 3.1 Drawings furnished by the Employer

Except otherwise stated, the works/components to be designed by the Contractor, all Drawings are provided in Volume IV of these Tender documents for Bidder's understanding of the works requirement. However, the levels indicated are provisional and may need to be verified by the contractor. The contractor may be required to prepare and produce the detailed shop/ working drawings of the works after exact site survey and ground verification and got approval of the Engineer before commencement of the work. The drawings given for the Design and Build works are tentative and for reference purposes only.

## 3.2 Site constraints

The Contractor shall note the constraint in terms of land available for the Works as shown in the drawings. The Works, include access roads, ducts and pipework, shall be located within the area shown on the drawings, and in accordance with the overall conceptual/ detailed design layout shown.

## 3.3 Site information

For the works to be designed by the Contractor, the contractor shall carry out such surveys, studies and analyses of any kind as are necessary for the purpose of his general and detailed designs and construction of works and to verify the information shown on the Tender drawings and other data furnished by the Employer. In case of any discrepancy between results of surveys, studies and analysis carried out by the contractor and the reports attached with these Tender documents, the more stringent condition/ result shall prevail. The Employer shall not be liable for any claim by the Contractor on account of incompleteness or inaccuracy of the data furnished by the Employer irrespective of when the Contractor shall discover such incompleteness or inaccuracy.

## 3.4 The Contractor's Documents

### 3.4.1 General

For the works to be designed by the Contractor, the Clauses below describe the various engineering documents to be submitted by the Contractor to the Engineer and the procedures for submitting and obtaining approval of them. The will also apply for shop/ working drawing furnished by the Contractor for the Employer's design save as design related responsibilities.

### 3.4.2 Design

The Design **(associated with new UGR's, BPS, SCADA etc.)** shall include designs and drawings of temporary works, functional plans and general designs, diagrams, detailed designs and working drawings for all aspects of the Works, together with any and all other studies, investigations, computations, analyses and evaluations necessary to comply with the requirements of the Specifications.

Functional plans and designs shall be based on the proposals submitted with the Contractor's Tender, subject to such modifications as the Employer and the Engineer may require under the terms of the Contract.

All required designs, drawings and documents relating to design of the Works shall be submitted by the Contractor to the Engineer for review and approval in accordance with the Condition of Contract. Submissions shall be accompanied by corroborative information and computations as necessary to enable the Engineer to check the Contractor's designs.

The Contractor shall be fully responsible for the content of all submissions to the Engineer irrespective of the source or origin of information contained in such submissions. All submissions irrespective of the source or origin of information shall be checked by the Contractor and endorsed as such before submission to the Engineer. The Engineer will not accept submissions for review unless these requirements have been met.

Approval by the Engineer of a submission by the Contractor shall mean that the Engineer has no objection in principle to the content of the submission, drawings, calculations, certificates samples and the like and that the Engineer finds the content of the submission good enough to allow the work relating to the submission to proceed. Approval by the Engineer shall not relieve the Contractor of his responsibility under the Contract. Approval will be given only on the basis of information available at the time to the Engineer on the understanding that subsequent events may require withdrawal or modification of such approval.

Review of designs, drawings and documents by the Engineer shall mean review in principle only and not verifying every dimension and detailed matter.

The Contractor shall carry out the Works only in accordance with designs, drawings and documents that have received the Engineer's approval.

### 3.4.3 Documents in electronic format

All documents submitted for approval shall be provided in both electronic format as well as paper copies of sufficient number as specified elsewhere. Each electronic submission shall be provided on read/writable CD clearly marked with the project title, submission reference and a description of the contents.

The Contractor shall provide the following electronic formats as a minimum:

| | |
|---|---|
| Word-processing documents | - Microsoft Word/Adobe acrobat |
| Spreadsheet documents | - Microsoft Excel/Adobe acrobat |
| Databases | - Microsoft Access |
| Programme of works | - MS Projects |
| Drawings | - Autocad as .dwg or otherwise as .dxf format |

The Contractor shall submit details of the proposed software versions for the Engineer’s approval.

### 3.4.4 Drawing standards

Drawings submitted by the Contractor shall be clearly printed with black lines on white paper, and shall be resistant to fading on exposure to light.

Prints shall be on durable paper of good quality and 80gm/m$^2$ minimum weight.

Sheet sizes shall be in accordance with A series to ISO 216, and be drawn electronically at A1 size unless otherwise stated in the Contract or agreed with the Engineer.

All drawings submitted by the Contractor shall use the English language and SI units.

All drawings shall be clearly and fully cross referenced to the Specification and the Engineer's drawings as relevant.

Where drawings are revised, the revision letter or number shall be incorporated in the title block and the revision shall be clearly indicated on the drawing with the revision letter or number shown in an adjacent triangle.

When drawings are revised, this shall be done electronically and not manually, and CDs containing the revised files of all drawings, which have been supplied in electronic format, shall be submitted at the same time as the paper prints.

## 3.5 Production, submission and approval of Design and Drawings

The production, submission and approval procedure for designs, drawings and documents shall comply with the following requirements:-

### 3.5.1 Meanings

The following meanings shall apply:-

- "Preliminary drawing" means drawings which the Contractor submits to the Engineer for comment and any drawings returned by the Engineer marked "Preliminary" or not marked "Approved".

- "Drawing for Approval" means drawings which the Contractor submits to the Engineer for approval, and which shall be clearly marked as such.

- "Approved" drawing means drawings which the Engineer so endorsed accordingly and returned to the Contractor. Approved in this context means that the work described thereon may proceed as long as it complies with the Contract.

"Preliminary", "For Approval" and "Approved" as applied to designs and documents shall have the same meanings as applied above to drawings. A drawing which forms part of an "Approved" design or document shall not be an "Approved" drawing unless it has been so marked.

Approval to a design, drawing, or document may be partial or conditional. Such documents

will, for example, be marked "Approved in respect of....certain parts...." or "Approved subject to... actions to be taken by the Contractor before the work described can proceed.....". In such instances the Contractor shall carry out the Works only in accordance with approved parts or after the conditional actions have been carried out and confirmed to the Engineer in writing.

### 3.5.2 Form of drawings

Every drawing shall have a title box in the bottom right corner showing:-

- Employer's name;
- Title of scheme;
- Title of Contract;
- Contractor's name;
- Title of work location;
- Title of drawing;
- Drawing number;
- Date;
- Author;
- Signature of Contractor (to the effect that the drawing, whether his own or from any other source, has been checked by him before submission to the Engineer;

Each drawing shall also have a separate revision box with space for up to 10 revisions, and including revision number, revision date, revision description and revision check. It shall also include adequate clear space for the Engineer's markings.

Drawings submitted for comment shall bear the word 'PRELIMINARY' either as an electronic watermark or as an ink stamp. Drawings submitted for approval shall bear the words 'FOR APPROVAL' either as an electronic watermark or as an ink stamp. Drawings submitted as record drawings shall bear the word 'RECORD' in similar fashion.

Drawings shall be drawn to specified scales or to such scales as are appropriate for clearly detailing and conveying the Contractor's proposals. Scales shall generally be 1:2, 1:5, 1:10 or multiples of 10 thereof. The appropriate measuring scales used shall be shown on the drawings.

Drawings shall include cross references where appropriate and key information such as vital levels and dimensions. All plans shall show the "north" direction. All drawings shall clearly indicate the level datum used and its value.

### 3.5.3 Form of designs and documents

Designs and documents submitted by the Contractor to the Engineer for approval shall comprise generally:-

- Contents list;
- Scope (description of the contents and purpose of the submission);
- Conclusions and recommendations;
- References, Specification requirements, codes, manuals and supporting documents used, drawing numbers, and titles of drawings which are based on the design;

- Description of design approach;
- Criteria, parameters and methods used;
- Test procedures, analyses and results;
- Calculations and schedules;
- Qualitative description and comments on results;
- Any other relevant information;
- Appendix.

Designs and documents shall be presented on A4 size paper with every page numbered and bound in order between covers formed of a transparent front and stiff back. The title of the submission shall be given on the front sheet beneath the transparent cover together with a reference number, Employer's name, title of scheme, title of Contract, Contractor's name, title of works location, author's reference, date, Contractor's signature, revision box and space for Engineer's markings as for drawings and any other relevant information. Drawings submitted as part of the design or document shall be folded into pockets at the back.

### 3.5.4 Numbering and titling

The Contractor shall institute a reference numbering system for designs, drawings and documents so that each number used is unique. The numbering and title information on designs, drawings and documents shall be designed so that management, transmittal and communication in connection therewith can be carried out expeditiously. The Contractor shall submit to the Engineer for approval, a comprehensive register of the Contractor's Documents he intends to submit prior to the submission of any drawings for approval.

### 3.5.5 Submission procedures

Every drawing submitted by the Contractor to the Engineer for review and approval shall be based on previously approved designs or documents. Interrelated drawings shall be submitted at the same time in a complete and self-sufficient set. Copies shall be collated into ordered bundles each with a list of contents and accompanied by a letter from the Contractor (not from subcontractors or suppliers). Revisions of previous submissions shall be highlighted and the reasons for these shall be stated in the covering letter.

On completion of checking, the Engineer will return the submission with one of the following comments:-

| | |
|---|---|
| "Approved" | to allow work to proceed; |
| "Approved subject to" | to allow work to proceed subject to stated amendments and conditions; |
| "Not Approved" | revised submission required to include stated requirements. |

Drawings with "Not Approved" and "Approved subject to" statuses shall be revised and re-submitted within a maximum of 14 working days from the date of return.

Subject to any specific requirements in the Contract, all submissions shall be made sufficiently early to allow the Engineer time for review and approval, and for the Contractor to provide and submit revisions or alternatives.

Unless otherwise specified or agreed before submission, the Contractor shall allow not less than 14 working days excluding weekends and public holidays for review by the Engineer of designs documents and samples which are required to be approved and 10 working days for review of re-submissions before manufacture or construction commences as part of the Works. The Contractor shall have demonstrated in his submissions that he has coordinated submissions by his subcontractor or suppliers to confirm that the Contractor is satisfied that they are acceptable for incorporation into the Works.

If the Engineer does not respond to any submission within the specified number of days, then the Contractor may proceed with the work but shall inform the Engineer in writing that he is proceeding with the work. Absence of response from the Engineer will not relieve the Contractor of his obligations to meet all the requirements of the Specification.

The Engineer will designate the address of his review office in respect of particular disciplines or work from time to time during the Contract. All submissions shall be made sufficiently early to allow the Engineer time for review and approval of drawings, documents and samples which are required to be approved before commencement of manufacture of plant or of installation or construction on site as the case may be and for the Contractor to provide and submit revisions or alternatives, or carry out further tests if, in the opinion of the Engineer, the initial submissions do not meet the requirements of the Contract.

Whichever status - "Approved", "Approved subject to" or "Not Approved" the Engineer assigns to any particular drawings designs or documents submitted for his review, will be based on the information provided in the submitted drawings designs or documents. It shall be the responsibility of the Contractor to ensure that all relevant information is provided to enable the Engineer to easily determine whether or not a submitted design complies with the specific requirements or intent of the Specification. Where the Engineer assigns an inappropriate status due to lack of clarity or incomplete or incorrect information submitted by the Contractor, this shall not relieve the Contractor of his obligations to provide the Works in compliance with the Contract. Any costs for abortive works or redundant equipment provided as a result of such situations shall be borne by the Contractor.

### 3.5.6 Copies for Approval and Approved documents/drawings

All documents and drawings to be submitted by the contractor shall be submitted in 4 copies and in electronic format. Out of these four, the Engineer shall return one copy after comment or approval as the case may be. After approval of the Engineer, the Contractor shall submit four copies of all "Approved" documents and drawings, which bear a mark of stamp or seal with the words "APPROVED".

## 3.6 Requirement of Design and Drawings for Approval

In addition to showing the submission of designs, drawings and documents on his programme for the works, the Contractor shall submit a specific programme for submitting designs,

drawings and documents to the Engineer for approval. The programme shall also make reasonable provision for re-submission of not approved designs, drawings and documents and for the time needed to transmit such designs, drawings and documents.

The programme for submission of designs, drawings and documents, wherever required, shall be based on the following general order, requirement of which may be adjusted with mutual decision to fit in a particular circumstances:-

For the works to be undertaken as Design and Built:

- Topographical survey reports;
- Contoured site drawings;
- Site investigation (geo-technical) reports;
- Outline design calculations;
- Hydraulic profile;
- Basic design criteria;
- Process and instrumentation drawings (P&IDs);
- General arrangement drawings;
- General civil works drawings;
- Structural designs;
- Structural drawings;
- Foundation drawings;
- Instrument schedules;
- Electrical single line diagrams;
- Substances and products schedules;
- Functional plans and functional design specifications;
- Fabrication and installation drawings;
- Detailed design calculations;
- General drawings for plant design;
- Plant drawings;
- Architectural drawings.

For the works to be executed as BOQ based (Employer's Design)

- Topographical survey reports (wherever required by the contract);
- Geo-technical investigation reports (wherever required by the contract);
- Trial Pits and Underground utility location survey (wherever required by the contract)
- Condition assessment (pipes, structure) reports (wherever required by the contract)
- Construction Drawings of Pipeline and Structural works
- Fabrication and Installation drawings of E/M Plants and Equipment;
- Manufacturer's approval, Materials Test reports etc.

### 3.7 As-built records and drawings

The Contractor shall prepare, and keep up-to-date, a complete set of as-built records of the execution of works, showing the exact "as-built" locations, sizes and details of the work as executed. As-built records shall include all such drawings, schedules, documentation and calculations as necessary for the complete understanding of the design, sizing and capacities of the structures and equipment. As-built drawings should be normally prepared in A3 sizes unless

otherwise approved by the Engineer.

The As-built records shall consist of the fully updated version of the approved construction documents incorporating any changes made during the construction/erection and commissioning of the works including additional information which will assist the Employer in operating and maintaining at a later date.

The contractor shall submit, after due verification and approval of the Engineer, six copies of the final As-built records including 2 sets of soft copies 30 days prior to the start of Trial Run of the Plant.

### 3.8 Operation and Maintenance manuals

The Contractor shall compile operation, maintenance and overhauling instructions for all the works executed under the contract in the form of Operation and Maintenance (O&M) manuals. The manual can be prepared for three distinct works separately in three parts as follows.

i. Pipeline systems and NRW management at UGR/DMA level
ii. BPS and UGRs
iii. Instrumentation and SCADA systems

The O&M manual should serve the following main functions:

- To provide technical information about the work, E/M plant, equipment and instruments used in the work
- Guidance regarding the operation of equipment and systems including start-up, shut down, and normal/alternative operations. To assist the operating staff in continuing standard operating procedures after start-up
- Guidance on routine general and preventive maintenance of the works, overhauling schedules, information on spare parts etc.
- As a text book to be used for start-up training and plant start-up for the operators

The greatest importance is attached to completeness and clarity of presentation. It shall be `user friendly' bearing in mind the training and abilities of the Employer's personnel responsible for operating and maintaining the Works.

The operation and maintenance manuals shall describe the installation as a whole and shall give a step-by-step procedure with assembly drawings for any operation likely to be carried out during the life of each item of plant, including its erection, commissioning, testing, operation, maintenance, dismantling and repair. Manuals shall identify and cover aspects liable to affect other installations and shall include all health and safety precautions to be taken.

Maintenance instructions shall include charts showing lubrication, checking, testing and replacement procedures to be carried out daily, weekly, monthly and longer intervals to ensure trouble-free operation. Where applicable, fault location charts shall be included to facilitate tracing the cause of malfunction or breakdown.

A separate section of the manuals shall be devoted to each size and type of equipment and to each item of Plant. It shall contain a detailed description of its construction and operation and shall include all relevant pamphlets, and a list of parts with the procedure for ordering spares. The detailed sections of the manual, if necessary, shall contain further maintenance instructions

and fault location charts.
The Contractor's attention is drawn to the need to ensure that the following items are included in the operation and maintenance manuals:-

- All health and safety instructions for chemicals and any precautionary measures necessary for ensuring health and safety and avoidance of misuse;
- General description of the scope, purpose and manner of working of each system or apparatus forming part of the Works, and the final functional design specification (FDS);
- Schedule of equipment supplied giving manufacturers' name and appropriate make, model/catalogue number, description of unit and component parts identified on drawings;
- Maintenance procedures for regular maintenance and preventive maintenance, including frequencies of routine operations, guide to fault diagnosis, fault finding charts, step-by-step procedures for dismantling, cleaning, servicing, part replacement and reassembling, including recommended clearances and tolerances;
- Maintenance procedures for the pumps;
- Schedule of spare parts with ordering reference numbers and parts identified on equipment drawings;
- Schedule of tools;
- Schedule of changeover frequencies for duty/standby equipment;
- Sectional arrangement drawings of major items of plant with dismantling instructions;
- Plant layout drawings showing the "as erected" installation;
- Schedules for "as installed" instrumentation;
- Electrical system single line diagrams;
- Electrical system protection grading characteristics and setting data;
- General arrangement and circuit diagrams for switchboards and control panels "as installed";
- Diagrams of all "as installed" connections between electrical plant and instrumentation systems;
- Operating procedures including step by step instructions for pre-start, starting up, including start up following emergency shut down, normal operation and normal and emergency shutting down of the Plant;
- "Do's" and "Don’ts" in plant operation with attention drawn to all operations considered to be hazardous to personnel or likely to damage plant;
- Data on general setting of controls associated with controlling design conditions, monitoring instruments and switchgear, together with the details of initial settings of all adjustable items;
- Test certificates for works and site tests carried out on plant, for site tests carried out on pipework, electrical and instrumentation installations and other items where appropriate;
- Pump performance and calibration characteristics as tested and system characteristics;
- Manufacturers' printed operating and maintenance instructions;
- Lubrication instructions including frequency of application and schedule of recommended lubricants and their equivalents, which must be readily obtainable;
- Typical log sheets for recording plant operating information with instructions for identifying departures for normal behaviour;
- Typical log sheets on which operating staff can record their service/maintenance checks on essential equipment and at periods recommended by the Contractor;
- Instrumentation, control and automation equipment operating instructions for normal

procedures in a step by step format including flow charts, control operations, requests for display or printing of data, performance monitoring, response to alarms or failures, changing of operation parameters, and manual data entry;

- Description of the plant control philosophy (a layman's guide for operator assistants) including plant trips and interlocks;
- A schedule of alarms, giving cause and action to be taken;
- Procedures for calibration of instruments;
- Data sheets for pumps, compressors etc giving capacities.

Any additions, alterations or deletions which may be required by the Engineer following the experience gained during the periods of running and further maintenance shall be incorporated in these copies in the form of additional or complete replacement pages and the cost of these amendments shall be deemed to be included in the Contract Price.

All drawings incorporated in the manuals shall be presented in such a way that they can be easily referred to whilst reading the associated description in the text.

The contractor should submit four draft copies of the O&M manual for the Works at least one month before the commencement of the Commissioning tests and trial run. After approval, six copies of the final O&M Manual, including soft copy files, shall be submitted within three months after the issue of Taking over Certificate.

If any further revisions are necessary as a result of operational experience during the O&M period, all copies shall be revised by the Contractor at no additional cost to the Employer.

# SUB-SECTION 4. SITE WORKS

## 4.1 The Site

The 'Site' as defined in the Conditions of Contract shall also include the Contractor's works areas and any temporary working areas described herein.

Possession of the Site, or parts thereof, to be given by the Employer shall be subject to any restrictions mentioned in the Contract.

Prior to any commencement of any site works, the Contractor shall undertake a survey of the site condition and provide detailed digital record photographs of the Site.

## 4.2 Site road and access

Except as may be otherwise provided in the Contract, the Contractor shall arrange for, construct, maintain and afterwards remove and reinstate all temporary site roads and accesses required for and in connection with the execution of the Works. Reinstatement shall include restoring the area of such roads and accesses to at least the degree of safety stability and drainage that existed before the Contractor commenced work.

## 4.3 Data for setting out the Works

Unless otherwise stated any levels and co-ordinates shown on the drawings or given in the Specification are related to 'GTS' survey of India. Stated levels are given to AMSL (Above Mean Sea Level) with regard to GTS. The Contractor shall be responsible for checking any levels given on the drawings or given in the Specification and providing copies of the survey data to the Engineer.

The Contractor shall carryout all survey and levelling work to establish reference points in order to fulfil his obligation under the Contract.

The Contractor shall provide all survey and measuring instruments of every kind necessary for his own use in the execution of the Works.

## 4.4 Geological, hydrological and meteorological information

Any geological or hydrological information given hereunder or elsewhere in the Specification or shown on the drawings is to assist the Contractor at the time of tendering. Such information shall be deemed to be information provided by or on behalf of the Employer under the Contract. The information is not warranted by the Employer or the Engineer and the Contractor shall make use of and interpret the same on his own responsibility.

## 4.5 Special hazards

The Contractors attention is drawn to the following special hazard.

- Intense monsoon season rainfall, lightning storms and consequent flooding.

The above is an example only and is not complete. The Contractor shall be deemed to have made, before tendering, his own examinations and inspections of the site and all interpretations of all relevant climatic and physical conditions and their impact on the works.

**4.6 Temporary working areas**

Where any parts of the Works are to be constructed on, over, under, in or through land other than the Site or public highways, and subject to any proviso stated below, the Employer will arrange for temporary occupation by the Contractor of temporary working areas and such areas shall be deemed to be part of the Site during the period of occupation.

The work in such areas shall be subject to method statements, which shall be prepared by the Contractor and will be subject to review and approval by the Employer and the Engineer.

The Employer will arrange also for the serving of any Statutory Notices in connection with temporary working areas but the Contractor shall give to the occupier of each such area seven days written notice of his intention to enter and shall ensure that his methods of working cause the minimum of disturbance to the land and to its owners and occupiers.

Where necessary, similar arrangements shall apply to provide the Contractor with access routes to temporary working areas and such routes shall be deemed to form part of the temporary working areas.

The extent of each temporary working area and the period of time for its occupation shall be such as the Engineer considers necessary having regard to the Contractor's reasonable requirements, which shall be submitted to the Engineer's Representative as soon as practicable after commencement of the Works and having regard to the Contractor's programme furnished pursuant to the Contract.

**4.7 Temporary buildings etc. classified as Temporary Works**

For the purposes of the Contract everything provided by the Contractor in compliance with the Contract Administration; Health, Safety and Welfare inclusive of Contractor's Equipment (whether it is owned by or is on hire to the Contractor) shall be deemed to be part of the Temporary Works. The permission of the Engineer for removal of temporary works from the Site may be withheld until the end of the issue of the Performance Certificate.

**4.8 Reinstatement of temporary working areas**

The Contractor shall reinstate temporary working areas to the standards specified in the Contract as soon as possible after other work in those areas has been completed so as to keep the period of occupation to a minimum. If the standards of reinstatement are not so specified the Contractor shall in any event restore the areas to a tidy, workmanlike and "as found" condition and shall carry out such additional reinstatement work as may be ordered by the Engineer.

**4.9 Existing services**

The Contractor shall be responsible for the security of all water, sewer, gas, electricity,

telephone and other services, drains, pipes and other apparatus belonging to or under the control of any public authority, company or person, which may be, or be liable to be, interfered with, by or in connection with the execution of the Works. The Contractor shall be responsible for organising or providing any temporary or permanent service diversions. The Contractor shall fully indemnify the Employer against any claim, action, expense, loss, damage or injury arising in this respect. The contractor requires to give a quick attention on repairs and a pre-planned arrangement or contingency plans must be made to act on such emergency situations.

The Contractor shall ensure that the location of all existing electrical cables is identified using proprietary cable detection equipment by personnel qualified to carry out such work.

The Contractor shall obtain copies of all up-to-date services records for the Site prior to commencing the Works, and supply one copy to the Engineer.

### 4.10 Amenities to be preserved

The Contractor shall cause the least possible interference with existing amenities, whether natural or man-made. No trees shall be felled except as authorised by the Engineer and clearance of vegetation of any sort shall generally be kept to the minimum necessary for the Works and Temporary Works.

### 4.11 Security on the Site

The Contractor shall provide, maintain and remove secure temporary fences of 2m height or more and of required quality as specified in the contract or required by any regulatory authorities, around the works areas, storage yards and compounds. The Contractor shall submit details of the proposed temporary fencing to the Engineer for approval prior to any works.

Access into the Site will normally be restricted to employees of the Employer, the Engineer and his staff and the Contractor for the Works. Where one Party wishes to bring visitors on Site, he shall discuss and agree any relevant procedures before such a visit takes place.

The Contractor shall be responsible for the security and safety of all his operations, including storage of his own materials, tools and equipment, protection of completed work in place, site offices and the like.

The Contractor shall allow for providing security guards on a 24 hrs basis for the Site. At any time there should be three guards – one for the Site entrance and two for patrolling. The Contractor shall consider either two shift or three shift operation for the Security guards.

### 4.12 Work in public highways

Where any work is to be carried out in or adjacent to a public highway (which for the purposes of the Specification shall be deemed to mean any street, road or footpath maintainable at public expense) the Contractor shall comply with, among other things, any requirements and recommendations of the police or other authority regarding traffic safety measures for roadworks.

Wherever single file traffic is necessary on a highway by reason of the construction of the Works the Contractor shall provide and maintain a minimum carriageway width of 2.5 metres, or wider where necessary at curves and junctions, and shall provide, operate and maintain sufficient suitable traffic signs. When alternative one-way working of traffic is required, the Contractor shall also provide trained operatives with 'Stop-Go' signs for the duration of those works. However the contractor should also note the following:

- For Byroads at colonies, road closure could only be allowed if there are alternative access to the residences
- Night work shall be permitted only after necessary precautions are made for road traffic and public safety and also there is no objections from residents at the surrounding of the working area.

No provision has been made for the closure of any public highway but if the Contractor wishes to apply for any such closure he shall make all the proper arrangements for the same with the appropriate persons and authorities. The Contractor shall not be entitled to any extra payment as a result of permission for such closure being refused.

### 4.13 Work in restricted forest areas

The work in restricted forest areas should be done in compliance with the conditions made by respective authorities. The contractor should act vigilantly to minimize any extra over damages to forest, allow authorized employees only to work in the restricted forest areas.

### 4.14 Access and trespass to adjoining property

If the Contractor's work will cause unavoidable interference with access to adjoining property the Contractor shall first give seven days' notice in writing to the occupier of such property and shall provide temporary means of access for vehicles, animals and pedestrians.

In carrying out the Works due regard shall be paid to the amenities of adjacent property and to the interests of owners, tenants and occupiers. The Contractor shall take adequate steps to prevent trespass by his employees and shall be wholly responsible for making good any loss or damage caused by such trespass.

The Contractor shall take all necessary steps to ensure that the activities of his employees (and those of his subcontractors) do not have any detrimental effect on the surrounding environment.

### 4.15 Claims for damage to persons or property (procedure)

Any claim received by the Employer in respect of matters in which the Contractor is required under the Contract to indemnify the Employer will be passed on to the Contractor who shall likewise inform the Employer of any such claim which is submitted directly to him by a claimant. The Contractor shall do everything necessary, including notifying the insurers of claims received, to ensure that all claims are settled properly and expeditiously and shall keep the Employer informed as to the progress made towards settlement, failing which the Employer shall be entitled to make direct payment to claimants of all outstanding amounts due to them in the Employer's opinion and without prejudice to any other method of recovery to deduct by way

of set-off the amounts so paid from sums due or which become due from the Employer to the Contractor. If the Contractor receives a claim which he considers to be in respect of matters for which he is to be indemnified by the Employer under the Contract, he shall immediately pass such claim to the Employer. All information as aforesaid shall be given in writing and shall be copied to the Engineer's Representative.

### 4.16 Advertisements

The Contractor shall not except with the written authority of the Engineer exhibit or permit to be exhibited on the Site any advertisement board. Any such advertisement may also be subject to the approval of the concerned govt. authority before it is put up and it shall be removed if the Engineer so demands.

### 4.17 Site Welfare

#### 4.17.1 Sanitation

The Contractor shall maintain the Site and all working areas in a hygienic condition and in all matters of health and sanitation shall comply with the requirements of the relevant authorities.

The Contractor shall be responsible for providing all sanitary services necessary to keep all offices and stores in a clean, neat and hygienic condition.

The Contractor shall provide all proper temporary sanitary facilities for the Contractor's employees and sub-contractor's. The sanitary facilities provided within the Site shall be of the portable type. The Contractor shall provide septic tanks as necessary for the disposal of sewage. Where the construction of septic tanks or water-borne sewerage is not feasible, the Contractor shall construct conservancy tanks and arrange for the removal and disposal of sewage. All such arrangements shall meet all the requirements as stipulated by the relevant local Health Authority and the Contractor's proposals shall be submitted to and approved by the Engineer.

In particular, the Contractor shall ensure that his employees (and those of his subcontractors) only use the toilet facilities provided by him as part of his site establishment. Any person found urinating or defecating elsewhere on the Site shall be removed from the Site immediately, and shall not be re-employed on the Site.

The Contractor shall also provide for the removal and legal disposal off the Site of all rubbish and solid waste from offices and other areas of the Site, with collections being made at least twice weekly.

#### 4.17.2 General hygiene and medical examination of Contractor's employees

Before commencing work on the Site, the Contractor shall ensure that all his employees are instructed about the necessity for the prevention of pollution. The Contractor shall immediately dismiss and remove from the Site any of his employees or representatives who have been polluting or fouling the Site or any of the water supply installations and shall take appropriate remedial measures to prevent a repetition of the occurrence and to disinfect the areas concerned all to the satisfaction of the Engineer.

During commissioning and subsequent operations the Contractor shall not employ upon the Site, or on periodic visits thereto, persons who are known to have any disease which could be water-borne or who is suffering from an illness associated with looseness of the bowels or who are carriers of typhoid bacillus or other potential pathogenic organisms or who are otherwise unsuited on medical grounds to be employed in or around water supply installations.

The Contractor shall if and when required to do so, arrange for his employees to be examined and tested in the manner approved by the local medical officer.

The Contractor shall immediately remove from the Site any such employees who as a result of such examination and testing may in the opinion of the medical officer or the Engineer constitute a danger to water supplies or who refuse to undergo an examination.

### 4.17.3 Works to be kept clear of water

The Contractor shall keep the Works well drained until the Engineer certifies that the whole of the Works is substantially complete and shall ensure that so far as is practicable all work is carried out in the dry. Trenches shall be kept well drained and free from standing water. All other excavated areas shall be treated similarly except where this is impracticable having regard to methods of Temporary Works properly adopted by the Contractor.

The Contractor shall construct, operate and maintain all temporary dams, watercourses and other works of all kinds including pumping and well-point dewatering plant that may be necessary to exclude water from the Works while construction is in progress. Such temporary works and plant shall not be removed without the approval of the Engineer.

Notwithstanding any approval by the Engineer of the Contractor's arrangements for the exclusion of water the Contractor shall be responsible for the sufficiency thereof and for keeping the Works safe at all times particularly during any floods and for making good at his own expense any damage to the Works caused by the fault or inadequacies of his arrangements.

### 4.17.4 Discharge of water and waste products

The Contractor shall make provision for the discharge or disposal from the Works of all water and waste products howsoever arising and the methods of disposal shall be to the satisfaction of the Engineer and of any authority or person having an interest in any land or watercourse over or in which water and waste products may be so discharged.

### 4.17.5 Dust hazard and nuisance

The Contractor shall take necessary measures including the spraying of water in order to keep down dust, which would otherwise be raised by the carrying out of the Works.

### 4.17.6 Fire hazard (naked lights)

No naked light shall be used by the Contractor on or about the Site without the consent of the Engineer. If in the Engineer's opinion the use of naked lights may cause a fire hazard, the

Contractor shall at no extra cost to the Employer take such additional precautions and provide such additional fire fighting equipment (including breathing apparatus) as the Engineer considers necessary.

The term "naked light" shall be deemed to include open fires, electric arcs and oxy-acetylene or other flames used in welding or cutting metals.

### 4.17.7 Water supplies

All water for use in the Works shall be fresh and free from harmful impurities to the satisfaction of the Engineer. The Contractor shall make adequate arrangements to deliver sufficient water to the Site for drinking, washing, sanitation and general cleaning down, in addition to any required for the construction, erection, testing, setting to work, testing for performance and guarantees at Site, commissioning and maintenance of the Works.

### 4.18 Work in the vicinity of electrical equipment

Any permanent fencing or other safeguards required to be erected around electrical equipment shall be completed as far as practicable before connection is made to the electricity supply. In so far as this is not practicable the Engineer may permit the use of temporary fencing or other safeguards.

If further work adjacent to electrical equipment is necessary after connection has been made to the electricity supply the Contractor shall put into operation a "Permit to Work" system to the approval of the Engineer.

### 4.19 Electricity supplies

The Contractor shall install, operate, maintain and subsequently remove temporary supplies of electricity for the heating, lighting and ventilation of all offices, stores and other temporary buildings used by the Contractor in addition to any supplies he may require in connection with the construction testing and maintenance of the Works. Such electricity supplies may be obtained either from NDPL Electricity and backed up with diesel generating plant provided by the Contractor.

The Contractor shall, at his own expense, supply, install, maintain and remove on completion, a temporary site electrical distribution system including wiring, cabling and distribution boards for power services, welding, lighting and all other electrical requirements in a safe and efficient manner. The Contractor shall submit details of the proposed temporary electrical distribution system to the Engineer. The Engineer may require the disconnection or alteration of any part of the electrical distribution system which, in his opinion, is dangerous or otherwise unacceptable. The Contractor shall not remove any of the installation without the approval of the Engineer.

### 4.20 Compressed air

The Contractor shall supply any necessary compressed air plant and equipment required for erection, testing and commissioning of the Works.

Diesel engine driven compressors shall not be sited within buildings or in a location that may cause a health hazard to personnel due to exhaust fumes.

### 4.21 Cleanliness of the Site

During the period of erection, the Contractor shall maintain the area of his operations in a clean, tidy and safe condition. All disused materials, packages and other debris in connection with the Works shall be removed from the Site by the Contractor at his expense and at the earliest opportunity.

If, in the Engineer's opinion, at any time the Site or part of it are not sufficiently clean and tidy, the Contractor shall take all necessary steps to rectify the situation as directed by the Engineer.

### 4.22 Contractor's offices etc

For the use of his own staff and work force the Contractor shall provide erect construct, maintain and subsequently remove all temporary offices, sanitary arrangements, stores, workshops, compounds, parking areas and the like necessary for the completion of the Works and maintenance of the Permanent Works and the siting and layout of these shall be to the approval of the Engineer.

The Contractor may if he chooses, include a workers canteen within the Contractor's office and storage compound. The Contractor shall not erect labour lines and canteens elsewhere on site.

Details and layout of such buildings and services shall be to the general approval of the Engineer and the Contractor shall also obtain any necessary approval from any local or other authorities concerned.

The Contractor shall maintain all offices, buildings, tanks etc referred to in this and other clauses in good condition.

# SUB-SECTION 5. HEALTH, SAFETY AND WELFARE

## 5.1 Applicable Regulations, Acts etc.

The Contractor shall comply with the relevant requirements of all local and the national health, safety and welfare acts and regulations issued by the Ministry of Labour (MoL) and other wings of the Government.

Compliance with the requirements of acts and regulations by the Contractor shall not relieve the Contractor from responsibility for the safety of his workers and employees and those of his subcontractors.

## 5.2 Failure to comply

In the event that the Contractor fails to comply with the requirements of the regulations or with the Specification in respect of safe working conditions or practices on the Site, the Engineer will have the authority to instruct the Contractor to stop work in any particular location until the unsafe conditions or practices have been rectified to the satisfaction of the Engineer. The Engineer will issue safety violation notices to the Contractor, informing him that he is working unsafely and describing the nature of the unsafe working practice, the time and date and the location. In this event, the Contractor shall be responsible for all costs and delays resulting from complying with such instruction by the Engineer and for the actual costs incurred on rectification of the unsafe conditions or practices.

## 5.3 Contractor's health, safety, welfare and security implementation plan

The Contractor shall prepare and submit to the Engineer for review a Site implementation plan specific to health, safety, welfare and security practices of the work to be carried out under the Contract. The Contractor shall carry out all work on the Site in accordance with the agreed Site implementation plan. The Contractor's plan shall reflect the requirement of the local and national requirements. It will include a methodology for carrying out risk assessments by the Contractor where these are deemed necessary. The plan will be updated from time to time to reflect any significant changes to laws and regulations or site activities.

## 5.4 Contractor's health, safety, welfare and security (HSWS) officer

The Contractor shall appoint a qualified and experienced HSWS officer for the duration of the Contract. The full time duty of the officer will be to implement the site implementation plan, to prevent accidents and enforce the requirements of legislation in force. The name and qualifications of the officer so designated shall be submitted to the Engineer by the Contractor for approval within two weeks of the commencement of the Contract. The officer shall attend full time on site during normal working hours and whenever work is in progress during out of hours working, public and national holidays approved by the Engineer and available by phone and mobile during non-working hours.

The Contractor shall engage senior site engineers and foremen that are properly trained in the application of correct Health and Safety practices. These individuals shall liaise closely with the

HSWS to maintain safety on site at all times. The Contractor shall submit the details of the Health and Safety qualifications of all such site personnel.

The HSWS officer will be responsible for ensuring all relevant information and posters are displayed at locations throughout the site in accordance with the site implementation plan.

The HSWS officer will be responsible for keeping a site accident book to record all site incidents or any major site rescue events. The book will be available for inspection by the Engineer or any MOL authorised person. Record keeping must also be maintained to comply with any other legal or regulatory requirements.

The HSWS officer will be responsible for ensuring that every site worker and regular visitor is given site HSWS procedure training when they first enter the site and refresher training at an appropriate frequency agreed by the Engineer. All occasional visitors will be trained on arrival and be provided with the appropriate personal, protective equipment. Records of the training will be kept and available for inspection by the Engineer.

### 5.5 First aid facilities

The Contractor shall provide a complete approved first aid kit in his site office. The kit shall be in the charge of either the Contractor's HSWS Officer or some other responsible person who will also be on the site during all working hours to ensure that the first aid kit is available without delay. Kits shall also be provided at all remote sites. The HSWS Officer and adequate numbers of other senior members of the Contractor's staff shall be trained in occupational site first aid duties including resuscitation to take account of numbers of site workers located on the permanent site and mobile site operations.

The Contractor will make arrangements with the emergency and rescue services to provide adequate support where on site first aid assistance is inadequate to meet the welfare requirements of all site workers.

The Contractor shall comply fully with all rules and regulations from time to time issued and orders given by the Health Service of the Government or the local medical or sanitary authorities.

### 5.6 Overhead hazards

Overhead protection shall be provided at any location where there is a hazard of falling objects. This shall particularly be observed around any scaffolding and in excavations.

‘Goalposts’ shall be erected beneath all overhead lines to prevent the arms or jibs of plant from approaching such lines. No plant shall be trafficked beneath overhead lines until the Engineer has inspected and approved the erected goalposts.

### 5.7 Excavations or underground hazards

Every excavation or underground space into or through which a person may fall shall be covered by a temporary cover fixed securely in position or guarded by an effective barrier to prevent falls except where free access is required by work actually in progress. In such a case where

work is in progress, the barrier shall be maintained in position to the extent possible, and suitable warning signs shall be erected.

### 5.8 Drowning hazards

Where the work involves filling tanks with water leaving an open surface, the Contractor shall provide at all times and at suitable locations equipment for promptly rescuing persons from the water and resuscitating rescued persons. The Contractor shall take all necessary steps to prevent any such accidents occurring by providing adequate guarding.

### 5.9 Slipping hazards

The Contractor shall not suffer or permit an employee to use a passageway, or a scaffold, platform or other elevated working surface which is in a slippery condition. Oil, grease, water and other substances causing slippery footing shall be removed, sanded or covered to provide safe footing.

### 5.10 Tripping hazards

All passageways, platforms and other places of work shall be kept free from accumulations of dirt and debris and from other obstructions that may cause tripping. Sharp projections shall be removed or covered.

### 5.11 Access to workplace

Temporary stairways, ramps or runways shall be provided as the means of access to working levels above or below ground except where the nature or progress of the work prevents their installation, in which case ladders or other safe means shall be provided. The Contractor shall not assume that access arrangements provided by the Employer will necessarily remain in place after the time that the Contractor commences work in a particular area.

### 5.12 Dust and gases

Dust and gases shall be controlled by ventilation or otherwise so as to prevent concentrations tending to injure health or obstruct vision or from exceeding safe levels.

### 5.13 Hazardous and corrosive substances

All alkalis, acids, gases and other hazardous and corrosive substances shall be so stored and used so as not to endanger employees in accordance with national and state regulations. Suitable protective equipment for the use of such substances shall be provided. Clean water supply shall be readily available for washing off any spillage of any corrosive substance on the employees.

### 5.14 Eye and ear protection

Suitable eye protection equipment shall be provided for and shall be used by employees while engaged in welding or cutting operations or in chipping, cutting or grinding any material from which particles may fly, or while engaged in any other operation which may endanger the eyes.

The Contractor shall ensure that fully equipped eye washing facilities are available on permanent and mobile site locations. Ear protectors shall be made available for employees when operating noisy machinery.

### 5.15 Respiratory and resuscitation equipment

Where required the Contractor shall provide sufficient numbers of respiratory equipment and the employee shall be trained to use respiratory equipment suitable for the type of operation for which it is to be used. The Contractor shall maintain such respiratory equipment in good condition and shall furnish the means for its continued efficient working condition. The Contractor shall provide regular inspection, cleansing and sterilisation of such equipment. Such equipment, when not in use, shall be stored in an accessible, closed container.

The respiratory equipment shall be either of the escape set type, where it is provided for possible emergency use, or working sets where work has to be carried out in conditions where toxic gases are present or where there may be a deficiency of oxygen identified by the HSWS officer or his appointed staff when a risk assessment is undertaken prior to a site operation commencing. Risk assessments will be available for inspection by the Engineer immediately on request.

All persons who may be required to use such equipment shall be adequately trained and shall have certificates to that effect. Individual certificates will be available for inspection from all authorised workers by the Engineer.

### 5.16 Work in confined spaces

Where work is required to take place in a confined space, defined as an enclosed space or excavation with limited access and where there is no natural ventilation, the Contractor shall provide equipment for monitoring the quality of the atmosphere within the space. The equipment will be calibrated to occupational standards to measure the range of gases and atmospheres identified as part of the risk assessment undertake prior to entry. The equipment shall be used to check the atmosphere before personnel enter, and shall remain in place while work is in progress to ensure that the confined space is free of harmful or noxious gases. The Contractor shall not permit anyone to enter or work in a confined space, including personnel from other contractors, the Engineer staff or the Employer's staff if harmful or noxious gases are detected. Any personnel inside shall be evacuated immediately.

Prior to the commencement of the work, the Contractor will document a safe system of work which will be available for inspection by the Engineer.

All personnel working in such conditions shall be provided with escape sets. The Contractor shall provide a "top-man" who shall be stationed immediately outside the entrance to the confined space, and who shall maintain communication with personnel working inside the confined space. In the event of a transverse entry, this may require additional personnel to be used to facilitate a reliable line of communication if evacuation has to take place. The top man shall have the means to raise the alarm in case of any emergency inside the confined space.

The Contractor shall provide adequate ventilation for workers carrying out work inside a confined space, pipeline or chamber or other enclosed areas by using blowers or other suitable means.

### 5.17 Personal Protective Equipment (PPE)

Every site worker and visitor shall be provided with a full set of personal protective equipment for use at all times including a luminous vest, helmet of a type tested and approved by the MOL, steel toe-capped boots, gloves and other specific work related clothing offering ear and eye protection. All site workers and visitors shall be required to wear PPE while working on the Site. The Contractor shall display a notice on the access to the site stating that entry is for authorised personnel only, and that PPE is to be worn at all times.

Every employee required to work in water, wet concrete or other wet footing shall be provided with suitable safety, waterproof boots.

Every employee required to use or handle alkaline, acid or other corrosive substances shall be provided with appropriate PPE.

### 5.18 Electrical hazards

Before work commences, the Contractor shall ascertain by inquiry or direct observation, or by instruments, where any part of an electric power circuit exposed or concealed is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact therewith. The Contractor shall post and maintain proper warning signs to his employees of the location of such lines, the hazards involved and the protective measures to be taken and shall, if practicable, de-energise the electric power circuit.

The Contractor shall not suffer or permit an employee to work in such proximity to any part of an electric power circuit that he may contact the same in the course of his work unless the employee is protected against electric shock by de-energising the circuit and earthing it or by guarding it, by effective insulation or other means acceptable to the Engineer. The location of underground powerlines that encroach on the Works shall be confirmed using cable detectors, the path of the cable shall be clearly marked. If such cables are adjacent to excavations, the cable location shall be confirmed by finding the cable using carefully controlled hand-dig methods under the supervision of a senior member of the Contractor's staff. No live cables shall be retained within working trenches or other excavations. Any such cables shall be diverted prior to excavation commencing. The Contractor shall at all times liaise with the local electricity supplier with regard to the locating and diverting of any supplies.

### 5.19 Power driven saws, abrasive wheels and grinders

All portable power-driven hand operated saws, abrasive wheels and grinders shall be equipped with guards above the base plate which completely protects the operator from contact with the saw blade when in motion and with self-adjusting guards below the base plate which completely covers the saw to the depth of the teeth when the saw is removed from the cut.

### 5.20 Public vehicular traffic

Whenever any work is being performed over, on, or in proximity to a highway or any other place where public vehicular traffic may cause danger to men at work, the working area shall be so barricaded as to direct traffic away from it or the traffic shall be specially controlled by

persons designated for that purpose.

### 5.21 Site traffic

All vehicles used at the worksite must be roadworthy and registered with the appropriate authority. No person shall drive a vehicle at the worksite unless they are a holder of the appropriate driving licence or certificate.
A site internal access management system including all appropriate road signs will be submitted by the Contractor to the Engineer for approval at the commencement of the Contract.

### 5.22 Stability of structures

No section of the plant or other structure or part of a structure shall be left unguarded in such condition that it may fall, collapse or be weakened due to wind pressure or vibration.

### 5.23 Storage of materials and equipment

All materials shall be stored or stacked in a safe and orderly manner so as not to obstruct any passageway or place of work. Material piles shall be stored or stacked in such a manner as to ensure stability. Hazardous materials shall be stored in secure areas and the HSWS shall maintain an up-to-date list of the persons with a key to those areas.

### 5.24 Disposal of debris

Debris shall be handled and disposed of by a method which will not endanger persons. Debris shall not be allowed to accumulate so as to constitute a hazard.

### 5.25 Excavations

No employee shall be permitted to enter any excavated area, including areas excavated by other contractors on the Site, unless sheet piling, shoring or other safeguard that may be necessary for his protection is provided. In most cases, excavations will be considered to be confined spaces and the appropriate procedures followed.

Where any employee in an excavation is exposed to the hazard of falling or sliding material from any bank or side more than 1.5 m high above his footing, adequate piling and bracing shall be provided against the bank or side to eliminate such hazard. The excavation and its vicinity shall be checked by a designated person after every rain, storm or other hazard-increasing occurrence and the protection against slides and cave-ins increased if necessary.

Shoring adequate to support the overhanging material shall be provided where banks are undercut.

Excavated material and other superimposed loads shall be placed at least 1 m back from the edge of open excavations and trenches and shall be so shored or retained that no part thereof can fall into the excavation, or cause the banks to slip or cause the upheaval of the excavation bed. Banks shall be stripped of loose rock or other materials which may slide, roll or fall upon persons below.

Open sides of excavations where a person may fall more than 1.5 m shall be guarded by adequate barricades, and suitable warning signs shall be put up at conspicuous positions.
No employee shall be allowed to work where he may be struck or endangered by an excavating machine with which his activity is not directly related.

### 5.26 Ladders, step ladders and access platforms

Every ladder, step-ladder and access platform shall be of good construction, sound material and adequate strength for the purpose of which it is used. Ladders, step-ladders and access platforms shall not stand on loose bricks or other loose packing, but shall have a levelled and firm footing. Ladders of over 2m in height shall be securely tied to the structure it is propped against. Free-standing, portable ladders over 4m in height shall not be used.

### 5.27 Working at height

All site workers who work at height shall be provided with appropriate PPE to prevent an accident by slipping or falling.

### 5.28 Positioning of machinery

No person shall be permitted to position or operate machinery in a manner likely to endanger himself or others.

### 5.29 Fixed and mobile cranes

Fixed and mobile cranes shall be so constructed, positioned and operated as to be stable. No crane shall be loaded beyond the safe working load except by an approved person or an inspector for the purpose of testing such machine.

Every crane including all blocks, shackles, sheaves, wire ropes and the various devices on the mast and jib shall be thoroughly inspected by an approved person at intervals not exceeding 12 months. Cranes shall be inspected before being first erected or operated on each job or after any major repair. Inspection and repair of crane jib shall be made only when the jib is lowered and adequately supported.

Outriggers and counter-weights shall be provided and used as specified by the manufacturer of the crane or by an approved person. Counter-weights shall be properly placed and secured. Levelling jacks or other suitable means shall be provided and used with outriggers of truck-mounted mobile cranes.

Firm and uniform footing shall be provided for cranes. When such a footing is not otherwise supplied it shall be provided by substantial timber, or other structural members sufficient to distribute the load so as not to exceed the safe bearing capacity of the underlying material.

Every power-operated crane shall be provided with efficient brake or brakes or other locking devices which will prevent the fall of the load when suspended and by which the load can be effectively controlled whilst being lowered. Hand or foot-operated bakes shall be provided with a substantial locking device to lock the brake in engagement.

No load-bearing part of any crane shall be replaced by another part, and no such machine shall be modified by the addition thereto or removal therefrom of any load bearing part, unless the replacement or modification shall be certified by either the manufacturer or the approved person who tested the crane.

A capacity chart shall be provided for every crane. Such chart shall be posted and maintained in a place clearly visible to the operator and shall set forth the safe loads for various lengths of jib at various jib angles and radial distances. Where outriggers are provided such loads shall be set forth with and without the use of outriggers.

Unless furnished by the manufacturer or builder of the crane, a capacity chart shall be prepared and certified by an approved person. Cranes shall have audible overload warning alarms.

A crane shall not lift any load that exceeds the corresponding safe working load specified by its capacity chart.

Every crane having a jib shall be provided with an accurate indicator which shows, clearly to the operator, the radius of the jib and the safe working load corresponding to that radius at all times and gives warning signal when the radius is unsafe.

Before hoisting any load at a new job site, the jib shall be operated to its maximum height.

Crane cabs shall be locked when the operator is not present and no unauthorised person shall enter the cab or remain immediately adjacent to any crane in operation. If locking of a crane cab is impracticable, the operating mechanism shall be locked as to prevent the crane from being operated by an unauthorised person.

No crane shall be operated in such a location that any part of the crane or of its load in any position of jib or swing may come within 3 metres of live power line.

All the lifting equipment used at site shall be registered with the appropriate GOI Ministry and shall have a valid certificate at the time of usage.

All crane operatives should be authorised to operate the particular type of fixed or mobile crane. Valid certificates will be available for inspection by the Engineer. All crane men will be formally trained to undertake their duties and refresher training will be given at an appropriate frequency agreed by the Engineer.

### 5.30 Attachment of loads

Where a sling is employed to hoist long-length material, a lifting beam shall be used to space the sling legs for proper balance. When load is suspended at two or more points with slings, the eyes of the lifting legs of the slings shall be shackled together and this shackle or the eyes of the lifting legs may be shackled directly on the hoisting block or balance beam. The eyes may be placed on the lifting hook without shackles if the hook is of the safety type.

Each container or receptacle used for raising or lowering filter media or other loose material of

any kind shall be so enclosed, constructed or designed as to prevent the accidental fall of such material.

Crane loads shall be raised vertically so as to avoid swinging during hoisting.

No crane shall travel with a suspended load except upon a safe runway. During travel without loads, crane's falls shall be secured or placed so as to prevent accident or damage by swinging.

## 5.31 Emergency Response Procedure

### 5.31.1 Coverage

Contractor shall prepare 'Emergency Response and Evacuation Procedure' separately under assistance of the Engineer. It will cover following emergencies:

i. Fire / Explosion
ii. Accident of serious nature
iii. Floods
iv. Man lost
v. Storm & Lightening with rain

The 'Emergency Response & Evacuation Procedure' will be available from the Contractor's Safety Officer and a copy provided to the Employer and Engineer.

### 5.31.2 Emergency Drills

Emergency drills shall be conducted every month at least at one working site, to test the proficiency of the workforce to handle the specific emergency. Each drill will be agreed upon with the Engineer prior to the drill. However, the drills will be carried out without warning, thereby demonstrating preparedness for response. The Safety Officer will maintain report of the emergency drills. Any action points arising out of the drill will be discussed with the Engineer and concerned employees and then the corrective actions shall be taken.

## 5.32 Occupational Safety and Health Audit

The Contractor should carry out the audit of the Occupational Safety and Health (OS&H) systems at workplace in accordance with IS 14489 periodically and submit a report to the Engineer. The frequency of such audits shall be 1 year for external audit and half-yearly for internal audits.

## 5.33 Contractor's Environmental Management Plan

The detailed requirements regarding Environmental Management Plan is given in separate chapter. The Contractor shall strictly observe and comply with the same.

The Contractor shall employ one full time inspector for supervising compliance with the environmental management plan. The environmental inspector shall keep one set of current environmental standards and regulations at the site at all times, available for consultation. The environmental inspector shall submit an Environmental Management Plan and a monthly environmental report for approval by the Engineer.

The Contractor shall regularly spray water on dry surfaces to reduce dust problems. The Contractor shall regulate vehicle emission and noise in accordance with current legislation of India. The Contractor shall avoid unnecessary noise, especially at night.

The Contractor shall remove and store topsoil for replacement after construction. The Contractor shall restore the surface vegetation in his work areas to the level found before the start of work. This includes the replacement of topsoil removed before construction.

The Contractor shall prevent spills of oil and lubricants from vehicles, engines, etc. Used engine oil must be removed in an environmentally acceptable manner in accordance with current legislation of India.

The Contractor shall work in strict compliance with the principles of the Environmental Management Plan. No part of the work shall be started before environmental and safety inspectors and first aid arrangements are present at the site. No part of the work shall be started, or if defects are found later, continued or restarted before complying with all conditions of this Section.

The Contractor shall remedy any damages resulting from non-compliance of stipulations of the Sub-section at his own cost. All work shall be stopped until compliance is assured.

If the Contractor is not able or unwilling to start remedial work within five working days after detection of any defect or omission, the Engineer can order remedial works through third parties. The costs for third-party services are to be borne by the Contractor and shall be deducted from the Contractor's invoices or from the Retention Money.

# SUB-SECTION 6. DELHI JAL BOARD CODES

## 6.1 General

The Contractor shall strictly follow Delhi Jal Board codes and other regulations given herein wherever relevant. In case of any conflict between these provisions and the relevant IS codes or other guidelines or in other sections of these documents, the contractor should follow whichever is more stringent or as per the direction of the Engineer.

## 6.2 Delhi Jal Board Safety Code

1. Suitable scaffolds should be provided for workmen for all works that cannot safely be done from the ground or from solid construction except such short period work as can be done safely from ladders. When a ladder is used an extra Mazdoor shall be engaged for holding the ladder and if the ladder is used for carrying materials as well suitable footholds and hand –hold shall be provided on the ladder and the ladder shall be given an inclination not steeper than ¼ to 1 (1/4 horizontal and 1 Vertical.)

2. Scaffolding of staging more than 3.6 m (12 ft.) above the ground or floor, swung or suspended from an overhead support or erected with stationary support shall have a guard rail properly attached or bolted, braced and otherwise secured at least 90 cm (3ft.) high above the floor, or platform of such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such opening as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure.

3. Working Platforms, gangways and stairways should be so constructed that they should not sag unduly or unequally and if the height of the platform or the gangway or the stairway is more than 3.6 m (12ft.) above ground level or floor level. They should be closely boarded should have adequate width and should be suitably fastened as described in (2) above.

4. Every opening in the floor of a building or in a working platform shall be provided with suitable means to prevent the fall of person or materials by providing suitable fencing or railing whose minimum height shall be 90 cm. (3ft).

5. Safe means of access shall be provided to all working platforms and other working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9 m (30 ft.) in length while the width between side rails in rung ladder shall in no case be less than 29 cm for ladder up to and including 3 m (10 ft.) in length. For longer ladders this width should be increased at least ¼" for each additional 30 cm (1 foot) of length. Uniform step spacing of not more than 30 cm shall be kept. Adequate precautions shall be taken to prevent danger from electrical equipment. No materials on any of the sites or work shall be so stacked or placed as to cause danger or inconvenience to any person or the public. The contractor shall provide all necessary fencing and lights to protect the public from accident and shall be bound to bear the expenses of defense of every suit, action or other proceedings at law that may be brought by any person for injury sustained owing to

neglect of the above precautions and to pay any damages and cost which may be awarded in any such suit, action or proceedings to any such person or which may, with the consent of the contractor, be paid to compensate any claim by any such person.

6. Excavation and Trenching- All trenches 1.2 m (4ft) or more in depth shall at all times be supplied with at least one ladder for each 30 m (100 ft. ) in length or fraction there of Ladder shall extend from bottom of the trench to at least 90 cm. (3 ft. ) above the surface of the ground. The sides of the trenches which are 1.5 m (5ft.) or more in depth shall be stepped back to give suitable slope or securely held by timber bracing, so as to avoid the danger of sides collapsing. The excavated materials shall not be placed within 1.5 m (5ft) of the edges of the trench or half of the depth of the trench whichever is more. Cutting shall be done from top to bottom. Under no circumstances undermining or undercutting shall be done.

7. Demolition- Before any demolition work is commenced and also during the progress of the work.
   i. All roads and open areas adjacent to the work site shall either be closed or suitably protected.
   ii. No electric cable or apparatus which is liable to be a source of danger ore cable or apparatus used by the operator shall remain electrically charged.
   iii. All practical steps shall be taken to prevent danger to persons employed from risk of fire or explosion or flooding. No floor, roof or other part of the building shall be so overloaded with debris or materials as to render it unsafe.

8. All necessary personal safety equipment as considered adequate by the Engineer should be kept available for the use of the person employed on the site and maintained in a condition suitable for immediate use. And the contractor should take adequate steps to ensure proper use of equipment by those concerned: - The following safety equipment shall invariably be provided.

   i. Workers employed on mixing asphalt materials, cement and lime mortars shall be provided with protective footwear and protective goggles.
   ii. Those engaged in white washing and mixing or stacking of cement bags or any material which is injurious to the eyes shall be provided with protective goggles.
   iii. Those engaged in welding works shall be provided with welder's protective eye shields.
   iv. Stone breaker shall be provided with protective goggles and protective clothing and seated at sufficiently safe intervals.
   v. When workers are employed in sewers and manholes which are in active use the contractors shall ensure that the manhole covers are opened and ventilated at least for an hour before the workers are allowed to get into the manholes and the manholes so opened shall be cordoned off with suitable railing and provided with warning signals or boards to prevent accident to the public in addition. The contractor shall ensure that the following safety measure are adhered to:

      a) Entry for workers into the line shall not be allowed except under supervision of the JE or any other higher officer.
      b) At least 5 to 6 manholes upstream and downstream should be kept open for

at least 2 to 3 hours before any man is allowed to enter into the manhole for working inside.

c) Before entry presence of Toxic gases should be tested by inserting wet lead acetate paper which changes colour in the presence of such gases and gives indication of their presence.

d) Presence of Oxygen should be verified by lowering a detector lamp into the manhole. In case no Oxygen is found inside the sewer line, workers should be sent only with Oxygen kit.

e) Safety belt with rope should be provided to the workers. While working inside the manholes such rope should be handled by two men standing outside to enable him to be pulled out during emergency.

f) The area should be barricaded or cordoned off by suitable means to avoid mishaps of any kind. Proper warning signs should be displayed for the safety of the public whenever cleaning works are undertaken during night or day.

g) No smoking or open flames shall be allowed near the blocked manhole being cleaned.

h) The malba obtained on account of cleaning of blocked manholes and sewer line should be immediately removed to avoid accidents on account of slippery nature of the malba.

i) Workers should not be allowed to work inside the manhole continuously. He should be given rest intermittently. The Engineer- in- charge may decide the time up to which a worker may be allowed to work continuously inside the manhole.

j) Gas masks with Oxygen cylinder should be kept at site for use in emergency.

k) Air- blowers should be used for flow of fresh air through the manholes. Whenever called for portable air blowers are recommended for ventilating the manholes. The Motors for these shall be vapour proof and of totally enclosed type. Non sparking gas engines also could be used but they should be placed at least 2 meters away from the opening and on the leeward side protected from wind so that they will not be a source of friction on any inflammable gas that might be present.

l) The workers engaged for cleaning the manholes sewers should be properly trained before allowing working in the manhole.

m) The workers shall be provided with Gumboots or non-sparking shoes , bump helmets and gloves non sparking tools safety lights and gas maska and portable air blowers (when necessary). They must be supplied with barrier cream for anointing the limbs before working inside the sewer lines.

n) Workmen descending a manhole shall try each ladder stop or rung careful before putting his full weight on it to guard against insecure fastening due to corrosion of the rung fixed to manhole well.

o) If a man has received a physical injury, he should be brought out of the sewer immediately and adequate medical aid should be provided to him.

p) The extents to which these precautions are to be taken depend on individual situation but the decision of the Engineer- in- Charge regarding the steps to be taken in this regard in an individual case will be final.

vi. The Contractor shall not employ men and women below the age of 18 years on the work of painting with products containing lead in any form. Wherever men above the age of 18 are employed on the work of lead painting. The following precaution

should be taken:-

a) No paint containing lead or lead products shall be used except in the form of paste or readymade paint.
b) Suitable face masks should be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint is dry rubbed and scraped.
c) Overalls shall be supplied by the contractors to the workmen and adequate facilities shall be provided to enable the working painters to wash during and on the cessation of work.

9. Contractor shall not employ women and men below the age of 18 on the work of painting with product containing lead in any form. Wherever men above the age of 18 are employed on the work of lead painting, the following principles must be observed for such use:

i. White lead, sulphate of lead or product containing these pigment, shall not be used in painting operation except in the form of pastes or paint ready for use.
ii. Measures shall be taken wherever required in order to prevent danger arising from the application of paint in the form of spray.
iii. Measures shall be taken, wherever practicable, to prevent danger arising out of from dust caused by dry rubbing down and scraping.
iv. Adequate facilities shall be provided to enable working painters to wash during and on cessation of work.
v. Overall shall be worn by working painters during the whole of working period.
vi. Suitable arrangement shall be made to prevent clothing put off during working hours being spoiled by painting material.
vii. Cases of lead poisoning and suspected lead poisoning shall be notified and shall be subsequently verified by medical man appointed by competent authority of DJB.
viii. DJB may require, when necessary medical examination of workers.
ix. Instructions with regard to special hygienic precautions to be taken in the painting.

10. When the work is done near any place where there is risk of drowning, all necessary equipment should be provided and kept ready for use and all necessary steps taken for prompt rescue of any person. In danger and adequate provision, should be made for prompt first aid treatment of all injuries likely to be obtained during the course of the work.

11. Use of hoisting machines and tackle including their attachments, anchorage and supports shall conform to the following standards or conditions:

i. These shall be of good mechanical construction. Sound materials and adequate strength and free from patent defects and shall be kept repaired and in good working order.
ii. Every rope used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength and free from patent detects.
iii. Every crane driver or hoisting appliances operator shall be properly qualified and

no person under the age of 21 years should be in charge of any hoisting machine including any scaffolding winch or give signals to operator.

iv. In case of every hoisting machine and of every chain ring hook, shackle swivel and pulley block used in hoisting or as means of suspension the safe working load shall be ascertained by adequate means. Every hoisting machine and all pears referred to above shall be plainly marked with the safe working load. In case of a hoisting machine having a variable safe working load each safe working load and the condition under which it is applicable shall be clearly indicated. No part of any machine or any gear referred to above in this paragraph shall be loaded beyond the safe working load except for the purpose of testing

v. In case of departmental machines, the safe working load shall be notified by the electrical Engineer- in –charge. As regards contractors machines the contractor shall notify the safe working load of the machine to the Engineer -in- charge whenever he brings any machinery to site of work and get it verified by the Electrical Engineer concerned.

12. Motors, gearing, transmission, electric wiring and other dangerous parts of hoisting appliances should be provided with efficient safeguards. Hoisting appliances should be provided with such means as will reduce to the minimum the risk of accidents descent of the load. Adequate precautions should be taken to reduce to the minimum the risk of any part of a suspended load becoming accidentally displaced. When workers are employed on electrical installations, which are already energized. Insulating mats, wearing apparel such as gloves, sleeves and boots as may be necessary should be provided. The worker should not wear any rings, watches and carry keys or other materials which are good conductors of electricity.

13. All scaffolds, ladders and other safety devices mentioned or described herein shall be maintained in safe condition and no scaffold, ladder or equipment shall be altered or removed while it is in use. Adequate washing facilities should be provided at or near places of work.

14. These safety provisions should be brought to the notice of all concerned by display on a notice board at a prominent place at work spot. The person responsible for compliance the safety code shall be named therein by the contractor.

15. To ensure effective enforcement of the rules and regulations relating to safety precautions the arrangements made by the contractor shall be open to inspection by the labour Officer or Engineer- in- Charge of the department or their representatives.

16. Notwithstanding the above Clauses from (1) to (15) there is nothing in these to exempt the contractor from the operations of any other Act or Rule in force In the Republic of India.

### 6.3 Safety Guidelines as per DJB circular dated: 12.06.2009

Following guideline/ instructions should be adhered to in true spirit:-

1. The door may be fixed at the entry of the stair case and the open portion of the staircase

of sump well should be protected by grill up to the height of 7 feet and compartments of the sump well should be covered with jallis/ grating or should be barricaded properly. Sewage pumping station should be secured by providing and fixing barbed wire fencing over the Boundary wall.

2. An inspection register should be placed at the sewerage pump house in which all the inspecting officers may record their observations. No unauthorized entry should be allowed.

3. Caution board showing the restricted entry area and name of components and moving mechanical part should be displayed.

4. The entry to all DJB infrastructures should be restricted to the person/ persons authorized by DJB or having I.D cards issued by the chief security officer.

5. Just after entering the premises do's and don'ts should be displayed at prominent places in all four languages.

6. Even authorized visitors should be provided proper uniform / visitor badges helmet and relevant safety gear and given instruction before showing such infrastructure.

No person below 18 years age should be allowed on the premises where chances of mission toxic gases are extensive.

# SUB-SECTION 7. INSPECTION AND TESTING OF PLANT & MATERIALS

## 7.1 Off-Site inspection and testing of Plant, Equipment and Construction Materials

The Contractor shall offer all items of Plant, Equipment and Construction Materials for inspection and testing by the Engineer and shall include for the testing of all Plant, Equipment and Materials as required by the Specification. The Engineer may witness any test, at his sole discretion. No Plant or materials for inclusion in the Works shall be brought in or dispatched from any manufacturer's works without the written permission of the Engineer.

As soon as practicable after receiving the order to commence the works, the contractor shall inform of the names of the Suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the Engineer which may be withheld until samples have been submitted and satisfactorily tested.

All plant, equipment and materials like pipes and fittings, pipe specials, valves, flow meters, pumps, generators, electrical and ICA equipment etc. including cement, aggregate, water, admixtures, structural steel and steel for reinforcement shall be of the best quality and subject to the mandatory tests. These tests shall be performed by the governmental agency or laboratories as approved or directed by the Engineer. All the testing charges including sampling, packaging, conveyance, test fees etc. shall be borne by the contractor, which is deemed to be covered by the Contract Price.

The Contractor shall make all necessary arrangements for to and fro travels for DJB Engineers/Officers for pre-delivery inspection in India and Abroad. The entire travelling cost including ticketing, boarding and lodging of the members of the DJB and PMSC team shall be borne out of the **contract provisional sum** by the Contractor (as per RBI Guideline for overseas visit). The Contractor shall keep a provision in the programme for 4 weeks' notice for inspection in India and 12 weeks' notice for testing/inspection overseas. The Contractor shall make all necessary arrangements for to and fro travels for DJB and PMSC Engineers/Officers for pre-delivery inspection in India and Abroad.

If during off-site testing, any Plant or materials fails to meet the requirements of the Specification, the defects shall be rectified forthwith. The rectified item shall be offered for re-inspection and witness testing, and all resulting additional costs incurred shall be borne by the Contractor.

When the Contractor is ready to carry out any off-Site test, he shall submit a detailed test procedure to the Engineer. The proposals shall give values, such as test parameters and make reference to Specification or Standards. The proposed format for the test sheets shall be submitted at the same time. The testing shall not start until the Contractor's proposals and test sheets have been approved by the Engineer.

No inspection or approval by the Engineer of the Plant or materials covered by the Contract shall release the Contractor from any of his obligations under the Contract.

In addition to above, before finalizing the Design and/or Procurement of major Plant & Equipment, the Contractor shall arrange for the Engineer/Employer's personnel to visit such places, nationally or internationally, if required by the Employer, in order to get acquainted with the Technology, Plant & Equipment proposed.

# SUB-SECTION 8. DELIVERY, STORAGE AND ERECTION OF E/M EQUIPMENT

## 8.1 Packaging and marking

Upon the successful completion of the prescribed off-Site testing and inspection and prior to despatch from the place of manufacture, all items of electro-mechanical equipment shall be thoroughly protected against corrosion and incidental damage from any cause.

Items intended to be painted shall receive the treatment specified and all unpainted parts liable to corrosion (with the exception of the electrical equipment) shall be thoroughly coated with high melting point grease or other approved protective substance, which is easily removable.

Electrical equipment shall be suitably protected against corrosion and incidental damage to the satisfaction of the Engineer. Temporary leads shall be fitted to electrical equipment to enable anti-condensation heaters to be energised when the plant is in store. The heaters shall be energised by the Contractor when conditions require.

Items shall be packed to withstand rough handling in transit. Packages shall be suitable for exposure to the atmosphere and storage in the open. The Contractor shall be responsible for items reaching the destination undamaged. The Contractor shall provide all necessary packing, cases and crates, properly strengthened. Packages containing dangerous or breakable goods shall be packed and marked in accordance with any statutory rules and orders applicable. Crates and packages shall be correctly and adequately marked.

The Contractor shall keep the Engineer informed of the state of deliveries. The Contractor shall send copies of all shipping documents to the Engineer. Shipping documents shall be accompanied by copies of test certificates as required.

## 8.2 Delivery

The Contractor shall be responsible for the safe delivery of items to the Site. Delivery of items shall comprise any of the following, which may be necessary but not be limited to:-

- Obtaining the necessary permits for all plant and equipment from relevant Authorities;
- Loading and transporting items by whatever means, including insurances;
- Taking charge of items at the port of entry or rail or air terminal in India, including payment of all handling charges, off-loading at terminal points, reloading and transporting to the Site;
- Taking delivery of items at the Site, off-loading and temporarily storing in store buildings or under cover until they are required for installation in the Works.

The Contractor shall examine items to the extent possible at the port or air or rail terminal, and more thoroughly whilst taking delivery at the Site. If the Contractor discovers that any item of Plant has been damaged in transit, he shall forthwith inform the Engineer who will inspect and may give instructions for its disposal.

Any item condemned by the Engineer shall be immediately removed and replaced by the Contractor.

Items with short shelf-life shall be delivered in the shortest possible time before use with the Plant.

## 8.3 Storage

The Contractor shall provide all facilities for the safe storage of Plant as recommended by the manufacturer. Stored items shall be laid out by the Contractor to facilitate their retrieval as required. Stacked items shall be protected from damage. No metalwork shall be stacked directly on the ground. Small items shall be held in suitable storage and shall be clearly labelled. Items shall be handled and stored so that they are not subjected to excessive stresses and their protective coatings are not damaged.

The Contractor shall comply with manufacturers' recommendations concerning the use of lifting arrangements.

## 8.4 Erection of Electro-Mechanical Plant and Equipment

Electro-mechanical Plant and equipment shall be erected in a neat and workmanlike manner on the foundations shown on the approved drawings. The Contractor shall be responsible for setting-up and erecting Equipment/ Plant to the line and level required and shall ensure that all equipment is securely held and remains in correct alignment during grouting-in. Foundations shall comply with the details shown on the approved drawings.

Where the Works are associated with are in physical contact with Equipment/ plant supplied under a separate contract, the Contractor shall satisfy himself that the work carried out by the other contractor is consistent with the correct operation of the Equipment/ plant. If the Contractor considers any work being done, or any work completed, to be detrimental to the plant, he shall report the matter at once to the Engineer.

The Contractor shall make all holes and openings in building structures required for fixing small plant items and shall provide any associated supports. If any other openings or holes or additional loads applied to the structures are found to be required, after approval of the drawings prepared by the Contractor, their locations and sizes and method of cutting shall be submitted by the Contractor to the Engineer for approval.

Any damage caused by the Contractor to any surface during erection shall be made good by the Contractor at his own expense to the satisfaction of the Engineer.

The Contractor shall be responsible for the provision of any scaffolding required.

## 8.5 Protective Coating and Plant protection on Site

On arrival at the Site all Plant shall be examined by the Contractor and the Engineer for damage to protective coatings. Damaged portions shall be cleaned down, all rust removed by grit blasting, if instructed by the Engineer, and the coating made good with a similar paint. The Contractor shall apply the protective coatings for the Plant at Site in accordance with the protective treatment system approved by the Engineer.

Plant shall be adequately protected during and after installation against damage to finished surfaces and fitted components and against ingress of dust, moisture and the effects of humidity. Structural finishing operations may have to be done near installed plant before it is taken-over and the Contractor shall take this into consideration in complying with the requirements.

# SUB-SECTION 9. COMMISSIONING TESTS AND TEST ON COMPLETION

## 9.1 Inspection

During execution of Work and/or erection of the Equipment/ Plant, the Engineer will inspect the execution/ installation from time to time in the presence of the Contractor to establish conformity with the Specification. Any deviations found shall be corrected forthwith to the satisfaction of the Engineer.

As soon as the Engineer is satisfied that the execution of Work and/or erection of the Equipment/ Plant and the Work/ Plant found to be in good working order and that the associated civil works have been substantially completed to an extent permitting the proper operation of the Work/ Plant, the Contractor shall start testing at Site.

## 9.2 Testing- General

Stages of testing at the Site shall be as follows:-

- **Individual tests** (also called pre-commissioning tests) which shall be at the first opportunity after installation of the Work/ Plant;
- **Commissioning tests** which shall be on whole systems to demonstrate to the Engineer that a section of the Works is ready to undergo trial operation;
- **Trial operation**

Before any testing involving water entering supply, disinfection of all Work/ Plant items in contact with water to be supplied shall be undertaken by the Contractor. The disinfection of structure and pipework shall be in accordance with the specification and subject to the approval of the Engineer.

When water is discharged to waste, the Contractor may, subject to such conditions as the Engineer and Employer may lay down, operate and adjust the Work/ Plant as necessary in order to test the operation of the Work/ Plant. No water shall be put into supply except with the prior authorisation of the Engineer and Employer and under such conditions as they may lay down.

No part of the Work/ Plant shall be set to work until it has been inspected and accepted by the Engineer.

## 9.3 Testing programme

The Contractor shall submit to the Engineer for his approval a programme for testing at least 28 days in advance of the proposed start of testing and shall agree the timing with the Engineer and Employer not less than one week before the start of testing.

The programme shall show the quantities of raw water and power required. Details of the proposed test procedures shall be submitted by the Contractor, including the manner and order in which each item of Work, Plant and Process will be tested. Associated flow rates and

durations shall be submitted, and log sheets shall be prepared for recording plant information and other operating, water quality parameters, and presentation and interpretation of test data. The programme shall be subject to approval by the Engineer and shall take into consideration the extent of progress on other contracts, the availability of water, power and the Employer's requirements for disinfection and discharges either to supply or to waste.

### 9.4 Labour, materials and sundry items for tests

For individual tests, commissioning tests and trial operation, the Contractor shall provide for all necessary labour, materials, chemicals, electricity, fuel, stores, apparatus, instruments and indicators necessary to carry out the tests. Electricity consumed during commissioning and trial run period shall be, however, paid by the Employer.

During testing of the Work/ Plant, until the issue of the Taking-Over Certificate, the Contractor shall be responsible for all work, plant and costs, except electricity cost, in connection with the commissioning of the Works.

The Contractor shall prepare test record sheets for recording of all test results for the approval of the Engineer at least one month before the programmed date for the tests.

### 9.5 Individual tests

Individual tests shall be in the presence of the Engineer and shall include the following:-

Hydraulic Test:
- Leakage tests for all water retaining structures and tanks;
- Hydrostatic pressure/ Leakage tests for pipe work.

Hydrostatic pressure/ Leakage tests shall be carried out on all pipe works. Where pipe work is to be built in, these tests shall be carried out after erection and before concreting. The Contractor shall ensure that the pipe work is suitably anchored and supported to sustain the pressure in the not-built-in condition.

Pipelines and valves shall be pressure tested to one and a half times working pressure unless otherwise specified.

Tests on all items of Plant and materials shall be in accordance with the requirements of the Specification and relevant Standard applicable to each items being tested.

- Electrical tests to demonstrate compliance of the electrical installation with specified and statutory requirements
- Operational test for all valves, appurtenances and equipment etc.
- Dry running test for all pumps, blowers, compressors, etc.
- Noise and vibration levels measurements shall be carried out for all rotating equipment.

All individual tests on items of plant or equipment making up a complete system shall be completed to the satisfaction of the Engineer, before starting the commissioning tests on that system.

## 9.6 Commissioning tests

The Contractor shall carry out such tests and re-tests on complete systems as are required to demonstrate to the satisfaction of the Engineer that substantial portions of the Works are ready to undergo the trial operation with a minimum of interruption in regular operation.

The commissioning tests shall demonstrate satisfactory performance of the items of Work/ Plant under normal operation and their response to abnormal and emergency conditions.

In case of Plant, each process system shall be set to work under manual control and commissioning tests shall be carried out for such time as is agreed by the Engineer as being appropriate. Subsequently the automatic control equipment shall be set to work and further commissioning tests shall be done.

The tests shall include simulation of the full ranges of alarm conditions over the full ranges of operation and include tests of emergency shutdown procedures including electricity power failure.

The period of commissioning tests shall finish after the Plant has been satisfactorily operated by the Contractor, as certified by the Engineer, for a continuous period as specified in the contract as Commissioning period.

## 9.7 Trial Run Operation

### 9.7.1 General

The Contractor shall start the trial run operation when the following conditions have all been completed:

- commissioning tests have been successfully completed
- the whole Work/ Plant is ready
- draft operating and maintenance manuals have been submitted;

Trial run operation shall be carried out on Sections of the Works and on the Works as a whole, as appropriate.

The trial operation shall demonstrate that the Works can fulfil all the hydraulic, process, mechanical, electrical, instrumentation, control and automation requirements of the Specification in the ambient conditions prevailing, using the raw water available at the time.

In addition, certain tests to demonstrate compliance with guaranteed or specified performance of particular items of Plant or parts of the Works shall be carried out independently from the Trial operation for the Works or Section of Works. These independent tests shall also be a condition precedent to the issue of the Taking-Over Certificate for the whole of the Works.

The overall trial run period shall be as stipulated in the Contract during which the works shall be operated under various conditions as required in order to demonstrate the compliance with the specification and performance/service level guarantees.

Any deficiencies or deviations from the guaranteed or specified performance of plant disclosed by the tests shall be corrected by the Contractor and tests shall be repeated as necessary until acceptable results are achieved to the satisfaction of the Engineer.

The Contractor shall be responsible for collecting and collating all data and test results and shall carry out all necessary calculations to confirm compliance with the Specification and Performance guarantees. A report comprising test data, results, calculations and conclusions shall be submitted within one week of the date of completion of the tests, or set of tests.

Satisfactory completion of the Tests on Completion is a prerequisite for the issue of the Taking over Certificate for the whole of the Works.

### 9.7.2 Test failures

If the performance during the tests of the Works (or any parts thereof) fails to comply with the Specification or with the Contractor's guarantees, the Contractor shall submit his proposals for meeting the requirement of the Specification and the guarantees to the Engineer for his approval and shall carry out at his own expense, whichever measures may be necessary to achieve the specified requirements. Such measures may include improvements, alterations or additions to the plant and/or civil works and the Contractor shall bear the whole cost of such modification including any changes to the civil, mechanical, electrical or instrumentation works.

The tests shall be completely repeated and shall be continued until the Engineer is satisfied that the requirements of the Specification and the guarantees have been met.

Despite all these, if the Contractor can’t meet the Performance/ Functional/ Service level Guarantees, it shall be subject to liquidated damages or penalties as per the criteria set out in the Contract.

# SUB-SECTION 10. TRAINING

## 10.1 Training requirements

The Contract is awarded as construction cum operation & maintenance of the works for a period of 10 years from the date of award of the contract. The Operation and maintenance is attached with a condition to reduce the Non-Revenue Water level at specified rate and level.

Therefore, the training of the Employer's personnel shall aim at familiarizing the Employer's personnel on all aspects of construction, operation and maintenance of the works/ plant including operational management of the entire zone for equitable distribution of water and the reduction of Non-revenue water.

The Contractor shall organise the training so as to enable the Employer's personnel to run the system/ plant efficiently in the eventual takeover of the works from the contractor.

## 10.2 Type, Number and Duration of Training

The training shall be given as per following.

| S.N. | Type | No. of batch | No. of Participants in each batch | Duration of training each time |
|---|---|---|---|---|
| 1 | Formal classroom and practical training during defects notification period | 3 | 10 | 3 days |

In addition to above, DJB shall nominate 3~5 JE level staff per cluster for on-the-job training on leak detection, step testing etc. The Contractor shall provide OJT to these nominated officials during routing works. The nominated staff shall be such that their tenure in DJB will be long enough to continue for at least 2~3 years after completion of O&M period

All the cost of training including trainee's transportation, boarding and lodging charges shall be deemed included in the contract cost and borne by the Contractor. Trainee's cost shall be provided as per RBI rules.

## 10.3 Contents of the Training

The Employer's personnel shall be trained mainly in following aspects

- Proper methodologies for repair of leaks in different kinds of pipeline,
- Proper methodologies for replacement of pipelines
- Equitable distribution of water in the distribution system using SCADA system and including flow and pressure management
- Operation and maintenance of Plants viz. Pumps, generators, SCADA & Telemetry systems, Power systems etc.
- Leak detection and NRW reduction
- DMA operation

- Health and Safety aspects

The Contractor shall provide an experienced training manager (with a minimum of ten years training experience and five years' experience in a similar capacity) to organise and supervise the training programme.

During installation of the Equipment/ Plant, the Contractor shall take videos (CD ROM format) where necessary illustrating all essential aspects of plant installation and testing for use during training of the Employer's personnel.

The Contractor shall ensure that, training on individual items of plant, equipment or systems such as instrumentation, control and automation systems (ICA) and similar shall be carried out by the manufacturer or specialist sub-contractor.

Training shall be based on the relevant approved operation and maintenance manuals and record drawings including P&I Diagrams and flow sheets, which shall be available before training commences.

At least one month prior to the start of training the Contractor shall provide a draft syllabus of the proposed training and shall then develop in liaison with the Engineer and the Employer a detailed programme

For Plant such as Pumping Equipment, SCADA & Telemetry works etc., the syllabus to be provided by the Contractor shall include, but not limited to, the following:

(i) Health and safety procedures, with particular respect to toxic and hazardous gas areas, chemical handling, electrical plant use, maintenance, entry/working in confined spaces and similar;
(ii) General plant description:
    - General description of electrical equipment;
    - General description of mechanical equipment;
    - General description of ICA system.
(iii) Detailed description, including operation principles/mechanism and demonstration on operation and control of all electrical, mechanical and ICA equipment;
(iv) Operating instructions, including normal operation, actions necessary under varying conditions and abnormal conditions, start-up and shut-down procedures for individual process units;
(v) Routine inspection and maintenance instructions;
(vi) Fault finding and correction;
(vii) Dismantling and re-assembly of plant, and replacement of consumable parts;
(viii) Emergency procedures, including process aspects such as start up after power failure and gas leaks and chemical spillages;
(ix) Set up and calibration of each control, protection, measuring and process equipment/system;
(x) Spares - strategic and consumables;
(xi) Special tools;
(xii) Trouble shooting and programme modifications to ICA systems, PLC and PC software and use of management systems provided under the Contract;

(xiii) Review of relevant drawings, P&IDs and O&M manuals.

## 10.4 Training During O&M Period

The Operator shall be responsible for training the Employer staff and hold at least the following training courses every 3 years of O&M Contract period and in the 9th year before the handing over of the works to a number of trainees deputed by the Employer/Engineer. The course material will have to be finalized with the Employer/Engineer and the Operator will have to provide the necessary facility and material for all trainees.

The course shall include both class room lectures and on-site training.

The training shall be designed to enable the trainees to understand full implications of satisfactory operations and preventive maintenance.

The Operator shall also provide full on-the-job operation training to employees assigned by the Employer/Engineer to be associated with the maintenance on a permanent basis. The number of such employees shall be fixed by the Employer/Engineer.

The Employer/Engineer can add any additional training courses if he found that it is necessary for the O&M of the water system. The training courses are as follows:

- O&M of water distribution system for five days
- Water loss reduction for five days.
- Sampling, testing and analysis of the water quality for 3 days
- O&M of Booster Pumping Stations for 5 days
- O&M of solar energy equipment for 3 days
- Operation of Local Water Management Centre for 3 days
- Customer care for 2 days
- Health & Safety for 2 days

# SUB-SECTION 11. ENVIRONMENTAL CONSIDERATION

## 11.1 Indian Environmental Legislation

The Constitution of India directs the State to endeavor to protect and improve the environment and to safeguard the forest and wildlife of the country. **Article 51(g)** of the constitution states that it shall be the duty of every citizen of India to protect and improve the national environment including forests, lakes, rivers and wildlife and to have compassion for living creatures. The language of the Directive principles of the **state policy (Article 47)** also contains a specific provision, which commits the state to protect the environment.

In addition to the Constitutional provisions, India has established a comprehensive set of laws for the management and protection of the environment. The Acts, Notifications, Rules and Amendments applicable to any type of development project include the following:

- The Environment (Protection) Act and Rules, 1986;
- The New Environmental Impact Assessment (EIA) Notification, 2006 and its Amendment for Prior Environmental Clearance;
- The Air (Prevention and Control of Pollution) Act, Rules and its Amendment, 1981;
- The Water (Prevention and Control of Pollution) Act and Rules, 1974;
- The Water (Prevention and Control of Pollution) Cess Act and Rules, 1977;
- Forest (Conservation) Act, 1980;
- Delhi Tree Preservation Act, 1994;
- The Public Liability Insurance Act, 1991;
- The Environmental Standards Notification, 1993, 1996;
- The Hazardous Waste Management and Handling Rules, 1989 and amendment Rules 2000
- The Municipal Solid Wastes (Management and Handling) Rules 2000, 2002;;
- The Biomedical Waste (Management and Handling) Rules, 1998 and Amendment Rules 2003
- The National Environment Tribunal Act, 1995; and
- The Noise Pollution (Regulation and Control) Rules, 2000.

The Ministry of Environment, Forests and Climate Change (MOEFCC) has stipulated general discharge standards for water effluents, and general standards for air and noise emissions. These standards, limit the concentration and volumes of the effluents and emissions released to the atmosphere. The respective State Pollution Control Boards (SPCBs) could make these standards more stringent based on the environmental sensitivity of a specific location.

In addition to the above, the Central Pollution Control board (CPCB) has also specified National Ambient Air Quality and Noise Standards for residential, commercial, industrial and sensitive zones for the country as a whole. All the major rivers of the country have also been classified based on the designated best use criteria (Five Designated Best Use Classes from A to E). It is the responsibility of the respective State Governments to ensure that the water quality criteria are met as per these specifications.

## 11.2 Applicable Environmental Standards

The Ministry of Environment, Forests and Climate Change (MOEFCC) has the overall responsibility to set policy and standards for the protection of the environment along with Delhi Pollution Control Committee (DPCC) and the Central Pollution Control Board (CPCB). This includes ambient air, ambient noise, surface & ground water, and hazardous waste standards. The relevant standards, which may be of significance to the proposed project, are as follows:

### 11.2.1 Ambient Air Quality Standards

The standards for National Ambient Air Quality (NAAQS) have been prescribed by MOEFCC, dated 18th November, 2009, which is given in Table 11-1.

Table 11-1 NATIONAL AMBIENT AIR QUALITY STANDARDS

| Sl. No. | Pollutant | Time Weighted Average | Concentration in Ambient Air | | |
|---|---|---|---|---|---|
| | | | Industrial, Residential, Rural and Other Area | Ecologically Sensitive Area (notified by Central Government) | Method of Measurement |
| (1) | Sulphur Dioxide ($SO_2$) µg/m$^3$ | Annual* | 50 | 20 | Improved West and Geake Method Ultraviolet Fluorescence |
| | | 24 hours** | 80 | 80 | |
| (2) | Oxides of Nitrogen ($NO_x$) µg/m$^3$ | Annual* | 40 | 30 | Jacob & Hochheiser Modified (Na-Arsenite) Method Chemiluminescence |
| | | 24 hours** | 80 | 80 | Gas Phase Chemiluminescence |
| (3) | Particulate Matter (Size less than 10 µm) or $PM_{10}$ µg/m$^3$ | Annual* | 60 | 60 | Gravimetric TOEM Beta attenuation |
| | | 24 hours** | 100 | 100 | |
| (4) | Particulate Matter (Size less than 2.5 µm) or $PM_{2.5}$ µg/m$^3$ | Annual* | 40 | 40 | Gravimetric TOEM Beta attenuation |
| | | 24 hours** | 60 | 60 | |
| (5) | Ozone ($O_3$) µg/m$^3$ | 8 hours** | 100 | 100 | UV Photometric Chemiluminescence Chemical Method |
| | | 1 hour** | 180 | 180 | |
| (6) | Lead (Pb) µg/m$^3$ | Annual* | 0.5 | 0.5 | ASS/ ICP Method after sampling on EPM 2000 or equivalent Filter paper ED – XRF using Teflon filter |
| | | 24 hours** | 1.0 | 1.0 | |
| (7) | Carbon Monoxide (CO) mg/m$^3$ | 8 hours** | 02 | 02 | Non Dispersive Infra-Red (NDIR) Spectroscopy |
| | | 1 hour** | 04 | 04 | |
| (8) | Ammonia ($NH_3$) | Annual* | 100 | 100 | Chemiluminescence |

| Sl. No. | Pollutant | Time Weighted Average | Concentration in Ambient Air | | |
|---|---|---|---|---|---|
| | | | Industrial, Residential, Rural and Other Area | Ecologically Sensitive Area (notified by Central Government) | Method of Measurement |
| | µg/m³ | 24 hours** | 400 | 400 | Indophenol blue method |
| (9) | Benzene ($C_6H_6$) µg/m³ | Annual* | 05 | 05 | Gas Chromatography based continuous analyzer<br>Adsorption and Desorption followed by GC analysis |
| (10) | Benzo (a) pyrene (BaP) – Particulate phase only, µg/m³ | Annual* | 01 | 01 | Solvent extraction followed by HPLC/GC analysis |
| (11) | Arsenic (As) µg/m³ | Annual* | 06 | 06 | AAS/ICP method after sampling on EPM 2000 or equivalent filter paper |
| (12) | Nickel (Ni) µg/m³ | Annual* | 20 | 20 | AAS/ICP method after sampling on EPM 2000 or equivalent filter paper |

*Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform interval.
**24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.
Source: National Ambient Air Quality Standards, Central Pollution Control Board Notification No. 29016/20/90/PCI-I dated 18 November, 2009

### 11.2.2 Ambient Noise Standards

The Ambient Noise Standards as per CPCB Standards is given in Table 11-2.

Table 11-2 AMBIENT NOISE STANDARDS

| Area Code | Area Category | Limits in dB (A) Req. | |
|---|---|---|---|
| | | Daytime | Nighttime |
| (A) | Industrial Areas | 75 | 70 |
| (B) | Commercial Areas | 65 | 55 |
| (C) | Residential Areas | 55 | 45 |
| (D) | Silence Zone | 50 | 40 |

*Notes:*
1. Daytime is between 6:00 am and 9:00 pm
2. Night time is between 9:00 pm and 6:00 am
3. Silence Zone is defined as areas up to 100 meters around such premises as hospitals, educational institutions and courts. The Silence Zones are to be declared by the Competent Authority. (Use of vehicular horns, loudspeakers and bursting of firecrackers shall be banned in these zones)

4. Mixed categories of areas should be declared as one of the four above - mentioned categories by the Competent Authority and the corresponding standards shall apply.

### 11.2.3 Noise Standards for Occupational Exposure

Noise standards in the work environment are specified by Occupational Safety and Health Administration (OSHA-USA) which in turn are being enforced by the Government of India through model rules framed under the Factories Act, which is given in Table 11-3.

Table 11-3 STANDARDS FOR OCCUPATIONAL NOISE EXPOSURE

| Total Time of Exposure per day in hrs. (Continuous or Short term Exposure) | Sound Pressure Level in dB (A) |
|---|---|
| 8 | 90 |
| 6 | 92 |
| 4 | 95 |
| 3 | 97 |
| 2 | 100 |
| 1½ | 102 |
| 1 | 105 |
| ¾ | 107 |
| ½ | 110 |
| ¼ | 115 |
| Never | >115 |

Notes:
1. No exposure in excess of 115 dB (A) is to be permitted
2. For any period of exposure falling in between any figure and the next higher or lower figure as indicated in column 1, the permissible level is to be determined by extrapolation on a proportional scale.

### 11.2.4 Noise Standards /Guidelines for Stationary DG Sets

The prescribed noise standards for control of noise pollution from stationary Diesel Generator (DG) sets are given below.

<u>Noise Standards for DG Sets (15-500 KVA)</u>

The total sound power level, Lw, of a DG set should be less than, 94+10 log10 (KVA), dB (A), at the manufacturing stage, where, KVA is the nominal power rating of a DG set. This level should fall by 5 dB (A) every five years.

<u>Mandatory acoustic enclosure/acoustic treatment of room for stationary DG sets (5 KVA and above)</u>

Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the room acoustically.

The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB

(A) Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/acoustic treatment. Under such circumstances the performance may be checked for noise reduction up to actual ambient noise level, preferably, in the night time). The measurement for Insertion Loss may be done at different points at 0.5m from the acoustic enclosure/room, and then averaged.

The DG set should also be provided with proper exhaust muffler with Insertion Loss of minimum 25 dB (A).

Guidelines for the manufacturers and users of DG sets (5 KVA and above)

- The manufacturer should offer to the user, a standard acoustic enclosure of 25 dB (A) Insertion Loss and also a suitable exhaust muffler with Insertion Loss of 25 dB (A);
- The user should make efforts to bring down the noise levels due to the DG set, outside his premises, within the ambient noise requirements by proper siting and control measures;
- The manufacturer should furnish noise power levels of the unlicensed DG sets as per standards prescribed under (A);
- The total sound power level of a DG set, at the user's end, shall be within 2 dB (A) of the total sound power level of the DG set, at the manufacturing stage, as prescribed under (A);
- Installation of a DG set must be strictly in compliance with the recommendation of the DG set manufacturer and
- A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

### 11.2.5 National Green Plan

National Green Tribunal vide its order dated 26.11.2014, 04.12.2014 & 07.04.2015, passed out certain directions to be strictly enforced by all concerned authorities.

Further a meeting was held under the Chairmanship of Chief Secretary Govt. of NCT of Delhi in which Chief Secretary directed that all concerned departments/ agencies to file their reply/ response/ status report before the Tribunal.

The full directions were issued in compliance of the Hon'ble National Green Tribunal order in the matter of Vardhman Kaushik vs. UOI & ORS, regarding air pollution in original application No. 21 of 2014 as follows:

- No government authority, contractor, builder or any person would be permitted to store / dump construction material or debris on the metaled road.
- Beyond the metaled road, the area where such construction material or debris can be stored shall be physically demarcated by the officers of all the concerned Authorities/Corporation. It shall be ensured that such storage does not cause any obstruction to the free flow of traffic and/ or inconvenience to the pedestrians. It should be ensured that no accidents occur on account of such permissible storage.

- Every builder or owner shall put tarpaulin on scaffolding around the area of construction and the building. No person including builder, owner can be permitted to store any construction material particularly sand on any part of the street, roads in any colony.
- The construction material of any kind that is stored at the site will be fully covered in all respects so that it does not disperse in the air in any form.
- All the construction material and debris shall be carried in the trucks or other vehicles which are fully covered and protected so as to ensure that the construction debris or the construction material does not get dispersed into the air or atmosphere, in any form whatsoever.
- The dust emissions from the construction site should be completely controlled and all precautions taken in that behalf.
- Every worker working at the construction site and involved in loading, unloading and carriage of construction material and construction debris shall be provided with a mask to prevent inhalation of dust particles.
- Every owner and or builder shall be under obligation to provide all medical help, investigation and treatment to the workers, involved in the construction of building and carry of construction material and debris relatable to dust emission.
- It shall be the responsibility of every builder to transport construction material and debris waste to construction site, dumping site or any other place in accordance with rules and in terms of this order.
- All to take appropriate measures and to ensure that the terms and conditions of the earlier order and these orders should be strictly in compliance by fixing sprinklers and creation of green air barriers.
- Compulsory use of wet-jet in grinding and stone cutting.
- Wind breaking walls around construction site.
- In the event of default they shall be liable to pay compensation for such environmental degradation or for pollution of ambient air quality in NCR, Delhi particularly.
- If any person, owner and or builders is found to be violating any of the conditions stated in this order and or for their non-compliance such person, owner, builder shall be liable to pay compensation of Rs. 50,000/- per default in relation to construction activity at its site and Rs 5,000/- for each violation during carriage and transportation of construction material debris through trucks or other vehicles, in terms of section 15 of the NCT Act on the Polluter Pays Principle. Such action would be in addition not in derogation to the other action that the Authority may take against such builder owner, person and transporter under the law in force.

## 11.3 Environmental Management Plan (EMP)

Environmental Management Plan (EMP) recommended for the proposed Delhi Water Supply Improvement Project in Chandrawal Water Treatment Plant (WTP) Command Area, has been discussed in this chapter. The EMP includes the following:

- Mitigation measures related to specific environmental issues;
- Responsible agencies for implementation and supervision;
- Institutional Set-up for EMP Implementation;
- Time frame for implementing mitigation measures;
- Cross-reference to documents and specifications;

- Project level environmental monitoring;
- Environmental Monitoring Plan (EMoP); and
- EMP Cost of Mitigation Measures

## 11.4 Potential Environmental Impacts and Mitigation Measures

### 11.4.1 Construction Impacts

Due to the proposed project, the air environment, noise and land environment are identified as the significant environmental components, likely to be affected during construction. The physical impact commonly associated with large-scale pipeline installation work should be minimal by the fact that this work will be conducted mostly in the dry season. As the depth of water table in Delhi is about 25 m, trench excavation may not interfere with the groundwater table. Rainfall in Delhi is limited and concentrated during the monsoon months of July-September. During the rainy season, there is a possibility of water accumulation in open trenches excavated for pipelines.

The contractor therefore shall implement the following:

- Avoid scheduling of excavation work during the monsoon months;
- Complete pipe laying work in excavated stretches and refill before onset of monsoons; and
- In unavoidable circumstances, protect open trenches from entry of rain water by raising earthen bunds with excavated soil and ensure that drains are not blocked with excavated soil.

#### 11.4.1.1 Air Quality and Dust

The work will be conducted mostly in the dry season, so there is a lot of potential for the creation of dust, from the excavation of dry soil and its storage, and leveling on the ground. Action will therefore be needed to reduce physical impacts at both the construction and disposal sites, by controlling dust and reducing the amount of material to be dumped.

During construction, the project would have two major impacts on ambient air quality due to increase in gaseous emissions by heavy construction equipment and vehicles, and an increase in dust by construction activities. Particulates ranging in size from 0.01 to 100 µm, can produce respiratory health effects, visibility problems, structural and material deterioration, and property value reductions. Dust can be mitigated through a structured regime of water spraying.

The Contractor will be required to:

- Cover or damp down by water spray on the excavated mounds of soil to control dust generation;
- Apply water prior to leveling or any other earth moving activity to keep the soil moist throughout the process;
- Bring the imported materials such as aggregate as and only when required;
- Ensure speedy completion of work – trench excavation, laying of sewer and refilling, to remove surplus soil as soon as possible; and
- Use tarpaulins to cover loose material that is transported to and from the site by truck.

Earth excavation work, foundation work, superstructure work, material storage, transportation and handling of construction materials, and wind erosion are the major factors that would produce a temporary, localized increase in Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM) levels. The increased movement of heavy vehicles carrying construction materials, operation of DG sets as a standby power back-up system would generate gaseous emissions. The degree of dust generated would depend on the soil compaction and moisture content of the ground surface during construction. Dust and exhaust particulate emissions from heavy equipment operations would temporarily degrade air quality in the immediate construction zone. The increase in air particulates shall be minimized by the performance of the work.

The construction contractor will visually monitor dust levels on the site during construction. Dust suppression will be instituted, using water tankers mounted on tractors, sprinklers and other means as necessary, in the event that high levels of dust are observed, strong winds and dry conditions make dust generation likely, and complaints about dust are received.
Other diffused source of gaseous emissions from the construction site would be if the construction laborers use fuel wood for cooking. The construction contractor will ensure that such practice is not adopted by the laborers and they are provided with LPG cylinders for cooking in their labor camps.

#### 11.4.1.2 Ambient Noise Quality

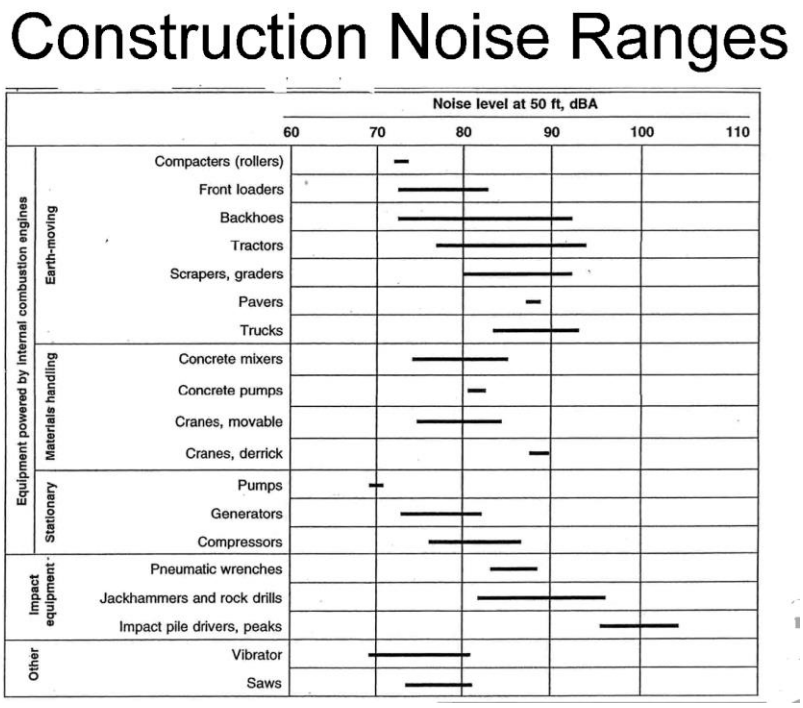


Fig 11-1. Construction Noise Chart

The construction of civil works in India cannot be conducted without creating such impacts as noise and increased traffic. Depending upon the location of the activity, these impacts can be

mitigated through appropriate scheduling of construction.

Construction activities normally result in temporary and short duration increases in noise levels. The main sources of noise during construction periods include movement of vehicles for loading and unloading of construction materials, fabrication, handling of equipment and materials, operation of concrete mixers, power shovels, generators etc. The areas affected are those close to the site. The noise levels due to operation of various construction equipment are given in the figure above.

To minimize the potential impacts due to higher noise levels, major construction activities would be scheduled during normal daylight working hours and would be implemented consistent with the applicable standards. The construction contractor will use equipment that is adapted to operate with appropriate noise muffling devices resulting in the least possible noise. Every effort would be taken to minimize the noise levels including the mandatory use of construction equipment with operable mufflers.

#### 11.4.1.3 Soil Quality

Civil works result in significant soil excavation. There is an active market for the purchase of quality soil that arises from excavation processes, but it is important to ensure the quality of the soil.

Contamination of soil during the construction phase is primarily due to allied activities. The sites where construction vehicles are parked and serviced are likely to be contaminated because of leakage or spillage of fuel and lubricants. Contamination of soil during construction might be a major long-term residual negative impact. Unwarranted disposal of construction spoil and debris will add to soil contamination.

#### 11.4.1.4 Terrestrial Resources

The site clearing and preparation activities for construction sites might involve removal of some existing vegetation. However, the project would take utmost care, not to disturb full grown trees on any of these sites. Any damage to trees, landscaping or farmland needs to be fully reinstated immediately after project construction. After careful assessment of alternative routes for major pipelines for transmission from the Chandrawal WTP and for secondary distribution feeder mains from UGRs/BPSs some selected alignments pass through portions of Park lands as described below.

1) Transmission Pipeline Route

After careful review of alternative transmission system routes for the 1,400 mm pipeline, a more suitable alignment was identified diagonally across the Roshanara Bagh rather than along the public right-of-ways, Draunacharya Guru Hanuman Marg and Guru Hanuman Marg thus reducing the length from 722m to 520 m, a saving of 202 m with the added advantage of saving considerable costs in road restoration. The 500m long construction through the Roshanura Garden can be accomplished without disturbing mature trees or other environmental impacts of terrestrial resources.

The photos taken on 23.02.2017 depict the natural condition of the transmission pipeline route in this vicinity with no mature trees to be impacted, only light vegetative growth.

2) Secondary Distribution Pipeline Routes in Naraina UGR Command Area

There is one distribution main serving DMA Nos 01 to 03 in this UGR Command Area.

500 m long 600 mm pipeline serving DMA Nos. B-04-01/02/03

This pipeline will be laid parallel and adjacent to the existing above ground pipeline, and then the route will extend into the centre of the access road. There is sufficient space to lay the pipeline so that only a limited number of smaller caliper trees and shrubs might be damaged or may have to be cut during construction, but all mature tree cutting within the forest area itself will be avoided. Where possible, the pipeline route will follow open space areas or utilization of walkways where no terrestrial resources will be impacted.

There are two distribution mains serving DMA Nos 04 to 06 in this UGR Command Area.

1. 260 m long 600 mm pipeline serving DMA Nos. B-04-04/05
2. 250 m long 350 mm pipeline serving DMA Nos. B-04-06

Similar to the distribution main serving DMA Nos 01 to 03, there is sufficient space to lay these two pipelines along roadways to avoid damage to the trees in the park area

3) Secondary Distribution Pipeline Routes in Shadipur and Rock Garden UGR Command Area

There are three secondary distribution mains serving DMAs 01 to 05 and the Rock Garden UGR area of this Command Area.

1. 130 m long 600 mm pipeline serving DMA Nos. B-02-01/02/03/05
2. 120 m long 600 mm pipeline serving Rock Garden UGR area
3. 130 m long 350 mm pipeline serving DMA Nos. B-02-04

4) Secondary Distribution Pipeline Routes in Shadipur UGR Command Area

There are two secondary distribution mains serving DMAs 06 to 10 in the Shadipur UGR Command Area.

1. 120 m long 500 mm pipeline serving DMA Nos. B-02-07/08
2. 120 m long 500 mm pipeline serving DMA Nos. B-02-06/09/10

#### 11.4.1.5 Construction Waste Disposal

The generation of waste material is inevitable during the construction phase. Waste is generated at different stages of the construction process. Excess fill would be generated from excavation of earth. Other wastes include glass, plastic material, general refuse, scrap metal, cardboard, plastic, and sewage wastes from the construction workers housing. The excess earth will be used as filling earth for the project construction activities and remaining earth will be used for filling low lying areas.

Unutilized or unused solid wastes generated during construction will be disposed off to designated solid waste dumping sites in the project area.

### 11.4.2 Impact on Economic Development

#### 11.4.2.1 Land Acquisition and resettlement

Pipelines will be laid in the ROW (right of way) of existing roads (either adjacent to the road, or beneath the road surface in narrower streets) and no land acquisition from private owners will be necessary. There should be no direct effect on the income or assets of landowners, or the livelihoods of tenants.

#### 11.4.2.2 Impeded access and Loss of Business

During the laying of transmission and distribution lines, particularly in narrow streets and streets with on-street commercial activities, there may be temporary disruption or relocation of hawkers and vendors.

Although the work will not require land acquisition, it could still have economic impacts, if the presence of trenches, excavated material, workers and machinery discourage customers from visiting shops and other businesses, which lose income as a result. These losses however will be short in duration as work at each site should be completed in about one week. Implementation of the following best construction measures will reduce the inconvenience and disturbance to the public:

- Informing all residents and businesses about the nature and duration of any work well in advance so that they can make necessary preparations;
- Requiring contractors employed to conduct these works to provide wooden planks across trenches for pedestrians and metal sheets where vehicle access is required;
- Consulting the Traffic Police regarding any such work so that it can be planned to avoid traffic disruption as far as possible, and road diversions can be organized if necessary; and
- Increasing workforce to complete the work in a minimum possible time

#### 11.4.2.3 Disruption to Other Infrastructure Services

During the laying of water pipelines along the roads, various infrastructure services may be affected. It is therefore required to implement the following measures to avoid or minimize the impact during construction:

- Identify the services to be affected in each zone and notify the respective agencies (electricity, telephone, etc.) about the construction work and if there is any need for shifting utilities;
- Coordinate with respective agencies and provide prior information to the public about the disruption in services during construction; this can be announced via mass communication systems like local/vernacular newspapers;
- Provide alternative arrangement for disrupted services; and
- During construction, the water supply service will be affected. In case of water supply being affected for more than a day, alternative water supply may be provided through mobile tankers.

Transport is another type of infrastructure that will be affected by the pipeline laying work, as in the narrower streets there is not enough space for excavated soil to be piled off the road. The road itself may also be excavated in places where there is no available land to locate pipes alongside. Traffic will therefore be disrupted, and in some very narrow streets the whole road may need to be closed for short periods.

Following measures can potentially avoid traffic disruptions:
Conduct work during light traffic periods; explore night working schedule ensuring workers and public safety

- Plan work such that trench excavation, pipe laying, and refilling including compacting, at a stretch is completed in a minimum;
- Provide for immediate consolidation of backfilling material to desired compaction to avoid future settlement risk - this will allow immediate road restoration and therefore will minimize disturbance to the traffic movement;
- Do not close the road completely, ensure that work is conducted on the edge of the road; allow traffic to move on one line;
- In unavoidable circumstances of road closure, provide alternative routes, and ensure that public is pre-informed about such traffic diversions with suitable signage in place;
- In case of closure of important roads, provide information to the public through media – daily newspapers and local cable television (TV) services, about the need and schedule of road closure, and alternative routes; and
- At all work sites public information/caution boards shall be provided – information shall inter-alia include: project name, cost and schedule; executing agency and contractor details; nature and schedule of work at that road/locality; traffic diversion details, if any; entry restriction information; competent official's name and contact for public complaints.

It is inevitable that there will be an increase in the number of heavy vehicles in the project area (particularly trucks carrying construction materials and removing waste), and this could disrupt traffic and other activities. These impacts will therefore need to be mitigated by:

- Careful planning of transportation (material and waste) routes in coordination with the Traffic Police to avoid sensitive areas as far as possible, including narrow streets, congested roads, and other important areas; and
- Scheduling the transportation of waste to avoid peak traffic periods

### 11.4.3 Impact on Social and Cultural Resources

There are some protected historical monuments in Central Delhi, and in context, Delhi is a historic City. There may be a risk that any work involving ground disturbance could uncover and damage archaeological and historical remains. There are monuments within the overall proposed project area but not within the boundaries of this Package 2. Therefore, there are no impacts on monument sites. However, it will be necessary to adopt a series of measures, to both avoid sensitive sites and recognize and protect any chance discoveries. These include:

- No infrastructure, except unavoidable water supply pipe lines, shall be constructed within 300 m of sites;

- Obtain permission from ASI for laying of pipelines within 300 m of sites; and
- Ensure that any chance finds are recognized and measures are taken to ensure they are protected and conserved.

If any chance finds are recognized, the Contractor should:

- Stop work immediately to allow further investigation if any finds are suspected; and
- Inform DJB; call in the ASI if a find is suspected, and taking any action they require to ensure its removal or protection in situ.

The water pipeline work may disturb some modern-day social and cultural resources, such as schools, hospitals, temples etc. Impacts will include noise, dust, and interrupted access for pedestrians and vehicles. Mitigation will therefore be needed to protect these resources and to enable usage by local people and visitors to continue throughout the construction work. This will be achieved through several of the measures recommended earlier, including:

- Avoiding working at sensitive times;
- Limiting dust by removing waste soil quickly, bringing sand to site only when necessary, covering and watering stockpiles, and covering soil and sand when carried on trucks;
- Increasing the workforce in sensitive areas to complete the work quickly;
- Providing wooden bridges for pedestrians and metal sheets for vehicles to allow access across open trenches where required (including access to houses); and
- Using modern vehicles and machinery with standard adaptations to reduce noise and exhaust emissions, and ensuring they are maintained to manufacturers' specifications.

### 11.4.4 Public and Worker Safety

A construction risk to laborers, which is partly the by-product of the greater use of manual versus mechanical labor, is a reality in India.

There is invariably a safety risk when substantial construction such as this is conducted in an urban area, and precautions will thus be needed to ensure the safety of both workers and the public. The Contractor will be required to formulate and implement health and safety measures at construction sites, which should include such measures as:

- Following standard and safe procedures for all activities – such as provision of shoring in trenches where required in deeper trenches of more than 2 m;
- Consulting the town authorities to identify any buildings at risk from vibration damage and avoiding any use of pneumatic drills for cutting roads;
- Excluding the public from the site – enclosing the construction area, warning boards and sign boards;
- Ensuring that all workers are provided with and use appropriate Personal Protective Equipment (helmet, hand gloves, boots, masks etc.); and
- Maintaining accidents reports and records.

During the construction period, the activities may also result in ponding of water in the excavated areas of the site. This has the potential for creation of mosquito breeding and spreading of vector borne diseases. Other mosquito breeding sites maybe created through the

use of uncovered water tanks. The project will give careful attention to the design and maintenance of earthworks and drainage systems during construction to avoid the creation of significant habitat areas for mosquito larvae. The use of larvicides may be required to prevent mosquito breeding in silt traps.

## 11.5 Implementation of the Environmental Management Plan (EMP)

The Environmental Management Plan with mitigation measures during the pre-construction, construction, and operation phases of the project is presented in Tables 11-4 to 11-6 that follow.

Following the award of the Contracts, the Contractors shall adhere to the environmental clauses in the Contract and the guidelines provided. In summary the Contractor shall give due consideration to the following:

### 11.5.1 General

- The Contractor shall take all reasonable steps to protect the environment and to prevent environmental damage and public nuisance resulting from construction activities.
- The Contractor shall comply with all statutory requirements, environmental regulations and environmental quality standards. The Contractor shall bear all costs associated with environmental pollution avoidance and environmental mitigation, including any clean-up operations if necessary.

### 11.5.2 Pollution from Waste

- The Contractor shall maintain all construction sites in a clean and safe condition and provide and maintain appropriate facilities for temporary storage of all wastes before transportation and disposal.
- The Contractor shall organise disposal of all wastes generated during construction in an environmentally acceptable manner. This shall include consideration of the nature and location of disposal sites, so as to cause least environmental impact.
- The Contractor shall take all precautionary measures when handling and storing fuels and lubricants, to avoid causing environmental pollution. This is to include establishment of contingency plans for any clean-up in the event of spillage.

### 11.5.3 Protection of Human Health

- The Contractor shall ensure provision of adequate drinking water supplies and sanitation facilities on all sites and labour camps.
- The Contractor shall ensure that disposal from all sanitary systems are undertaken to avoid causing environmental pollution. Wastewater should be routed through suitable designed septic tanks and soakaways, without contaminating either ground or surface water or causing a health risk.
- The Contractor shall provide an adequate supply of water for drinking and washing purposes for all site personnel, including all workers, as appropriate. Drinking water quality should comply with Indian standards.
- The Contractor shall provide adequate health care clinics and first aid facilities.

### 11.5.4 Noise

- The Contractor shall avoid any unnecessary noise for disturbance during construction.
- The Contractor shall ensure maintenance of all vehicles and equipment to a high standard, in accordance with manufacturers maintenance procedures.
- The Contractor shall ensure careful handling of noise generating activities to avoid unnecessary noise disturbance to local residents.

### 11.5.5 Air Quality and Dust

The Contractor shall minimise dust nuisance by regular watering of material stockpiles, access roads, bare soil, sand and other areas, as appropriate and as determined by weather conditions.

## 11.6 Environmental Monitoring Plan (EMoP)

The environmental monitoring plan is prepared to check the effectiveness of the mitigation measures during the construction and operational phases. To ensure the effective implementation of an appropriate environmental monitoring plan (EMoP), prepared with objectives outlined below:

- To evaluate the performance of mitigation measures proposed in EmoP;
- To evaluate the adequacy of Environmental Management;
- To suggest improvements in management plan, if required;
- To satisfy the legal and community obligations; and
- To respond the unanticipated environmental issues at an early stage and to verify the accuracy of environmental prediction.

At the project level, the vital parameters or performance indicators that will be monitored during construction and/or operational phases of the project include:

- Ambient air quality measures such as PM10, PM2.5 SO2, CO, NOx, HC etc.;
- Noise levels;
- Water quality; and
- Tree plantation survival rate.

The recommended environmental monitoring plan is presented in Table 11-7 The methods for sampling and analysis will be as per prevalent requirements of CPCB and Indian Standard (IS) codes.

Table 11-4: PRE-CONSTRUCTION STAGE MITIGATION MEASURES

| Sl. No. | Adverse Impact | Mitigation Measures | Cross Reference to Documents | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| 1 | Improvement schemes minimize/ avoid cutting of trees | Try to save the tree to the possible extent. An approval from appropriate Authority of Delhi is required so that new trees can be planted to maintain the ecological balance. Compensatory afforestation and additional trees for landscaping. | Delhi Tree Preservation Act, 1994 | Before Start of Construction of relevant section | DJB | DJB/PMSC |
| 2 | Local Traffic Arrangements | Temporary traffic arrangements during construction have to be planned. This plan shall be periodically reviewed with respect to site conditions. | - | During site clearance | Contractor | DJB/PMSC |
| 3 | Land Acquisition | Land Acquisition is not applicable. . | - | - | - | - |
| 4 | Air Quality | Adequacy of measures shall be checked to control air pollution. | Central Pollution Control board (CPCB) - National Ambient Air Quality Standards | Before Start of Construction of the project | DJB | DJB/PMSC |
| 5 | Water Quality | Adequacy of measures shall be checked to control water pollution. | Central Pollution Control board (CPCB) - Water Quality Standards | Before Start of Construction of the project | DJB | DJB/PMSC |
| 7 | Noise Level | Noise screening by trees plantation scheme proposed as noise barriers.<br>Adequacy of measures shall be checked to control noise pollution. | Central Pollution Control board (CPCB) -Noise Standards | Before Start of Construction of the project | DJB | DJB/PMSC |

| Sl. No. | Adverse Impact | Mitigation Measures | Cross Reference to Documents | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| 8 | Relocation of utility lines/community utilities | Affected utilities shall be relocated with prior approval of the concerned agencies. | | Before start of the project | Contractor | DJB/PMSC |
| 9 | Road Drainage | Provision of adequate size and number of cross-drainage structures (Culverts) as well as drains along the road | | Throughout the project | Contractor | DJB/PMSC |

Table 11-5: CONSTRUCTION STAGE MITIGATION MEASURES

**Table 11-6: OPERATION PHASE MITIGATION MEASURES**

| Adverse Impact | Mitigation Measures | Cross Reference to Documents | Time Frame | Responsibility | |
|---|---|---|---|---|---|
| | | | | Implementation | Supervision |
| Air quality impact | Ambient air concentration of various pollutants shall be monitored as presented in project report | Project requirement | Starting immediately after completion of construction | Contractor | DJB/PMSC |
| Water quality | Water quality parameters shall be monitored as presented in project report | Project requirement | Starting immediately after completion of construction | Contractor | DJB/PMSC |
| Noise pollution | Monitoring of noise levels at sensitive receptors as per monitoring plan | Project requirement | Starting immediately after completion of construction | Contractor | DJB/PMSC |

**Table 11-7: ENVIRONMENTAL MONITORING PLAN**

| Sl. No. | Adverse Impact | Mitigation Measures | Cross Reference to Documents | Time Frame | Responsibility | |
|---|---|---|---|---|---|---|
| | | | | | Implementation | Supervision |
| 1. | Excavation will produce large quantity of Waste soil, which needs proper disposal. Description. Laying of pumping mains and distribution network estimated to produce the large amount of waste soil, which needs proper disposal. This soil however will not be produced at one location but spread over different zones in the City. | Construction will be taken phase-wise so that road surface is open for traffic movement and major construction work during off-peak/night hours<br>Area under construction will be covered and equipped with dust collectors.<br>Construction material shall be covered or stored in such a manner so as to avoid being affected by wind direction.<br>Vehicles carrying construction materials will have covered top and beds. The fall height will be kept low so that least amount of dust is airborne, during unloading of materials. | | Entire construction phase | Contractor | DJB/PMSC |
| 2. | Water accumulation in trenches during rains and related impacts | Avoid scheduling of excavation work during the monsoon months<br>• Complete pipe laying work in excavated stretches and refill before onset of monsoon<br>• In unavoidable circumstances, protect open trenches from entry of rain water by raising earthen bunds with excavated soil and ensure that drains are not blocked with excavated soil. | | Entire construction phase | Contractor | DJB/PMSC |
| 3. | Generation of noise and vibrations from Excavation<br><br>Description: High noise/vibration activities Like rock blasting/pile construction are not anticipated. However, activities like breaking<br>of CC/BT road surface using pneumatic drillers for laying pipelines may create | Provide prior information to the local public about the work schedule<br>• Do not conduct noise generating activities in the night<br>• Ensure that there are no old and sensitive buildings that may be in risk due to use pneumatic drills<br>•Employ manual methods, where required | Central Pollution Control board (CPCB) –Air and Noise Standards | Entire construction phase | Contractor | DJB/PMSC |

| | | | | | | |
|---|---|---|---|---|---|---|
| | noise & vibration | | | | | |
| 4. | Unplanned dumping of excavated material | The excavated material to be deposited in relatively low-lying areas away from water bodies. Care should be taken that dumped material does not block natural drainage systems. | Project requirement | During construction | Contractor | DJB/PMSC |
| 5. | Dust nuisance due to construction Description: Earthwork excavation, refilling, handling and transportation of construction Materials (like sand and aggregate), and handling, transportation and disposal of waste soil will produce dust if it is not done properly. | Cover or damp down by water spray on the excavated mounds of soil to control dust generation;<br>• Apply water prior to leveling or any other earth moving activity to keep the soil moist throughout the process;<br>• Bring the material (aggregate) as and when required;<br>• Ensure speedy completion of work – trench excavation, laying of pipe and refilling, to remove surplus soil as soon as possible;<br>• Use tarpaulins to cover loose material that is transported to and from the site by truck.<br>• In case of surplus soil is provided for other departments or private persons, it will be the responsibility of contractor to ensure that it proper handling, transport & utilization<br>• Use tarpaulins to cover loose material/soil that is transported to and from the site by truck Control dust generation while unloading the loose material (particularly aggregate) at the site by sprinkling water and unloading inside the barricaded area<br>• Clean wheels and undercarriage of haul trucks prior to leaving construction site<br>• Stabilize surface soils where loaders, support equipment and vehicles will operate by using water | Project requirement | During construction | Contractor | DJB/PMSC |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | and maintain surface soils in a stabilized condition where loaders, support equipment and vehicles will operate<br>• Don't allow access in the work area except workers to limit soil disturbance and prevent access by fencing | | | | |
| 6. | Cutting of trees Description. Road side trees are limited to few areas like model town. Pipelines will be laid avoiding trees; alignment will be altered slightly to save the trees, wherever possible during the work. There are no trees in reservoir sites. | No trees shall be cut/pruned for laying pipeline<br>• Only remove trees if it cannot be avoided at WTP site<br>• Plant and maintain two trees for every one removed | Project requirement | During construction | Contractor | DJB/PMSC |
| 7. | Impacts due to improper mining for construction materials Description. Large quantities of construction material like sand and aggregate will be required for WTP and reservoir constructions. As the excavated soil will be used for refilling trenches, pipeline construction will require Minor quantities. Normally material for Panipat is procured from licensed mines – sand from Panchkula (Yamuna River), and aggregate from Panchkula and Bhiwani District. | Ensure that construction materials (sand, aggregate and gravel) are obtained from quarries licensed by GoH (Directorate of Geology and Mining). | Project requirement | During construction | Contractor | DJB/PMSC |
| 8. | Excavation could damage existing infrastructure<br>Description. Water supply lines will be laid along/within the road avoiding sewers, Telephone/ electricity infrastructure. As in most of the areas, water supply lines already exist, and therefore there is no major interference with the other infrastructure. But it cannot be altogether | identify the services to be affected in each zone<br>• Coordinate with respective agencies (PWD - WSSD – sewerage section; telephone & electricity department) in shifting those infrastructure<br>• Provide prior public information about the likely disruption of services<br>• Provide alternate arrangements for services like water supply in the event of disruption beyond reasonable time, for instance, through tankers | Project requirement | During construction | Contractor | DJB/PMSC |

| | | | | | | |
|---|---|---|---|---|---|---|
| | avoided | | | | | |
| 9. | Traffic, people and activities could be disturbed due to laying of water supply lines<br>Description. The roads in old city are very narrow. Commercial activity is very dominant, and roads congested with traffic and people. Construction work will affect the people, activities and business. | Provide information to the public through media – daily newspapers and local cable television (TV) services, about the work (nature & schedule) likely disturbances, and need and schedule of road closure if any, and alternative routes. This shall provide<br>locality/zone-wise information (where &when the work will be taken up and when it will be completed)<br>• Ensure that the work is completed as scheduled; ensure that well experienced contractors are engaged and discourage delays by suitable penalties built into the contracts<br>• Plan work such that trench excavation, pipe laying, and refilling including compacting, at a stretch is completed in a minimum possible time<br>• Avoid complete closure of road; ensure that work is conducted onto edge of the road; allow traffic to move on one line Do not deploy heavy/large equipment, which will occupy & disturb traffic/people movement; if necessary use only during light traffic hours (6 AM – 10 AM)<br>• In unavoidable circumstances of road closure, provide alternative routes, and ensure that public is informed about such traffic diversions<br>• At all works sites public information/caution boards shall be provided (name of the project, cost, schedule, contractor name, implementing & executing agency, schedule of work at that locality, | Project requirement | During construction | Contractor | DJB/PMSC |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | details of traffic diversion and responsible officer for implementation. | | | | |
| 10. | Site of social/cultural importance (schools, hospitals and religious places) may be distributed by noise, dust, and impeded access during laying of pipelines. Description. In addition to ASI monuments listed above, there are a number of schools, religious places of local importance. | avoid work at sensitive times, such as religious and cultural festivals<br>• Remove waste quickly, cover/spray stockpiles, cover soil/sand on trucks<br>• Increase workforce to finish work quickly<br>• Use wooded planks and metal sheets to allow access (people/vehicles)<br>• Use modern vehicles/machinery & maintain as specified to reduce noise and exhaust emissions | Project requirement | During construction | Contractor | DJB/PMSC |
| 11. | Workers and public at risk from accidents on site<br>Description. Excavations for distribution lines will be mostly limited to 1.1 m except few which may 1.4 m deep. Rising main – 1.3 m to 2 m. Excavations for foundations (WTP and reservoirs) may go to a depth of 5-10 m. Public will be at risk as trenches for pipelines will be located along the roads. | Follow standard and safe procedures for all activities – such as provision of shoring in trenches of 2 m or more<br>• Consulting the town authorities to identify any buildings at risk from vibration damage and avoiding any use of pneumatic drills for cutting roads;<br>• Excluding the public from the site – enclose the construction area, provide warning/sign boards<br>• Ensuring that all workers are provided with band use appropriate Personal Protective Equipment (helmet, hand gloves, boots, masks etc.);<br>• Report accident and maintain records | Project requirement | During construction | Contractor | DJB/PMSC |
| 12. | Economic benefits for people employed in workforce | Ensure that most of the workforce is from local communities | Project requirement | During construction | Contractor | DJB/PMSC |
| 13. | Compensatory plantation | Compensatory plantation if required shall be done in line with Tree Authority guidelines. | Delhi Tree Preservation Act, 1994 | During Construction | Contractor | DJB/PMSC |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14. | Ambient Air quality, Water quality & Noise level monitoring | Ambient air quality, water quality and noise level monitoring is required once every pre-monsoon and post-monsoon during the construction period. The frequency will be 24 hours/ day. | Project Requirement | During Construction | Contractor | DJB/PMSC |

| Mitigation measures | Location | Responsible For Mitigation | Monitoring Method & Parameters | Monitoring Frequency | Responsible For monitoring |
|---|---|---|---|---|---|
| **Construction** | | | | | |
| Utilize surplus soil for following activities in order priority:<br>• Utilize for raising the ground-level of construction sites<br>• Utilize in other construction works of other departments within Chandrawal<br>• Provide to local people for filling up low laying areas. | Pumping main & distribution Network sites | Contractor | Observations on-site/offsite; Contractor records; | Weekly | DJB/PMSC |
| Avoid scheduling of excavation work during monsoon<br>• Complete work in excavated stretches before monsoon<br>• Regulate drainage by earthen bunds, if required<br>• Cover or damp down soil mounds to control dust<br>• Apply water prior to leveling/ any earth moving activity<br>• Bring the material (aggregate) as and when required<br>• Ensure speedy completion of work<br>• Use tarpaulins to cover loose material in transport<br>• In case of surplus soil is provided for other departments or private persons, it will be the responsibility of contractor to ensure that it proper handling, transport & utilization<br>• Use tarpaulins to cover loose material/soil that is transported to and from the site by truck<br>• Control dust generation while unloading the loose material (particularly aggregate) at the site by sprinkling water and unloading inside the barricaded area<br>• Clean wheels and undercarriage of haul trucks prior to leaving construction site<br>• Stabilize surface soils where loaders, support equipment and vehicles will operate by using water and maintain surface soils in a stabilized condition where loaders, support equipment and vehicles will operate<br>• Don't allow access in the work area except workers to limit soil disturbance and prevent access by fencing | All construction sites | Contractor | Observations on-site/offsite; Contractor records; | Weekly | DJB/PMSC |
| Provide prior information to the local public about the work<br>• Do not conduct noise generating activities in the night<br>• Do not use pneumatic drills near old and sensitive buildings | Pumping main, & distribution | Contractor Observations | Observations on-site/offsite; people | Weekly | DJB/PMSC |

| Mitigation measures | Location | Responsible For Mitigation | Monitoring Method & Parameters | Monitoring Frequency | Responsible For monitoring |
|---|---|---|---|---|---|
| • Employ manual methods, where required | network | | interviews; Contractor records | | |
| No trees shall be cut/pruned for laying pipeline<br>• Only remove trees if it cannot be avoided at WTP site<br>• Plant and maintain two trees for every one removed | All construction sites | Contractor | On-site observation; Contractor records | Weekly | DJB/PMSC |
| Procure construction material from licensed quarries | NA | DJB | Contractor records | Weekly | DJB/PMSC |
| Consult local people: inform them of work in advance<br>• Leave spaces for access between mounds of soil<br>• Provide walkways and metal sheets over trenches<br>• Increase workforce in these areas to finish work quickly | Pumping main & distribution network sites | Contractor | Observations on-site/offsite; people interviews; Contractor records | Weekly | DJB/PMSC |
| Identify the services to be affected<br>• Coordinate with respective agencies for utilities, e.g. sewerage section; telephone & electricity department)<br>• Provide prior public information<br>• Provide alternate arrangements for disturbed services | Pumping main & distribution network sites | DJB | Observations on-site/offsite; people interviews; Contractor records | Weekly | DJB/PMSC |
| Provide information to the public<br>• Ensure that the work is completed as scheduled; and discourage delays by suitable penalties built into the contracts<br>• Plan to complete work in minimum time (excavation to refill)<br>• Avoid complete closure of road; allow one-line traffic<br>• Do not deploy heavy/large equipment in narrow streets,;<br>if necessary use only during light traffic hours (6 AM –10 AM) | Pumping main & distribution network sites | Contractor & DJB | Observations on-site/offsite; people interviews; Contractor records | Weekly | DJB/PMSC |
| Avoid narrow streets/ congested areas/sensitive areas for material transport<br>• Plan work to avoid peak traffic hours | All construction | DJB | Observations on-site/offsite; | Weekly | DJB/PMSC |

| Mitigation measures | Location | Responsible For Mitigation | Monitoring Method & Parameters | Monitoring Frequency | Responsible For monitoring |
|---|---|---|---|---|---|
| | sites | | Contractor records | | |
| avoid work at sensitive times (religious/cultural festivals)<br>• Remove waste quickly, cover soil/sand on trucks<br>• Increase workforce to finish work quickly<br>• Use wooded planks and metal sheets to allow access<br>• Use modern vehicles/machinery & maintain as specified | Pumping main & distribution network sites | Contractor | Observations on-site/offsite; people interviews; Contractor records | Weekly | DJB/PMSC |
| Follow standard and safe procedures for all activities<br>• Consulting the relevant authorities to identify any buildings at risk<br>• Enclosing the construction area, provide warning/sign boards<br>• Provided Personal Protective Equipment to workers<br>• On/off-site Health and Safety Training for all site personnel;<br>• Report accidental and maintain records | All construction sites | Contractor | Observations on-site; worker interviews; Contractor records | Weekly | DJB/PMSC |
| Ensure that most of the workforce is from local communities | All sites | Contractor | Worker interviews; Contractor records | Randomly | DJB/PMSC |

# Technical Specifications

# C1. Civil Works

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## SUB-SECTION 1. GENERAL

### 1.1 Applicable Specification, Codes and Standards

This section deals with civil construction of various works under this contract.

i) All the civil & structural works shall be carried out as per latest CPWD specifications with up to date corrections slips issued upto the date of submission of tender unless otherwise specified herein. In case the CPWD specifications shall not be found applicable or inadequate, then the relevant IS specifications (latest version) on the date of submission of tender shall be used. Further, in case, any of above two shall not be applicable, to particular/specialized works, then the manufacturer's specifications or their relevant instructions after Engineer's approval shall be followed. Specifications mentioned anywhere in the bid document shall prevail over CPWD Specifications and BIS specifications as the case may be.

ii) In the absence of any CPWD or IS specifications, equivalent International Standard Specifications such as those issued by the International Organization for Standardization (ISO) or British Standards (BS) or the International Electro-technical Commission (IEC) or American Society for Testing and materials (ASTM) or American National Standards Institute (ANSI) or Japanese Industrial Standards (JIS) any other equivalent international standard, specifications or Manual shall be followed or proposed by the contractor at the sole discretion of the Engineer or as shall be agreed in the Contract.

iii) All raw materials including Cement and reinforcement/structural steel wherever to be used by the contractor shall confirm to the latest IS/CPWD specifications. All mandatory tests as required by IS/CPWD specifications shall be carried out and test certificates to be submitted to the Engineer. However, the contractor shall be fully responsible for required performances of civil/ structural work. Costs of such tests shall be borne by the contractor.

iv) For testing of all materials, following shall be strictly adhered to -

a) All the tests shall be done in laboratories approved by the Employer. The contractor shall be required to take written approval from Engineer, in this respect.

b) Cement and Steel shall be of a make approved by the Employer as detailed out in respective material sections of this document.

### 1.2 Public Convenience:

Contractor shall also ensure that no public inconvenience is caused due to excavation, stacking of excavated material, storage of pipe at pipeline alignment. All safety measures mentioned in relevant Indian Standards and the rules and regulations of local authorities in regard to safety provision shall be observed by the Contractor. Any compensation, resulting from carelessness towards the safety requirements during all phases of work will be on the part of the Contractor.

## 1.3 Materials

### 1.3.1 Cement

i) The Contractor shall procure, unless otherwise stated separately conforming to IS specifications IS 1489 part 1, Fly Ash based Portland Pozzalana cement, as required in the work only from reputed manufacturers as approved by Employer and Ministry of Industry, Government of India and holding license to use BIS certification mark for their product, whose name shall be got approved from Engineer. Supply of cement shall be taken either in silos or in 50 kg bags bearing manufacturer's name and BIS marking. Samples of cement to be arranged by the Contractor shall be taken by the Engineer and got tested in accordance with provisions of relevant IS codes. Cost of such tests shall be borne by the contractor. If test results of the cement shall not conform to the relevant IS codes, the same stand shall be rejected and shall be removed from the site by the Contractor at his own cost within one week time of written order from the Engineer.

ii) The cement shall be brought at site in bulk supply of approximately 50 tonnes from the manufacturer directly, or as decided and approved by the Engineer, as the case may be.

iii) The cement godown of the sufficient capacity shall be constructed by the contractor and at all time it shall have a stock of minimum of 2000 bags. The contractor shall facilitate the inspection of the cement godown by the Engineer at any time. Storage of cement shall be as per CPWD specification.

iv) Cement to be brought at site and cement remaining unused after completion of work shall not be removed from site without written permission of the Engineer.

Cement is expressed as Type IP (X) to indicate a Portland-pozzolana (P) cement in which "X" denotes the targeted percentage of pozzolan expressed as a whole number by mass of the final blended cement. Thus, Type IP (15) is the cement that contains 15 percent pozzolan. Typical replacement rates for blended cements are 15 to 25 percent for Type IP.

### 1.3.2 Steel

#### a. TOR / TMT Steel & Structural Steel

i) The contractor shall procure TOR/TMT steel reinforcement bars and structural steel conforming to relevant IS codes (Gr Fe 500 or more, IS code 1786-1985) from main producers as approved by the Ministry of Steel. Reinforcement will be high strength deformed bars with a specified characteristic strength of Fe 500 N/mm$^2$ or more or mild steel bars with a characteristic strength of M250 N/mm$^2$. The steel reinforcement, structural steel shall be brought to the site in bulk supply of 10 tonnes or more or as decided by the Engineer. For small or occasional quantities of TOR steel reinforcement bars that less than 10 MT, the Engineer may authorize the contractor to purchase the same from authorized dealers of the approved manufacturers. The contractor shall have to obtain and furnish test certificates to the Engineer in respect of all supplies of steel to be brought by him to the site of work. Samples shall also be taken and got tested by the Engineer as per the provisions in this regard in relevant CPWD/IS codes. Cost of such tests shall be borne by the contractor. In case the test results indicate that the steel to be arranged by the contractor shall not conform to CPWD/IS codes, the

same shall stand rejected and shall be removed from the site of work by the Contractor at his cost within a week's time after written orders from the Engineer.

ii) The steel reinforcement, structural steel shall be stored by the contractor at site of work in such a way as to prevent distortion and corrosion. Bars of different sizes and lengths shall be stored separately.

iii) For checking nominal mass, tensile strength, band test, re-band- test etc. specimen of sufficient length shall be cut from each size of the bar at random at frequency not less than that specified below: -

| Size of Bar | For consignment below 100 tonnes | For consignment over 100 tonnes |
|---|---|---|
| Under 10 mm dia | One sample for each 25 tonnes or part thereof | One sample for each 40 tonnes or part thereof. |
| 10mm to 16 mm dia. | One sample for each 35 tonnes or part thereof | One sample for each 45 tonnes or part thereof. |
| Over 16 mm dia | One sample for each 45 tonnes or part thereof | One sample for each 50 tonnes or part thereof. |

iv) Steel to be brought to site and steel remaining unused shall not be removed from site without the written permission of the Engineer.

### 1.3.3 Quarry Materials

The Contractor shall be wholly responsible to identify the suitable sources for quarry materials required for the Works, such as earth, sand, stone, morrum, etc., and to make his own arrangements for collection and transportation of the materials irrespective of the leads and lifts required. The quarry shall have proper license from the concerned Government. All materials to be supplied by the Contractor shall satisfy the requirements set forth in the Specifications and shall be subjected to the approval of the Engineer. The Contractor shall take this into account while offering rates, and no claims whatsoever shall be entertained for extra costs on this account.

## 1.4 Precautions during Execution

i) The contractor shall comply with the instructions in all respects to be issued by the Employer in respect of road maintenance and inter utility code of conduct for excavating trenches.

ii) The contractor shall have to provide MS sheet barricading upto a minimum height of 2 metres above ground level all around the site of project as per direction of Engineer. Such barricading shall be provided before taking up the excavation work and shall remain in position till complete filling back of excavated trenches and resurfacing work, if any. The MS sheets shall be painted in with fluorescent paint as per direction of Engineer.

iii) Proper supporting of all underground services such as water mains, sewers, cables, drains, and Water and sewer connections shall be provided by the contractor without any additional cost. If the services/connections are damaged, the contractor will be responsible for the restoration of the same to original specifications at his own cost.

iv) The contractor shall provide necessary red flickering lights (blinkers) at all roads and at required places at night for diversion/smooth flow of traffic without any extra cost. He shall also provide necessary sign boards painted and written with luminous paint for traffic diversion as per direction of Engineer. The warning notice boards shall be put atleast 100 metres before the approach to the area on either sides of the construction site. In addition, proper lighting arrangement shall be made for all excavations works.

v) As a result of excavation of trenches, the underground services (UGS) such as water mains, electric poles/cables/Telephone cable and sewer line etc. may become exposed and unsupported. It will be the responsibility of the contractor to make suitable and necessary arrangement for supporting such UGS to keep them functional. Such arrangement shall be done as per direction of the Engineer. No separate payment for supporting the services shall be made by the deptt. Any damages caused to the above mentioned underground services due to negligence of the contractor or otherwise shall be made good by the contractor at his own cost. After laying the pipe, the contractor shall have to construct RCC pillars to support the water lines/U.G.S. before the temporary supports are removed and filling of trenches shall be done.

vi) If necessary, the excavation below sub-soil water level shall be classified as excavation in saturated soil. The trench shall be kept in dry condition during the laying of pipelines and construction of manholes etc. Water table should be lowered at least 300 mm below the pipe bed level.

vii) Existing drains shall not be blocked by excavated earth or any other materials, The contractor shall ensure that sullage/storm water flows uninterruptly.

viii) The Contrator should submit detailed method statements prior to commence any excavation work incorporating the following aspects

a. Plant & Machinery schedule with standby arrangements
b. Prepratory works prior to excavation
c. EMP & Safety Plan during excavation
d. Obtaining prior approval for Shop drawings for temporary supports or false works at excavation with design calculations based on soil properties
e. Method of disposal of excavated material either at temporary yards with stock piling or the approved location as dumping yards
f. Method of backfilling, compaction or consolidation and arrangements for carrying out related tests after compaction

## 1.5 Non Destructive Test

Rebound Hammer Test, Ultrasonic Pulse Veolicty test, core cutter test , cover meter test & rebar location test for concrete shall be mandatory and the same shall be carried out as per the provision and as per Engineer’s requirement. Non Destructive testing of pile i.e. piles integrity test etc shall be done along with the other tests as per IS-2911.

## 1.6 Bar Bending Schedule

The Contractor shall be required to prepare the bar bending schedule prior to taking up all the reinforcement cutting and bending works at site. No reinforcement work shall be allowed without the bar bending schedule.

## SUB-SECTION 2. SITE INVESTIGATION (GEO-TECHNICAL)

### 2.1 Scope

This section covers for any site investigation (soil/geo-technical) which the Contractor may require to carry out to augment or validate the existing information on soil conditions and design parameters for the purpose of any design of the Works or the construction/working drawings and bill of quantities. All test results of the geotechnical investigation to be conducted by Contractor shall be compared with the tendering stage geotechnical invetigation and critical results among the two geotechnical investigations shall be adopted for the design purpose as approved by Engineer.

### 2.2 Reference Standards

The following Standards, Codes of Practice and Manuals shall be referred, but not limiting to, in this section.

| | |
|---|---|
| IS 2720 (1-38) | Methods of test for soils |
| IS 1725 | Soil product |
| IS 1888 | Method of load test on soil |
| IS 4434 | code of practice for in situ-shear test |
| SP-36-2 | Compendium of Indian standard on soil engineering part 2, Field testing of soils for civil engineering purpose and foundation engineering. |

### 2.3 Approvals required by the Contractor

#### 2.3.1 Approval of plant and equipment

Before the commencement of work, the Contractor shall provide for the Engineer's approval a detailed list of equipments and test to be done. The Contractor shall ensure that the equipment shall be suitable for the terrain. The list shall include, but not limited to:

- Number of bore holes and required test shall be done as per Engineer’s approval. Number of boreholes shall be such that at least one borehole shall be carried out for each structure. For structure, one bore hole per 200 m2 has to be carried out as approved by the Engineer. Bore holes may be required along the pipe alignment and at crossings too.

#### 2.3.2 Approval of laboratory and storage facilities

Before the commencement of work, the Contractor shall provide for the Engineer’s approval the full details of the laboratory at which samples shall be tested. If required, the Contractor shall arrange for the Engineer to inspect and visit the proposed laboratory before approval. The Contractor shall submit for the Engineer's approval his proposed arrangements for storage of samples on Site, at the laboratory and at all other locations required in the Contract.

## 2.4 Workmanship

### 2.4.1 Boring

Boring rigs shall be capable of completing holes to at least 20m with minimum diameter of 150mm. Boring shall be carried out at least 5m below the foundation level for pile foundation

A hole shall be cased in any stratum which shall be friable or not sufficiently strong to stand unsupported. When a borehole shall be cased, the bottom of the casing shall always be maintained within 150mm of the bottom of the borehole. The casing shall never be in advance of the bottom of a borehole during undisturbed sampling or standard penetration tests.

The Contractor shall ensure that casings shall be of suitable size and shall be inserted in such a manner as to render them recoverable. Neither casing shall be removed nor shall any filling be introduced into a hole until work in the hole shall be completed. Casings shall be gradually withdrawn and the filling shall be kept above the bottom of the casing during withdrawal. Holes shall be backfilled with well-compacted soil.

### 2.4.2 Standard penetration tests

The Contractor shall carry out standard penetration tests. All external and internal faces of the sampler shall be smooth and free from scars. The Contractor shall carry out the SPT test at every 1.5m depth. A cone-ended adaptor with a 300 half-angle shall replace the open-ended driving shoe for gravelly soils. Every precaution shall be taken to minimize disturbance of the soil to be tested. If the shell is used, it shall be worked gently up and down to avoid disturbance of the soil by surging, the distance through which the shell is dropped shall be small and the shell shall be removed slowly to minimize sanction. If possible the casing shall be turned down through the overlying 300mm of soil and it shall not penetrate the soil to be tested. The test shall be stopped if the total blow count, including the seating drive, reaches 75. A small disturbed sample and, for cohesive soils, a field moisture content sample shall be taken from each soil type in the sampler core. The water level in the hole at the time of the test shall also be recorded.

## 2.5 Particular Requirements for Soil Investigation under the Contract

Tentative number of boreholes is as given in the BOQ. The number may vary significantly depending upon the actual site condition. After the completion of soil investigations & laboratory tests, the Contractor shall submit an analytical report based on his investigation findings. Report shall also elaborate the onsite actions where necessary for strengthening or stabilization of the properties of soil and interpretation of analytical results for verification of structural design features.

### 2.5.1 Scope of Investigation

The following are the scope of works to be undertaken by the contractor

i) To carry out sub-soil investigation at required locations.
ii) Boring in Overburden Soil

- Conducting Standard Penetration Test (SPT) at 1.0 m interval.
- Collection of disturbed and undisturbed soil samples and water samples for laboratory testing.
- Laboratory tests on disturbed/undisturbed soil samples:
  a) Natural Moisture Content (NMC)
  b) Sieve and hydrometer analyses
  c) Atterberg limits & soil classification
  d) Specific gravity
  e) Bulk density and dry density
  f) Unconfined compressive strength
  g) Tri-axial test
  h) Consolidation analysis
  i) Chemical analysis of soil and water samples for pH, sulphate, chloride and other organic content.

iii) Boring in Rock

- Following information regarding rock strata are required:
  a) Geological System
  b) Depth of rock strata and its variation over site
  c) Whether isolated boulder or massive rock formation
  d) Extent and characters of weathered zone
  e) The structures of rock including bedding planes, faults, fissures, solution cavities etc.
  f) Properties of rock material like strength, geological formation etc.
  g) Quality and quantity of returning drill water
  h) Erodibility of rock to the extent possible
  i) Rock Quality Designator (RQD) value to be noted.
- Visual identification and laboratory testing shall be conducted to find out the quality and strength of the rock satisfying the relevant clause of IRC:78-2000.
- The rock cores obtained shall be subjected to tests to get necessary data for design as follows:
  a) Visual identification for
     - Texture
     - Structure
     - Composition
     - Color
     - Grain Size
     - Petrography
  b) Laboratory tests may be done for
     - Specific gravity
     - Porosity
     - Water absorption
     - Compressive strength

### 2.5.2 Location & Depth of Boreholes

Subsoil investigation shall be carried out at an interval of 1.0 km along the pipe line route as specified in IS 1892. Soil exploration depth shall satisfy the following requirements:

i) For Transmission main, Depth as specified to a depth of 6 m or to a layer having consecutive SPT value of 50 or more for a continuous depth of 1.0 m whichever is met earlier. For Distribution main, Depth as specified to a depth of 3 m.

ii) If rock is encountered, depth of bore will be at least 1 m inside the rock layer having total core recovery greater than 50% except for two boreholes near the railway crossing.

iii) For Bore Hole near railway crossing (Phulbangas- 2 Nos, Najafgarh Drain 2 Nos, Pratap Nagar Metro Station 2 Nos, Sarai Rohilla Railway Crossing- 2 Nos, Phulbangas Vegetable Market-1 Nos), Depth as specified to a depth of 20 m or to a layer having consecutive SPT value of 100 or more for a continuous depth of 20.0 m whichever is met earlier.

For each borehole, the depth of termination shall be determined after consultation and certification from the Engineer on the field bore log.

### 2.5.3 Preliminary Report and Records

On completion of each borehole, three copies of a preliminary borehole log shall be submitted to the Engineer.

These preliminary borelogs shall show:

i) Ground level referred to the Chart Datum.
ii) The locations of the boreholes on a plan.
iii) The preliminary description of each stratum.
iv) The thickness of each stratum with the boundaries referred to the Chart Datum.

a) The position, type and identification of each samples and in-situ test with reference to Chart Datum.

b) Any in-situ test results available with reference to Chart Datum.

c) The levels at which each separate ground water level is first encountered and at which it comes to rest (standing water level).

### 2.5.4 Draft and Detailed Report

On completion of all field and laboratory testing, two copies of draft report shall be submitted for the review. The report shall include detailed borelogs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, the supporting calculation for the conclusions drawn etc.

After getting the draft report approved, three (3) copies of the detailed final report shall be submitted along with the graphs, tables, etc. An electronic (soft) copy of the final report in 'MS Word' and 'MS Excel' format shall also be submitted in CD. The graphs and drawings shall also be submitted in AutoCAD 'DWG'. The detailed report shall include:

- A plan showing the position of all boreholes.
- A description of regional geology of the site.
- A description of the procedures of investigation and testing employed and list of equipment used.

- Detailed borelogs, subsoil sections, laboratory and field test results both in tabular as well as in graphical form, showing variations of each of the soil properties with depths in each borehole.
- A true cross section of all individual bore holes with reduced levels and coordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted and samples collected at different depths and the rock stratum, if met with.
- Field and laboratory test results along with graphs and tables used for computation.
- Plot of SPT value (both field and corrected) with depth.
- The stress-strain diagrams as well as Mohr circle envelopes for unconfined compression tests and triaxial tests.
- 'e' vs log 'p', compression vs. log 'f or compression vs. 'square root t' plots depending upon the shape of the plot to determine the coefficient of consolidation.
- Recommendation regarding the allowable bearing capacity of soil along with the depth of foundations for shallow foundation.
- Recommendation regarding the type of cement to be used and any treatment to the concrete based on the chemical composition of soil and sub-soil water.
- Any other information of special significance encountered during the investigation and likely to have a bearing on the design and construction of foundations.
- Photographs of field and laboratory activities shall be included in each copy of the report.
- If there is any weak soil then recommendation on strengthening techniques of soil properties has to be given in the soil report.

### 2.5.5 Execution of Trial pits

Execution of Trial pits along the pipe traces is suggested for the following three distinguished purposes:

i) For identification or further verification of underground utilities for Utility Mapping prior to deciding the final alignment of pipe traces. The number of pits, depth of pits and their appropriate locations depend upon the pipe routes. Contractor shall incorporate the cost for this activity under the overall activities of the “general site requirements”.

ii) Once the alignments are finalized both in Transmission mains & Distribution mains, there would be a need to have trial pits at critical locations where the bore hole investigations results are not available at a close proximity. Especially the locations where the pipe lines are having critical turning points (Tees, Sharp bends etc) observation & classification of soil properties would be preferred. Approximately 250 numbers will be required along the transmission main and distribution network. The exact number may vary depending on the ground situation. The depth of trial pits would be from 2.0 m to 3.0 m depending upon the line diameter and the subsoil strata. Payments are on the basis of BOQ unit rates.

iii) The other purpose would be to assess and verify the pipe conditions where the existing pipes are connecting to the new networks. This could be on sample basis and most importantly for larger diameter pipes where the connections are proposed to take place to existing CI/DI/MS pipes. This would rather be essential at the suspicious locations where the alignment of existing pipe is not confirmed by the available as-built details. Prior to cutting those pipes trial pit excavation could be done to observe the external pipe properties and as well as to confirm the alignment at the connecting point. As per the directive of the Engineer, some cut pipe pieces on sample basis could be dug out from those trial pits in order to ascertain the pipe condition and to confirm the

suitability for connecting to the new network. Contractor shall incorporate the cost for this activity under the unit rate of the BOQ activity of connecting existing pipes to the new pipe network.

Brief specification of the above works is as follows:

1) Location of trial pits will be proposed by the Contractor and determined jointly by the Engineer and the Contractor.
2) Cost of road restoration charges is included in the BOQ rates and thus the rates quoted by the Contractor should include this cost. The Contractor shall initiate, make payment, and follow-up the process for obtaining pit digging permission from land owning agencies. PMSC and DJB will provide documentary support for acquiring the permission as necessary.
3) Payment will be based on the surface area of bituminous or concrete layer cutting plus volume of earth digging. The depth of the pit will be between 2 to 3 m depending on the pipe diameter and subsoil strata.
4) The Contractor shall take utmost care not to cause any damage to other utilities' facilities such as telephone line, gas line, power line, and so on. The Contractor shall bear all the responsibility and liability for any damage to such facilities and its consequences.
5) Safety of public and workers will be of highest importance. In order to prevent any mishap the Contractor shall take all precautionary measures including but not limited to, warning sign boards, notices, illuminating lights, temporary fences, standby-security personnel, and so on.
6) The Contractor will assign a stand-by security on site during the entire process from the beginning of digging to the completion of backfilling.
7) As necessary, the Contractor will coordinate with traffic police, local Residents' Associations, and other persons in order to minimize disturbances during excavation.
8) For every pit the Contractor shall take digital photographs, record GPS coordinates (WGS 1984), and record measurements. These will be included in the periodic Reports to be submitted by the Contractor.
9) The Contractor shall anticipate and make proper arrangement, such as drainage pump, generator and hose pipe to drain water from the pit. The drained water should be disposed of at suitable location not objectionable to public.

**Reporting:**

The Contractor shall dedicate a separate section for this work in its monthly progress report. Its report shall include a GIS map showing the location of pits and summary containing the numbers completed, size (length, breadth, and depth) of each pit excavated, soil type, size and material of existing pipe found and any other pertinent information.

## SUB-SECTION 3. SITE PREPARATION AND EARTHWORKS

### 3.1 General

This Section covers requirements for earthworks including site preparation, mass excavation, trench excavation, structure excavation, filling and compacting and miscellaneous site works.

### 3.1.1 Reference Standards

The following Standards, Codes of Practice and Manuals shall be referred, but not limiting to, in this section.

| | |
|---|---|
| IS 2720 (1-38) | Methods of test for soils- in Various Parts |
| IS 3764 | Excavation work - Code of Safety |
| IS 5529 | In-situ Permeability test |

### 3.1.2 Definitions

1. **Site:** The site for the work is shown in the drawing and the contractor's working and storage areas, where so specified are within the site.

2. **Earthwork:** Earthwork shall include all site preparation, excavation, handling, hauling and compaction of required fill materials, disposal of all excess excavated materials, shoring and protection work, preparation of sub-grades, dewatering as necessary, protection of adjacent property, backfilling and embankment to the lines and grades indicated in the drawings for the works described in the Contract Documents and/or shown on the Drawings.

3. **Fill:** Compacted suitable fill materials in all areas of the site requiring filling and for filling trenches as shown on the drawings.

4. **Structural fill:** Compacted suitable fill materials which will support a structure or some part of a structure.

5. **Structural backfilling:** Compacted suitable fill material placed between the wall of a structure and construction excavation slope up to finished grade or back filling of trenches excavated for laying pipes.

6. **Suitable materials:** As specified herein shall be any materials excavated from the cut areas or imported that in the opinion of the Engineer is suitable for use in constructing fills.

7. **Unsuitable materials:** Materials from project excavations, which is not suitable for use in backfilling or compacted fills.

8. **Surplus materials:** Materials from the Project excavation to excess to that required to be used for backfilling or constructing fills.

### 3.1.3 Site Investigation

The Trial pit summaries and related information depict subsurface conditions only at the specific locations and at the particular time designated in the logs. Soil conditions at other locations may differ from conditions occurring at these locations.

The Contractor shall take care in order to determine the full extent of the work required to make the completed work conform to the Drawings and Specifications. The Contractor shall satisfy himself as to the character, quality and quantity of surface and subsurface materials or obstacles or utilities to be encountered. Any inaccuracies or discrepancies between the actual field conditions and the drawings, or between the drawings and specifications shall be brought to the Engineer's attention in order to clarify the exact nature of the work to be performed.

## 3.2 Site Clearance

Site preparation, shall include, within the boundaries of the work as shown on the Drawings, the grubbing stripping and removal of all vegetation, organic materials, and other unsuitable excess materials. Areas which will be under fills shall be cleared and grubbed to a depth of 12 cm or sufficiently deep to remove large roots, loose rocks, and other unsuitable materials as determined by the Engineer. The materials pronounced useful by the Engineer will be removed and properly stacked as directed within specified lead.

All rock foundation and abutment surfaces shall be cleared of all loose materials by hand or other effective means and shall be free of standing water when fill is placed. Fill immediately adjacent to such rock foundations or not accessible with large compaction equipment shall be compacted to the specified density by means of hand tamping or manually directed power tampers or plate vibrators.

Where ordered by the Engineer topsoil shall be stripped, to such depths and over such areas as a separate operation prior to any further excavation which may be required. Topsoil shall be stored for reuse.

### 3.2.1 Site Grading Generally

After all unsuitable material has been removed from the site, the existing surface shall be excavated or filled to the elevations and slopes and dimensions indicated on the drawings or as directed by the Engineer and the Contractor shall perform all operations related thereto. It will be the responsibility of the Contractor to install substantial reference marks, bench marks etc. and maintain them in position as long as required. Road and drainage works required within the property limits at each site shall be provided as part of the site grading.

## 3.3 Excavation, Backfilling and Surface Reinstatement

The Contractor shall excavate all materials of whatever nature encountered, to lines, levels, curves and grades as required or as shown on the Drawings. After completion of this excavation and before any further work is done the Engineer will examine the sub-grade.

The Contractor shall notify the Engineer before starting excavation to enable him to take cross sectional / L-sectional levels for measurement before ground is disturbed. Where excavation

is progressive, the cross-sections and L-sections will be demarcated by substantial pillars or stakes. The Contractor may be required to carry out excavation deeper than shown on the Drawing.

The entire areas within the limits of earthwork as indicated shall be constructed to the lines, grades, elevations, slopes and cross sections indicated on the Drawings with added allowance for the thickness of free draining fills or other special materials such as clay where required. Slopes and drainage features shall present a neat, uniform appearance upon completion of the work and shall be subject to approval by the Engineer.

Excavated materials meeting the requirements of fill materials may be conserved for subsequent use or placed as earth fill immediately after excavation provided the Engineer gives his approval. Large rocks unacceptable as earth fill materials may be stockpiled for use as riprap where required. The suitability of all excavated materials for specific purposes shall be determined by the Engineer. The Contractor shall not waste or otherwise dispose of suitable excavated materials. All excavations shall be performed under the limitations and requirements set out in this Specification pertaining to control of water content**.**

### 3.3.1 Choice of Blasting and Chiseling

Blasting for Excavation in rocky areas shall not be permitted. It shall be cut with chisels. Excavated rock shall be stacked as per directions of Engineer and as per CPWD specifications. The item of excavation in hard strata specifies clearly the mode of excavation and shall be done as per that method.

### 3.3.2 Shoring or Earthwork Supports

All excavation shall be suitably and effectively supported at the sides and ends to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation. Unless specifically provided for in the tender the shoring and strutting shall be deemed to be part of excavation item only and nothing extra shall be paid to the Contractor. If for any reason, any portion of the bottoms, sides or ends of any excavations shall give way, the Contractor shall at his own expense take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed both within and outside the nominal limits of excavation and such extra excavation shall not be paid for.

The Contractor shall submit a detailed plan for review showing the design of shoring, bracing, sloping, or other provisions to be made for worker protection from the hazard of caving ground during the excavation of such trench or trenches or during the pipe installation or any construction therein.

If ordered by the Engineer, the Contractor shall provide additional supports or sheeting or modify the arrangements as directed without extra cost. Excavation of any particular section or portion for earthwork shall not be commenced without prior approval of the Engineer.

This shall not exempt the Contractor from the liability of damages to persons and property due to failure of the shoring etc.

### 3.3.3 Sloping Faces

Where the Contractor elects and is permitted by the Engineer to perform excavations with sloping faces, other than sloping excavations where required by the Engineer or as specified

in the Contract and without shoring, the excavated faces shall be stable slopes and heights and the resulting extra excavation shall not be paid for. The decision of required slope (or steps) to be allowed for such open excavation will be that of the Engineer whose decision will be final and binding on the Contractor.

### 3.3.4 Trimming Excavations

When excavating to specified levels for the foundation of any structure or to specified limits for the face of any structure or for laying pipelines, the Contractor shall not excavate the last 150 mm until commencing the constructional work.

Before commencement of any constructional work, all shattered and loose material shall be removed from the excavation by hand, so as to ensure that the work rests on a solid and perfectly clean foundation or abuts against solid ground.

### 3.3.5 Diversion and protective works

The Contractor shall plan, construct and maintain necessary diversion and protective works, so as to keep the work safe at all stages. The coffer dam where required shall be built to required depths and heights and safety designed and constructed with suitable dimensions and protection and shall be made watertight enough for construction inside it. The coffer dam shall leave sufficient clearance for construction and inspection facility and permit installation of pumping machinery as required.

Cement grouting or other approved method shall be used by Contractor at his choice to reduce seepage, for which no extra payment shall be made. In any case, method statement shall be submitted prior to commencement of excavation (or during the excavation where necessacity has been arisen) describing the applicability of such soil stabilization methods.

### 3.3.6 Dewatering and Disposal of water

The Contractor shall ensure at his cost that the excavation and the structures shall be free from water during construction and shall take all necessary precautions and measures to exclude ground/ rain water / seepage water so as to enable the works to be carried out in reasonably dry conditions in accordance with the construction programme. Sumps made for dewatering must be kept clear of the excavations/ trenches required for further work.

The method of pumping shall be approved by Engineer, but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction. The dewatering shall be continued for at least (7) seven days after the last pour of the concrete. The Contractor shall, however, ensure that no damage to the structure results on stopping of dewatering.

The Contractor shall study the sub-soil conditions carefully and shall conduct any test necessary at the site with the approval of the Engineer to test the permeability and drainage conditions of the sub-soil for excavation, concreting etc., below ground level.

The scheme for dewatering and disposal of water shall be approved by the Engineer.

In cities and towns the water may be led to nearest road side gutters. In other places water may be led to the nearest natural drain or pond through properly laid and dug channels or

pipes. The disposal shall not cause any inconvenience or nuisance to inhabitants of the area and also not cause damage to structures and property. Draining of dewatered water to the existing sewer manholes should be avoided.

The Contractor shall suitably divert the water to be obtained from dewatering from such areas of site where a build up of water in the opinion of the Engineer shall obstruct the progress of the work, leads to unsanitary conditions by stagnation, shall retard the speed of construction and is detrimental to the safety of men, materials, structures and equipment.

When there shall be continuous inflow of water and the quantum of water to be handled is considered in the opinion of Engineer, to be large, a well point system-single stage or multistage, shall be adopted. The Contractor shall submit to the Engineer, details of well point system including the stages, the spacing number and diameter of well points, headers etc., and the number, capacity and location of pumps for approval.

If any foundation pits shall be filled due to accumulation of surface flow during the progress of work or during rainy season, or due to any other cause, all pumping to be required for dewatering the pits & removing silt shall be done without extra cost.

Grading in the vicinity of excavation shall be such as to exclude rain/ surface water draining into excavated areas. Excavation shall be kept clean of rain and such water as the Contractor may be using for his work, by suitably pumping out the same.

### 3.3.7 Pumping arrangement

Adequate pumping arrangement shall be made for dewatering the foundation/pipe trenches and other construction areas so as to keep them dry during the progress of the work until concrete or mortar masonry work has sufficiently set or pipe laying and backfilling works completed in that particular section. The dewatering arrangement shall preclude the possibility of movement of water to fresh concrete or masonry. The Contractor shall make his own arrangement for labour, materials and equipment for coffer dams, pumps, engines and other machinery and services required for execution of item. The pumping shall not cause any damage to the adjoining property.

If any foundation pits are filled during the progress of work due to any cause, the pumping required for dewatering pits and for de-silting shall be done without extra cost to the Employer.

All protective works required for dewatering shall be designed and provided by the Contractor to ensure full safety of work, workmen, machinery and property. The Contractor shall be responsible for only damage and injury caused by execution of this item.

The works constructed such as coffer dam, sumps for facility of diversion and dewatering shall be removed after they have served their purpose, in the manner and to the extent instructed by the Engineer. If any excavation is made outside the enclosed area for facility of construction, the Contractor shall refill the same with proper ramming of foundation work so as to bring river bed to its original condition similarly any material deposited with the stream or from any excavation shall be removed and the stream is made free from obstruction.

### 3.3.8 Additional Excavation required

When the specified levels or limits of excavation are reached, the Engineer will inspect the ground exposed, and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, masonry, selected excavated material or selected imported material as directed by the Engineer.

If the material forming the bottom of any excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or due to flooding or have become puddle, soft or loose during the progress of the works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. Such further excavation and consequent backfilling shall not be paid for. After each excavation is completed the Contractor shall notify the Engineer to that effect and no footing or pipe will be allowed to be laid until the Engineer has approved the depth and dimensions of excavation and nature of foundation material and levels/ measurements are recorded.

If through mistake by the Contractor, excavation is done deeper than shown on plans or ordered by the Engineer, the extra depth shall be made up with concrete or masonry as directed by the Engineer and the cost of excess excavation and the filling by masonry/concrete shall not be paid for.

### 3.3.9 Surface reinstatement

The materials excavated shall be separated and stocked so that in the refilling they may be re-laid in the same order and thus least possible damage be done to public roads, fields, etc. The road material excavated shall be stacked separately as directed by the Engineer. The refilling with excavated boulders and metal shall be done in the previous order to original level with allowances for sinking. The concrete/asphalt pavements shall not be done by the Contractor unless provided for specifically in the contract. Materials for Backfilling of Trenches shall be as per the IS 12288.

### 3.3.10 Finish Grading

All areas of the work, including excavated and filled sections and transition areas shall be uniformly graded to the elevations shown on the Drawings. The finished surface shall be reasonably smooth, compacted and free from any irregular surface changes. The degree of finish shall be that ordinarily obtainable from scraper operations, though a manual finish to the same standard will be acceptable. The finished surface will be not more than 5 cm above the established grade.

### 3.3.11 Top-soiling and landscaping

Topsoil shall be evenly spread and trimmed over embankments or areas surrounding structures to the slopes and levels shown on the Drawings or ordered by the Engineer. The depth after spreading and trimming shall be a minimum of 20 cm unless otherwise directed, measured perpendicularly to the surface. All clods and lumps shall be broken up and any rubbish, stones larger than 50 mm, roots and weeds shall be removed.

### 3.3.12 Fossils and other materials

All fossils, relics, coins, minerals and any other items of archaeological importance found in excavation or dismantling shall be the property of the Employer and shall be handed over to the Engineer's representative. Should any structure be uncovered, the Engineer's instruction shall be obtained before its demolition or removal.

### 3.3.13 Testing

Testing will be performed when, where, and as directed by the Engineer. The costs of compaction testing shall be borne by the Contractor. The Contractor shall adjust his operations so as to permit the Engineer time to make tests, and shall excavate and fill such holes as may be required for sampling and testing. Extensive regular testing will normally be required only during the construction of embankments, and side and top fillings for steel pipes.

### 3.3.14 Control of compaction

The moisture content shall be controlled as specified herein and the surface materials of the foundation shall be compacted, the surface bounded with the first layer of earth fill. Subsequent layer of earth fill shall be bounded in a similar manner. No pounding or jetting shall be permitted.

Fill material shall be moistened or dried to within two (2) percent of optimum moisture content (Proctor) and compacted to meet or exceed the following listed values when in accordance with these specifications.

1. Fills and backfills under and adjacent to structures shall be compacted to not less than 95 percent of maximum dry density.

2. All other fills shown on the plans shall be compacted to not less than 90 percent of maximum dry density.

All working areas shall be protected from damage by water and site drainage shall be maintained at all times, and water shall be prevented from standing on the top of constructed fills and backfills. Heavy equipment shall not be operated within 1.5m of any structure.

## 3.4 Excavation for Structure

Excavation and backfilling for all structures and appurtenances associated with the structures shall include the entire cost of any required shoring, timbering, stabilization or dewatering unless specifically separately provided for, in the contract, and workmanship shall comply with the appropriate provisions of these specifications. Structure excavation shall include the removal of all materials to such depth as indicated in Drawings, including all obstructions of any nature that would interfere with the proper execution and completion of the work. The removal of such materials shall conform to the lines and grades shown on the Drawings and/ or herein specified. It shall be the Contractor's responsibility to provide all required pumping, ditching or other approved measures for the removal or exclusion of water from the excavated space. The item of dewatering shall be taken as included in excavations unless otherwise provided for in the separate tender item. All excavation works shall be done as per IS 3764 "Code of Safety - Excavation Work".

### 3.4.1 Excavation Side Slopes

Loose cobbles or boulders shall be removed from the sides of the excavation for structures before allowing workmen into the excavation, or the excavation side slopes must be protected with screening or other methods approved by the Engineer. In no case shall surcharge loads due to construction equipment be permitted with 1.5 meters of the top of any excavation slope. If the Contractor selects to shore or otherwise stabilize the excavation sides, he shall submit in writing his plans & method statement for such proposal to the Engineer for approval before commencing any excavation. Shoring and strutting shall be deemed to be included in the item of excavation, if not specifically provided for separately in the contract.

### 3.4.2 Excavation for Foundations Trenches

The foundation trenches shall be kept dry by resort to pumping alone or pumping in combination with diversion channels, cofferdams, bunds, diversion weirs, drainage channels, or other method suitable for the local conditions, at the choice of the Contractor. The responsibility of adequacy of dewatering arrangements and quality and safety of work rests solely with the Contractor

## 3.5 Structural Fill

### 3.5.1 Materials for Structural Fill

When the quantities of suitable materials obtained from excavations are insufficient to construct the specified fills, additional materials shall, if directed by the Engineer, be obtained by the Contractor from approved burrow areas. Borrow pits shall be excavated and finally dressed in a manner to eliminate steep or unstable side slopes or other hazardous or unsightly conditions. The extent and depth of burrow pits within the limits of the designated borrow areas shall be subject to approval by the Engineer.

Excess excavated or fill material may be deposited on the Site in accordance with compaction requirements and subject to the approval of the Engineer.

Rocks or other solid material which are larger than 15 cm in greatest dimensions shall not be used as fill without the Engineer's approval. Smaller rocks shall be well distributed throughout the fill area and sufficient earth or other fine material shall be placed around the larger materials as it is deposited so as to fill the interstices and produce a dense, compact fill.

### 3.5.2 Deposition of Structural Fill

Materials for fills may be obtained from the required excavations. Fill material shall be deposited in layers of not more than 20 cm in loose thickness for hand compacted fill, including manually directed power tamping, and compacted to the required densities by suitable compaction equipment. Additional fill may be required and shall be obtained from approved borrow areas. The Contractor is responsible for the arrangement and payment for all embankment material and the material selected shall meet approval of the Engineer.

## 3.6 Structural Backfill

### 3.6.1 Materials for Structural Backfill

Materials for structure backfill shall be non-expansive material selected from on Site material obtained from the excavation and approved by the Engineer. Should on-Site materials prove of insufficient quantity, the material shall be provided at Contractor's expense and shall be subject to approval by the Engineer. No rocks larger than 8cm in diameter or trash, roots or detrimental quantities of organic material shall be permitted in structure backfill. The Contractor may, at his option and at no cost to the Employer, substitute rock or other material approved by the Engineer for use as structure backfill.

### 3.6.2 Placement of Structural backfill

Before beginning backfilling, all foreign material, including water, shall be removed from the space to be backfilled and the area to be backfilled shall be inspected and approved by the Engineer. No backfill shall be placed around or upon any structure until the concrete or masonry in the structure has attained the specified compressive strength. The compressive strength shall be determined by test on representative cylinders or cubes made from the same concrete and cured under conditions similar to those prevailing at the site. Backfill shall not begin until after the forms have been removed and patching of the concrete and water proofing has been completed and the work approved.

### 3.6.3 Compaction of Structural Backfill

Structure backfill shall be placed in horizontal layers of such depths compactable to the type of compaction equipment being used, but in no case shall be the lifts exceed 20cms. Each layer shall be evenly spread; the moisture content brought to bear optimum conditions and then compacted.

Permission to use specific compaction equipment shall not be construed as guaranteeing or implying that the use of such equipment will not result in damage to adjacent ground, existing improvements, or improvements installed under the Contract. The Contractor shall make his own determination in this regard.

Flooding, jetting or pounding will not be permitted for the compaction of any backfill.

The top surface of all embankments shall be approximately level during construction except that a crown or cross slope (super elevation) of not less than 2 percent shall be maintained for effective drainage. Though not shown on the Drawings, all finish grade embankment top surfaces shall be finished a 2 percent crown or cross-slope as applicable for the Site drainage.

### 3.6.4 Deterioration of backfilling material

If the material being placed as backfilling, while acceptable at the time of selection, become unacceptable to the Engineer due to exposure to weather conditions or due to flooding or have become puddle, soft or segregated during the progress of the works, the Contractor shall at his own expense remove such material and replace it with fresh approved material.

The Contractor shall when placing the backfilling make due allowance for any settlement that may occur before the end of the defects liability period. Where necessary, the Contractor shall at the end of the defects liability period remove any excess material or make up any deficiency

of backfilling to the specified level.

## 3.7 Trench excavation and backfill for Pipeline, Cable and Duct works

### 3.7.1 Trenches

Trench excavation means excavation of trenches into which pipes are to be laid and the term pipes shall mean pipes of all kinds and for whatever purpose and shall also include cables and cable ducts. The line and level of trenches shall be as shown on the Drawings or as may be directed by the Engineer. Before commencing trench excavation, the route of the trench shall be pegged out accurately and the natural ground levels shall be agreed with the Engineer. Strong sight rails shall then be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary. On these rails shall be marked the centre line and the level to which the excavation is to be carried out, such rails being not more than 40m apart. In case the above is not be possible due to narrow roads or otherwise as per site conditions, paint marking on top of road surface or marked at the adjoining structures indicating the off-set to the pipe centre as per the approval of the Engineer.

The trenches for laying of pipes should be so dug that the pipes may be laid to the required alignment and at required depth.

a) Authorized quantities or those actually excavated, whichever are less shall be allowed for payment.

b) Authorized widths: Minimum width of trench excavation shall be 500 mm. Normally the trench width shall be W = OD + 2x200 as per IS 12288.

c) Depth: The finished depth of the trenches shall be to ensure specified minimum soil cover of 0.9 meter measured from top of the pipe barrel (not the socket). In special cases (e.g. placing pipes at RC ducts) depth may be reduced by providing precautionary measures as per the details given in STD or as directed by the Engineer.

d) In strata mixed with boulders and rock ground authorized width and depth of trench excavation shall be as per the direction given by the Engineer of the work.

e) Inspection of Trenches: The finished trenches shall be inspected and cleared for lying of pipes by the Engineer.

### 3.7.2 Trial pits

The Engineer may direct that trial pits shall be excavated well ahead of the trench excavation to such depths as he shall order to determine the alignment of the trench. Any further trial pits required by the Contractor to determine the position of underground services, subsoil drains or for any other reason shall be excavated and reinstated at the Contractor's expense.

After the required information is obtained, the Contractor shall arrange for the re-filling and reinstatement of trial pit to be carried out immediately to the approval of the Engineer and in accordance with the requirements of the authority or the persons having jurisdictions of the area.

### 3.7.3 Trench excavation- General

Following preliminary works shall be required to be carried out by the Contractor, without any extra payment. Hence no extra payment for these work shall be payable to the Contractor.

a) Site Clearance: Pegging out, clearing and disposal of all shrub, grass, bushes, hedges, fences, gates, portions of old masonry and derbies from pipe line alignment.
b) Marking of Alignment on Ground.
c) Listing of Underground Utilities: i.e., Telephone cables, Electric cables, Manholes and Sewer lines and Contractor is required to inform and get clearance from the concerned authority for such utilities before starting excavation.
d) Approval of Alignment: After completing activities as mentioned in above para (a), (b) and (c) the Contractor shall obtain clearance of alignment in written in the site book from the Engineer.

#### 3.7.3.1 Method of excavation

Excavation by manual methods shall only be employed at locations near existing pipe lines, sewer lines, underground cables, for finishing of trenches, narrow streets and at locations directed by the Engineer or his representative.

At all other locations excavation may be done by manual or mechanical appliances as practicable and safe. Method statement should be submitted prior to excavation indicating the size, capacity and schedule of plant & machnary which are supposed to be used for trench excavation. Advance planning shall be on pipe section or road sector wise.

#### 3.7.3.2 Avoidance of existing Services:

As far as possible, the pipe lines shall be laid below existing services, such as cables, cable ducts and small drains but not below sewer lines, nallahs carrying polluted water. If it is unavoidable, pipelines should be suitably protected.

Adequate arrangements shall be made by Contractor to protect and support other services during all phases of the work. The pipeline shall be so laid as not to obstruct access to the other services for inspection, repair and replacement. When such utilities are met with during excavation, the authority concerned shall be informed and arrangements should be made to support the utilities in consultation with them. If the Contractor fails to call before digging and any damage occurs to any underground utility, Contractor shall pay for the damages so caused.

Trench excavation shall be carried out by such methods and to such lines, dimensions and depths as shall allow for the proper constructions of the works, provided always that, unless the Engineer permits otherwise, no trench excavation shall be less than the nominal widths specified.

The sides of trench excavation shall be vertical unless the Engineer permits otherwise. Any widening or deepening of trench excavations necessary to accommodate curves, joints or bends in the pipe or to provide extra working space for the construction thereof shall be held to be allowed for in the Contractor's rates for overall linear meters of length.

No length of trench excavation shall be started until the pipe to be laid in that length is available on the site.

The Contractor shall carry out further excavation as may be necessary to accommodate structures such as thrust blocks and valve chambers.

### 3.7.4 Trench excavation in the Roads

Programme of excavation shall be decided in consultation with the Engineer so as to cause least traffic interruption. Appropriate signs for public guidance like "street closed for traffic" etc. shall be exhibited by the Contractor. Excavation in roads and other work carried out within the vicinity of any road shall be completed as rapidly as possible and not more than half of the carriageway shall be obstructed at one time unless otherwise permitted by the Engineer or competent authorities. Road drains shall be kept free from obstruction.

The Contractor shall take special precautions, which shall include the continuous support of the sides of the excavation, from the time when excavation is begun until the refilling of the trench is placed, to ensure that there is no disturbance of any road or road foundation or structure.

All excavated material shall be stacked in such a manner as not to endanger work or cause obstruction on footpath or driveways. All excavated stuff suitable for bedding or refilling shall be separately stacked. Where excavated materials have temporarily been deposited on a grass margin, the margin shall, on completion of refilling, be restored entirely to its original condition and left free from loose stones. Access to the premises shall not be blocked by the excavation of trenches and at least trenches shall be covered with a suitable Plates for making temporary access and facilitating single entry of light vehicle.

The Contractor shall have particular regard to the safety of traffic, persons and livestock using rights of way through the Site and shall ensure that all open excavations, access routes and steep or loose slopes arising from the Contractor's operations in roads or other areas are adequately shored and protected.

### 3.7.5 Trench bed preparation

The bottom of trench excavations shall be carefully finished and trimmed true to grade with the aid of a straight edge at least 6m long so as to ensure a continuous support for the pipes. Where directed by the Engineer the trench bottom shall then be picked over with a fork and any stone or flints either likely to cause the pipe to bed unevenly or to damage the pipe and its coating shall be removed. Stones greater than 20mm in size shall be picked out of the pipe bed and any holes so formed shall be filled in with the soft material and trimmed to the correct level. Where bedding material is specified, all shattered and loose material shall be removed from the bottom of the trench excavation so that the bedding material rests on a solid and clean foundation. Minimum depth of pipe bed should be 150mm and designed pipe beds may be required if the soil formation has low bearing capacity than the design requirement. Where the pipe trenches are having excavated rock at the bed then the bed material should be granular sand (IS 2405) or a silimilar suitable material approved by the Engineer. Standard drawings are provided as the guide for pipe bed materials and bed requirements and/or it shall be in accordance with the IS 12288 for standard pipe trench details.

### 3.7.6 Progress of trenching

Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the contract, the refilling and surface reinstatement of trench excavations shall be

commented and completed as soon as reasonably practicable after the pipes have been laid and jointed.

Pipe laying shall follow closely upon the progress of trench excavation and the Contractor shall not permit excessive lengths of trench excavation to remain open while awaiting testing or lining of the pipeline. Availability of pipes and specials required at Site for the work shall be considered before progressing work of excavation. The Contractor shall take precautions to prevent flotation of pipes in locations where open trench excavations may become flooded, and these precautions may include the partial refilling of the trench leaving pipe joints exposed while awaiting tests of the joints at the approval of the Engineer.

If the Engineer considers that the Contractor is not complying with any of the foregoing requirements he may prohibit further trench excavation until he is satisfied with the rate of laying and testing of pipes and refilling of trench excavation.

### 3.7.7 Refilling/ Backfilling of trench

This shall be generally done as per IS 12288.

Where necessary the Contractor shall adjust the moisture content of the refill material to obtain optimum conditions either by drying out or by adding water to assist the compaction of the material. Under no circumstances will flooding or ponding be permitted.

Should the material being place as backfilling, while acceptable at the time when approved, become unacceptable to the Engineer due to exposure to weather conditions or due to flooding or have become puddle, soft or segregated during the progress of the works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material.

Where directed by the Engineer, pipelines shall be bedded or surrounded with concrete.

If the filled up trenches sink during subsequent monsoon, responsibilities of making good the sinking by providing additional filling rests with the Contractor, even though the measurements of work have been recorded and paid for. The refilling shall be carried out with due allowances for such sinking.

For the purpose of back-filling, the depth of the trench shall be considered as divided into the following three zones from the bottom of the trench to its top:

| | |
|---|---|
| Zone A:<br>From the bottom of the trench to the level of the centre line of the pipe | Back-filling by hand with sand, fine gravel or other approved material placed in layers of 150 mm and compacted to a density of not less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. The back-filling material shall be deposited in the trench for its full width of each side of the pipe, specials and appurtenances simultaneously. Special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe. |
| Zone B:<br>From the level of the centre line of the pipe to a level 300 mm above the top of | Back-filling and compaction shall be done by hand or approved mechanical methods in layers of 150 mm, special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe. The compacted density shall be not less than 90% of the maximum dry density at optimum moisture content of the |

| | |
|---|---|
| the pipe | surrounding material. |
| Zone C:<br>From a level 300 mm above the top of the pipe to the top of the trench. | Back-filling shall be done by hand or approved mechanical methods in 150 mm layers after compacting and carried to the level necessary to allow for the temporary restoration of road and path surfaces, and also for hard-core (if and where ordered) on roads or to such level as will leave the requisite space for the top soil, road surface etc. to be reinstated as directed by the Engineer. The compacted density shall be not less than 90% of the maximum dry density at optimum moisture content of the surrounding material.<br>In case of agricultural or waste land and after approval by the Engineer back-filling may be made in thicker layers and with less compaction up to 200 - 300 mm above the initial ground level. |

Where the excavation is made through permanent pavements, curbs, paved footpaths, or where such structures are undercut by the excavation, the entire back-fill to the subgrade of the structures shall be made with sand in accordance with IS 12288.

The excavated material may be used for back-fill in the following cases, provided it complies with IS 12288 Clause 4.11.1:

a) In Zone C: In cases where settlement is unimportant the back-fill shall be neatly rounded over the trench to a sufficient height to allow for settlement to the required level.
b) In any zone, when the type of back-fill material is not indicated or specified, provided that such material consists of loam, clay, sand, fine gravel or other materials which are suitable for back-filling in the opinion of the Engineer.

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Engineer, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall be subject to the approval of the Engineer, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

Trenches crossing a road shall be backfilled with selected material placed in layers not exceeding 15 cm in thickness after compacting, wetted and compacted to a density of not less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any deficiency in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

On completion of pressure and leakage tests exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with the requirements of the above specifications. The Contractor shall not use backfilling for disposal of refuse or unsuitable soil.

### 3.7.8 Bedding Materials and Types

The bedding and backfilling shall be carried out as per the standard drawing as specified. Sand

bedding, if specified, shall be carried out as per drawing provided to the Contractor.

Excavation for pipe bedding should be done in accordance with the invert levels of the pipe traces as shown on the drawings. The maximum depth of excavation shall not exceed 150 mm below the invert levels and may depend upon the type of bedding. If any part of trench for bedding is excavated deeper or wider than specified, the extra erroneous portion to be filled with grade 15 concrete or otherwise as the engineer may require.

Before placing the bedding material the excavated surface should be properly levelled & trimmed with manual means and to be compacted with vibratory compactors to ensure stabilized foundation for pipes. Boulders, loose particles and other impurities shall be removed before compaction & to be wetted if necessary for achieving CBR value > 95%. As explained before if the water table is at or above bed level, shall be lowered 30cm below the formation level.

Types of bedding may depend upon the soil condition of the formation level of the pipe inverts and the other environmental features of the ground profile. Bedding type shall be decided in accordance with the findings of the investigation of soil logs of the pipe traces standard beddings with granular materials (at the range of 2.5mm to 20mm US sieve size) could widely be used for average soil conditions of the trenches at water logged areas with detail designs for bearing & settlement. Where rock is encountered in trench beds the trimmed rock surface at the pipe bed to be filled with clean sand for at least for a 150mm thickness, (in accordance with IS 2405 or equivalent) followed by side filling of the pipe trenches by the same material up to the mid-point of the pipe diameter. Once the granular filling is introduced as pipe bedding it shall be compacted with water jetting before placing the pipes in accordance with their specified invert levels. If required, 150mm – 300mm long pockets could be provided along the pipe bed for pipe joints.

Prior to pipe laying it should be ensured that the pipe bedding is in conformity to the invert levels of the pipe traces as specified in the drawings and free from foreign materials, boulders, sharp edges etc.

### 3.7.9 Existing services

Where trench excavation is carried out close to or across the line of sewers, pipes, cables and other services or structures, the Contractor shall, where necessary, provide temporary supports or slings and where such sewers, pipes, cables and other services are temporarily disturbed, they shall be replaced.

Where, in the opinion of the Engineer, construction of the pipeline cannot reasonably be carried out unless the sewer, pipes, cables and other services are severed and/or replaced or permanently diverted or permanently supported by concrete he may order the Contractor to undertake such work.

Notwithstanding any relevant information furnished by the Employer or Engineer, the Contractor shall be responsible for ascertaining from his own inspection of the site and from the respective supply authorities and other public bodies the position of all mains, pipes and cables whether underground or overhead, within or near the site.

### 3.7.10 Lighting and Guarding of Trenches

The excavation rate shall be inclusive for barricading, lighting at night by red lights or a

construction sign in charge of a watchman to avoid any accidents till road is safe for traffic. Local Authority's Rules, if any, in this behalf shall be observed. Accidents, if there be any, shall be the responsibility of the Contractor.

### 3.7.11 Trench not to be backfilled before inspection

The trench shall not be filled in until the joints have been tested and alignment examined and passed and the level/measurements are recorded by the Engineer.

The Engineer may order refilling of trenches before testing in which case joints shall have to be opened by the Contractor during testing at his own cost.

### 3.7.12 Sequence of works for ensuring good pipe laying

The required fittings, valves and jointing material should be carefully worked out in the beginning. These materials should be received before excavation/laying of the pipeline and stored as per directions of manufacturer or as per the directions given elsewhere in this specification or Standards.

The pipes should be received on site only after the above fittings, valves and material for joints has been received and all necessary preparation for laying has been made.

The material received should be checked for inspection certification as per contract and damage during transportation. All damaged material should be separated and not used.

The pipes received should be stored strictly as per directions of the manufacturer or as mentioned elsewhere in this specification or standards.

The pipes and other material should be again inspected for any damage before use in the trench.

The fittings and valves should be installed in sequence with the laying of pipes without leaving any gaps.

It is desirable to lay the pipe lines from the end from where it can be connected to the water source to enable regular flushing of laid pipes.

The entry of dirt or any foreign material in the pipe should be religiously prevented.

Each joint should be carefully checked for its completeness before covering up.

There should be a commensurate progress in trench excavation, laying and jointing of pipes, fittings, valves etc. and testing of laid pipes in sections so as to complete testing of all pipes laid in quick follow up of completing laying and jointing.

Disinfection of pipe lines should be carried out before commissioning.

# SUB-SECTION 4. CONCRETE AND ALLIED WORKS

## 4.1 Scope

This Part contains requirements which, where relevant to the contract, shall apply to the supply of materials for concrete; design of mixes; quality control; mixing, transporting and placing; and curing of concrete.

## 4.2 Reference Standards

All the relevant latest Indian Standards, Codes of Practice and Manuals shall be referred.

## 4.3 Submissions by Contractor

### 4.3.1 Certificates

Manufacturers' and suppliers' certificates of compliance with relevant standards in respect of the following materials:

– cement, reinforcement steel, aggregates, admixtures, ready mixed concrete

Calibration certificates shall be furnished by an approved person/agency for:

– weighing devices, dispensing devices, batching plant

The results shall be certified by an approved agency for tests carried out subsequently on:

– aggregate, moisture content of aggregate, fresh concrete, concrete test tubes, hardened concrete

### 4.3.2 Samples

Samples of all the foregoing materials except concrete and water shall be submitted, and those approved shall be kept in suitable containers, properly labeled and stored on Site for reference.

### 4.3.3 Concrete mixes

**Nominal mix concrete** shall be used for plain cement concrete only.

**Design mix concrete** shall be used for concrete of grade M 25 and above in accordance with IS 3370 / IS 456.

The contractor shall get the mix design approved from IIT Delhi or any other Govt Approved institure/Laboratory as approved by Engineer in Charge. The Contractor shall not alter the approved mix proportions or the approved source of supply of any of the ingredients without obtaining the approval of the Engineer.

The mix design requirements are given in the table below:

| Concrete Grade | Maximum Water/Cement ratio | Maximum Aggregate Size(mm) | Minimum Cement Content (Kg/m3) |
|---|---|---|---|
| M 25 | 0.45 | 20 | 300 |
| M 30 | 0.45 | 20 | 320 |
| M 35 | 0.42 | 20 | 340 |

The Contractor's proposed mix design shall take into account the requirements of any proposed admixture regarding fine aggregate proportions to avoid bleeding or segregation in the mix.

Concrete may incorporate admixtures to ensure that workability is maintained within the specified water/cement ratio.

**Mix design Compressive Strength Requirements:**

The mixing of concrete shall be strictly carried out in the BATCHING & MIXING PLANT FOR CONCRETE installed at site.

The contractor shall submit method statement describing work procedure to be carried before commencing the concrete work. The method statement shall be approved by the Engineer. Routine quality control tests such as slump, cube strength, sieve analysis and any other test as directed by Engineer shall be done in the presence of Engineer or its representative in the laboratory established by the contractor at site.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes shall not give the stipulated strengths, the Engineer reserves the right to order the Contractor to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, etc. The Engineer also reserve the right to ask the Contractor to dismantle and re-do such unacceptable work, at no cost to the Employer.

**Batching Plant:**

The contractor shall supply, transport and erect a fully automatic concrete batching plant as per site requirement and as approved by Engineer.

The automatic plant shall be controled through a single push button for batching of all aggregates, cement, water and additives. The capacity of automatic plant shall be of 30 $m^3$/h and above.

The automatic plant shall be capable of accurate batching and mixing of aggregates, sand, cement additives, etc. The plant shall be charged by devices which, when actuated by asingle starter switch, will automatically start the weighing operation of each material and stop automatically when the designated weigh to feach material has been reached. Each weighing unit shall be equipped with a visible indicator which shall register the load at any stage of the weighing operation.

The equipment of plant shall be capable of controlling the delivery of material for weighing or volumetric measurement so that the combined inaccuracies in feeding the material during normal operation shall not exceed 1% for water, 1% for cement, 3% for admixtures, 2% for

sand and 3% for aggregates.

A reservoir tank for storage of water shall be provided with the automatic batching plant. Reservoir shall be complete with water piping, float valves and other fittings for direct delivery to mixers without coming in contact with cement or the aggregate prior to the mixing operations.

Storage shall be provided either on the ground or in the bins for different sizes of fine and coarse aggregates and cement. The compartments for each type of aggregates shall approximately be equal or of sizes to suit the requirement for specific job on site.

For plants of 30m3/h capacity and above, cement silo may be provided.

Cement weigh batcher shall be provided separately with independent structure and the cement compartment shall be water-tight and provided with necessary air vent, aeration fittings for proper flow of cement and emergency cement cut off gate. Cement silo may be provided as per agreement between the Contractor and the Engineer.

Contractor needs to carry out the calibration of the batching plant once in three months time. For small concreting works, mechanical concrete mixers may be used. Hand mixing of concrete shall not be permitted at all.

### 4.3.4 Records of concreting

Daily returns in respect of all concrete placed during the previous day. The returns shall detail:

**(a) in respect of each grade of concrete -**

- the number of batches mixed;
- the number of batches and the total volume of concrete placed;
- the number of batches wasted or rejected;
- the weight of cement used.

**(b) in respect of each location in the Works -**

- the position of the pour (e.g. bay or lift reference number);
- the grade of the concrete placed;
- the total volume of concrete placed and the number of batches used.

In addition, the Contractor shall maintain an accurate and up to date record showing dates, times, weather and temperature conditions when each part of the Works shall be concreted. The record shall be available for inspection by the Engineer at all times.

Results of all tests on concrete shall be recorded and identified with the parts of the Works to which they relate.

## 4.4 Materials

### 4.4.1 Aggregates

Aggregates for concrete shall be obtained from an approved source, shall conform to the grading and other requirements of the relevant standard and shall be washed clean.

Aggregates shall consist of naturally occurring stones (crushed or uncrushed), gravel and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of

limited porosity, free from dust/silt/ organic impurities/deleterious materials and shall conform to relevant latest Indian Standard. Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used. Aggregates shall be washed and screened before use where necessary or if directed by the Engineer. Aggregates containing reactive materials shall be used only after tests conclusively prove that there shall be no adverse effect on strength, durability and finish, including long term effects, on the concrete.

The Contractor shall provide means of storing the aggregates at each point where concrete shall be made such that (i) each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times, (ii) contamination of the aggregates by the ground or other foreign matter shall be prevented at all times, and (iii) each heap of aggregate shall be capable of draining freely.

The Contractor shall be wholly responsible to identify the suitable sources for quarry materials required for the Works, such as earth, sand, stone, murrum, etc., and to make his own arrangements for collection and transportation of the materials irrespective of the leads and lifts required. The quarry thus shall be identified by the Contractor shall have proper license from the concerned Government. All materials to be supplied by the Contractor shall satisfy the requirements set forth in the Specifications and shall be subjected Engineer's approval. The Contractor shall take this into account while offering rates, and no claims whatsoever shall be entertained for extra costs on this account.

### 4.4.2 Sand

Only good washed sand conforming to CPWD specifications shall be used for the concrete and masonry work. The sand shall not contain more than 8% silt.

Whenever a mention of "fine sand" shall be made, the same shall be made by mixing in proportion of 1 part of coarse sand (Badarpur) and 2 parts of Jamuna sand by volume.

In all plain and reinforced concrete work coarse sand shall be used.

### 4.4.3 Water

Water to be used for both mixing and curing shall conform to IS 456. Potable waters shall be generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used.

### 4.4.4 Admixtures

Admixtures shall mean material added to the concrete materials during mixing for the purpose of altering the properties of the concrete mix. Accelerating, retarding, water-reducing and air entraining admixtures shall conform to IS 9103 and integral water proofing admixtures to IS 2645.

Admixtures shall be used in concrete as per manufacturer's instructions only with the Engineer's approval. An admixture's suitability and effectiveness shall be verified by trial mixes with the other materials to be used in the works. If two or more admixtures be used simultaneously in the same concrete mix, their interaction shall be checked and trial mixes to be done to ensure their compatibility. There shall not be increase in risk of corrosion of the reinforcement or other embedment.

Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride shall be permitted such as in mass concrete works, it shall be dissolved in water and added to the mixing water by an amount not exceeding 1.5 percent of the weight of the cement in each batch of concrete. The designed concrete mix shall be corrected accordingly.

### 4.4.5 Samples and Tests

All materials to be used for the works shall be tested before use. Manufacturer's test certificate shall be furnished for each batch of cement/steel and when directed by the Engineer samples shall also be got tested by the Contractor in a laboratory approved by the Engineer at no extra cost to Employer. The Contractor shall furnish manufacturer's test certificates and technical literature for the admixture proposed. If directed, the admixture shall be tested at an approved laboratory at no extra cost.

## 4.5 Concrete Jointing and Protection

### 4.5.1 Construction Joint and Keys

Construction joints shall be as shown on the drawing or as approved by the Engineer. Construction joints shall be located so as not to impair the strength of the concrete. Waterstops shall be provided in the construction joint as per the drawings. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made with the approval of the Engineer.

Dowels for concrete work, not likely to be taken up in the near future, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as approved by the Engineer. As soon as the exposed concrete shall be sufficiently hardened, the surface of the joint shall be water jetted or brushed with a stiff brush to expose the larger aggregate without being disturbed. Roughening of the surface by chipping or hacking shall not generally be approved. Before placing fresh concrete against a construction joint all loose material shall be removed and the surface sluiced with water until it shall be perfectly clean, thereafter all ponded water shsll be removed.

When concreting is to be resumed on a surface, not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed and a coat of cement slurry applied. On this, a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

### 4.5.2 Materials - General

Materials for concrete jointing and protection shall be obtained from manufacturers approved by the Engineer. Unless otherwise approved, all materials for concrete jointing and protection which shall be in contact with each other or jointed together to form a jointing and/or protective system shall be obtained from a single manufacturer.

All materials for concrete jointing and protection, which shall come into contact with one another, shall be compatible with each other. They shall not cause any change in properties of the materials with which they shall be in contact shall make them unsuitable for use in concrete jointing or protection, or shall reduce the working life of joints or protection.

The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching and mixing equipment and the quality control system. Such an inspection shall be arranged and the Engineer's approval obtained, prior to starting of concrete work. This shall, however, not relieve the Contractor of any of his responsibilities. All materials which do not conform to the specifications shall be rejected. Volumetric mix concrete will not be allowed.

Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/standards shall generally be used. Other materials may be used after approval of the Engineer and after establishing their performance suitability based on previous data, experience or tests.

### 4.5.3 Waterstop

The material for the PVC water stops shall be a plastic compound with the basic resin of polyvinyl chloride and additional resins, plasticizers, inhibitors, which satisfies the performance characteristics specified below as per IS 12200 and CRD-C-572. Testing shall be in accordance with IS 8543 & CRD-C-572.

| | | | |
|---|---|---|---|
| a) | Tensile strength | : | 12.17 N/mm$^2$ minimum |
| b) | Ultimate elongation | : | 300% minimum |
| c) | Tear resistance | : | 4.9 N/mm$^2$ minimum |
| d) | Stiffness in flexure | : | 4.13 N/mm$^2$ minimum |
| e) | Accelerated extraction | | |
| | i) Tensile strength | : | 10.30 N/mm$^2$ minimum |
| | ii) Ultimate elongation | : | 280% minimum |
| (f) | Effect of Alkali | : | 7 days |
| | i) Weight increase | : | 0.25% maximum |
| | ii) Weight decrease | : | 0.10% maximum |
| | iii) Hardness change | : | ± 5 points |

PVC water stops shall be either of the bar type, serrated with centre bulb and end grips for use within the concrete elements.

PVC water stops shall be of approved manufacture. Samples and the test certificate shall be got approved by the Engineer before procurement for incorporation in the works. Where not otherwise specified on the Drawings and relavant standards:

- the width of the waterstop shall be not less than 80% of the thickness of the concrete section and not less than 230 mm;
- the web thickness shall be not less than 8mm in the case of waterstop for use within the concrete thickness;
- waterstop at joints shall incorporate a central hollow bulb

Waterstops shall be cleaned before placing them in position. Oil or grease shall be removed

thoroughly using water and suitable detergents.

Waterstops shall be procured in long lengths as manufactured to avoid joints as far as possible. Lapping of waterstops shall not be permitted. Waterstops shall be placed at the correct location/level and suitably supported at intervals with the reinforcement to ensure that it does not deviate from its intended position during concreting and vibrating. Particular care shall also be taken to ensure that no honey-combing occurs because of the serrations/end grips. Projecting portions of the waterstops embedded in concrete shall be thoroughly cleaned of all mortar/ concrete coating before resuming further concreting operations.

Each waterstop system shall be made up of straight lengths of waterstop and factory-produced intersections and junctions, jointed together so as to form a continuous impermeable barrier. Waterstop shall not be stretched or kinked during handling or installation. It shall not be in contact with reinforcement or built-in items. The concrete shall be properly compacted around it so that no voids or porous areas shall remain.

## 4.6 Foundation Bedding

All earth surfaces upon which or against which concrete to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy areas shall be cleaned out and filled with lean concrete as approved by the Engineer. The surfaces of absorptive soils shall be moistened.

## 4.7 Repair and Replacement of Unsatisfactory Concrete

Immediately after the shuttering is removed, all defective areas such as honey-combed surfaces, rough patches, holes left by form bolts etc, shall be inspected by the Engineer who may permit patching of the defective areas or reject the concrete work.

Rejected concrete shall be removed and replaced by the Contractor at no additional cost to the Employer.

For patching of defective areas all loose materials shall be removed and the surface shall be prepared as approved by the Engineer.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar or by applying epoxy. The decision of the Engineer as to the method of repairs to be adopted shall be final and binding on the Contractor. The surface shall be saturated with water for 24 hours before patching shall be done with cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as approved by the Engineer.

## 4.8 Hot Weather Requirements

Concreting during hot weather shall be carried out as per IS 7861 (Part I).

Concrete when deposited shall have a temperature of not more than 40°. The formwork and reinforcement shall have been shaded and cooled to a temperature low enough to prevent the flash setting of the concrete

When the temperature of the concrete at placing exceeds 40°C, concreting is shall be allowed once below mentioned precautions are taken by Contractor.

The Contractor shall at all times during the hot weather conditions do the following things:

(a) Provide sun shades over stockpiles of aggregates, cement silos, mixing water tanks and pipelines.
(b) Spray clean cool water over the aggregate stockpiles. The Contractor shall carry out regular tests on the aggregates to ensure that concentrations of sulphates or chlorides do not rise to unacceptable levels, and to ensure that moisture content determinations allow for such spraying.
(c) Shade or wet the outside of the formwork.

The Contractor shall also do the following if directed by the Engineer.

(d) Apply a fine moisture (fog) spray of clean cool water in order to cool and moisten the surrounding air and the sub-surface, to cool the formwork and reinforcement, and to lessen rapid evaporation from unformed concrete surfaces.
(e) Pour concrete at night.

The Contractor shall provide the Engineer with details of the precautions he proposes to take to comply with the above. No concreting in hot weather shall be put in hand until the proposed measures have received the approval of the Engineer.

## 4.9 Cold Weather Requirements

Concreting during cold weather shall be carried out as per IS 7861(Part II).

The ambient temperature during placement and up to final set shall not fall below $5^{O}$C. Approved antifreeze/accelerating additives shall be used where directed.

For major and large scale concreting works the temperature of concrete at times of mixing and placing, the thermal conductivity of the formwork and its insulation and stripping period shall be closely monitored.

## 4.10 Testing Concrete Structures for Leakage

The Contractor shall take special care for concrete for liquid retaining structures, underground structures and those others specifically called for to guarantee the finish and water tightness.

The Contractor shall make all arrangements for hydro-testing of structure as per IS 3370, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines etc.

Any leakage that shall occur during the hydro-test or subsequently during the defects liability period shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as approved by the Engineer. All such rectification shall be done by the contractor to the entire satisfaction of the Engineer at no extra cost to the Employer.

Hydrostatic test for water tightness shall be done at full storage level i.e. free board shall be directed by the Engineer, as described below:

In the case of structures whose external faces shall be exposed, the requirements of the test shall be deemed to be satisfied if the external faces shall show no sign of leakage or sweating and shall remain completely dry during the period of observation of seven days after allowing

a seven day period for absorption after filling with water.

In the case of structures whose external faces shall be buried and shall not be accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling; the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs over a period of seven days. The total drop in surface level over a period for seven days shall be taken as an indication of water tightness of the structure. The Engineer shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures shall be open or closed and the corresponding effect on evaporation losses. Unless specified otherwise, a structure for which top to be covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days shall not exceed 40 mm.

Each compartment/segment of the structure shall be tested individually and then all together.

For structures such as pipes, tunnels etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period, the loss of water shall not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

## 4.11 Shuttering

The centering and shuttering for all RCC and concrete work shall be of steel as per CPWD specification and as approved by the Engineer. However Plywood shuttering can be used for only unavoidable portion and very small work upto 1 Sqm area for which 12mm thick waterproofing ply of approved quality shall be used. Joints shall be sufficiently tight to prevent loss of cement slurry from concrete. Shuttering can be of Aluminium as per the international standard as approved by Engineer in Charge.All joints and holes in form work shall be caulked with putt, cloth or other approved material. Care shall be taken to ensure that such filling shall be kept away from reinforcement. All formwork shall be leveled, aligned and all rubbish particularly clippings wood shavings, sand dust and adhered grout shall be removed from the interior of the forms before the concrete shall be placed.

All formwork shall be removed without causing shock vibration to the concrete. Before the soffit and struts shall be removed, the concrete surface shall be exposed wherever necessary in order to ascertain that the concrete shall be sufficiently hardened.

Specially formulated blend of mineral oils and speciality chemical having release properties which are superior to those of conventional mould oil shall be used over concrete formwork as approved by Engineer.This chemical react with the alkali in the concrete to form a thin water repellent skin on the surface of the mould, thereby enabling easy stripping mould from concrete and acting as a protection to steel formwork. This shall be applied with Spray on the form work. The formwork should be like this that it shall not affect the color of the concrete. There should not be any mark left on the concrete.Concrete finish should be completely smooth.

No through bolts shall be permitted in the form work for liquid retaining structures. Wall ties with plastic cones as per CPWD specification shall be used.

The surface on the RCC/ concrete work to be obtained after removal of shuttering shall be smooth and without honey combing/pin holes, undulations and shall be such that it shall not require any plastering. If at all any pin hole/undulations shall be required to be made good,

this shall be done with cement mortar 1:2 using coarse sand and finished smooth with steel trowel or as directed by Engineer.

For proper cover, cover block of different sizes shall be used and readymade steel spacers shall be provided by the contractor as per Indian Standard.

Necessary lapping of the reinforcement shall be done as per IS codes of practice and tied with GI binding wire of required gauge as per IS codes of practice. Welding of reinforcing bars shall not be done. Welding can be permitted by the Engineer in exceptional cases where due care will be exercised as per IS Specifications.

## 4.12 Curing Compound

Liquid curing compounds for use on concrete shall comply with the following and it has to be approved by Engineer before using at site. The curing period for the PPC cement needs to be increased as per the relevant standard or as directed by the manufacturer.

i. An approved curing compound shall be applied to all unformed concrete surfaces as soon as possible after finishing work is completed. The Contractor shall ensure that use of the proposed curing compound will not affect the bonding of subsequent coatings,
ii. Curing compounds shall not be applied to surfaces to which further concrete or a surface finish is subsequently to be bonded.
iii. All materials shall be supplied in the containers marked by the manufacturer with his name, date of manufacture, shelf life, pot life and instructions for handling and application.
iv. The compound shall be applied as directed by the manufacturer with approved spray equipment. The equipment shall be maintained in good order at all times and a complete back-up set shall be available at all times
v. As soon as the curing compound has dried the concrete surfaces shall be covered with overlapping heavy gauge clear plastic sheeting. Immediately at the start of the following day, the plastic sheeting shall be temporarily removed, the concrete covered with pre-soaked, washed hessian and the plastic sheeting replaced. The hessian shall be kept damp continuously until completion of the curing period. All curing water shall be of potable quality and permanently available at the location of the concrete pour.
vi. All concrete shall be cured as above for a minimum of 10 days after the day of pour and the Contractor shall provide full time attendance on site dedicated to concrete curing.
vii. Formed surfaces shall receive the full curing process as above, including curing compound, if the form work is removed within 10 days of the day of pour.
viii. The Contractor shall keep available sufficient curing materials and provide sufficient attendance at all times to ensure that his construction programme is maintained while meeting the specification requirements.
ix. Shading removal and termination of water curing shall be to Engineer's approval.

## 4.13 Coatings on Concrete Surfaces

Internal Walls (Water face) of water retaining structure:

Food Grade Epoxy resin coatings shall be applied to concrete structures in order to protect the concrete against aggressive effects of saline groundwater or other unwanted matters.

Generally, protective coatings shall be applied to surfaces of concrete structures which are underground and/or in contact with groundwater. The food grade epoxy coating shall exhibit excellent bond strength with substrate when tested as per ASTM D4541. The product shall be formulated to have high build thickness exceeding 200 micron per coat on average and shall be applied to achieve the overall thickness of 400 micron in two coats.

Before application of such coating contractor shall prepare surface properly by mechtanical grinding to ensure surface shall be free of latience, cracks. Cracks if any to be treated by cutting V groove and filled with epoxy putty followed by low viscous epoxy injection.

The Contractor shall supply, deliver and apply all paints protective coatings. The type of coating to be used shall be as approved by the Engineer.

All priming-coats and undercoats shall be obtained from the same manufacturer and shall be the type of primer and undercoat recommended by the manufacturer for that particular coating.

All coating shall be applied strictly according to the instructions of the manufacturer. All the paints shall be delivered to the site(s) in sealed containers with the manufacturer's name clearly shown. All coatings shall be applied by skilled labour under supervision of a competent foreman and to the satisfaction of the Engineer. No Epoxy resin coatings shall be applied until the concrete has been cured as specified and prior approval of the Engineer has been obtained. The surface should be cleaned of all loose gravel, dirt and foreign material with high pressure wash or mechanical means or grinding before application of the primer. After application of primer the surface should be allowed to dry for 6 hours.

| S.No | Parameter | Test Method | Result |
|---|---|---|---|
| **Food Grade Epoxy coating** | | | |
| **1** | Volume Solids | | 100% |
| **2** | DFT, in two coats | | 400 microns |
| **3** | Adhesive bond strength to concrete | ASTM D 4541 | >1.5 MPa (concrete failure) |
| **4** | Abrasion resistance CS17 wheel | ASTM D4060, 1000 cycles | < 20 mg |
| **5** | Tear strength, N/mm | JIS 6252 | 13 |

## 4.14 Expansion Joint

Expansion Joint shall be treated as follows.

Surface should be cleaned along the side walls of the expansion joint equal to the width of expansion joints on both sides with the help of mechanical means to remove all dirt, dust and debris. Fill the joint both sides with PE board or high density thermocol packing followed by Polyurathane 2 component gun grade sealant over the top of packing. Apply 2 component Sagemetal epoxy bonding on the side of the expansion joint, paste 1 mm thick TPO membrane over the bonding agent and cover the sides of the Expansion joint with Sagemetal bonding agent again. Finally provide aluminium non-corrosive material over the treated joint capable of accommodating joint movement.

## SUB-SECTION 5. STRUCTURAL STEELWORK

### 5.1 General

All workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined/ground smooth true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Tolerances for fabrication of steel structures shall conform to BIS 7215. Tolerances for erection of steel structures shall conform to IS 12843.

### 5.2 Minimum thickness of metal - Corrosion Protection

Unless, otherwise specified, the thickness of steel section shall be governed as below:

a) Steel work exposed to weather

Where steel work shall be directly exposed to weather and shall be fully accessible for clearing and repairing, the thickness shall not be less than 6 mm (excluding corrosion allowance); and where steel shall be exposed to weather and shall not be accessible for cleaning and painting, the thickness shall not be less than 8 mm. This shall not apply for hot rolled sections covered by Indian Standards.

b) Steel work not directly exposed to weather

The thickness of steel work not directly exposed to the weather shall be not less than 6 mm. The thickness of steel in secondary members shall be not less than 6 mm. For hot rolled sections to Indian Standards, the mean thickness of flange shall be considered and not the web thickness.

c) The requirements (a) and (b) above shall not apply to light structural work or sealed box section or to steel work in which special provision against corrosion shall be made and also in case of steel work exposed to highly corrosive fumes or vapour in which case the thickness shall be as approved by the Engineer.

d) Corrosion allowance of 2 mm shall be taken over and above the minimum thickness as mentioned above or design thickness.

### 5.3 Drawings prepared by the Contractor

The contractor shall prepare all fabrication working and erection drawings for the entire work. The drawings shall preferably be of one standard size and the details shown there in shall be clear and legible.

All fabrication drawings shall be submitted to the Engineer for approval.

No fabrication drawings shall be accepted for Engineer's approval unless checked and approved by the contractor's qualified structural engineer and accompanied by an erection plan showing the location of all pieces detailed. The contractor shall ensure that connections shall be detailed to obtain ease in erection of structures and in making field connections.

Fabrication shall be started by the contractor only after Engineer's approval of fabrication drawings. Approval by the Engineer of any of the drawing shall not relieve the contractor

from the responsibility for correctness of engineering and design of connections, workmanship, fit of parts, details, material, errors or omissions or any and all work shown thereon.

The drawings to be prepared by the contractor and all subsequent revisions etc. shall be at the cost of the contractor for which no separate payment shall be made.

## 5.4 Submissions by the Contractor

The following submissions shall be required by this Part of the Specification:-

(a) Design
- Design principles and Design calculation
- Codes and standards used

(b) Drawings:
- general arrangements;
- general assembly, detailed shop and erection drawings;
- detailed manufacturing drawings.

(c) Data:
- calculations for connection details, where requested by the Engineer;
- welding procedure sheets.

(d) Certificates:
- material tests;
- Inspection certificates;

## 5.5 Workmanship

### 5.5.1 Detailing and welding procedure sheet

The detailing and fabrication of structural steelwork shall be such as to minimize the need for site welding. Structures and components such as trusses, combined columns and beams shall be shop fabricated so as to form sub-assemblies of the largest practical size suitable for transportation, handling and erection. Connections between members at the erection stage shall generally be bolted.

Structural steelwork shall be so detailed and fabricated as to minimise the formation of pockets to hold condensation, water or dirt. Where such pockets shall be unavoidable, suitable drainage shall be provided.

The Contractor shall prepare detailed shop and erection drawings and welding procedure sheets for all structural steelwork and these shall be submitted to the Engineer for approval before fabrication commences. The sequence of submissions shall match the order of fabrication and erection.

Shop drawings for fabrication shall show full details of the type of steel, member sizes and dimensions, weld details, welding sequences and any requirements for weld stress relieving. Welding procedure sheets shall show all details of the welds including:

– welding method;

- current type, voltage and amperage;
- welding positions;
- preparation angles and methods;
- number of runs and their welding positions;
- type, size and class of electrode;
- shielding gas type and flow rate (where applicable);
- non-destructive testing methods and extent of coverage;
- pre-heat, post-heat and stress-relief methods, temperatures and the like.

### 5.5.2 Connections

Shop/field connections shall be as per approved fabrication drawings.

In case of bolted connections, taper washers or flat washers or spring washers shall be used with bolts as necessary. In case of high strength friction grip bolts, hardened washers shall be used under the nuts or the bolt heads whichever shall be turned to tighten the bolts. The length of the bolt shall be such that atleast one thread of the bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be at least three times the pitch of the thread.

In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness shall be provided to exclude the threads from the bearing thickness, if a longer grip bolt shall be used for this purpose.

All connections and splices shall be designed for full strength of members or loads. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice.

All members likely to collect rain water shall have drain holes provided.

### 5.5.3 Riveting

Rivets shall be heated uniformly throughout their length without burning or excessive scaling and shall be of sufficient length to provide a head of standard dimensions. They shall, when driven, completely fill the holes and if counter sunk, the counter sinking shall be fully filled by the rivet; any protrusion of the countersunk head being dressed off flush if required.

Riveted members shall have all parts firmly drawn and held together before and during riveting and special care shall be taken in this respect for all single riveted connections. For multiple riveted connections, a service bolt shall be provided for every third or fourth hole.

Wherever practicable, machine riveting shall be carried out by using machines of the steady pressure type. All loose bored or otherwise defective rivets shall be cut out and replaced before the structure shall be loaded and special care shall be taken to inspect all single riveted connections.

Special care shall be taken in heating and riveting long rivets.

## 5.6 Inspection

### 5.6.1 General

The Contractor shall give due notice to the Engineer in advance of the works being made ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the Engineer's inspection. The fact that certain material shall be accepted at the Contractor's shop, shall not invalidate final rejection at site by the Engineer if it fails to conform to the requirements of these specifications, to be in proper condition or has fabrication inaccuracies which prevent proper assembly nor shall it invalidate any claim which the Employer shall make because of defective or unsatisfactory materials and /or workmanship.

No materials shall be painted or dispatched to site without inspection and approval by the Engineer unless such inspection shall be waived in writing by the Engineer. Cost of such inspections shall be borne by the contractor.

The Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified.

For fabrication work to be carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to the Engineer.

Inspection and tests on structural steel members shall be as set forth below.

### 5.6.2 Material Testing

If mill test reports shall not be available for any steel materials, the same shall be tested by the Contractor to the Engineer's satisfaction to demonstrate conformity with the relevant specification.

## 5.7 Tests on Welds

**(a) Radiographic Inspection**

All full strength butt welds shall be radiographed in accordance with the recommended practice for radiographic testing as per relevant IS code.

**(b) Dimensions, Workmanship & Cleanliness**

Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown in the Contractor's approved fabrication drawings.

## 5.8 Test Failure

In the event of failure of any member to satisfy inspection or test requirement, the Contractor shall notify the Engineer. The Contractor must obtain permission from the Engineer before any repair shall be undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by the Engineer.

The Engineer has the right to specify additional testing as he deems necessary, and the

additional cost of such testing shall be borne by the contractor.

The Contractor shall maintain records of all inspection and testing which shall be made available to the Engineer.

### 5.9 Shop Matching

For structures like, bunkers, tanks, etc. shop assembly is essential. For other steel work, such as columns along with the tie beams/bracings may have to be shop assembled to ensure satisfactory fabrication, obtaining of adequate bearing areas etc., if so desired by the Engineer. All these shop assemblies shall be carried out by the Contractor.

### 5.10 Shop Assembly

a) The steel work shall temporarily shop assembled complete or as arranged with the Authority so that accuracy of fit may be checked before dispatched. The parts shall be shop assembled with sufficient numbers of parallel drifts to bring and keep the parts in place.

b) In case of parts drilled or punched, through steel jigs with bushes resulting in all similar parts being interchangeable the steel work shall be shop erected in such position as arranged with the Authority.

### 5.11 Packing

All projecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed; and all rivets, bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit.

### 5.12 Inspection and Testing

a) The Engineer in charge shall have free access at all reasonable times to those parts of the manufacturers' works which shall be concerned with the fabrication of steel work and shall be afforded all reasonable facilities to satisfy that the fabrication shall be undertaken in accordance with the specifications.

b) Unless specified otherwise, inspection prior to dispatch shall not interfere with the operation of the work.

### 5.13 Site Erection

a) Plant and Equipment

The suitability and capacity of all plant and equipment used for erection shall be to the satisfaction of the Engineer.

b) Storing and Handling

All structural steel shall be so stored and handled at the site that the members shall not subject to excessive stress and damage.

c) Setting Out

The positioning and levelling of all steelwork, the plumbing of stanchions and the placing of every part of the structure with accuracy shall be in accordance with approved drawings and to the satisfaction of Engineer.

d) Security during Erection

Safety precaution during erection shall conform to IS 7205:1974. During erection, the steel work shall be securely bolted or otherwise fastened and, when necessary, temporarily braced to provide for all load to be carried by the structure during erection including those due to erection equipment and its operation.

No riveting, permanent bolting or welding shall be done until proper alignment shall be obtained.

## 5.14 Field Connections

All field assembly by bolts, rivets and welding shall be executed in accordance with the requirements of shop fabrication excepting such as manifestly apply to shop conditions only. Where the steel shall be delivered painted, the paint shall be removed before field welding, for a distance of 50 mm at least on either side of the joint.

Chequered plates shall be fixed to supporting members by tack welding or by countersunk bolts as shown/specified in relevant drawings and/or as approved by the Engineer.

## 5.15 Painting after Erection

a) All the surfaces of structural steel shall be cleaned by sand blasting.

b) Before painting of such steel to be delivered, all surfaces to be painted shall be dry and thoroughly cleaned from all loose scale and rust.

c) The specified protective treatment shall be completed after erection. All rivet and bolt heads and site welds after de-slugging shall be cleaned. Damaged or deteriorated paint surfaces shall be cleaned. Damaged or deteriorated paint surfaces shall be first made good with the same type of paint as the shop coat. Where specified, surfaces which shall be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while paint shall be still wet.

d) Where the steel shall be received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds and site rivets and bolts; but subject to the approval of Authority, protection shall be completed by painting on site. Bolts galvanized or similarly treated shall be exempted from this requirement.

e) Surfaces which shall be inaccessible after site assembly shall receive the full specified treatment before assembly.

f) Site painting shall not be done in frosty or foggy weather, or when humidity shall cause condensation on the surfaces to be painted.

## 5.16 Marking of Members

After checking and inspection, all members shall be marked for identification during erection.

This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they shall be easily discernible when sorting out members. The stamped marking shall be encircled boldly by a distinguishable paint to facilitate easy location.

Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

### 5.17 Errors

Any error in shop fabrication which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins or moderate amount of reaming shall be classified by the Engineer as defective workmanship. Where the Engineer rejects such material or defective workmanship, the same shall be replaced by materials and workmanship conforming to the Specifications by the Contractor, at no additional cost to Employer.

## SUB-SECTION 6. BUILDING AND STRUCTURE FINISHING WORKS

### 6.1 Brickwork

#### 6.1.1 Materials

Bricks/Blocks used in the works shall conform to the requirements laid down in IS: 1077, IS: 2180, IS 2222, IS 2691, IS 3952, IS 6165, IS13757, IS 2572. The class of the bricks shall be as specifically indicated in the respective items of work prepared by the Contractor.

Common burnt fly ash bricks shall be classified on the basis of compressive strength as given below:

| | | |
|---|---|---|
| Class designation | 100 | 75 |
| Avg. compressive strength kg/cm$^2$ | 100 | 75 |

Bricks shall be sound, hard, and homogenous in texture, well burnt in kiln without being vitrified, hand/ machine moulded, deep red, cherry or copper coloured, of regular shape and size and shall have sharp and square edges with smooth rectangular faces. The bricks shall be free from pores, cracks, flaws and nodules of free lime. They shall have smooth rectangular faces with sharp corners and shall be uniform in colour. Hand moulded bricks shall be moulded with a frog and those made by extrusion process shall not be provided with a frog. Bricks shall give a clear ringing sound when struck.

Hollow fly ash concrete blocks shall be provided with reinforcement as per the IS-2572.

Brick shall conform and be tested as per relevant BIS/CPWD specification.

#### 6.1.2 Preparation of mortar

**a) Materials**

**1. Water:**

Water shall be clean and reasonably free from injurious or deleterious materials such as oils, acids, alkalis, and salts. Quality of water shall conform to BIS/CPWD specification for construction purposes.

**2. Cement:**

Portland Pozzollna Cement shall be used and conform to the requirements of IS: 1489 Part-1.

**3. Sand:**

Sand for masonry mortars shall confirm to IS: 2116.

Mortars shall be prepared and tested as per IS: 2250. Mixing of cement mortar shall be done in a mechanical mixer.

### 6.1.3 Workmanship

Workmanship of brickwork shall conform to IS 2212. All bricks shall be thoroughly soaked in clear water for at least one hour immediately before being laid. The cement mortar for brick masonry work shall be as specified in the respective item of work prepared by the Contractor. Brick work 230 mm thick and over shall be laid in English Bond unless otherwise specified. 100mm/ 115mm thick brickwork shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be slightly pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Only full size bricks shall be used for the works and cut bricks to be utilised only to make up required wall length or for bonding. Bricks shall be laid with frogs uppermost.

All brickwork shall be plumb, square and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be leveled. The thickness of brick courses shall be kept uniform. In case of one brick thick or half brick thick wall, at least on e face should be kept smooth and plane, even if the other shall be slightly rough due to variation in size of bricks. For walls of thickness greater than one brick both faces shall be kept smooth and plane. All interconnected brickwork shall be carried out at nearly one level so that there shall be uniform distribution of pressure on the supporting structure and no portion of the work shall be left more than one course lower than the adjacent work. Where this shall not be possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 45 deg. But in no case the level difference between adjoining walls shall exceed one meter. Brick work shall not be raised more than one metre per day.

Bricks shall be so laid that all joints shall be well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 10 mm/ 15 mm by raking tools during the progress of work when the mortar shall be still green, so as to provide a proper key for the plastering/ pointing respectively to be done later. When plastering or pointing shall not br required, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course shall be laid on top.

During harsh weather conditions, newly built brick masonry works shall be protected by tarpaulin or other suitable covering to prevent mortar being washed away by rain.

Brickwork shall be kept constantly moist on all the faces for at least seven days after 24 hrs of laying. The arrangement for curing shall be got approved from the Engineer.

Double scaffolding having two sets of vertical supports shall be provided to facilitate execution of the masonry works. The scaffolding shall be designed adequately considering all the dead, live and possible impact loads to ensure safety of the workmen, in accordance with the requirements stipulated in IS : 2750 and IS : 3696 (Part - I). Scaffolding shall be properly maintained during the entire period of construction. Single scaffolding shall not be used on important works and shall be permitted only in certain cases as decided by the Engineer. Where single scaffolding shall be adopted, only minimum number of holes, by omitting a header shall be left in the masonry for supporting horizontal scaffolding poles. All holes in the masonry shall be carefully made good before plastering/ pointing.

In the event of usage of traditional bricks of size 230 mm x 115 mm x 75 mm, the courses at

the top of the plinth and sills as well as at the top of the wall just below the roof/ floor slabs and at the top of the parapet shall be laid with bricks on edge.

All brickwork shall be built tightly against columns, floor slabs or other structural members.

To overcome the possibility of development of cracks in the brick masonry following measures shall be adopted.

For resting RCC slabs, the bearing surface of masonry wall shall be finished on top with 12 mm thick cement mortar 1:3 and provided with 2 layers of Kraft paper Grade 1 as per IS: 1397 or 2 layer of 50 micron thick polyethylene sheets.

RCC/ steel beams resting on masonry wall shall be provided with reinforced concrete bed blocks of 150 mm thickness, projecting 150mm on either sides of the beam, duly finished on top with 2 layer of Kraft paper Grade 1 as per IS : 1397 or 2 layers of 50 micron thick polyethylene sheets.

Steel wire fabric shall be provided at the junction of brick masonry and concrete before taking up plastering work.

Bricks for partition walls shall be stacked adjacent to the structural member to pre deflect the structural member before the wall shall be taken up for execution. Further, the top most course of half or full brick walls abutting against either a deshuttered slab or beam shall be built only after any proposed masonry wall above the structural member shall be executed to cater for the deflection of the structural element.

Reinforced cement concrete transomes and mullions of dimensions as indicated in the construction drawings to be prepared by the Contractor shall be generally required to be provided in the half brick partition walls.

Where the drawings prepared by the Contractor indicate that structural steel sections to be encased in brickwork, the brickwork masonry shall be built closely against the steel section, ensuring a minimum of 20 mm thick cement-sand mortar 1:4 over all the steel surfaces. Steel sections partly to be embedded in brickwork shall be provided with bituminous protective coating to the surfaces at the point of entry into the brick masonry.

### 6.2 Miscellaneous Inserts, Bolts etc.

All the miscellaneous inserts such as bolts, pipes, plate embedments etc., shall be accurately installed in the building works at the correct location and levels, all as detailed in the construction drawing to be prepared by the Contractor. Contractor shall prepare and use templates for this purpose, if so directed by the Engineer. In the event, of any of the inserts shall be improperly installed, contractor shall make necessary arrangement to remove and reinstall at the correct locations/levels all as directed by the Engineer.

### 6.3 Wood work in doors & partitions

Timber to be used shall be first class Teak wood as per IS: 4021. Timber shall be of the best quality and well seasoned by the suitable process before being planed to the required sizes. The maximum permissible moisture content shall be from 10 to 16 percent for timber 50mm and above in thickness and 8 to 14 percent for timber less than 50mm in thickness for different regions of the country as stipulated in IS: 287. Timber shall be close grained, of uniform

colour and free from decay, fungal growth, boxed heart, pitch pockets of streaks on the exposed edges, borer holes, splits and cracks. Flush door shutters of the solid core type with plywood face panel shall conform to IS: 2202 (Part-1)

Transparent sheet glass shall conform to IS: 2835 or IS: 2553 (Part-1). Wired and figured glass shall be as per IS: 5437. Hardware for fittings and fixtures shall be of the best quality from approved manufacturers. Each wooden door shutter shall have a minimum of three hinges and two fastenings like tower bolt, handle and tachle mortise lock etc. Floor stoppers, handles, kick plates etc. shall also be provided.

## 6.4 Aluminium Doors, Windows, Ventilators & Partitions

### 6.4.1 Materials

Aluminium alloy to be used in the manufacturer of extruded sections of the fabrication of doors, windows, ventilators shall conform to designation HE9-WP of IS: 733.

Transparent sheet glass shall conform to IS 2835. Wired and figured glass shall be as per IS: 5437.

All Aluminium doors, windows, ventilators and partitions shall be of the type and size as specified. The doors, windows, ventilators shall conform to the requirements of IS: 1948. Aluminium windows shall conform to IS 1949; if so specified.

All Aluminium units shall be supplied with anodized finishing; the minimum anodic film thickness shall be 0.015mm.

Doors windows and ventilators shall be of an approved manufacture. Fabrication of the units shall be with the extruded sections, cut to correct lengths, mitred and welded at the corners to a true right angle conforming to IS 1948. Tolerance in overall dimensions shall be within + 1.5 mm. The frames and shutters shall be free from warp or buckle and shall be square and truly plane. Punching of holes, slots and other provisions to install fittings or fixtures later shall be made at the correct locations, as per the requirements.

Aluminium swing type doors, Aluminium sliding windows, partitions shall be as specified.

IS 1948 and IS 1949 shall be referred to incorporate the sizes, shapes, thickness and weight per running metre of extruded sections for the various components of the units. However, new sizes, shapes, thickness with modifications to suit snap-fit glazing clips etc. shall be continuously being add by various leading manufacturers of extruded sections, which shall be available in the market. As such, the sections of the various components of the unit proposed by the Contractor, shall be reviewed by the Engineer and accepted only if they shall be equal to or marginally more than that given in the codes/ad specified.

The framework of partitions with mullions and transoms shall be with anodized Aluminium box sections. Anodised Aluminium box sections shall be in-filled with timber of class 3 (silver oak or any other equivalent) as per IS 4021. The outer frame shall be of size 101.6 x 44.45 x 3.11 mm rectangular tubular section and the shutter shall be made out of specially extruded tubular section of size for sill member shall be 99.2 x 44.45 x 3.18 mm including glazing of 5.5 mm thick plain glass PVC/Neoprene weather stripping screw less Aluminum bidding fixer such as lock, handle, tower bolt and self closing device of approved make. Panels of double / single glazing/plywood shall be fixed as per details indicated in the drawing

to be prepared by the Contractor. Partitions shall be fixed rigidly between the floor and the structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the construction drawings to be prepared by the contractor.

Specific provisions as stipulated for steel doors, windows, ventilators under clause 7.6 shall also be applicable for this item work. Glazing beads shall be of the snap-fit type suitable for the thickness of glazing proposed as indicated in the items of works to be prepared by the contractor. A layer of clear transparent lacquer shall be applied on aluminium sections to protect them from damage during installation. This lacquer coating shall be removed after the installation shall be completed.

## 6.5 Steel Rolling Shutters

Rolled shutters shall be of an approved manufacture, conforming to the requirements specified in IS 6248.

The type of rolling shutter shall be self coiling type (manual) for clear areas upto 10 sqm, gear operated type (mechanical) for clear areas upto 35 sq.m and electrically operated type for areas upto 50 sqm. Mechanical type of rolling shutters shall be suitable for operation from both inside and outside with the crank handle or chain gear operating mechanism duly considering the size of wall/column. Electrical type of rolling shutter shall also be provided with a facility for emergency mechanical operation.

Rolling shutters shall be supplied duly considering the type, specified clear width/height of the opening and the location of fixing as indicated in the drawings to be prepared by the Contractor.

Rolling shutters of approved make, shall be made of 80 x 1.25mm MS laths interlocked together through their entire length and jointed together at the end by end locks mounted on specially designed pipe shaft with brackets, side guides and arrangements for inside and outside locking with mechanical device chain and crank operation for operating rolling shutters exceeding 10.00 sqm including spring hooks, providing and fixing necessary 25.3 cm long wire springs grade No.2 and MS top cover 1.25 mm thick (RS). Shutters shall be built up of interlocking laths 75 mm width between rolling centers formed from cold rolled steel strips. The thickness of the steel strip shall not be less than 0.90 mm for shutters upto 3.50 m width and not less than 1.20 mm for shutters above 3.50 m width. Each lath section shall be continuous single piece without any welded joint.

## 6.6 Flooring

### 6.6.1 Base Concrete

200 thick grade slab in M25 Grade of Concrete shall be provided in all the building at ground floor as base slab. Reinforcement in the grade slab shall be 10 dia bar at 250 c/c at top & bottom in both direction.

Before placing Base Concrete, the sub-base of shall be properly wetted and rammed. Concrete for the base shall then be deposited between the forms, thoroughly tamped and surface finished level with the top edges of the forms. Two or three hours after the concrete shall be laid in position, the surface shall be roughened using steel wire brush to remove any scum or laitance and swept clean so that the coarse aggregates shall be exposed. The surface

of the base concrete shall be left rough to provide adequate bond for the floor finish to be provided later.

### 6.6.2 Terrazzo Tile flooring

Terrazzo tiles shall generally conform in all respects to standards stipulated in IS 1237. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than 14 $N/mm^2$.

The type, quality, size, thickness, colour etc. of the tiles for flooring/dado/skirting shall be as specified.

The aggregates for terrazzo topping shall consist of marble chips which shall be hard, sound and dense. Cement to be used shall be white cement with light colouring pigments. The mix shall be with 3 parts of cement to 1 part of marble powder by weight. The proportion of cement shall be inclusive of any pigments. For every one part of cement -marble powder binder mix, the proportion of aggregates shall be 1.75 parts by volume, if the chips shall be between 1 mm to 6 mm and 1.50 parts by volume and if the chips shall be between 6 mm to 25 mm.

The minimum thickness of wearing layer of terrazzo tiles shall be 5 mm for tiles with chips of size varying from 1 mm upto 6 mm or from 1 mm upto 12 mm. This shall be 6 mm for tiles with chips varying from 1 mm upto 25 mm. The minimum thickness of wearing layer of cement /coloured cement tiles shall be 5 mm. This shall be 6 mm for heavy duty tiles. Pigment to be used in the wearing layer shall not exceed 10 percent of the weight of cement used in the mix.

Laying and finishing of tiles shall conform to the requirements of workmanship stipulated in IS 1443.

Tiling work shall be commenced only after the door and window frames are fixed and plastering of the walls/ceiling is completed. Tiles which are fixed to the floor adjoining the wall shall go 10 mm under the plaster. Wall plastering shall not be carried out upto about 50 mm above the level of proposed skirting /dado.

### 6.6.3 Kota Stone Slab Work

#### 6.6.3.1 Materials

The slab shall be of approved selected quality, hard, sound, dense and homogeneous in texture, free from cracks, decay, weathering and flaws. The percentage of water absorption shall not exceed 5 percent as per test conducted in accordance with IS: 1124.

The slabs shall be machine cut and 25 mm thick. Tolerance in thickness for dimensions of tile shall be more than 100mm shall be ± 5mm. This shall be ± 2 mm on dimensions less than 100 mm.

Slabs shall be supplied to the specified size with machine cut edges to the full depth. All angles and edges of the slabs shall be true and square, free from any chipping giving a plane surface. Slabs shall have the top surface machine polished (first grinding) before being brought to site. The slabs shall be washed clean before laying.

#### 6.6.3.2 Workmanship

The thickness of the slabs for dado/skirting work shall not be more than 25mm. Slabs shall be so placed that the back surface is at a distance of 12 mm. If necessary, slabs shall be held in position temporarily by suitable method. After checking for verticality, the gap shall be filled and packed with cement sand mortar of proportion 1:3. After the mortar shall be acquired sufficient strength, the temporary arrangement holding the slab shall be removed.

### 6.6.4 Glazed Tile Finish

Glazed earthenware tiles shall conform to IS 777. Tiles shall be of the best quality from an approved manufacturer. The tiles shall be flat, true to shape and free from flaws such as crazing, blisters, pinholes, specks or welts. Edges and underside of the tiles shall be free from glaze and shall have ribs or indentations for a better anchorage with the bedding mortar. Dimensional tolerances shall be as specified in IS: 777.

The total thickness of glazed tile finish including the bedding mortar shall be 20 mm in flooring/dado/skirting. The minimum thickness of bedding mortar shall be 12 mm for flooring and 10 mm for dado/skirting work. Size of Tiles shall be atleast 300mm x 450 mm.

The bedding mortar shall consist of 1 part of cement to 3 parts of sand mixed with just sufficient water to obtain proper consistency for laying. Sand for the mortar shall conform to IS 2116 and shall have minimum fineness modulus of 1.5.

Tiles shall be soaked in water for about 10 minutes just before laying. Where full size tiles shall not be fixed, tiles shall be cut to the required size using special cutting device and the edges shall be rubbed smooth to ensure straight and true joints.

All the joints shall be cleaned of gray cement with wire brush to a depth of at least 3 mm and all dust, loose mortar etc. shall be removed. White Cement with or without pigment shall then be used for flush pointing the joints. Curing shall then be carried out for a minimum period of 7 days of the bedding and joints to set properly. The surface shall then be cleaned using a suitable detergent, fully washed and wiped dry.

### 6.6.5 Epoxy Coating over Kota Stone for Flooring

Wherever designated in particular specification or drawings, Epoxy MMA (methyl methacrylate) blend coating of ECC (epoxy cement composite) of minimum thickness 1000 micron over 200 micron prime coat shall be applied over Kota stone.

### 6.6.6 Acid Resisting Brick / Tiling Work

The ceramic unglazed vitreous acid resisting tiles shall conform to the requirements of IS 4457. Acid resistant bricks shall conform to IS 4860. The size of tiles shall be 198.5 mm x 198.5mm.

The finished tile/brick when fractured shall appear fine grained in texture, dense and homogeneous. Tile/brick shall be sound, true to shape, flat, free from flaws and any manufacturing defects affecting their utility. Tolerance in dimensions shall be within the limits specified in the respective BIS.

The tiles/bricks shall be bedded and jointed using chemical resistant mortar of the resin type

conforming to IS 4832 (Part II). Method of usage shall generally be as per the requirements of IS 4443.

The mortar joints shall be cured for a minimum period of 72 hours with 20 to 25% hydrochloric acid or 30 to 40% Sulphuric acid. After acid curing, the joints shall then be washed with water and allowed to thoroughly dry. The joints shall then be filled with mortar to make them smooth and plane. Acid curing shall not be required to be carried out if epoxy or polyester and furane type of resin shall be used for the mortar.

Resin mortars shall be normally self curing. The area tiled shall not be put to use before 48 hours in case epoxy, polyester and furane type of resin shall be used for the mortar. If phenolic or cashew nut shell liquid resin shall be used for the mortar, the area tiled shall not be put to use for 7 to 28 days respectively, without heat treatment. This period shall be 2 to 6 days respectively, if heat treatment shall be given with infrared lamp.

## 6.7 Cement Plastering Work

Unless otherwise specified, the proportions of the cement mortar for plastering shall be 1:4 (one part of cement to four parts of sand). Cement and sand shall be mixed thoroughly in dry condition and then just enough water shall be added to obtain a workable consistency. The quality of water and cement shall be as per relevant BIS standards. The quality and grading of sand for plastering shall conform to IS 1542.

Preparation of surfaces and application of plaster finishes shall generally conform to the requirements specified in IS 1661 and IS 2402.

Plastering operations shall not be commenced until installation of all fittings and fixtures such as door/ window panels, pipes, conduits etc. shall be completed.

All joints in masonry shall be raked as the work proceeds to a depth of 10 mm / 20mm for brick/ stone masonry respectively with a tool to be made for the purpose when the mortar shsll be still green. The masonry surface to be rendered shall be washed with clean water to remove all dirt, loose materials, etc. Concrete surfaces to be rendered shall be roughened suitably by hacking or bush hammering for proper adhesion of plaster and the surface shall be evenly wetted to provide the correct suction. The masonry surfaces shall not be too wet only damp at the time of plastering. The dampness shall be uniform to get uniform bond between the plaster and the masonry surface.

a) Interior plain faced plaster

This plaster shall be laid in a single coat of 12 mm thickness. The mortar shall be dashed against the prepared surface with a trowel. The dashing of the coat shall be done using a strong whipping motion at right angles to the face of the wall or it shall be applied with a plaster machine. The coat shall be trowelled hard and tight forcing it to surface depressions to obtain a permanent bond and finished to smooth surface. Interior plaster shall be carried out on jambs, lintel and sill faces, etc. as shown in the drawing and as directed by the Engineer.

b) Plain Faced Ceiling plaster

This shall be applied in a single coat of 6 mm thickness.

## 6.8 Water-Proofing Admixtures

Water-proofing admixtures shall conform to IS 2645 and shall be of approved manufacture. The admixture shall not contain calcium chloride. The quantity of the admixture to be used for the works and method of mixing etc. shall be as per manufacturer's instructions and as directed by the Engineer.

## 6.9 Painting of Concrete, Masonry & Plastered Surfaces

### 6.9.1 Plastic Emulsion

Plastic Emulsion paint shall conform to IS 5411. The primer shall be of the same manufacture as that of the emusion.

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Engineer for selecting the brand of manufacture and the colour/ shade. All materials shall be brought to the site of works in sealed containers.

### 6.9.2 Workmanship

Contractor shall obtain the approval of the Engineer regarding the readiness of the surfaces to receive the specified finish, before commencing the work on painting. Painting of new surfaces shall be deferred as much as possible to allow for thorough drying of the sub-strata.

The surfaces to be treated shall be prepared by thoroughly brushing them free from dirt, mortar droppings and any loose foreign materials. Surfaces shall be free from oil, grease and efflorescence. Efflorescence shall be removed only by dry brushing of the growth. Cracks shall be filled with wall putty. Workmanship of painting shall generally conform to IS 2395. A minimum of 2 finishing coats over two coat of primer shall be provided unless otherwise specified.

### 6.9.3 Acid, Alkali Resisting Paint

A minimum of 2 coats of acid/ alkali resisting paint shall be applied over the prepared dry surfaces by brushing. Primer coat shall be as per manufacturer's instructions.

### 6.9.4 Textured Exterior Paint

A minimum of 2 finishing coats over one coat of primer shall be provided unless otherwise specified. All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Engineer for the brand of manufacture and the colour/ shade. All materials shall be brought to the site of works in sealed containers.

## 6.10 Painting & Polishing of Wood Work

### 6.10.1 Materials

Wood primer shall conform to IS 3536
Filler shall conform to IS 110
Varnish shall conform to IS 337
French polish shall conform to IS 348
Synthetic enamel paint shall conform to IS 2932

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Engineer for selecting the brand of manufacture and the colour/ shade. All materials shall be brought to the site of works in sealed containers.

### 6.10.2 Workmanship

The type of finish to be provided for woodwork of either painting or polishing, the number coats, etc. shall be as specified in the respective items of work to be prepared by the Contractor.

Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

Painting shall be done either by brushing or spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirements of IS 2338 (Part I).

All the wood surfaces to be painted shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it across the grains and dusted off. Wood primer coat shall then be applied uniformly by brushing. The number of primer coats shall be as specified in the item of work to be prepared by the Contractor. Any slight irregularities of the surface shall then be made-up by applying an optimum coat of filler conforming to IS 110 and rubbed down with an abrasive paper for obtaining a smooth surface for the undercoat of synthetic enamel paint conforming to IS 2932. Paint shall be applied by brushing evenly and smoothly by means of crossing and laying off in the direction of the grain of wood. After drying, the coat shall be carefully rubbed down using very fine grade of sand paper and wiped clean before the next coat shall be applied. At least 24 hours shall elapse between the applications of successive coats. Each coat shall vary slightly in shade and this shall be approved by the Engineer. The number of coats of paint to be applied shall be as specified in the item of work to be prepared by the Contractor.

All the wood surfaces to be provided with clear finishes shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it in the direction of the grains and dusted off. Any slight irregularities of the surface shall be made up by applying an optimum coat of transparent liquid filler and rubbed down with an abrasive paper for obtaining a smooth surface. All dust and dirt shall be thoroughly removed. Over this prepared surface, vanish conforming to IS 337 shall be applied by brushing. Varnish shall not be retouched once it shall be begun to set. Staining if required shall be provided as directed by the Engineer. When two coats of varnish shall be specified, the first coat shall be a hard-drying undercoat or flatting varnish which shall be allowed to dry hard before applying the finishing coat. The number of coats to be applied shall be as specified. For works where clear finish of French polish shall be specified the prepared surfaces of wood shall be applied with the polish using a pad of woolen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles to give an even finish over the entire area. The surface shall be allowed to dry before applying the next coat. Finishing shall be carried out using a fresh clean cloth over the pad, slight dampening with methylated spirit and rubbing lightly and quickly in circular motions. The finished surface shall have a uniform texture and high gloss. The number of coats to be applied shall be as specified.

## 6.11 Painting of Steel Work

### 6.11.1 Materials

Zinc chrome primer shall conform to IS 2074
Epoxy paint shall conform to IS 14589
Aluminium paint shall conform to IS 2339

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Engineer for selecting the brand of manufacture and the colour/ shade. All the materials shall be brought to the site in sealed containers.

### 6.11.2 Workmanship

Painting work shall be carried out only on thoroughly dry surfaces. Painting shall be applied either by brushing or by spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to IS 1477 (Part 2).

The type of paint, number of costs etc. shall be as specified in the respective items of work.

Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

All the surfaces shall be thoroughly cleaned of oil, grease, dirt, rust and scale. The methods to be adopted using solvents, wire brushing, power tool cleaning etc., shall be as per IS 1477 (Part - I) and as indicated in the item of work.

It shall be essential to ensure that immediately after preparation of the surfaces; the first coat of red oxide-zinc chrome primer shall be applied by brushing and working it well to ensure a continuous film without holidays. After the first coat shall become hard dry, a second coat of primer shall be applied by brushing to obtain a film free from 'holidays'. After the second coat of primer shall be hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface shall become dry, the under cost of synthetic enamel paint of optimum thickness shall be applied by brushing with minimum of brush marks. The coat shall be allowed to hard-dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking adequate care to ensure that at no place the undercoat shall be completely removed. The surface shall then be allowed to dry.

The first finishing coat of paint shall be applied by brushing and allowed to hard-dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing.

At least 24 hours shall elapse between the applications of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the Engineer.

### 6.11.3 False Ceiling

False ceiling shall be provided at all the specified areas. Tiled False ceiling of 12.5mm thick square edge PVC Laminated Gypsum tile of size 595 x 595 mm made of Gypsum plasterboard manufactured from natural gypsum as per IS 2095 Part1 shall be provided. This false ceiling shall be laminted with white 0.16mm thick fire retardant PVC film on the face side and 12

micron metalized poluseter on the back side with all edges sealed with the face side PVC film which goes around and wraps the edges and is bonded to the edges and back side metalized polyester film so as to make the tile a completely sealed unit. Flase ceiling shall be suspended on inter locking metal grid of Hot dipped Galvanized steel section (galvanized @120 grams/sqm, both side inclusive) consisting of main "T" runner with suitably spaced joints to get required length and of size 24x38mm made from 0.3mm thick (minimum) sheet spaced at 1200 mm center to center and cross "T" of size 24x25mm made of 0.3 mm thick (minimum) sheet, 1200 mm long spaced between main "T" at 600 mm center to center to form a grid of 1200x600mm and secondard cross "T" of length 600 mm and size 24x25mm made of 0.3mm thick (minimum) sheetto be interlocked at middle of the 1200x600 mm panel to for grids of 600x600 mm. Main 'T" runners to be suspended from ceiling using GI slotted cleats of size 27x37x25x1.6mm fixed to ceiling with 12.5mm diq and 50 mm long dash fasterners, 4mm GI adjustable roads with galvanized butterfly level clips of size 85x30x0.8 mm spaced at 1200 mm c/c along main T..

## SUB-SECTION 7. ROADS AND ALLIED WORKS

### 7.1 General

Normally the Roadwork shall be done by the concerned department or by a separate agency. However, wherever required or specified in the BOQ/ drawings, the contractor has to do the new roads formation and/or road restoration after the pipe laying works. The roads shall be given berms, camber and longitudinal slopes as required.

The work shall also include preparation of sub-grade to the required level and camber, leveling and dressing of the filling and compaction up to 97% of laboratory dry density as per IS 2720 (Part 8) by vibro roller. The earth of soaked CBR value not less than 5% required for making the roads i/c embankment for access road shall be arranged by the contractor at his own cost if required.

### 7.2 Granular Sub Base

Unless otherwise specified or required by specification, this work shall be generally done as per below.

**Scope:** This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications. The material shall be laid in one layer as sub base to a 150mm thickness as necessary according to lines, grades and cross sections shown on the drawings or as directed by the Engineer.

**Materials:** The material to be used for the work shall be natural sand, moorum, gravel, crushed stone or combinations thereof depending upon the grading required. The gradation shall be as specified below.

**Grading for coarse-graded Granular Sub-base materials**

| Sieve Designation | Percentage passing by weight Grade II |
|---|---|
| 75 mm | - |
| 53 mm | 100 |
| 26.5 mm | 50-80 |
| 9.5 mm | - |
| 4.75 mm | 15-35 |
| 2.36 mm | - |
| 0.425 mm | - |
| 0.075 mm | <10 |
| CBR value | 25 |

**Physical requirements:** The material shall have a 10 percent fines value of 50 KN or more when tested in compliance with BS 812 (part 111). The water absorption value of the course aggregate shall be determined as per IS 2386 (part 3); if this value shall be greater than 2 percent, the soundness test shall be carried out on the material delivered to the site as per IS: 383 for grading II materials, the soaked CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 percent and shall not be less than 30%.

Strength of sub Base: It shall be ensured prior to actual execution that the material to be used in the sub base shall satisfy requirement of soaked CBR and other physical requirements when

compacted and finished.

When directed by the Engineer, this shall be verified by performing CBR tastes in the laboratory as required on specimens remoulded at Field dry density and moisture content and any other tests for the quality of materials as necessary.

## 7.3 Wet Mix Macadum (WMM)

**Scope**: This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, pre-mixed with water, to a dense mass on a prepared sub base in accordance with the requirements of these specifications. The material shall be made in one or more layers as necessary to lines, Grade and cross sections shall be shown on the approved drawings or as directed by the Engineer. Vibrating or other approved types of Compacting equipment shall be used; the compacted depth of single layer of WMM course shall be 150mm.

**Materials**

**Aggregates**:

**Physical requirements**: Coarse aggregates shall be crushed stone. If crushed gravel or shingle shall be used, not less than 90 percent by weight of the gravel or shingle pieces retained on 4.75mm, sieve shall have at least two fractured faces. The aggregate shall conform to the physical requirements set forth in table shown below:

**Physical requirements of coarse aggregates for WMM for sub-base or base courses**

| S. No. | Test | Test Method | Requirements |
|---|---|---|---|
| 1 | Los Angeles Abrasion value or | IS: 2386 (part 4) | 40 percent (max.) |
| | Aggregate Impact Value | IS: 2386 (part4) or IS:5640 | 30 percent (max.) |
| 2 | Combined Flakiness and Elongation indices (Total) | IS: 2386(part1) | 30 percent (max.) |

If the water absorption value of the coarse aggregate shall be greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS: 2386 (part-5).

**Grading requirements**:

The aggregates shall conform to the grading given in table shown below:

**Grading requirements of aggregates for WMM**

| Sieve Designation | Percent passing by weight passing the IS sieve |
|---|---|
| 53 mm | 100 |
| 45 mm | 95-100 |
| 26.5 mm | - |
| 22.4 mm | 60-80 |
| 11.2 mm | 40-60 |
| 4.75 mm | 25-40 |
| 2.36 mm | 15-30 |
| 600 Microns | 8-22 |
| 75 Microns | 0-8 |

Materials finer than 425 micron shall have plasticity index (PI) not exceeding 6.

The final gradation to be approved within these limits shall be graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on adjacent sieve or vice versa.

## 7.4 Dense Bituminous Macadam (DBM)

**Scope**: This work shall consist of construction, in a single course of 50 mm thick base course to the following specifications on a previously prepared WMM course with prime coat.

**Materials:** The bitumen shall be a paving bitumen of penetration grade S65 or A65 as per Indian standards specifications for "Paving bitumen" IS: 73. In case of a non-availability of bitumen of this grade, S90 grade bitumen shall be used with the approval of Engineer.

**Coarse aggregates**: The coarse aggregates shall consist of crushed stone, crushed gravel or shingle or other stones. They shall be clean, strong, durable, of fairly cubical shaped and free from disintegrated pieces, organic or other deleterious matter and adherent coating. The aggregates shall preferably be hydrophobic and of low porosity. If hydrophilic aggregates shall be used, the bitumen shall be treated with anti-stripping agents of approved quality in suitable doses. The aggregate shall satisfy the physical requirements set forth in table below.

If crushed gravel or shingle shall be used, not less than 90 percent by weight of gravel or shingle pieces retained on IS 4.75 mm, sieve shall have at least two fractured faces. The plasticity index of the fraction passing through the 425-micron sieve shall not exceed 4.

**Physical requirements of coarse aggregates for DBM**

| S.No. | Test | Test Method | Requirements |
|---|---|---|---|
| 1 | Los Angeles Abrasion value | IS: 2386 (part 4) | 40 percent (max.) |
| 2 | Aggregate Impact Value | IS: 2386 (part4) | 30 percent (max.) |
| 3 | Flakiness and Elongation indices (Total) | IS: 2386(part1) | 30 percent (max.) |
| 4 | Coating and stripping of Bitumen | AASHTO T 182 | Minimum retained coating 95 percent |
| 5 | Soundness | | |

**Physical requirements of coarse aggregates for DBM**

| S.No. | Test | Test Method | Requirements |
|---|---|---|---|
| | i) loss with sodium sulphate | 5 cycles | 12 percent maximum |
| | ii) Loss with magnesium sulphate | 5 cycles | 15 percent maximum |
| 6 | Water absorption | IS: 2386(part3) | 2 percent maximum |

**Fine aggregates**: Fine aggregates shall be the fraction passing 2.36 sieve and retained on 75 microns sieve, consisting of crusher-run screening, gravel, sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

**Filler**: Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement as approved by the Engineer. The filler shall be graded within the following limits:

**Grading requirements of aggregates for DBM**

| Sieve | Percent passing by weight passing the IS sieve |
|---|---|
| 600 Microns | 100 |
| 300 Microns | 95-100 |
| 75 Microns | 85-100 |

The filler shall be free from organic impurities and shall have a plasticity Index not greater than 4. The plasticity Index requirement shall not apply if the filler shall be cement or lime. When the coarse aggregate shall be gravel, 2 percent by mass of total aggregate of Portland cement or hydrated lime shall be added and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime shall not be required when the gravel shall be limestone.

**Aggregate gradations**: The combined course and find aggregates and filler shall produce a mixture to conform to the grading set for a table below.

**Aggregate gradation for DBM**

| Sieve Designation | Percent passing by weight |
|---|---|
| 37.5 mm | 100 |
| 26.5 mm | 90-100 |
| 13.2 mm | 56-80 |
| 4.75 mm | 29-59 |
| 2.36 mm | 19-45 |
| 300 Micron | 5-17 |
| 75 Micron | 1-7 |

**Preparation of Surface**

This work shall consist of preparing of WMM surface. The work shall be done on such widths as shown in drawings. The existing surface shall be firm, cleaned with mechanical broom and treated with prime coat (@ 0.9kg /sq.m), 24hrs. In advance of laying of DBM course. The

laying shall be done with paver finishers and compacted with road roller.

## 7.5 Premix Carpet

The Dense Bituminous Macadam roads shall be provided with 2cm thick premixed bitumen carpet surfacing with 1.8 cum of stone aggregate, 12.5mm nominal size and 0.90 cum of stone aggregate, 10mm nominal size using 144kg. This shall be of residual petroleum of penetration 80/100 (S-90) of approved quality per 100 sq.m and 52 kg of hot bitumen per cum of 12.5 mm nominal size stone and 56 kg of hot bitumen per cum of 10mm nominal size including a tack coat with residual petroleum bitumen of penetration 80/100 (S-90) of approved quality @ 0.35 kg/sq.m of road surface including consolidation with road roller etc.

This shall be provided and consolidated with road roller seal coat of premixed stone dust with residual petroleum bitumen of penetration 80/100 (S-90) of approved quality and using 68 kg. This shall be of residual petroleum bitumen of penetration 80/100 (S-90) and 0.6 cum of stone dust per 100 sq.m. of complete road surface. The seal coat shall be provided immediately after laying the bitumen carpet layer.

Pipe culverts with size not less than 300mm dia NP3 S&S pipes S&S Rubber rings joint with necessary 150mm CC/RCC M15 cradle & encasement with C.C. / R.C.C. M 15 with nominal reinforcement as per site requirement shall be provided at road crossings for storm water drainage of the area at the required number of places. Pipe shall be ISI marked.

Adequate / classified road roller of 8/10 MT capacity for the use of work as directed by the Engineer shall only be arranged by the contractor for consolidation. Log books of such road rollers shall be maintained. Maximum quantity of any items to be consolidated by each sprayer or roller / day shall be as under:

| | | |
|---|---|---|
| (i) | Prime Coat | 3200 sq.m |
| (ii) | Consolidation of sub-grade | 1860 sq.m |
| (iii) | Granular subbase | 100 cum. |
| (iv) | Wet Mix Macadam | 100 cum. |
| (v) | Dense Bituminous Macadam | 40 cum. |
| (vi) | 2 cm Premix carpet | 930 sq.m |

Aggregate and bitumen shall be mixed in a mechanical mixer of approved type, and shall be heated to required temperature as directed by Engineer. Bitumen boiler of suitable design avoiding local heating and ensuring continuous supply shall be arranged by Contractor. The Contractor shall maintain a thermometer for measuring the temperature at site of work. The contractor shall also make the necessary arrangement for weighting the material at site of work.

Fresh supply of bitumen from Bharat Petroleum / Indian Oil / Hindustan Petroleum as approved by Engineer shall be arranged by the Contractor and brought to the site of work and stored properly. Receipt for purchase in original as proof of purchase shall be submitted to the department by the contractor.

No variation in bitumen on lower side shall be allowed. In case bitumen to be used by contractor shall be found less than the quantity calculated theoretically, based on the coefficient for bitumen consumption given in CPWD specification or as decided by the Engineer for the items for which coefficient shall not be available in CPWD specification. The cost of bitumen not so used shall be recovered from the contractor.

Wherever, necessary RCC pipe / Box culvert shall be provided for crossing of drain pipes and effluent channel etc. For pipe culverts NP3 RCC pipes to be fully encased in concrete / RCC shall be used. All RCC cover slabs of drains / channels & of culverts subjected to vehicular traffic shall be designed for I.R.C. class AA loading.

## 7.6 Quality Control

For quality control of road works following tables shall be used for frequency of tests:

Tests on Earthwork for Embankment, Sub-grade Construction and Cut Formation

**Borrow material**: Grid the borrower area at 25 m c/c(or closer, if the variability is high) to full depth of proposed working. These pits shall be logged and plotted for proper identification of suitable sources of material. The following test on the representative samples shall be carried out:

1) **Sand Content [IS: 2720 (Part-4)] :** 2 tests per 3000 cubic metres of soil.

2) **Plasticity Test [IS: 2720 (Part 5)] :** Each type to be tested, 2 test per 3000 cubic metres of soil.

3) **Density Test [IS: 2720 (Part-8)] :** Each soil type to be tested, 2 test per 3000 cubic metres of soil.

4) **Deleterious Content Test [IS: 2720 (Part-27)] :** As and when required by the Engineer.

5) **Moisture Content Test [IS: 2720 (Part-2)] :** One test for every 250 cubic metres of soil.

6) **CBR Test on materials to be incorporated in the sub grade on soaked/un-soaked samples [IS: 2720 (Part-16)] :** One CBR test for every 3000 cubic metre at least or closer as and then required by the Engineer.

7) **Compaction control:** Control shall be exercised on each in their by taking at least one measurement of density for each 1000 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluating a day's work on statistical basis. The determination of density shall be as per IS: 2720 (Part- 28).

**Control Tests and their minimum frequency for sub-base & base (excluding bitumen bound bases)**

| S. No. | Type of Construction | Test | Frequency (min.) |
|---|---|---|---|
| 1. | Granular | (i) Gradation | One test per 200 $m^3$ |
| | | (ii) Atterberg limits | One test per 200 $m^3$ |
| | | (iii) Moisture content prior to | One test per 250 $m^2$ |
| | | (iv) Density of compacted layer | One test per 500 $m^2$ |
| | | (v) Deleterious constituents | As required |
| | | (vi) C.B.R | As required |
| 2. | Wet Mix Macadam | (i) Aggregate Impact value | One test per 200 $m^3$ of |
| | | (ii) Grading | One test per 100 $m^3$ |
| | | (iv) Atterberg limits of portion of aggregate passing 425 micron sieve | One test per100 $m^3$ of binding material |
| | | (v) Density of compacted layer | One test per 500 $m^3$ |

**Control Tests and their minimum frequency for bituminous works**

| S. No. | Type of Construction | Test | Frequency (min.) |
|---|---|---|---|
| 1. | Prime Coat / Tack Coat | (i) Quality of binder | Two samples per lot to be subjected to all or some tests as directed by the Engineer |
| | | (ii) Binder temperature for application | At regular close intervals |
| | | (iii) Rate of spread of Binder | Two tests per day |
| 2. | Seal Coat / Surface Dressing | (i) Quality of binder | Two samples per lot Dressing to be subjected to all or some tests as directed by the Engineer |
| | | (ii) Aggregate Impact Value | One test per 50 m3 of aggregate |
| | | (iii) Flakiness Index and Elongation Index | -do- |
| | | (iv) Stripping value of aggregates | Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates. |
| | | (v) Water absorption of aggregates | -do- |
| | | (vi) Grading of aggregates | One test per 25 m3 of |
| | | (vii) Stone polishing value | As required |
| | | (viii) Temperature of binder at application | At regular close intervals |
| | | (ix) Rate of spreading of materials | One test per 500 m2 of work |
| 3. | Dense Bituminous Macadam / Semi-Dense Bituminous Concrete / Bituminous Concrete | (i) Quality of binder | Two samples per lot to be subjected to all or some tests as directed by the Engineer |
| | | (ii) Aggregate Impact Value | One test per 50 m3 of |
| | | (iii) Flakiness Index and Elongation Index | One test per 200 m3 of aggregate |
| | | (iv) Atterberg limits of portion of aggregate passing 425 micron sieve | One test per100 m3 of binding material |
| | | (v) Density of compacted layer | One test per 500 m3 |

**Acceptance Criteria**

The acceptance criteria for test shall be subjected to the conditions that the mean value shall not be less than the specified values plus [1.65 – 1.65/(No. Of Samples)$^{0.5}$] times the standard deviation.

## SUB-SECTION 8. WATER SUPPLY & SANITARY WORKS FOR BUILDINGS

### 8.1 Piping and Plumbing

In general, all plumbing and installations shall be done with dual piping system in the buildings. One pipe system shall carry the potable water used for drinking purposes, bathing and in the kitchen. Another set of pipes shall be used to carry the reclaimed/reused water which shall be used for Toilet flushing and outdoor uses such as landscaping.

### 8.2 Sanitary Installation

All sanitary appliances including sanitary fittings, fixtures and toilet requisites shall be of size, and design as approved by the Engineer.

All porcelain fixtures, such as wash basin, sink drain board, water closet pan, urinal, 'P' trap etc., shall have hard durable glazed finish. They shall be free from cracks and other glazing defects. No chipped porcelain fixtures shall be used. The colour and shades of fixtures shall be approved by the Engineer.

All the urinal flusher and taps in sinks and wash basins shall be sensor operated. Hand dryer, paper dispenser and soap dispenser shall be provided at all toilet locations. All W.C. shall be of wall hanging type.

Joints between iron pipes shall be made perfectly air and watertight by lead caulking.

### 8.3 Indian Type Water Closet

This shall be the long pan pattern with separate footrests to be made of glazed earthenware, glazed vitreous china or of glazed fire clay. The general requirements shall conform to IS: 2556 (Parts III and X). Pans shall be provided with 100 mm vitrious china trap 'P' or 'S' type with a minimum 50 mm water seal and 50 mm dia. Vent horn. Pan shall be laid at the correct location and level over a bed of cement-sand admixture. It shall be of I$^{st}$ quality WC, Orissa pan of size 580 mm x 440 mm.

### 8.4 European Type Water Closet

Water closets shall be of glazed vitreous china as specified and shall be of "Double Siphonic type" conforming to IS: 2556 (Part VIII). The closets shall be of one piece construction with approved plastic/bakelite seat and cover. Each water closet shall have 4 fixing holes having a minimum diameter of 6.5 mm for fixing to floor and shall have an integral flushing rim of suitable type.

### 8.5 Urinals

Urinals shall be of the bowl pattern, either flat back or angle back type lipped in front. They shall be of glazed vitreous china and of size 610 x 400 x 80 mm conforming to IS 2556 (Part VI) with 25 mm dia. GI waste pipe coupling etc. The urinals shall be of one piece construction. Each urinal shall be provided with not less than two fixings holes of a minimum dia of 6.5 mm on each side. Each urinal shall have an integral flushing box rim of suitable type and inlet or supply horn for connecting the flush pipe. The flushing rim and inlet shall be of the self-draining type. It shall have a weep-hole at the flushing inlet of the urinal. At the bottom of the urinal, an outlet horn for connecting to an outlet pipe shall be provided. The

exterior of the outlet horn shall not be glazed and the surface shall be provided with grooves at right angles to the axis of the outlet to facilitate fixing to the uniform and smooth throughout to ensure efficient flushing.

## 8.6 Flushing Cisterns

The flushing cisterns shall be automatic or manually operated high level or low level, as approved by the Engineer. For water closets and urinals high level cistern shall be intended to operate with minimum height of 125 cm and a low level cistern a maximum height of 30 cm between the top of the pan and the underside of the cistern, They shall be of glazed vitreous china or of PVC as per IS 774. Automatic flushing cistern for urinals shall conform to IS 2326.

## 8.7 Wash Basins

a) Wash basins shall be of glazed vitreous china as approved by the Engineer and conforming to IS 2556.

| | |
|---|---|
| Flat Back | 630 x 450 mm |
| Flat Back | 550 x 400 mm |

b) Wash basins shall be of one piece construction, including a combined overflow. All internal angles shall be designed so as to facilitate cleaning. Each shall have rim sloping inside towards the bowl on all sides except skirting at the back. Basins shall be provided with single or double tap holes as approved. The tap holes shall be square. A suitable tap hole button shall be supplied if one tap hole shall not be required in installation. Each basin shall have a circular waste hole to which the interior of basin shall drain. The waste hole shall be either rebated or bevelled internally with diameter of 65 mm at top and a depth of 10 mm to suit a waste plug having 64 mm diameter. Each basin shall be provided with nonferrous 32 mm waste fittings. Stud slots to receive the brackets on the under side of the wash basins shall be suitable for a bracket with stud not exceeding 13 mm diameter, 5 mm high and 305 mm from the back of basin to the centre of the stud. The stud slots shall be of depth sufficient to take 5 mm stud. Every basin shall have an integral soap holder recess or recesses which shall fully drain into the bowl. The position of the chain stay-hole shall not be lower than the overflow slot. A slot type of overflow having an area of not less than 5 sq.cm. shall be provided and shall be so designed as to facilitate cleaning of the overflow. The Employer's Requirements for waste plug, chain and stay shall be the same as given for sinks.

c) All the waste fittings shall be chromium plated, Bottle trap shall conform to IS 5434. The chromium plating shall be of service grade No. 2 conforming to IS 1068.

## 8.8 Sinks

(a) The sinks shall be of glazed vitreous china as approved by the Engineer conforming to IS 2556 (Part V) and shall be of the following sizes.

450 x 300 x 150 mm.
600 x 450 x 200 mm.

(b) They shall be of one piece construction, including a combined overflow. The floor of the sink shall gently slope towards the outlet. The outlet shall in all cases be suitable for

waste fitting having flange of 64 mm. diameter and the waste hole shall have a minimum diameter of 65 mm at the bottom to suit the waste fittings. The waste hole shall be either rebated or bevelled having a depth of 10 mm. Each sink shall be provided with a non-ferrous 40 mm dia. waste fitting. The sink shall have overflow of the weir type and the inverts shall be 30 mm below the top edge. Each sink shall be provided with a waste plug, of suitable dia. chain and stay. The plug shall be of rubber or other equally suitable material and shall be water tight when fitted. Plug chains shall be of brass wire chromium plated. It shall have an overall length from the collar to the stay of not less than 300 mm. There shall be a triangular or D shackle at each end, one of which shall be brazed to the plug and the other securely fixed to the stay. The 150 mm long shank of the waste shall be threaded conforming to IS 2556 for sinks only. The waste fittings and plug fittings shall be chromium plated. The chromium plating shall be of service grade No. 2 conforming to IS 1068.

## 8.9 Stop Cock and Bib Cock

A bibcock (bibtap) shall be a draw off tap with a horizontal inlet and free outlet and stopcock (stoptap) shall be a valve with a suitable means of connections for insertion in a pipeline for controlling or stopping the flow. They shall be of specified size and shall be of the screw down type. The closing device shall work by means of a disc carrying a renewable non-metallic washer, which shall shut against water pressure on a seating at right angles to the axis of the threaded spindle for operation. The handle shall be either crutch or butterfly type securely shall be fixed to the spindle. The cocks shall open in anti-clockwise direction. When the bib cocks and stop cocks shall be required to be chromium plated, the chromium plating shall be of service Grade No. 2 conforming to IS 1068 in finish and appearance, the plated articles shall be free from plating defects such as blisters, pits, roughness and shall not be stained or discoloured.

These fittings shall be of brass heavy class; chromium plated (C.P.) and of approved manufacture and pattern with screwed of flanged ends as specified. The fittings shall in all respects comply with the requirements of IS 781. The standard size of brass fittings shall be designated by the nominal bore of the pipe to which the fittings shall be attached. A sample of each kind of fitting shall be approved by the Employer and all supplies shall be made according to the approved samples.

All cast fittings shall be sound and free from laps, blow holes and fittings, both internal and external surfaces shall be clean, smooth and free from sand etc. Burning, plugging stopping or patching of the casting shall not be permitted. The bodies, bonnets, spindles and other parts shall be truly machined and when assembled the parts shall be axial, parallel and cylindrical with surfaces smoothly finished. The area of the water way of the fittings shall not be less than the area of the nominal bore.

The fittings shall be fully examined and cleared of all foreign matter before being fixed. The fittings shall be fitted in the pipeline in a workman like manner. The joints between fittings and pipes shall be made leak-proof. The joints and fitting shall be leak proof when subjected to a pressure test approved by the Employer's Representative and the defective fittings and joints shall be replaced or redone.

## 8.10 Cast Iron Soil Waste and Vent Pipes and Fittings

All cast iron pipes and fittings shall be of uniform thickness with strong and deep sockets, free from flaws, air holes, cracks, sand holes and other defects and conform to IS 1536. The

diameter approved shall be internal diameter of pipe. The pipes and fittings shall be true to shape, smooth and cylindrical and shall ring clearly when struck over with a light hand hammer. All pipes and fittings shall be properly cleaned of all foreign material before fixing.

All plug bends of drainage pipes shall be provided with inspection and cleaning caps, covers, which shall be fixed with nuts and screws. Pipes shall be fixed to the wall by W.I. or M.S. holder bat clamps, unless projecting ears with fixing holes are provided at socket end of pipe. The clamps shall be fixed to the walls by embedding their hooks in cement concrete blocks (1:2:4) 10 cm x 10 cm making necessary holes in the walls at proper places. All holes and breakages shall be made good. The clamps shall be kept 25 mm clear of the finished face of the walls to facilitate cleaning and painting of pipes.

C.I. pipes and fittings exposed shall be first cleaned and then painted with a coat of red lead primer. Two coats of zinc paint with white base and mixed with pigment of required colour to get the approved shade shall be given over the base primer coat.

The thickness of fittings and their socket and spigot dimensions shall conform to the thickness and dimensions approved for the corresponding sizes of straight pipes.

The connection between the main pipe and branch pipes shall be made by using branches and bends with access for cleaning. Floor traps shall be provided with 25 mm dia puff pipe where the length of the waste shall be more than 1800 mm or the floor trap shall be connected to a waste stack through bends.

All cast iron pipes and fittings including joints shall be tested by a smoke test to the satisfaction of the Engineer and left in working condition after completion. The smoke test shall be carried out as stated under:

Smoke shall be pumped into the pipe at the lowest end from a smoke machine which shall consist of a bellow and a burner. The material usually burnt shall be greasy cotton waste which shall give out a clear pungent smoke which shall be easily detectable by sight as well as by smell if there shall be a leak at any point of the pipeline.

Water test and air test shall be conducted as stipulated in IS 5329.

### 8.11 Galvanised Mild Steel (G.I.) Pipes

The pipes shall be galvanised mild steel welded pipes and seamless screwed and sockets types conforming to the requirements of IS 1239, for medium grade. They shall be of the diameter (nominal bore) approved. The sockets shall be designated by the respective nominal bores of the pipes for which they shall be intended. The pipes and sockets shall be finished neatly, well galvanised on both inner and outer surfaces, and shall be free from cracks, surface flaws, laminations and other defects. All screws, threads shall be clean and well cut. The ends shall be cut cleanly and square with the axis of the tube.

All screwed tubes and sockets shall have pipe threads conforming to the requirements of IS 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

The fittings shall be of galvanised or mild steel types complying with all the appropriate requirements as approved for pipes. The fittings shall be designated by the respective nominal bores of the pipes for which they shall be intended. The fittings shall have screw threads at the ends conforming to IS 554. Female threads on fittings shall be parallel and male threads

(except on running nipples and collars of unions) shall be tapered.

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over tight white lead and few turns of spun yarn wrapped around the screwed end of the pipe. The end shall then be screwed in the socket, tee, etc. with the pipe wrench. Care shall be taken that all pipes and fittings shall be properly jointed so as to make the joints completely water tight and pipes shall be kept at all times free from dust and dirt during fixing. Burrs from the joint shall be removed after screwing. After laying, the open ends of the pipes shall be temporarily plugged to prevent access of soil or any other foreign matter.

Any threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved anticorrosive paint to prevent corrosion.

For internal work the galvanised iron pipes and fittings shall run the surface of the walls or ceiling (not in chase) unless otherwise specified. The fixing shall be done by means of standard pattern holder bat clamps, keeping the pipes about 1.5 cm clear of the wall. Pipes and fittings shall be fixed truly vertical/ horizontal, when found necessary to conceal the pipes, chasing shall be adopted or pipes fixed in the ducts of recesses etc. provided there shall be sufficient space to work on the pipes with the usual tools. The pipes shall not ordinarily be buried in walls or solid floors. Where unavoidable, pipes shall be buried for short distances provided adequate protection shall be given against damage, but the joints in pipes shall not be buried. M.S. pipe sleeve shall be fixed at a place where a pipe shall pass through a wall or floor for reception of the pipe and to allow freedom for expansion/contraction and the movements/maintenance. In case the pipe shall be embedded in walls or floors, it shall be painted with anti-corrosive bitumanastic paint of approved quality. The pipe shall not come in contact with lime mortar or lime concrete as the pipe shall be affected by lime. Under the floors the pipes shall be laid in layer of sand filling or as approved by the Engineer.

The work of excavation and backfilling shall be done true to line and gradient in accordance with general requirements for earthworks in trenches for pipes to be laid underground.

The pipes shall be laid on a layer of 10.0 cm sand and filled up to 15 cm above the pipes. A sand cushion of 15 cm on either side of the pipe shall also be provided. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be got rid of as directed. When excavation shall be done in rock, the bottom shall be cut deep enough to permit the pies to be laid on a cushion of sand 75 mm minimum.

The pipes and fittings, after they shall be laid and jointed, shall be subjected to hydrostatic pressure test as approved by the Engineer and shall satisfactorily pass the test. Pipe line system shall be tested in sections as the work shall proceed, keeping the joints shall be exposed for inspection. Pipes shall be slowly and carefully charged with water allowing all air to escape. All draw off taps shall then be closed and water pressure gradually shall be raised to test pressure. Care shall be taken to ensure that pressure gauge shall be accurate and preferably shall be recalibrated before the test. The section of the pipeline shall maintain the test pressure for at least half an hour for non-operation of pumps. Any joints or pipes found leaking shall be removed and replaced by the Contractor.

The exposed pipes shall be painted with two coats of white paint over a ready mixed priming coat and all underground pipes shall be painted with two coats of anti-corrosive bitumastic paint.

## 8.12 Stoneware pipes and fittings

All pipes with socket and spigot ends shall conform to IS 651/3006 and shall be of grade 'A'. These shall be sound, free from visible defects such as fine cracks or hair cracks. The glaze of the pipes shall be free form crazing. The pipes shall give a sharp clear note when struck with a light hammer.

The following information shall be clearly marked on each pipe and fitting:

1) Internal diameter;
2) Grade;
3) Date of manufacture;
4) Name of manufacturer or his registered trade-mark or both

All pipes and fittings shall have ISI mark. Laying and Jointing of GSW pipes and fittings shall conform to IS: 4127

## 8.13 Manholes

### 8.13.1 Location

Manholes shall be constructed at places approved by the Engineer.

### 8.13.2 Frame and Covers

Frame and covers for manholes shall be of required type and dimensions as per the relevant drawings prepared by the Contractor. The following information shall be clearly marked on each cover.

i. Year of Manufacture,

ii. Identification mark of the purchaser,

iii. Water/Sewers/ Storm water drainage (SWD)/Water whatever the case may be,

a) Steel Fiber Reinforced Concrete (SFRC) Cover

Steel Fiber Reinforced Concrete (S.F.R.C.) cover and frame (heavy duty, HD – 20 grade designation) of suitable size confirming to IS: 12592 shall be provided by the contractor. Cover shall be designed and provided with MS Rims of adequate thickness welded around with provision of lifting hooks welded at appropriate locations. MS rims and cover shall be suitably quoted using corrosion resistant paint. Cover shall be suitably marked on the top surface clearly indicating – Employer's Name/Sewer or SWD or Water/ Grade/Date of Manufacturer/Trade Name etc.

## 8.14 Miscellaneous

If any damage caused to the other services such as water supply pipeline, sewer, cable, etc. during the construction of manholes and erection of vent shafts, the Contractor shall be held responsible for the same and shall replace the damaged services to the full satisfaction of the Engineer. The interior of manholes shall be cleared of all debris after construction and before testing the same for water tightness by the Contractor.

# SUB-SECTION 9. PIPELINE, DMA FORMATION AND NRW REDUCTION WORKS

## 9.1 General

### 9.1.1 Scope

This section shall apply to the supply, handling, installation and testing of pipelines for the conveyance of treated (potable) water including Pipes, Fittings, Specials and appurtenances where required to be laid in, on or above ground or to be fixed on or built into other parts of the Works. It does not apply to pipework for Plants, Building services and drains.

Excavation and refilling of pipe trenches shall be carried out as specified for Earthworks subject to further requirements as specified in this section.

### 9.1.2 Definitions

The following terms shall have the meanings hereby assigned to them :-

| | |
|---|---|
| 'Pipes' | straight pipes, whether whole or cut, and their joints. |
| 'Fittings' | all components fitted to a pipe for jointing, connecting or changing the direction or bore of a pipe (including bends, tees, tapers, collars and couplings). |
| 'Pipeline appurtenances' | all items additional to pipes and fittings required to complete a pipeline including but not limited to internal and external protection systems, supports and anchorages, chambers, washouts, marker posts and any apparatus or construction required for testing, cleaning, disinfecting or operating the pipeline. |
| 'Pipeline' | the whole pipeline inclusive of pipes, fittings, pipeline appurtenances and, except where the context requires otherwise, valves, flowmeters and the like. |

### 9.1.3 Reference Standards

All Pipes and fitting including their materials shall comply with the relevant IS Codes or in their absence recognized International Standards. Work methodology and workmanship for every kind of activity such as laying, jointing, testing etc. shall also be done based on respective codes and standards as applicable.

### 9.1.4 Certificate of Quality of Pipes and specials

With every consignment of pipes and specials delivered under this contract the Contractor shall furnish a certificate worded as follows:-

"This is to certify that the quality of pipes and specials delivered in this consignment is not inferior to the quality laid down in the Specification".

No payment shall be made in respect of any consignment of pipes and specials which is not accompanied by such certificate.

The Contractor shall operate a Quality Assurance System, including:-

1. Records of Tests performed by suppliers on materials brought in;
2. Testing of materials for this Contract at various stages of manufacture as herein specified, and preservation of the results of such testing;
3. Sequence numbering of pipes and fittings.

The Quality Assurance System records shall be open to inspection by the Engineer, and shall be maintained in such a way that any pipe or fitting is identified by a unique sequential production number and can be uniquely related to each stage of its manufacture including material origin and quality, date and time of each operation, operator(s) involved and results of relevant quality control tests.

On completion of the Contract, the Contractor shall pass a complete set of the Quality Assurance records to the Engineer.

**Certificates of tests from the laboratory approved by the Engineer**

(a) works tests on pipes and fittings;
(b) material tests;
(c) inspection;
(d) welder-qualification tests;
(e) non-destructive tests on completed welds.

The Contractor shall submit for the approval of the Engineer details of his proposed methods for pipeline testing, swabbing, disinfection and cleaning (including details of test and cleaning equipment).

Note: The following aspects and procedures need to be established to minimize the ambuiguities during the real execution of supplies

- Master Procurement Plan (MPP) for supply of pipes and specials (with sub-plans on Cluster wise) should be prepared by the Contractor and agreed upon with the Engineer prior to proceed with the further batches of supplies. It shall be in line with the Construction schedules. Timely reviews and suitable modifications and adjustments could be made for procurement plans but not much deviating from the MPP
- Prior to deliver any of the consignments to the site as per the PP, Manufacturer's test certificate with third party inspection report should be submitted to the Engineer for his review and approval.
- Scheduled Inspection (on-site & off-site) of the Engineer will be carried out as a parallel process and if any defects observed by the Engineer's Inspection or further tests are ordered by the Engineer, then such items shall not be allowed for execution of real work until the subsequence remedial actions are accepted and satisfied to the Engineer.
- Submittal register should be maintained for the supplies which shall be covering all steps of procurement. Date of submissions, request for clarifications (if any) are some of the essential elements in that register. The entire procurement procedure under each consignment shall be properly documented in serial order

### 9.1.5 Marking of pipes and specials

Each Pipe shall have as cast or stamped or legibly and indelibly painted on it with the

following marks.

- The manufacturer's name or trademark on each pipe
- Standard ISI certification mark for the pipes conforming to IS or to such other standards to which they are supplied
- Project's name as "JICA-DWSIP". This shall be painted on only after the pipes or specials have been found to satisfy the tests and all other requirements of the Specification
- The nominal diameter of the pipe, class, year and batch number
- In case of DI pipe, a white ring line or any such mark showing the length of insertion at spigot end.
- Any important information that the manufacturer deems fit to be inscribed in the pipe.

## 9.2 Mild Steel (MS) Pipes

### 9.2.1 Materials and process of manufacture

Mild steel pipes and specials shall be manufactured out of new mild steel plates/ steel strips/ coils which shall be free from any cracks, surface flaws, laminations, excessive pitting or any other defects. Steel pipes and specials shall be made by submerged-arc welding from carbon steel with a minimum tensile stress of 410 MPa and yield stress of 235 Mpa. Pipe material properties and tolerances shall be in accordance with IS 3589- "Steel Pipes for Water and Sewage". Hot-rolled carbon steel strip in coils shall comply to IS 10748, Fe 410, Grade III. The general requirement of steel shall comply to IS 2062 and supply of structural steel to IS 8910. Spiral welded pipes shall be manufactured as per IS 5504. The general requirements relating to supply of spiral welded pipes shall conform to IS 1387.

The supply of M.S. plate sheets/ strips/ coil for fabrication of pipe shall be made from the approved vendors only. The pipes shall be made by either:-

- Longitudinally butt welding internally and externally preformed carbon steel plate or strip, by an automated submerged metal-arc welding process and circumferentially butt welding these shells internally and externally by the same process into standard length pipes with a maximum of four circumferential welds or,
- Rolling a strip, sheet or plate so that a helical seam is formed around the circumference of the pipe. The helical seam shall be butt welded internally and externally by an automated submerged arc welding process.

### 9.2.2 Thickness and Diameter

The minimum thickness of the steel plates for each diameter of the pipes shall be as specified under clause 3.2.1 (4) scope of work.

The Effective Length (the actual length that a pipe contributes when assembled in a run of piping) of each pipe shall be as the Contractor chooses provided that the Constant Length is not less than 7 meters or not greater than 14.0 meters and that all full-length pipes are of the same Constant Length. Certain details of the Drawings are based on an assumed Effective Length for the purposes of illustrating the Work, and the Contractor shall be responsible for designing and constructing at his own cost and to the Engineer's approval any additional or revised supports, restraints or other details necessitated by the Contractor's choice of

Effective Length. The variation of pipe length from the agreed or specified length shall be kept to the minimum possible and shall in any case not exceed 50 mm. Fineshed pipe shall not deviate from straightness by more than 0.2 percent of the total length.

### 9.2.3 Welding

Welding of pipes shall be done by butt joints (V-groove) or any other procedure as approved by the Engineer. The welding electrodes shall be as per IS 814 and IS 4353, and the welding in field should be done in accordance with IS 816. The wire-flux combinations shall comply to IS 3613.

The weld metal shall have a smooth finish with no abrupt edges and shall not stand more than 1.5 mm proud of the pipe shell internally or externally. Mismatches of adjacent surfaces at sectional welds shall not exceed 2 mm and shall be faired out on the outside of the pipe or fitting only. End preparation for welding shall conform to IS 2825. Final welding of closure gaps shall be carried out as per IS 5822.

All components of a standard shell, either straight or bent, shall be welded, wherever possible by use of automatic arc welding machine by submerged arc welding process. Hand welding shall not be permitted except for sealing runs and such other minor works and at the discretion of the Engineer. The strength of joint shall be at least equal to that of the parent material. Only qualified welders shall be used on actual job. Qualification standard for welding procedures, welders and welding operation shall conform to the requirements of IS 7307 and IS 7310.

In case of thin sheets, electric arc welding may not give satisfactory results and gas welding shall be resorted to. Gas welding shall be subject to the same specifications and tests as those of electric welds. Welding shall be carried out inside as well as outside.

The welded joints shall be tested in accordance with IS 3600 (part-1) and other relevant codes.

Prior to start of fabrication, the contractor shall submit to the Engineer for his approval the "welding procedure method statement" both for the machine welding at workshop or manual welding at the field.

#### 9.2.3.1 Radiography of Welded Joints

Soon after welding, each longitudinal/spiral and circumferential welded (minimum length as specified in the code) length of the weld at random for each pipe shall be radio graphed to detect welding defects as per requirements of IS 4853. Also the welded joints shall be tested as per IS 5822.

For MS pipes manufactured in factory/workshop fabricated from MS plate, 15% of the welded joints shall be subjected to ultrasonic test. All cross or T joints shall be raiographically tested. In case of field joints, 15% of the number of joints and T joints at random shall be put to ultrasonic and radiography test respectively. All these testing shall be done by the contractor at his own risk and cost.

The radiography shall be done as per IS 2595 using the latest and most efficient technique

either with X-ray or gamma ray equipment. The safety requirements during radiography shall be in accordance with IS 2598.

#### 9.2.3.2 Tolerance

Tolerance for pipes and fittings in respect of diameter and straightness shall be in accordance with IS 3589, however negative tolerance in pipe wall thickness is not permissible. The shell in the completed work shall be almost full round. The difference between maximum and minimum inside diameters at any cross section shall not exceed 1% of the nominal diameter of the cross section under consideration subject to a maximum of 5 mm. Straight pipes shall have faces perpendicular to the axis of the section with a maximum deviation of 2 mm on either side of the plane. Permissible tolerance for specials for diameter arm length and angular deviation shall be in accordance with IS 7322 or BS 534.

#### 9.2.3.3 Testing of Welded Joints (Shop and Site Welding)

After fabrication, but before application of lining and protective coatings, all pipes and specials shall be subjected to as hydraulic test as per IS 3589. In case of use of spirally welded and plate welded pipes conforming to IS 5504, the tests shall be carried out as prescribed in the same. The pipe shall withstand the test without showing any signs of weakness, leakages, oozing or sweating. If any leak or sweating is observed in the welded joints, the same shall be repaired by gouging or re-welding after dewatering the pipe.

In case of site welded joints, it shall be tested for Tensile test and Bend test in accordance to IS 3600 method of testing fusion welded joints and weld metals in steel.

#### 9.2.3.4 Pre-dispatch Inspection and Tests on Pipe and Fittings/Specials

Each special or fittings shall be subject to tests as per IS 7322 before inner and outer coating. The mechanical tests, workmanship and hydraulic test pressure shall be as per IS 3589 for pipes and specials. Dye penetration test as prescribed in IS 7322 is acceptable in lieu of hydraulic test for bends only. Sampling of pipes shall be taken as per IS 4711. The Engineer or the authorize inspection agency shall have free access to the manufacturing process, testing process, quality compliance documents and reasonable facilities and logistics without charge for inspection and testing purposes.

### 9.2.4 Fabrication of MS Specials & Fittings

#### 9.2.4.1 General

Unless otherwise specified, the dimensions of all MS specials and fittings (bends, tees, scour tee, reducers, enlargers etc.) shall in general conform to the principles of IS 3589 and IS 7322 using MS plate/sheet conforming to IS 2062. The thickness shall be adequate to sustain field test pressure but shall not be less than the thicknes of the pipe at that point. Tolerance for steel fittings shall confirm to the requirements of IS 7322.

The contractor shall submit the detailed shop drawing for each special to be used in the pipeline. On approval of the same by the Engineer, the contractor shall take up the

manufacturing. All specials shall be manufactured and coated at the manufacturer's premises. In exceptional circumstances when welding in trench is unavoidable as advised by the Engineer, a flanged opening shall be provided for access inside the special for welding. The contractor has to ensure the timely manufacturing of the MS specials so that they can be laid in synchronization with the pipe laying. The joints of adjacent pipe stretches have to be made with gap-pieces approved by the Engineer.

On completion of the manufacturing, the material shall be inspected by the Engineer or the authorized inspection agency at the manufacturer's place. On approval of the latter, the coating and lining for the special shall be done by the contractor as per the specifications for coatings.

#### 9.2.4.2 Sized pipes

Where stated in the Bills of Quantities sized pipes shall be supplied truly circular throughout their length for cutting to provide closing lengths. The tolerances on the outside diameters of such pipes shall be as set out shall be as per IS 3589.

#### 9.2.4.3 Pipe ends

The Cement mortar lining and the external coating of pipes and specials to be joined by welding shall be omitted for a sufficient distance at least 150mm from the ends to prevent damage to the protection during site welding. The external coating of pipes and specials to be jointed by mechanical couplings or flange adapters shall be omitted for such additional distance from the ends as is necessary to permit assembly of the joints. The internal surfaces from which the concrete lining is omitted shall be protected with a suitable approved rust inhibitor during manufacture (probably with approved quality epoxy inner coating or similar) so that extensive cleaning of the surface is not required after jointing on site.

Care shall be taken to ensure that butterfly valve discs will not foul cement mortar linings of adjacent pipework.

#### 9.2.4.4 Sleeve joints

Sleeve Joints shall comply with IS 3589.

Type 1 joints: The pipes shall be supplied with spigot end parallel and sleeve end with diameter tapered to approx. 3.0 mm per 100 mm length of sleeve. The minimum length of sleeve shall be 75 mm. The sleeve shall be sized to ensure that the spigot will enter the sleeve freely and be engaged by the socket when fully home.

#### 9.2.4.5 Slip joints

The slip joints shall be designed to allow the pipes to be laid with an angular deflection of not less than two degrees between adjacent pipes. The minimum lap shall be 75 mm. The ends of pipes shall be machined so that fillet welds can be used for jointing. The spigot shall fit accurately into the socket so that the amount of metal required to form the weld is reduced to a minimum. The sleeve end of the pipes shall have a suitable tapped hole provided with matching plug to permit an air pressure test of the joint to be carried out on completion of welding.

### 9.2.4.6 Flexible couplings and flange adapters

Flexible couplings and flange adapters shall be of mild steel suitable for making a watertight flexible connection between plain ended pipes, or between a plain ended pipe and a flanged fitting. Flexible mechanical coupling shall be without the centre register. Unless otherwise specified, the external surfaces of couplings and adapters shall be cleaned down to metallic finish and primed and painted with two coats of red lead oxide paint. The internal surfaces shall be similarly treated and protected with two coats of non-toxic approved epoxy bituminous paint.

All mechanical couplings shall be of appropriate internal diameter and shall be capable of withstanding the maximum works test pressure specified for the pipes they are to connect, at a joint deflection of up to 3 degrees in any direction. All mechanical couplings and flange adapters shall be supplied complete with all necessary couplings, rings, nuts, bolts, washers and rubber rings. Bolts and nuts shall be hexagonal with dimensions in accordance with IS 1363.

### 9.2.4.7 Flanged Branches

Flanged branches shall be fabricated in accordance with the general specification. Flanged branches for air and scour valves shall be welded into pipe in the required position. The branch for an air valve shall be vertical and at right angle to the longitudinal axis of the pipe. The invert of the branch for a scour valve shall be horizontal and at right angles to the axis of pipe and shall align with the invert of the barrel of the main pipe.

### 9.2.4.8 Flanged Joints

Flanges shall be provided at the end of pipes or special where sluice valves, blank flanges, tapers etc. have to be introduced. All flanges shall be of steel, welded to the pipe by the electric arc process or other approved method. Flanges shall be square to the longitudinal axis of the pipe and truly faced over their whole width. The bolt holes, which shall be drilled off-centre, shall be truly in line end-to-end with the longitudinal axis of the pipe. Flanges shall be in accordance with IS 6392 and IS 7322. Each set of flange jointing materials shall be complete with nuts, bolts, washers and rubber sheet. Bolts and nuts shall be hexagonal and shall be in accordance with IS 6603. The flange drilling shall conform to IS 1538 for flanges up to 1500 mm ID.

### 9.2.4.9 Bends

Bends to provide change of alignment in pipe laying shall be manufactured to suit the site conditions. Bends shall be metered bends as specified in IS 7322. Bends shall be manufactured from tested pipes by angle cutting of the barrel or by such other standard procedure and re-welding. Bends shall be lined internally and coate externally as specified for the pipes.

The bends shall have welded joints and the upstream and downstream of each bend shall have a straight piece of variable lengths as required. Bends shall be designed with deflection angle not more than 10 deg. between two segments. When the point of intersection of a horizontal angle coincides with that of a vertical angle, or when these points can be made to coincide, a single combined bend shall be used. Details of thrust anchor bolts, holding down straps,

saddle plates should be furnished together in contractor's fabrication drawing.

#### 9.2.4.10 Reducers

Reducers shall be manufactured out of steel plates and lined internally and coated externally. The reducers shall be suitable for connections to the sluice valves or flanged tail piece or equipments such as flow meters on one side and MS pipe on the other side. Stiffener rings shall be provided to afford rigidity to pipe. They shall be manufactured generally in accordance with IS 7322.

#### 9.2.4.11 Blank flanges

Blank flanges shall be provided at all ends left unattended for the temporary closure of work and also for commissioning a section of the pipeline or for testing the pipeline laid. For temporary closures, non-pressure blank flanges consisting of mild steel plates, tack welded at pipe ends may be used. For pipes subject to pressure, the blank flanges or domes suitably designed as per Engineer's requirements shall be provided. The thickness of the blank flanges shall be as per IS 6392 and flange drilling shall conform to IS 1538.

#### 9.2.4.12 Stiffener Rings

The contractor shall provide stiffener rings as per drawings or as directed by the Engineer. The contractor should weld the same to the pipes with one circumferential run on each side.

#### 9.2.4.13 Dismantling Joint

All valves shall be installed between flanges with a flexible MS dismantling joint on one side. The joint must allow dismantling of valves, meters etc. without causing stress to the joints of the attached pipes. The minimum clearance of the dismantling joint shall be five (5) cm. The pressure class of the dismantling joint shall be the same as that of the valve. The Nuts and Bolts of the joint shall be galvanized. The joints shall be painted/coated as per specification.

#### 9.2.4.14 Special Joint

Where a joint occurs between a steel pipe (or special) and a valve the internal diameter of the steel pipe or special shall be finished to match the bore of the valve by gradually decreasing or increasing the thickness of the concrete lining in the steel pipe or special. However the lining shall be no where less than 6 mm thick. Any increase or decrease in the thickness of the concrete lining along the length of such a pipe or special shall be gradual and smooth and the Contract Rates shall be deemed to include for all costs incurred in providing such a lining.

### 9.2.5 Cement Mortar lining for Internal Surface of MS Pipeline

#### 9.2.5.1 General

All steel pipes and specials shall be lined internally to the required thickness of Cement Mortar made from Ordinary Portland Cement and fine aggregate. The materials used for lining, the method of lining and curing of the finished lining and the manufacture and testing of test cubes shall comply with IS 3589 and shall be carried out to the approval of the

Engineer.

### 9.2.5.2 Thickness of Lining

Minimum lining thickness shall be as under However, positive tolerance as per clause 7.2 of IS 11906 shall be acceptable.

| | |
|---|---|
| 150 to 300 mm dia. pipe | 6 mm |
| 350 to 600 mm dia. pipe | 7 mm |
| 700 to 1100 mm dia. pipe | 9 mm |
| 1200 to 2500 mm dia. pipe | 12 mm |

### 9.2.5.3 Cement mortar lining- materials, methodology and tests

The pipes shall be lined at plant with centrifugally applied cement mortar made from Ordinary Portland Cement conforming to IS 8112, grade 43, and specially graded washed silica sand complying to IS 11906. The cement mortar shall have a minimum cement content of 330 kg / m3. The mix used shall be generally in 1:2 ratio (1 cement : 2 sand) but the work strength of the mortar to be tested in IS 3589 shall not be less than 31 N/mm2 after 28 days of curing.

The interior surface of pipe to be lined shall be clened to remove rust, chemical or other deposits, loose mill scale and deteriorated remains of old materials, oil, grease, and all accumulation of water, dirt and debris. Also the cleaning of surface shall be carried out by the use of suitable chemicals and by mechanical means (i.e. sand blasting or any other appropriate technique to near white). After sand blasting, the sand remaining inside the pipeline shall be cleaned by use of power-driven cleaner, incorporating revolving brushes on rotating arms. After this cleaning the pipe shall be flushed with potable water and all standing water removed.

The cement mortar lining shall be applied by centrifugal spinning process for pipes. For specials and fitting, manual application may be allowed complying to IS 11906. The mortar shall be applied by high speed spinning centrifugal process. The consistency of the mortar mix and the speed and duration of the spinning shall be such that the segregation of the aggregates from the cement is minimized. After the mortar has been evenly distributed, the pipe shall be spins at high speed to produce a dense lining with smooth surface and a minimum of shrinkage. Water centrifuged from the mortar shall be removed.

After being lined, the pipes shall be marked with the date of lining and stored undisturbed for 7 days for maturing when Water curing is used. Means shall be employed to prevent the lining from drying too rapidly, particularly during the 48 hour period after lining operation. The lining shall be kept damp by spraying with water or by other means for a period of 14 days. Method & period of curing other than water shall be accepted if approved by the Engineer.

Test blocks of the same material as used for pipe lining shall be made in 100 mm moulds and subjected to cube crushing tests. Each block shall be removed from its mould as soon as practicable and cured under conditions of temperature and humidity identical with in which lining of the pipe is cured. The cube strength of the test cube shall not be less than 31 N /mm2 after 28 days of curing or 18 N/mm2 after 7 days of curing. The density of the test cube shall not be less than 2100 kg/m3.

The surface of the lining shall be smooth and free from irregularities such as cavities, visible

air bubles and pinholes and shall be thoroughly compacted throughout. Fine surface crazing, hair cracks or cracks upto 0.25 mm wide in saturated lining and not over 300 mm in length shall not be a cause for rejection.

Lining thickness shall not be less than the required thickness with tolerance of +3 mm. and -0 mm.

Hand finishing of the end of the bore of the pipe for not more than 100 mm shall be permitted to rectify the thinning of linings. Fittings and specials shall be lined by centrifugally process and the same requirements as straight pipes, or if this is precluded by their shape, they shall be hand finished and cured so as to achieve comparable results.

Lining of bends, specials, area closely adjacent to valves and other such places where centrifugal placing may not be practical shall be performed by hand. Cement mortar for hand work shall be of the same materials as the mortar for machine placed lining.

Laterals and connections to the pipe that is being lined shall not be obstructed by the lining operations. Before lining is placed, the openings in the pipeline leading to air valves, blow offs, manholes and appurtenances, as well as to laterals and connections that transmit pressure or carry water from the pipeline, shall be temporarily covered or plugged with suitable devices. These shall be removed later without damaging the cement mortar.

Pipes and specials supplied with cement mortar lining which are to be joined together by internal welding shall have the lining stopped back at the ends a distance of 150 mm to permit welding of the joints without damage to the lining. After the welding is completed the gap between C.M lining of two pipes shall be made up manually using C.M 1:2 and cured by curing compound.

### 9.2.6 Internal surface coating in Trenchless section by Epoxy Coating

There will be limited pipe sections utilizing trenchless technologies both with the transmission & distribution pipe laying due to certain constraints at the pipe alignments. For such sections, food grade epoxy coating shall be used instead of cement mortar lining to prevent possible damage when pushing the pipes. Thickness of lining shall be greater than 450 microns. In all cases, food grade epoxy coatings are paramount using as inner lining for pipes at potable water supply or trenchless section.

### 9.2.7 External coating for underground pipes- Fiber reinforced coal tar enamel coating

#### 9.2.7.1 General

Unless otherwise specified or stated in drawings, the MS pipeline to be laid underground shall be externally coated with Fiber Reinforced Coal Tar Enamel at pipe manufacturing mill. Fiber reinforced coal tar enamel shall be done in accordance with IS 10221.

Shop applied- Hot applied coal tar enamel coating complete with inner and outer reinforcing wraps.
Field applied- Cold applied self adhesive PVC backed tape for field joints.

This consists of double coat coal tar enamel; double wraps of glass fiber mat and finished with the wrap of coal tar in accordance with AWWA C-203 and IS 10221. The thickness of

finished coating will be about 5 mm. The surface preparation of coating is by sand blasting or with the other approved techneques

### 9.2.7.2 Materials

**Primer:** The primer shall be coal-tar primer, Type-A, in accordance with IS 10221 and shall be highly compatible with the coal tar enamel used. The primer shall have the characteristics as specified in IS 9912. The coverage shall be uniform and shall result in a dry film thickness of minimum of 50 microns.

**Coal Tar Enamel:** Coal tar enamel used for coating shall have characteristics specified in IS 10221. The enamel shall have the characteristics as specified in IS 9912.

**Inner Wrap:** The inner wrap shall be of non-woven fiber glass fiber tissue consisting of uniform porous mat of chemically resistant Boro-silicate glass. The glass fiber tissue shall be bonded with suitable inert material like phenolic or urea type resin compatible with coal tar enamel. The glass fiber shall have the characteristics as specified in IS 14695.

| | |
|---|---|
| Weight | 50 g/m2 (min.) |
| Thickness | 0.5 mm (min.) |

**Outer Wrap:** The outer wrap shall be glass fiber tissue conforming to IS 14695. It shall have glass fiber tissue saturated with plasticized coal tar enamel in accordance with IS 10221.

| | |
|---|---|
| Weight | 585 g/m2 (min.) to 730 g/m2 (max.) |
| Thickness | 0.75 mm |

### 9.2.7.3 Field applied Tape

General requirements of pipeline wrapping tapes shall be in accordance with IS 10221. Primer shall be suitable by brush or spray application and materially in accordance with tape manufacturer's recommendation.

Tape shall be PVC backed bituminous compound with excellent adhesion to itself and to steel pipe and highly conformable to valves, flanges etc. and shall have the following minimum characteristics.

| | |
|---|---|
| Adhesion to steel | 2 N/mm |
| Thickness of adhesive compound | 0.90 mm |
| Thickness of PVC backing | 0.75 mm |
| Total thickness | 1.65 mm |
| Tape strength | 12 N/mm |
| Elongation | 260% |
| Dielectric strength | 20,000 V/mm |

### 9.2.7.4 Method of Application

Generally there are three methods application; Mill/yard wrapping, field wrapping and line wrapping. However, choice of method of application shall depend on several factors such as site conditions and technical aspects as specified in IS 10221 and AWWA C-204.

Whatever be the method of wrapping, general procedure of application shall be followed as per IS 10221.

**Mill/Yard or Shop Application:** The detailed procedure given in IS 10221 for Mill/Yard or Shop Application should be followed. There shall be two coats of coal tar enamel. Each coat of enamel shall have a minimum thickness of 2.4 mm at any point with an overall thickness of minimum 5 mm on the pipe body and shall be reinforced by a spiral inner wrap of fiber glas tissue pulled into the hot enamel in such a manner that the fiber glass tissue is embedded half way into the enamel without touching the steel surface or appearing at the enamel surface.

The coal tar impregnated outer wrap shall be simultaneously applied with the inner wrap. Both inner wrap and outer wrap shall be overlapped by 25 mm. The overlaps of the inner and outer wraps shall be staggered from each other by a minimum distance of 100 mm. There should be a minimum of 0.8. mm of enamel between pipe surface and the inner wrap.

The completed coating shall be well bonded to the pipe metal, uniform, smooth and free from holidays, laminations or other defects. The coating and wrapping shall be carefully trimmed off 150 mm from the ends of the pipe.

**Field Application**: On completion of welding and hydrostatic testing, the expressed section of pipe shall be thoroughly cleaned free from loose mill scale, metal bars, weld spatter and any dirt, rust, grease, moisture and any foreign matter. Adjoining area of shop coating near field joint of approximately 150 mm shall be prepared by hand wire brushing where field applied tape will overlap.

The primer shall be applied to joint area ensuring coverage is complete, especially at welds. Tapes shall be wrapped in accordance with manufacturer's instructions. Application rate and time for overlapping shall be in accordance with tape manufacturer's recommendations. Tapes shall be applied with a 50% overlap and even tensioning to ensure good confirmation with no wrinkles or air pockets. Wrapping shall start and finish to give a minimum 75 mm overlap onto the adjoining shop coating.

### 9.2.7.5 Handling of Pipes

Handling, lowering and backfilling of coated pipes must comply with the requirements of IS 10221 in addition to the other applicable codes and standards.

### 9.2.8 External Coating of MS Pipes above ground- Fusion Bonded Epoxy (FBE) Coating

External coating of MS pipes laid above ground shall be done with fusion bonded epoxy powder coating not less than 250 micron thick made of 100% solids thermosetting fusion-bonded, dry powder epoxy coating.

The material and workmanship shall comply with relevant international standards such as AWWA C213, CSA Z245.20, ISO 21809-2 etc. The surface shall be removed of dusts and coating shall be started before formation of visible oxidation of surface. The metal shall be preheated to a temperature recommended by the manufacturer but not exceeding 260 deg C in accordance with AWWA C213.

Each batch of FBE shall be accompanied by a certificate stating the tests such as Gel time, Cure time, moisture content, particle size distribution, density, infrared scan, Thermal

analysis etc. have been carried out on every batch and results are in accordance with the coating material manufacturer's product specification.

The coating shall be applied by electrostatic spray with the pipe at earth potential and the powder charge to high potential.

The thickness of the coating, including any repaired areas, shall be checked with a calibrated tester. Spark testing, for pin holes, contamination, cracks and damaged areas, shall use a high-voltage spark generator. Repairs done for coating imperfections or damage shall be done using a brush-applied compatible two-pack liquid compound. The area to be repaired shall be cleaned to remove dirt, grease, scale and damaged coating contaminants which could impair the adhesion of the repair material. The surface coating shall be applied by an approved applicator.

The FBE coating shall be 100% holiday tested as per relevant codal procedure. Other tests include Impact test,

### 9.2.9 External Coating of MS Pipes above ground- Polyurea spray coating

Wherever pipeline falls in the high humidity, moist or wet environment, Polyurea spray coating shall be done instead of fusion bonded epoxy. However, the coating shall comply with the VOC regulations. The physical properties of polyurea shall comply with the relevant international standards such as DIN 53504, ASTM D 4060-90 and ISO 180.

### 9.2.10 Expansion Joint

For all pipelines laid above ground, expansion joint shall be provided of the type and as specified in the drawing in accordance with IS 5822. Single end slip type expansion joint are commonly used. The body of the Expansion Joint shall be made of Carbon steel with a hard chrome-plated slip pipe. The spacing of expansion joint depends on local conditions but provision of expansion joint at intervals of 300 m on exposed steel pipeline is generally recommended. Expansion joints should always be provided between two fixed supports or anchorages.

### 9.2.11 Transportation, Handling, Stacking and Inspection of MS Pipes, fittings and specials

All pipes and specials manufactured at the mill shall be transported to the site of laying after cleaning them internally. Vehicles on which pipes are transported shall have a body of such length that the pipe do not overhang.

The pipes and specials shall be handled in such a manner as not to distort their circularity or cause damage to their surface. Under no circumstances shall pipes be dropped, be allowed to strike one another, be rolled freely or dragged along the ground. Slings of canvas or equally non-abrasive materials of suitable width of special attachment shaped to fit the pipe ends shall be use to lift and lower the pipes to prevent damage to the coatings provided.

Storage areas shall be set out to facilitate unloading, loading and checking of materials. The contractor will provide temporary props in order to prevent any sagging of the pipes while they are stacked in their yard and while transporting to the site of laying. End covers and other protections shall not be removed until incorporation of pipes or fittings into the works. All gaskets, nuts and bolts, flange adaptors and other similar items shall be stored in dry

conditions, raised off the ground in sheds or covered areas. Until required for incorporation each rubber rings or gasket shall be stored away from windows, electrical equipment and other materials like oil and chemicals and also from heat and cold.

Pipes, specials and appurtenances should be handled, stored and stacked in a suitable manner as directed by the Engineer. Padding shall be provided between coated pipes and timber skids to avoid damage to the coating. Any damage to coating shall be repaired by the contractor at his own cost to the satisfaction of the Engineer. It will be the responsibility of the contractor to protect pipes, specials and other items stacked along the alignment against any possible damages or thefts.

### 9.2.12 Installation of Mild Steel Pipes and fittings

MS Pipe shall be laid as per IS 5822 including the tranching and bedding in different kind of soils. The methods for laying of MS pipeline, welding in the field, testing of pipeline, flushing and disinfection before commissioning etc. shall also be done as per IS 5822.

At crossings over canals and ditches, the exposed steel pipes and fittings shall be painted as specified in previous section. The underground steel pipe shall be tied around with synthetic asbestos cloth. Steel sleeve pipe shall be painted with two coats of coal tar epoxy.

The end of the pipe shall have wooden stiffness installed inside of the pipe at quarters points and at both end of the pipe. This blocking shall remain inside the pipe until the pipe has been installed.

When field cutting or mitering of the pipe is required the cutting shall be done by the acceptable cutting machine, leaving a smooth cut a right angle to the axis of the pipe or deflection angle. Cut end of the pipe shall be beveled with a special tool made for the purpose, and the beveled end shall be exactly the same as the plain as manufactured at the factory.

Steel pipe with plain ends shall be joined together with a flexible coupling as specified or where shown on the drawings. The Contractor shall make excavation of sufficient width and depth to provide the suitable room for jointing the pipes the pipes and fittings. The Bedding at the joint shall be installed and compacted after the jointing has been completed. Where fittings such as bends, tees and blanks are used, all fittings shall be jointed with single butt welded joints unless otherwise shown on the drawings.

Any damages to the exterior coatings and interior coating and interior lining shall be repaired in accordance with the specification or manufacturer's recommendations. If, in the opinion of the Engineer, the damage is not properly repaired by the field methods, the Engineer reserve the right to order the Contractor to use the method of repairing that is the same as the specification or manufacturer's procedure. The expense of repairs shall be borne by the contractor.

Welded joints shall be butt weld and in full conformance with specification IS 3589. Welders in charges shall have the qualification stipulated in or approved equal.

The Contractor shall submit the qualification of the proposed welders for the steel pipe jointing for the approval of the Engineer. The Engineer may request the contractor to conduct the testing the examination of the capability of the welders. The contractor shall when requested by the Engineer make the necessary arrangements for such testing for joint welding at his own cost.

After all field welded joints have nee made, and inspected and approved by the Engineer. Unless otherwise permitted by the Engineer, shop coating and filed painting materials shall be from the same manufacturers.

## 9.3 Ductile Iron Pipes

### 9.3.1 General

In general, Centrifugally Cast Ductile Iron is defined as cast ferrous material in which a major part of the carbon content occurs as graphitic carbon in substantially nodular or spherodial form.

The material, design, manufacture, dimensions, tolerances, mechanical properties, internal cement mortar lining, external zinc coating along with bituminous finished layer, inspection and testing of Ductile Iron (DI) pipes shall comply with the IS 8329. Pipes and fittings of equivalent international standards such as BS EN 545:1995 or ISO 2531:1991 may also be used. The fittings shall be as per IS 9523 including the external diameter and wall thickness of the fittings. All straight pipes shall be spun or centrifugally cast and fittings and joint components shall be cast in sand moulds. Pipes and fittings shall be coated externally with metallic zinc. Except where otherwise required, pipes and fittings shall be lined internally with cement mortar (sulphate resistant) in accordance with the relevant code.

The DI Pipes to be used in the project shall be as per given in the BoQ and Drawings. They are mainly as follows.

| | |
|---|---|
| Transmission Main, Secondary/ Feeder Main (i.e. from UGR to the entry point of DMAs) | K9 |
| Distribution Pipes i.e. all pipes within DMA | K7 |

In case of spigot and socket pipes and fittings the socket shall be without centering ring. In case of flanged pipes, the flanges shall be at the right angles to the axis of the pipe and machined on face. The bolt holes shall be drilled and located symmetrically off the centre line. The bolt hole circle shall be concentric with the bore and bolt holes equally spaced. The flanges shall be integrally cast with the pipes and fittings and two flanges of the pipe shall correctly aligned.

All tests such as Mechanical test, Brinell hardness test, Retests, Hydrostatic tests shall be carried out during manufacturing of pipes and fittings as specified in IS 8329 and IS 9523.

Dimensions of standard pipes and fittings shall be in accordance with the above stated Standards unless otherwise shown on the Drawings or required for special purposes. Where pipes or fittings are required in dimensions other than those specified in ISO 2531 : 1991 or BS EN 545 : 1995, they shall be of the same classes as listed above and shall be designed for the works proof test pressures specified in Table 9 of ISO 2531 or Table 13 of BS EN 545 : 1995 for the relevant nominal diameter.

Similarly the dimensions and tolerances of DI fittings are given in the Table 10.1 to Table

10.20 of the ANSI/AWWA C110/A21.10 shall be followed.

Manufacturer's product catalogue, showing dimensions, mass and other details of all standard fittings shall be submitted to the Engineer for his approval prior to manufacture. Also Manufacturer's detailed drawings of all special fittings shall be submitted to the Engineer for his approval prior to manufacture.

In general Socket and Spigot pipes shall be supplied in standard length of 5.5m or 6m and flanged pipes in lengths of 4m, 5m and 5.5m as per requirements.

Standard pipe lengths shall comply with Table 3 and 4 of BS EN 545: 1995 for socket and spigot and flanged pipes respectively or Table 7 of ISO 2531: 1991 for socket and spigot pipes, unless otherwise stated. If any deviation with the pipe lengths as a result of following other standards it has to be referred to the engineer for his prior approval.

### 9.3.2 Joints

Push on flexible joints shall be provided for pipe to pipe connections as per IS 8329. Wherever flange joints are required, welded on flanges shall be used conforming to the requirements of IS 9523. Rubber sealing rings/gaskets used for jointing shall conform to IS 638, IS 12820 or EPDM elastomer conforming to IS 5382. The material of joint rings shall be of EPDM/SBR and shall be dual hardness punching type with 76-84 IRHD at the heel of the ring and 46-55 IRHD at the bulb of the ring. Joint rings shall be supplied by the pipe manufacturer.

Jointing of DI pipes and fittings shall be done as per IS 12288 and manufacturer’s recommendation. The cutting of pipe, if required, for inserting valves, fittings etc. shall be done with suitable tools as per IS 12288 and according to the recommendations of the manufacturer. Cutting of the pipes shall be reduced to a minimum and done in unavoidable cases only. It shall be done in a neat and workman like manner without damage to the pipe or lining so as to leve a smooth end at right angles to the axis of the pipe. The spigot end has to be chamfered again at the same angle as the original chamfered end. If there is no mark for the insetion depth on the spigot ends of the cut pipe it shall be marked again according to the instructions of the manufacturer.

#### 9.3.2.1 Spigot and socket Joints

These shall have sockets, which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS 12820 and IS 5382. In jointing DI pipe and fittings, the contractor shall take into account the manufacturer’s recommendations as to the methods and equipment to be used in assembling the joints.

The joints shall permit pipes to be deflected angularly by up to 2° axially for diameters up to 900 mm and by up to 1.5° axially for diameters over 900mm.

#### 9.3.2.2 Flanged Joints

This shall comply with dimensions and drilling details as specified in IS 8329. Flanged joints shall be complete with all nuts, bolts, gaskets and two washers per bolt. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts.

The flanges of all fittings shall be integrally cast. The flanges of flanged pipes shall either be integrally cast or screwed or factory welded unless otherwise stated. 'Factory welded' means that the flanges are welded to the pipes at the point of manufacture under factory conditions with inspection agency certification.

The Gaskets shall also comply with the relevant provisions in BS 2494 for effects on water quality and resistance to microbiological deterioration. The nuts, bolts and washers for flanged joints shall be of high tensile steel and shall comply with relevant standards. Stainless nuts & bolts should be provided where the applications at aggressive working environment with low pH values. The Gaskets shall be supplied by the same manufacturer and shall suit for PN 16 flanges unless otherwise stated.

While jointing, each bolt should be tightened at a time taking care to tighten diametrically opposite bolts alternatively.

DI fittings with restrained joints shall be utilized in underground application where pipelines have to cross the roads through existing ducts or in areas with restricted accessibility where use of concrete anchor blcks is prohibited, or as directed by the Engineer.

The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, including where connections are required to pipe work and valves associated with pumping plant and inlet/outlet pipe work at service reservoirs or other structures.

### 9.3.2.3 Mechanical couplings, Repair clamps and Flange aaptors

All mechanical couplings, repair clamps and flange adaptors shall comply with the relevant standards and ISO 9002 on quality assurance system. Mechanical couplings and repair clamps shall comply with PN 16 pressure rating unless otherwise stated. All fittings shall be protected against corrosion by the application of polymeric anti-corrosion coatings. The mechanical couplings and repair clamps shall be designed for a safe allowable angular deflection of 6 deg without leakage while it shall be 3deg for flange adaptors. All fasteners of couplings, clamps and adaptors shall be electroplated to BS 1706; grade 10 or equivalent followed by a suitable primer and then with a polymeric anti-corrosion coatings.

Slip on couplings shall include: straight flexible couplings and stepped flexible couplings. Slip on couplings shall be procured from approved suppliers whose fittings meet the same specification. Couplings shall be installed fully in accordance with the manufacturer's recommendation.

All detachable flexible couplings on buried ductile iron pipelines shall be of the sleeve type with a ductile iron collar and two bolted-gland joints.

### 9.3.2.4 Specials

Standard DI fittings shall be in accordance with IS 9523. Wherever standard DI specials are not available, they shall be manufactured in mild steel to suit site requirements, lined and protected, and tested as per requirements with the approval of the Engineer.

### 9.3.3 Coatings

All ductile iron pipes and fittings shall be protected internally and externally against corrosion.

#### 9.3.3.1 External Coating

**Pipe to be laid below ground:** The external protection shall comprise a coating of metallic zinc complying with ISO 8179: 1985 followed by two coats of bituminous based black paint complying with BS 3416, Type II or an approved coat of epoxy. Zinc coating shall be applied by spraying the mass of which shall not be less than 130 g/m2 as per ISO 8179. Bitumen coating shall be of normal thickness of 75 microns complying to BS 3416 Type II, suitable for tropical climates, factory applied in accordance with manufacturer's instructions. Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

Where polythene sleeving is specified to be applied in addition to bitumen coating above it shall comply with ISO 8180. Storage should avoid direct sunlight or exposure to the sunlight shall be kept to a minimum. Joints in the sleeving shall be properly overlapped and tapped in accordance with manufacturer's instructions to provide continuous sleeving.

**Pipe to be laid above ground:** Unless otherwise specified, Pipes and fitting above ground shall be expoxy painted. All exposed pipes and fittings shall be painted with Zinc rich epoxy primer and epoxy paint. Both shop and site application shall be done by airless spray equipment. Each lot of primer and paint used contractor shal be accompanied by certified copies of the test results on hardness, impact and heat resistance and resistance to corrosion carried out by the manufacturer in accordance with relevant Indian or International standards.

Surface preparation shall be done in accordance with manufacturer's instructions but as a minimum the pipes shall be abrasive blast cleaned to BS 7079 Grad Sa 2.5 or equivalent to achieve surface roughness profile of 40-50 microns. The primer shall be applied within 2 hours of surface preparation before flash rusting can occur. Two coats of zinc rich epoxy primer shall be applied by spray equipment on the pipes and fittings. The finishing coats with epoxy paints shall be applied after allowing the film to cure at least 48 hours. The final dry film thickness shall be a minimum of 300 microns. This may be achieved by applying 2 to 4 coats.

On completion of the work, the contractor shall remove any oil stains or paint spots, leaving the pipes and fittings in a clean and acceptable condition.

#### 9.3.3.2 Internal Coating/Lining

The internal protection shall be a cement-mortar lining complying with specified thickness in Table 8 of BS EN 545 : 1995 or relevant Table in ISO 4179 : 1985 or ISO 6600 : 1980. The relevant Indian Standard IS 11906 shall also be complied with.

All such coatings and linings shall be applied under factory conditions, in complying with BS EN 545 : 1995 or ISO 4179 : 1985/ISO 6600 : 1980.

No admixtures in the mortar shall be used without the approval of the Engineer. Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the

satisfaction of the Engineer.

Lining shall be uniform in thickness all along the pipe. Unless otherwise specified in relevant codes, the minimum thickness of factory applied cement mortar lining shall be 3 mm for the pipe up to DN 300 mm; 5 mm for DN 350 to 600 mm; and 6 mm for pipes larger than DN 600 mm.

### 9.3.4 Installation of DI Pipes and Fittings

The DI pipes shall be laid in accordance to IS 12288.

In the event of a fusion-bonded epoxy coating being damaged after leaving the factory, the item shall be returned to the factory for repair or, with the consent of the Engineer, be repaired at Site in accordance with the manufacturer's recommendations.

All pipes shall be carefully inspected for defects before installation. No pipes or fitting which shows defects excluded by the specifications shall be used. Any injury to protective coating of the pipe or fittings shall carefully be repaired before installation.

The Contractor shall, after excavation the trench and preparing the bed for the pipes, furnish all necessary facilities for properly lowering and placing the section of the pipe in trench without damage and shall properly install the pipe. The section of the pipe shall be fitted together correctly and shall be laid true line and grade in accordance with the bench mark established by the Contractor.

As far as possible, the pipe shall be lowered into trench using cranes. No pipe shall be rolled into place for lowering into trench except over suitable timber planking free roughness likely to damage any coatings. If the prepared bed is damaged for any reason, the pipe shall be raised and the bed made good before pipe laying is continued.

Whenever the work ceases for any reason, the unfinished end of the pipeline shall be securely closed with a tight fitting plug or cover. The interior of each pipe after being laid shall be thoroughly cleaned.

Any pipe which is not in true alignment both vertical and horizontal, or shows any undue settlement after laying shall be taken up and re-laid correctly by the Contractor at his own expenses when so ordered by the Engineer.

When subsoil water is encountered, it shall be kept below the sockets when joining by pumping or other means. In no case shall pipes and/or fittings be jointed before being lowered into position.

If any damage should occur to any pipes through failure of the Contractor to comply with these conditions, the damage shall be made good at the Contractor's expenses.

When the pipes are specified to be installed with the polythene sleeves or tape wrap, the contractor shall take necessary care to do it strictly in accordance with the specifications of the manufactures, using the recommended material, tools and equipment and methods.

If in the opinion of the Engineer, the sleeves or wrap fails to provide the protection to the pipe as intended due to improper material, tools or methods used by the contractor, he shall replace the sleeves or tape wrap in the affected area as directed by the Engineer, at his own cost.

#### 9.3.4.1 Cutting of Pipes

Pipe shall be cut using power driven abrasive wheel cutting machine. Acetylene torch and chisel methods will not be permitted in any circumstances. Cut spigot ends shall be beveled to the same dimensions as the normal spigot ended pipe. The edges of the cutter shall be given two coats of approved paint and the internal coating shall be repaired if damaged. The Contractor shall ensure that the diameter at the point of cutting will match the pipe to which it is to be jointed.

#### 9.3.4.2 Welding

No site welding work on ductile iron pipe an fittings shall be undertaken without the approval of the Engineer. Where approved, welding work shall be undertaken in accordance with the manufacturer's recommendation.

#### 9.3.4.3 Push in Joints and Restrained (Self Anchored) Joints

Installation shall be in accordance with the manufacturer's recommendations. Sockets and spigots shall be thoroughly cleaned prior to making the joint. Only lubricant recommended by the manufacturer shall be used and it shall be non-toxic. The completed joint shall have a uniform contract by the gasket between the outer surface of the spigot and the rubber ring seat of the socket.

A mobile crane or well-designed shear legs should be used for the positioning of pipes & keep them in well-balanced alignment for jointing. Insertion & tightening of socket & spigot ends shall be done by means of jacking or gently pushing by mechanical devices. While jacking or pushing through the non-entering edges of pipes, it must be properly protected with pillows or padding. No impact loading or dynamic loading is permitted for jointing of pipes.

#### 9.3.4.4 Flange Joints

Joints shall be made up square with even pressure upon the gasket and shall be properly water tight Gasket shall fit the inside dimension of the pipe accurately so that no surface material projects out into the flow area. The completed joint shall be perfectly aligned. Flanged joints shall be coated including all bolts and nuts with Denso paste and primmer, Denso mastic, Denso Mastic tape and PVC or polythene outer wrapping.

#### 9.3.4.5 Slip-on Coupling and Flange Adapters

Coupling and flange adapters shall be used where shown on the drawings approved by the Engineer. Installation shall be accordance with the manufacturer's recommendations. Gasket seats and gaskets shall thoroughly cleaned before assembly. The completed joint shall have uniform contract by the gasket between the outer surface of the spigot and the gasket seat at the socket. Coupling and flange adapters shall be coated including all bolts and nuts with Denso past and primer, Denso tape and PVC or Polythene outer wrapping.

#### 9.3.4.6 Laying of DI pipe above ground

The following will be applicable only when no additional bending moments except that those due to self weight of pipe and its contents are present. If any additional moments are present, the contractor has to supply the design or manufacturer's guidelines to the Engineer and lay the pipes accordingly.

**Socket and Spigot Pipes:** Socket (bell) and Spigot Pipes shall be provided with one support (usually pedestal or steel pipe support) per pipe. The support shall be positioned behind the socket of each pipe. Pipes shall be fixed to the supports with mild steel straps so that axial movement due to expansion and contraction resulting from temperature fluctuations is taken up at individual joints in the pipeline. Joints shall be assembled with the spigot end withdrawn 5 to 10 mm from the bottom of the socket to accommodate thermal movements. The designed anchorage shall be provided to resist the thrusts developed bu internal pressure at bends, tees etc. where a pipeline crosses a watercourse, the design and method of construction shall take into account the characteristics of the watercourse to ascertain the nature of bed, scour levels, maximum velocities, high flood levels, seasonal variations etc., which affect the design and laying of pipeline.

**Flanged Pipes:** The maximum unsupported span for flanged pipes shall not be more than 8 m. The supports shall be lcated at the centre of every second pipe. The maximum unsupported span at watercourse shall not be more than 8m. The relative position of pipe joints and supports shall be as per IS 12288. The supports of all flange pipe work spans shall be unyielding due to movements in the pipeline. The straps shall prevent any movement or lifting of the pipelines but not restrict expansions and contractions caused by temperature fluctuations.

### 9.3.4.7 Concrete protection of pipe

When indicated on the drawings or ordered by the Engineer, pipe shall be encased in concrete in accordance with the details shown on the drawings. Such concrete shall not be placed until the joints at each end of the pipe have been completed. Each pipe to be encased shall be supported on at least two purposes made precast concrete blocks of same grade of encasement concrete which shall be left in place and full width and depth of concrete encasement shall be placed and carefully tamped beneath the pipe followed at once by the addition of the encasing concrete.

### 9.3.4.8 Deflection of Pipelines

Minor changes in direction of pipeline both vertically and horizontally shall be made through deflection at the joints. Unless otherwise specified in the Standards, such deflection shall not exceed the values given below.

| Nominal Diameter (mm) | Maximum Allowable Push-on Joint | Deflection (Degree) Mechanical Joint |
|---|---|---|
| 80 to 200 | 5.0 | 5.0 |
| 250 to 350 | 4.0 | 4.0 |
| 400 to 600 | 3.0 | 2.5 |
| 700 to 900 | 2.5 | 2.0 |

| | | |
|---|---|---|
| 1000 to 1200 | 2.0 | 1.5 |

Joints with deflection shall be installed in accordance with the manufacturer's instruction

#### 9.3.4.9 Protection of Joints

All buried flange joints, and any un-coated mechanical coupling shall be protected by wrapping as specified in code or elsewhere in the document, and if not, the same shall be done with "Denso Paste", "Densyl Mastic", "Densyl Tape" and "PVC Outerwrap" or similar approved materials.

The joints shall be thoroughly cleaned to remove all loose rust and extraneous matter and thoroughly coated with "Denso Paste" over the whole of the joint. A liberal amount of paste should be left around all bolt heads, narrow cavities etc. "Densyl Mastic" shall then be applied to coverall bolt heads and nuts to from a triangular fillet against flanges and to fill all gaps and abrupt changes in contour to provide an even contour for wrapping. "Densyl Tape" shall than be applied circumferentially, care being taken to smooth and eliminate any air pockets and to from the tape well into all angles and changes in contour. The tape should be applied with an overlap of at least 25 mm and should extend at least 50 mm on either side of the joint. Finally an outer wrapping of "PVC Outerwrap" shall be applied with minimum lap of 25 mm to completely cover the "Densyl Tape"

## 9.4 Galvanized Iron (GI) Pipe

### 9.4.1 General

The following standards/codes shall govern the GI pipes as applicable.

| | |
|---|---|
| IS 1239 (Part I) | Specification for medium grade GI Pipes |
| IS 1239 (Part II) | MS Tubular or Wrought Steel Fittings for GI Pipes |
| IS 4736 | Specification for galvanizing |
| IS 554 | Specification for Pipe Threads of Screwed Tubes and Sockets |

The Pipes shall be Galvanized mild steel Hot Finished Seamless (HFS) or welded ERW, HRIW or HFW screwed and socketed conforming to IS 1239 (part I) for medium grade. The zinc coating shall be uniform adherent, reasonably smooth and free from imperfections.

All screwed pipes and sockets shall have pipe threads conforming to the requirements of IS 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

Dimensions, weight and tolerance in thickness of pipes shall be as specified in the codes.

The fittings for GI pipes shall be of mild steel tubular or wrought steel fittings conforming to IS 1239 (Part-II). The fittings shall be designated by the respective nominal bores of the pipe for which they are intended.

### 9.4.2 Jointing and Installation of GI Pipe and Fittings

Only pipes, fittings and accessories which are in accordance with the requirement of IS specification shall be used in this work. Installation of pipes, fittings and accessories shall be in conformance with the manufacturer's recommendations, or as directed by the Engineer. Gibault or flange joints may be used if necessary.

All threads for screw joints shall be clean, machine cut, and all pipes shall be reamed before erection. Each length of pipes as erected shall be up-ended and rapped to dislodge dirt and scale.
Screwed joints shall be made up with good quality thread compound and applied to the male thread only. After having been set up, a joint must not be backed off unless the joint is completely broken, the threads cleaned, and new compound applied.

No close right and left hand nipples shall be used. All nipples shall be of such that the correct size of pipe wrench can be used on them when in place.

At crossing over canals or ditches, the pipe shall be laid in accordance with the details and/or construction method specified on the drawings or as directed by the Engineer.

Pipe laid under ditches, shall be in accordance with the details shown on the drawings or as directed by the Engineer. Pipe bedding shall be compacted for the entire length of the pipe good alignment shall be preserved and fittings may be used where necessary.

## 9.5 Polyethylene (PE) Pipe

High Density Polyethylene (HDPE) pipe and fittings for pressure pipelines shall be in accordance with ISO 4427, IS 4984 and other relevant codes such as IS 14333 (for sewerage) as the case may be. Medium Density Polyethylene (MDPE) pipe may comply with ISO 4427, IS 7634-2:2007 and other relevant codes. The raw materials shall be of grade PE 100 for HDPE and PE 80 for MDPE. The Pressure Rating class of MDPE pipe to be used in the works shall be PN 16 & PN 12.5. The Contractor can procure the pipe only from the reputed make and Engineer's approval of manufacturer shall be given after due consideration on the quality, availability of fittings and specials etc.

The manufacturer shall be responsible for all testing and quality assurance. Pipes exceeding 90 mm nominal diameter shall not be supplied in coils. Pipes up to nominal size 63 shall further comply with BSEN 12201-1, 2 & 5.

All tooling and equipment used for thermal fusion jointing shall be of types approved by the Engineer and shall include all equipment necessary to cut, plane and clean, clamp, heat and align pipe and indicate or control temperatures and heating and cooling periods to an acceptable international standard. Fusion tools and heating plates shall be electrically heated and thermostatically controlled.

All MDPE pipe and fittings for thermal fusion jointing to form an individual pipeline or pipeline system shall be supplied by one manufacturer unless the Engineer approves otherwise. Electro-fusion couplings are excepted from the requirement but must be of a type as approved.

Mechanical joints shall be of the Viking Johnson 'Quick-lock' type and shall be complete with liners.

Material used for manufacturing of pipe should not cause toxic hazard, should not support microbial growth and should not rise to unpleasant test or odour, cloudiness and unpleasant test of water. Pipe manufactures' shall obtain the certificate of this effect from the manufacturer of raw material.

The specified base density shall be between 940.5 kg/m3 and 946.4 kg/m3 (both inclusive)

when determined at 27 ºC according to procedure prescribed in Annex of IS 7328. The value of density shall also not differ from nominal value by more than 3kg/m3 as per IS 7328.

The MRF of the material shall be between 0.41 and 1.10 (both inclusive), when tested at 100ºC with nominal load of 5 kg as determined by method prescribed in 7 of IS 2530. The MRF of the material shall also be ±20 percent of the value declared by the manufacture.

The resin shall be compounded with carbon black. The carbon black content in the material shall be within 2.5±0.5% and the deprecation of carbon black shall be satisfactory when tested accordingly to the procedure described in IS 2530.

The percentage of antioxidant used shall not be more than 0.3 percent by mass of finished resin. The antioxidant used shall be physiologically harmless and shall be selected from the list given in IS 10141.

PE Classification as per ISO 4427 is shown in Table below.

| Designation | Classification MRS (MPa) | Design Stress(MPa) water at 20°C |
|---|---|---|
| PE100 | 10.0 | 8.0 |
| PE80 | 8.0 | 6.3 |
| PE60 | 6.3 | 5.0 |
| PE40 | 4.0 | 3.2 |

PE100 materials produce stronger pipes which are used for higher pressure operation in gas and water distribution systems. Colour of HDPE pipe for water supply should be black with blue stripe as per IS 4984. The color for MDPE pipe shall be light blue for PE80 within the rnage 18E51 to 18E53 conforming to ISO 4427.

Pipe material should be such that the pipe has life expectancy from 50 to 100 years. PE pipe is normally joined by butt fusion method for which the joint is as strong as or stronger than the pipe itself, and is virtually leak free. Black PE pipe containing 2 to 3% carbon black can be safely used outside in the sun without damage from UV exposure. Average e modules of pipe should be 900 to 1200 mpa.

Pipes shall be classified by pressure rating (PN) corresponding to the maximum permissible working pressure at 30°C as follows.

| | | | | | | |
|---|---|---|---|---|---|---|
| Pressure rating of pipe in (PN) | 2.5 | 4.0 | 6.0 | 10 | 12.0 | 16 |
| Maximum permissible working pressure (Mpa) | 0.25 | 0.4 | 0.6 | 1.0 | 1.20 | 1.60 |

Material of pipe should be classified as per following stress condition

| Material Grade | MRS at 20°C, 50 Years in MPa | Maximum Allowable Hydrostatic Design Stress(σs) MPa | |
|---|---|---|---|
| | | At 20 ºC | At 30ºC |
| PE63 | 6.3 | 5.0 | 4.0 |

| | | | |
|---|---|---|---|
| PE80 | 8.0 | 6.3 | 5.0 |
| PE100 | 10.0 | 8.0 | 6.3 |

### 9.5.1 Pipe Marking

Each straight length of pipe shall be clearly marked in indelible ink/paint on either end and for coil at both ends or hot embossed on white base every meter throughout the length of pipe/ coil with the following information.

(a) manufacturer's name/ Trade- mark
(b) Designation of pipe (example PE 63 PN 10 DN 200)
(c) Lot number/ Batch number and year.
(d) Letter of DJB.

### 9.5.2 Pipe Jointing, Bending and Storage

Flanged fittings shall not be used unless directed by the engineer. Joints between polyethylene pipe and metal flanges, such as at valves, shall be by means of metal–PE flange adaptors, specifically designed for this purpose.

#### 9.5.2.1 Thermo-Fusion Welding

Butt fusion welding shall be done using approved proprietary equipment and shall on no account be made by hand. Joints shall be made in accordance with manufacturer's instructions, but shall in any case include the following steps:

1) Surface Preparation: The mating surfaces of the components to be jointed shall be square and free from imperfections. Pipes for cutting shall be cut using appropriate pipe-cutters designed for the purpose. On no account shall pipes be cut by hand using improvised methods, e.g. knife, hacksaw etc.

2) Heating the surfaces: The surface of the heated plate shall be clean and maintained at 210 °C, or as otherwise stipulated by the pipe manufacturer. The mating surfaces shall be pressed constantly against the plate until a small bead of molten material is formed. Thereafter the pressure shall be reduced to ensure that the bead does not continue to grow whilst heating is continued.

3) Welding: The hot plate shall be removed and the heated faces brought together under pressure. Pressure shall be maintained until the joint area has cooled sufficiently. The ridge produced inside and outside the pipe, shall have a height not exceeding a quarter of the wall thickness.

#### 9.5.2.2 Bending

Pipe shall not be heated and stressed to form curves or bends. Gradual curves may be introduced into the pipe at ambient temperatures to form direction changes. The inside radius of the bend shall be not less than 20 times the outside diameter of the pipe.

#### 9.5.2.3 Storage

Pipes shall be stored on flat, clean surfaces free of sharp objects or any other item that may mark or damage the pipe in any way. Pipes shall not be stored on or against hot surfaces. Blue and Black polyethylene pipe shall be stored under cover and out of direct sunlight.

Coils may be stored either on edge or stacked flat one on top of the other. Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set.

### 9.5.3 Certificates

The Contractor shall forward to the Engineer the following certificates, where relevant:

(a) works tests on pipes and fittings;
(b) material tests;
(c) inspection;
(d) welder-qualification tests;
(e) non-destructive tests on completed welds.

### 9.5.4 Laying of PE Pipelines

#### 9.5.4.1 Installation of buried pipes

When laying pipes in hot weather, the trench shall be partially backfilled before making the final connections and locating anchor blocks.

Only coiled pipe shall be installed by moling. Moling methods may include pulling pipe through holes pre-drilled by mole-bore, and mole-ploughing using a proprietary ploughing machine.

The Contractor shall ascertain that ground conditions are suitable for moling before commencing any such work. The Contractor shall ensure that he has complete knowledge of any services that may lie along, or in the immediate vicinity of the pipeline route, and has taken appropriate mitigation in accordance with the Specification, before he commences.

The diameter of the mole should be 1½ to 2 times the outside diameter of the pipe being laid.

The following procedures shall apply when installing pipe:

(1) Any trenches/pits required for launching and receiving moles, pulling pipe, and making joints, shall be made in advance of the works and clearly identified. The pits should be planned at intervals slightly shorter than the length of the coils to be used. Starting and intermediate pits shall be at least 1.5 m long and 0.3 m wide and to the depth it is intended to plough.

(2) Pipes shall be uncoiled and laid on the ground in the direction of pulling (or in a wide circle) near the hole at which they will be needed. The ends of the pipe shall be covered or bunged in order to keep soil from entering the bore.

(3) Pulled pipes shall be laid individually between pits and pulled by tractor or winch through to the next pit. Only continuous lengths shall be pulled, pulling of coupled pipes shall not be permitted. In hard soils the friction may be reduced by pouring a little water into the hole made by the plough.

(4) The Contractor shall make adequate allowance for expansion of the pipe due to pulling or laying by plough. Pipes shall be left overnight following laying and before making joints, to allow for contraction of the pipe.

### 9.5.4.2 Above ground installations

Pipe fitted above ground shall be black pipe supplied in straight lengths, unless otherwise agreed by the Engineer. Where pipe is cut from a coil, fixing shall be arranged so that the curvature of the pipe is corrected by contact with the surface to which it is being fixed. Pipe shall not be straightened by applying tension.

Pipe clips shall be plastic and shall be correctly aligned to provide a flat smooth surface for contact with the pipe. No sharp edges shall be present on supports. Valves and other such items shall be properly supported.

Pipes shall not be placed adjacent to hot surfaces.

Support spacing's: Pipe shall be continuously supported or on fixings such as pipe clips, brackets etc. which shall be used at approximately the following spacing's. Values are for use in temperatures up to 20 °C. Spacing's shall be reduced by 25% between 20-30°C. Pipes shall be continuously supported where temperatures are above 40°C.

| Nominal Size | Spacing (m) | Nominal size | Spacing (m) |
|---|---|---|---|
| 16 | 0.45 | 50 | 0.7 |
| 20 | 0.6 | 63 | 0.85 |
| 25 | 0.6 | 90 | 0.85 |
| 32 | 0.6 | 110 | 0.9 |
| 40 | 0.7 | 140 | 1.1 |
| | | 160 | 1.3 |

Support distances may be doubled for vertical pipes.

Expansion and contraction: Adequate means shall be provided to account for expansion and contraction. This shall be by means of bends/changes of direction at appropriate intervals or purpose designed bellows, sliding gland expansion joints or expansion loops.

### 9.5.4.3 Laying Methodology

Laying of the pipe and making of connections shall be undertaken in a dry trench. During pipe laying operations the ends of the pipe shall remain sealed by end closures, until immediately prior to jointing. Pipe handling shall be in accordance with the requirements given elsewhere of this document and the pipe manufacturer's recommendations. Exposed PE pipe shall be properly supported and protected from mechanical damage.

The induction of stresses in the pipe or in joints during installation shall be avoided where possible and the following precautions shall be taken:

- Ensure that the pipe is not damaged by coming in to contact with sharp or abrasive materials during handling, jointing or installation and that it is regularly supported along its length.

- When pipes are pulled as part of the jointing or laying process care shall be taken to ensure that the drag force does not exceeding the allowable force as specified by the pipe manufacturer. Pipes shall only be pulled when they are supported by roller assemblies and are free of the ground surface and other obstructions in order to ensure that they are not damaged during the process.

The contractor shall comply with the minimum allowable bending radii, PE100 pipes may be bent or curved on site down to a minimum radius as recommended by the manufacturer. In the event of the manufacturer providing no recommendation, the minimum bend radius shall not be less than 25 times the pipe OD. Where there are space restrictions the bend radius may be reduced down to 20 times the pipe OD, but only with the written permission of the Engineer.

No electro-fusion or mechanical joints should be incorporated in the sections of pipe work which are to be bent. Instead a formed bend or elbow should be welded in the pipeline in order to prevent excessive stress.

- Ensure that the trench is in compliance with the requirements of general condition of the specification and that proper bed and surround material are used.
- Whilst placing the bed and surround materials ensure that no stones or other hard materials impinge on the surface of the pipe.
- If the pipe is laid in a sleeve, ensure that the sleeve ends are fitted in such way that no stress or cutting effect can be transmitted to the PE carrier pipe.

## 9.6 Design, Laying/Installation Methodology and Workmanship

### 9.6.1 External Protection

The Contractor shall carry out the soil resistivity study along the right of way of the pipeline using Wenner's 4 pin method or other suitable methods. On completion of all field work, a report incorporating resistivity (on semilog graph sheets) data shall be submitted to the Engineer. In case of highly corrosive soil (soil resistivity less than 1000 ohm-cm), cathodic protection or polyethylene sleeving for encasement of the pipes or other suitable methods as approved by the Engineer shall be adopted for protection of metallic pipes (MS and DI) against the corrosion.

### 9.6.2 Laying and Jointing of Pipes- General

The Contractor shall install pipelines without damaging the pipes, their ends including the exterior and interior coatings. Wire-rope or chain slings shall not be used for handling pipeline materials.

Trench Excavation shall be carried out in accordance with the relevant specifications for Earthworks and Trenching for pipelines. Where Trench Excavation is to be carried out in areas where buried pipes or cables are likely to be encountered, the location of such pipes or cables shall, whenever practicable, be determined ahead of Trench Excavation.

The pipeline shall be accurately installed to the lines, levels, grade and positions as set out in the approved drawing. Unless required otherwise, pipes shall be installed singly and shall not be jointed until after they have been laid. Pipes shall be laid in dry trenches. The Contractor shall make appropriate arrangements for dewatering, which shall be subject to the approval of the Engineer. Pipes shall be lowered carefully into the trench using appropriate mechanical

lifting equipment with ropes or slings, no hooks shall be used. No pipe shall be rolled and dropped into the trench or allowed to assume an inclination of more than 5 degrees to the horizontal whilst on slings.

Pipes shall be laid to even grades for as long a length as possible, with a minimum grade in the direction of flow of 1 in 300 (0.33%) on declined pipe and 1 in 500 (0.2%) on inclined pipe. Changes in direction or in grade of the pipeline shall be carried out by making use of any permissible deflection of joints between straight pipes or by the introduction of bends where shown in the Drawings.

The Contractor shall keep the interior of pipes clean and free from water, dirt, stones and other foreign matter as installation proceeds. At the end of the day's work or at other times when installation work is not proceeding, the open ends of pipes shall be sealed by a suitable stopper. The Contractor shall take such precautions as are necessary to prevent pipes from floating.

Wherever pipes, cables, ducts and similar services are buried in the ground a marker tape shall be laid 300mm above each and every service in the trench.

Bedding and backfill material shall be placed and compacted in accordance with the procedure approved in the Trial. Bedding material shall be laid to the depths shown in the drawings. Bedding shall be laid such that the base of the pipe is embraced over a 120 degree arc. Backfill material shall be compacted in layers. Not withstanding to whatever written elsewhere the compaction shall be generally done at 150 mm thick for pipes over 700 mm in diameter, 100 mm for pipes 300-700 mm in diameter, and 75 mm for pipes less than 300mm diameter, and surround material shall be compacted at near optimum moisture content (about 95%) by approved hand, mechanical or pneumatic tampers to the specified density. Care shall be taken to ensure that the material under the haunches of the pipe is thoroughly compacted. Stones that are likely to damage the pipe or its coating shall be excluded from the bedding and surround material and heavy mechanical compactors shall not be used within 300mm of the pipe crown. No reinstatement shall be done until the Engineer has approved the backfill.

Before making any joint, the Contractor shall ensure that the interior of each pipe or fitting is clean. All mechanical joints shall have their coating made good before assembly in accordance with the coating manufacturer's recommendations.

The Contractor shall use only the proper jointing parts as specified and obtained from the suppliers of pipes or fittings. All joints shall be capable of passing tests for individual joints and for the completed pipeline as specified.

After the jointing operation is complete, wherever applicable, all the joints and fittings in pipelines to be buried shall be wrapped with material and methodology as per the relavant codes.

Concrete anchor and thrust blocks shall be constructed at dead ends, tees, bends, tapers, valves and hydrants for the anchorage of the pipeline as appropriate. Unless otherwise detailed in the Drawings, thrust blocks shall be constructed with the bottom and thrust side surfaces bearing against undisturbed ground.

All specials like bends, tees etc. and appurtenances like valves etc. shall be laid in synchronization with the pipes. The contractor has to ensure that the specials and accessories are available at site ready to be installed together with the pipes.

### 9.6.3 Chambers and manholes

Valve chambers, air valve chambers, flowmeter chambers, manholes and similar structures shall be built into the pipeline wherever necessary in accordance with the Drawings and Specification.

Valve chambers in which pipes are anchored shall be treated as specified for anchor and thrust blocks.

If undisturbed ground has not been maintained next to a thrust-bearing surface, the gap shall be backfilled with mass concrete.

All pipework and fittings within the chamber shall be set to exact line and level prior to the construction of the chamber walls. Pipes, fittings and valves in chambers shall be protected from damage and soiling of coatings during construction. After construction all chambers and manholes shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter and shall be free of any such accumulation at the time of final inspection.

Pre-cast chambers are allowed after submission of proposal with the structural design details and associated shop drawings. Depend upon the ground suitability and the locations of construction it shall be permitted by the Engineer after the prior approval process.

### 9.6.4 Pipelines built into structures

Any pipeline, except continuous welded steel, which is built into a chamber, manhole or other structure, including a thrust block, shall be provided with two flexible joints outside each face of the structure. The flexible joints shall be either flexible spigot and socket joints or detachable flexible couplings.

Pressure pipes passing through the walls of valve chambers or other structures shall be ductile iron or steel provided with anchorage flanges designed to transmit the full end thrust with closed valve under test into the structure's wall. Boxouts, if used, shall be designed to fulfil the above requirements.

Where no anchorage flanges are detailed for pipes passing through the walls of structures the pipe shall be provided with a puddle flange integral with the pipe wall or bolted on to resist movement of water along the pipe to concrete interface. Such puddle flanges shall protrude at least 50mm from the pipe barrel.

### 9.6.5 Exposed Piping

The contractor shall furnish and install sleeve or wall casting for all pipes passing through masonry and concrete floors or walls and concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting these items, the Contractor shall check all and figures which have a direct bearing pipe location and he shall be responsible for the proper location of his pipes during the construction of the structures.

Piping shall be installed to the required lines and grades and as closely as possible to walls, ceilings, columns and other structural parts so as to occupy the minimum of space, and all offsets and fittings required to accomplish this must be furnished. All dimensioned pipes and fittings shall be installed that no stress or strain is created in the lines and associated equipment due to forcing parts into position.

Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.

Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken placing piping to prevent damage to the pipelining or pipe coating or to adjacent structures or equipment. All supporting piers and blocking shall be in place before temporary supports and bracing are removed.

Flange piping shall have couplers and adapters as per drawings in order to allow for convenient removal of piping.

The contractor shall furnish and place all inserts for the support of piping installed under this section in masonry and in concrete forms before concrete is placed, unless otherwise permitted.

System shall be arranged with low points and drains to arranged with unions or union connections at low points to permit draining. Fill connections shall also be provided on closed systems where required.

Air vents shall be provided as per drawings at high points. All exposed piping shall be rigidly supported by pipe hangers and supports specified hereinafter.

All pipes shall be sound and clean before installation.

In case interference develops between piping and appurtenances, the Engineer will decide which work is too relocated regardless of which was first installed.

Upon completion of installation and testing, the contractor shall paint all exposed piping.

Where the pipe passes through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the pipe manufacturer and approved by the Engineer. Sealing compounds shall be applied in accordance with the manufacturer's instructions.

### 9.6.6 Pipelines in the same trench

Where two or more pipelines are detailed as being laid in the same trench, the pipes shall be laid so that there is a minimum distance of 300mm between the barrels of the pipes, measured in plan at mid-barrel height. The invert levels of the pipelines shall be the same at any cross section, unless otherwise required. However, decision to lay multiple pipelines in the same trench shall be decided and/or approved by the Engineer based on the unavoidable site conditions.

### 9.6.7 Installation of pipelines other than buried pipelines

The Contractor shall take due care to support adequately the pipework during installation until permanent supports and anchorages have been completed. The Contractor shall ensure that no excessive loads or stresses are imposed on the pipework or structure during installation.

Pipework systems shall be completed and checked for correct position and alignment with adjacent structures immediately before and after being embedded in concrete.

Exposed pipework on pipe supports shall be provided with straps unless otherwise indicated on the drawings. Straps shall be formed and placed such that they conform accurately to the circumference of the pipe when securely bolted down. Straps and appurtenances shall be primed and then coated with zinc paint as approved by the Engineer.

Where pipes are to have free axial movement the pipe straps shall not be tightened in such a way that axial movement is prevented, and the clearance between the pipe and strap is not more than 3mm around the upper arc.

Pipes between supports shall be straight and at constant gradient, changes of gradient shall only occur at fittings as shown on the drawings.

### 9.6.8 Deflection of pipes

Where deflection of any section of any pipe exceeds the maximum allowable values stated below at any time including during handling storage or installation before or after backfilling, the pipe shall be removed from the works and disposed of by the Contractor who shall provide a replacement pipe.

| Pipe material | Maximum allowable deflection as proportion of true circular diameter |
|---|---|
| Steel pipes (with mortar or concrete lining) | 2% |
| Steel pipes (without mortar or concrete lining) | 5% |
| MDPE, uPVC and ABS pipes | 5% |

### 9.6.9 Cover

Except as otherwise indicated in the drawings, the minimum cover shall be as follows:

| **Land Type** | **Minimum cover(m)** |
|---|---|
| Open land | 0.9 |
| Roads | 1.0 |
| Highway | 1.2 |

### 9.6.10 Thrust and Anchor blocks

Concrete thrust and anchor blocks shall be formed at bends, tees and valves in accordance with the typical sections shown on the drawings or otherwise as directed by the Engineer. The additional excavation shall be made after the bends etc. have been jointed and the concrete shall then be placed with all possible speed. The back of supports and blocks shall abut on to solid ground, all loose material being removed before concreting.

The concrete used for thrust and anchor blocks shall be Grade M20 or as specified. After placing the concrete shall be kept in view for not less than six hours. No pressure shall be applied in any section of main until the concrete has had at least three day's curing.

The thrust blocks shall be cast directly against the undisturbed soil. If this is not possible, the backfilled soil at the contact surface shall be compacted well to full satisfaction of Engineer so

that anchor block is not displaced during operation and testing.

### 9.6.11 Backfilling around chambers and thrust blocks

After the completion of chambers and thrust blocks the space between the structure and the excavation shall be backfilled with compacted material. Such backfill shall be placed in layers of 15 cm measured before compaction, wetted, if necessary, to optimum moisture and compacted well as per instruction of Engineer.

Embankment around structures shall be done at levels and with slopes as shown in the drawings.

## 9.7 Inspection and testing

### 9.7.1 Field Hydrostatic Pressure test

Hydrostatic pressure test for the pipelines shall be done as per the relevant codes or Standards depending on the material of pipeline.

Hydrostatic pressure test procedure for the pipeline shall not be less than 1.5 times of the maximum working pressure or site test pressure as specified.

For all pipe sizes, the working pressure shall be of water column based on the elevation of the lowest point in the pipeline under test, and corrected to the elevation of the test gauge.

All tests shall be conducted on the pipelines in the sections after the trench is backfilled, but before pavement restoration. Joints shall be exposed during the test wherever possible.

Before a length of pipeline tested, each pipeline securely anchored, all thrust and anchor block shall have been constructed.

Maximum length of pressure testing shall be 1 km.

Before commencing pressure testing, the Contractor shall clean out the part of the pipeline to be tested to the satisfaction of the Engineer. After the whole pipeline has been successfully pressure tested (whether as a whole or in sections) and the Contractor has removed all temporary works and has reconnected any parts temporarily removed from the pipeline, the Contractor shall finally clean out the whole pipeline and flush it through with clean water.

The pipeline shall be prepared for testing by closing all scour valves and hydrants; placing substantial stops and bulkheads at openings, opening air valve assemblies and fitting air release taps at all other high points along the pipeline. Theses taps shall later be removed after completion of the testing and disinfection and, unless otherwise specified, replaced with permanent plugs.

The pipeline shall be slowly filled with water, allowing all air pockets to be released, until the pipe is completely filled and under working pressure at which condition it should be allowed to stand for 24 hours. Any apparent defects in the pipeline at this stage shall be rectified by the contractor. To demonstrate that air has been removed the Contractor shall add a measured amount of water at filling point and measure outflow at remote points of pipe being tested. If remote points of pipeline do not contain convenient points to measure outflow, the Contractor shall install taps.

Before filling for pressure testing is started, the 'open' ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts, wedges or thrust blocks. All thrust blocks and valve chambers shall have been completed with backfill placed around them and the concrete shall have attained its specified 28-day strength, all pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened and backfilling of the trench between pipe joints shall have been placed to the extent necessary to prevent movement of the pipeline. Thrust to the valve chambers shall not be permitted because the chamber designs have different inbuilt safety factors. There is a possibility to crack chamber walls if externally forces are applied. Contractor should have sufficient thrust anchors independently for this purpose of hydraustatuc tests and he should not use the section valve for that purpose.

The pressure shall then be raised by pumping in water until the specified test pressure is reached and shall be maintained at this pressure by further pumping for a period of not less than 2 hours during which time the pipeline shall be inspected for points of concentrated leakage. Any defective pipe, fittings, joint, valve or hydrant shall be removed and replaced and the test shall be repeated until satisfactory to the Engineer.

### 9.7.2 Test standard for pressure pipelines

In the case of pipelines of absorbent materials, this period shall be extended as necessary until the absorption has ceased. Pumping shall then cease and the time (T) for the observed pressure head to fall by 10 m shall be recorded. Pumping shall then be resumed and the quantity of water (Q) pumped into the pipeline from calibrated container(s) in order to restore the test pressure shall be recorded. Provided that if the observed pressure head has not fallen by 10 m before an expired period of three hours, then pumping shall be resumed at once and the time (T) shall be recorded as being three hours. The rate of loss shall be calculated as being the quantity (Q) into the pipeline from calibrated container(s) divided by the time (T).

If the rate of loss as calculated above does not exceed the figure given below, the pipeline (or section there of) shall be deemed to have passed the pressure test, provided that there is no evidence of concentrated leakage.

| Type of pipeline | Allowable rate of loss (litres per 24 hours per 10mm of nominal internal pipe diameter per kilometre of pipe for each 30m head of pressure applied) |
|---|---|
| Steel pipelines with butt-welded or internally and externally welded sleeve and spigot joints, and less than 10% flexible joints | 0.25 |
| All other pipelines | 1.0 |

### 9.7.3 Action following test failures

If the pipeline (or a section thereof) fails to pass the pressure test the Contractor shall locate the faults and shall uncover, repair, retest and reinstate the pipeline as may be necessary until all parts of the pipeline shall have passed the pressure test.

### 9.7.4 Working pressure and site test pressure

Works and site test pressures and definitions of design pressures/pressure ratings for different materials are as follows:

| Material | Design / Rating pressure (DP) | Works test pressure (WTP) | Site test pressure (STP) |
|---|---|---|---|
| Steel | Design pressure as STP | Pipe: according to steel grade<br>Fittings:<br>1.5 × MSOP | 1.5 × MSOP |
| Ductile iron | Class suitable for MSOP (K9, 12, 14 etc) | According to Class | MSOP + 5 bar |
| MDPE | Class suitable for MSOP | According to SDR | 1.5 × MSOP |

MSOP = Maximum sustained operating pressure
SDR = Standard dimension ratio (OD/thickness)

### 9.7.5 Field Leakage Test- Alternative method

The leakage test shall be conducted after the pressure test has been satisfactorily completed. The duration of each leakage test shall be two (2) hours, and during the test the pipeline shall be subjected to the same test pressure stated in the preceeding paragraph. The pipeline leakage shall be taken as the amount of water, as measured by the metering device needed to be injected into the maintain the test pressure for the two (2) hours leakage test period.

The allowable pipeline leakage shall be less than 2.3 litres per 24 hours per mm-pipe diameter per km-length as presented by the formula below.

$$\frac{Q}{D \times L \times H} \times 24 < 2.3$$

Where:

Q : Amount of Leakage in liters
D : Diameter of pipe in millimeters
L : Length of pipeline in kilometers
H : Duration of leakage test in hours

Should any test of pipe laid disclose a leakage greater than the specified above, the Contractor shall locate and repair or replace the defective materials or the satisfaction of the Engineer. The test shall be repeated until any leakage falls within the permitted allowance.

## 9.8 Commissioning of Pipelines

Commissioning shall mean the progressive disinfection of sections of the main, bringing the main into service and operating it for the period designated in the Specification. The Contractor shall submit a programme to the Engineer one month in advance of the date of commencement of commissioning and the programme shall be subject to the approval of the Engineer.

As part of the commissioning the Contractor shall demonstrate that all valves are operable, functioning, and the mains behaves safely when static pressure is fully developed such that no movement occurs at thrust blocks / anchor blocks, valve chambers, pipe supports on piers of bridges, etc.
Cleaning and disinfection shall be considered in two distinguished areas as follows.

(a) Portion of network with new pipes as distribution pipes:- Transmission Pipeline system & Secondary mains are basically new and independent and it shall be considered separately. In Distribution pipes, cleaning and disinfection procedure should be completed before the service connections are transferred from the existing distribution system to those new pipes in the DMA networks.

(b) Connection of Existing Distribution pipes to the new network pipes:- Mainly distribution pipes of 100 to 150mm or rider mains fall under this category. Prior to connection of both of those existing and new pipes, cleaning and disinfection shall be undertaken. By that all connection transfers are made of new lines and the existing line has its own service connections, there should be a sufficient advance notice to the customers before the process of disinfection. In both cases service lines also need to be cleaned and disinfected before connecting to the final consumer inlets after water meter.

It is a responsibility of the contractor to provide such notices to the customers and avoiding risks at the disinfection process by not allowing to use highly concentrated chlorine water. Also the Contractor should alert on discharging disinfected water after the process.

## 9.9 Cleaning/Flushing and Disinfection of Pipelines

### 9.9.1 Cleaning of pipelines- Swabbing (wherever required by the Engineer)

After the pipelines have been completed and pressure tested satisfactorily in accordance with the relevant Clause, then the Contractor shall on the instructions of the Engineer prove any length of pipeline to be free from obstruction.

If required by the Engineer, proving shall be carried out by means of passing through the pipelines a polyurethane foam swab of approved grade in accordance with the following procedure.

Pipelines shall be proved in sections between entry and exit points. The locations of the permanent swabbing points are indicated on the Drawings. Temporary swabbing points shall be provided in the distribution system by insertion of tees and valves which shall be removed after proving and replaced by short lengths of straight pipe. If the provision of swabbing point or chambers are not possible due to congestions and small diameter pipes, contractor may use washouts as per the consent of the Engineer.

At the start of the isolating valves on either side of the entry point the swab will be free to travel along the pipeline towards the downstream exit point.

The theoretical loss of head between the entry point and either end of the section will previously have been determined by the Engineer for a flow of water which will cause the swab to travel through the section at a suitable predetermined velocity. This flow and the

corresponding required velocity of the swab will be controlled by throttling of valves at the exit point or at hydrants or washout.

Washout or hydrants downstream of swabs shall be controlled so that any rubbish, slit, debris

or other extraneous matter may be discharged during the passage of the swab along the pipeline.

Proving of any section shall be repeated as required by the Engineer in the event of the initial or any subsequent operation not being to his satisfaction.

The contractor shall provide all transport and labour required to prove a pipeline free from obstruction.

Diameters 300 mm and greater:

Visible dirt and debris should have been removed either manually or by the use of cleaning pigs before testing.

After the pipelines have been completed and pressure tested satisfactorily as herein specified the Contractor shall flush out and cleanse the pipelines

Pipeline shall be cleaned in sections and this shall be carried out by passing polyurethane foam swabs through the pipeline. The swabs shall be to the approval of the Engineer. Water for passing swabs will be made available by the Employer.

Diameter less than 300mm:

Pipelines shall be cleansed in sections by flushing with portable water.

Cleansing of any section shall be repeated as required by the Engineer's representative in the event of the initial or subsequent operation not being to his satisfaction.

The Contractor shall supply all necessary equipment for the cleansing and sterilizing operations, including sufficient swab and swab detectors.

Swabs shall be passed through pipelines at speed of between 0.2 and 0.4 meters per second to obtain the best cleaning result with the minimum number of passes. Should it be appear from the debris collected by the swab that damage to the lining has occurred, the Contractor shall be wholly responsible for repairing the lining the satisfaction of the Engineer's Representative.

The cost of the initial sampling analyses and preparing reports on the bacteriological quality of water be borne by the Employer but, in the case of the initial reports be unsatisfactory the cost of any subsequent sampling analyses and preparing reports shall be borne by the Contractor.

### 9.9.2 Disinfection of pipelines

Before being placed into service or before certification of completion by the Engineer whichever occurs earlier all new pipelines which will convey the filtered water shall be disinfected with chlorine, and a satisfactory bacteriological analysis of the water shall be submitted to the Engineer.

Disinfecting pipelines shall be carried out in accordance with AWWA C651 or relevant IS codes. Liquid chlorine, calcium hypochlorite or sodium hypochlorite may be used for disinfecting. If liquid chlorine is to be used it shall be used only in conjunction with proper equipment and under the supervision of qualified personnel who are familiar with the physiological, chemical and physical properties of this element and who are properly trained and equipped to handle any emergency that may arise.

Potable water pipelines shall be disinfected by the continuous feed method. Water entering the pipeline shall be maintained at a minimum of 20 mg/l available chlorine or such level as may be necessary to ensure that at the end of 24 hours the treated disinfecting water shall contain not less than 2 mg/l of chlorine at all points in the pipeline being disinfected. The chlorine concentration shall be measured at regular intervals in accordance with AWWA M12 to assure that the required concentration is maintained.

After the required retention period, the heavily-chlorinated water shall be flushed from the main using potable water until the chlorine concentration in the water leaving the main is no higher than that generally prevailing in the systems and not exceeding 0.1 mg/l. Chlorine-residual determinations shall be made to ascertain that the heavily chlorinated water has been removed from the main.

After final flushing and before a potable water pipeline is put into service, a sample, or samples, shall be collected from the end of the main which is remote from the source of supply and tested for bacteriological quality. Such samples shall show the absence of coliform organisms.

The point of application of the chlorination agent is normally at the beginning of the pipeline through a corporation stop insertion on the top of the laid pipe, and the point of withdrawal (normally by blow-off) is at the opposite end of the line.

Should the initial treatment fails to result in the conditions stipulated above, the chlorination procedure shall be repeated until satisfactory results are obtained.

## 9.10 Valves in the Pipe Network

The various types of valves generally required in the distribution network are Check valves, Gate valves, Pressure reducing valves (PRVs), Flow Control Valves (FCV), Level Control Valves and Air valves (AVs). Gate valves are basically needed to divide the networks into smaller sections or sub-zones so as to enable preventive maintenance, repairs, or for providing new service connections. Sub-joining within DMAs is recommended for such purposes as well as for monitoring purposes of NRW.

Section valves will also be needed to create hydraulically discrete DMA boundaries. In that respect such isolation shall either be with sectioning valves or plugging with pipe end caps. Scour valves are another important element within the network for periodic maintenance. Table below indicates the standard norms for installation of such valves but it could be reviewed on a case to case basis, depending on the field conditions. Besides, the installation of such valves shall also to be considered with a view to facilitating NRW measurements. Specifications of the valves and their pressure ratings will be covered under tender specifications.

**Table Type and Location of Valve**

| Type of Valve | Recommended location | Remarks |
|---|---|---|
| Check Valves/Non-return Valves | Soon after the pump header at the outlet, and as per the surge analysis. | Governed by the outlet pipe diameter |
| Centered Disc Butterfly Valves ( with gear system) / Large diameter Resilient Gate Valves with gear system (Probable greater than and equal to 700 mm) | Larger sized motorized valves on transmission and secondary distribution mains and distribution pipes for isolation of sections, branching of transmission & secondary distribution mains, | Appropriate locations to suit O&M requirements, starting point of each branch or to suit O&M requirements. Also at the upstream of bulk flow meters. Depend upon the diameter & other ground conditions of the valve location, those valves could be CI or DI |
| Resilient Gate valves | Branching or sectioning distribution mains & for large diameter bulk connections. Also isolation of distribution networks to create DMAs as per the design requirements | Do above. For long distribution pipes, preferably at 2.0 Km intervals.<br>Those valves could probably be DI considering the limited space available at the congested routes where placing chambers rather difficult. (Recommended to DI Gate Valves upto 300 mm dia as buried valves without chamber and with extended spindle and surface box) |
| Stop Valves ( smaller dia gate valves) | For each service connection | Plastic stop valves ( Male –Female threaded type ball valve )compulsorily prior to water meter and some additional valves upon the location of service connection |
| Double Orifice Air Valves with isolation valves | For Pumping mains | Locations & diameter depend upon elevation of pipe and surge analysis. |
| Single Orifice Air Valves | For Distribution network with gravity flows ( where line diameter < 600 mm) | Do above |
| Pressure Reducing valves ( PRVs) | Especially for distribution networks within DMAs | Based on hydraulic network modeling results to create pressure contours where applicable. |
| Scour valves ( Sluice valves) | For both transmission & distribution systems | Diameter depends upon the technical details of washout size. In general 150mm or 200mm diameter for distribution system but for larger diameter transmission systems scour valve diameter shall depend on the sectioning length of the main and the time of emptying. |

**Note**: Table indicates the selection criteria for valves with pipe sizes both section valves and without valves

## 9.11 Valves- Specification

Specification for Valves is generally given in the Mechanical Section of the Specification. However, these specifications lay down the additional requirements while installing the valves in the Pipeline works.

All Valves to be supplied and installed shall be done as per the relevant standards of Indian Standard Codes and equivalent international standards in their absence. In case of Motor Operated Valves (MOV), the actuator and other electro-mechanical components shall also meet the respective standards as applicable.

All valves shall be designed to avoid cavitations and vibration in all positions, to minimize head loss in the open position and to seal the water passage when completely shut. All

operating spindles and gears shall be provided with adequate points for lubrication. Unless otherwise specified, all valves shall be closed in a clockwise direction. Lifting lugs shall be provided for valves for sizes 600 mm and above. Head loss curves through the valves for throttled flow conditions shall be provided for all valve sizes. Valves shall be suitable for use with water supplies.

### 9.11.1 Valve Coatings

Unless the Engineer has approved an alternative coating system, the internal and external surface of valves shall be prepared and coated as described in IS 14846:2000 Para 9.

### 9.11.2 Flanges

Unless otherwise stated, all valves shall be double flanged and all valve flanges shall be in accordance with IS 1538.

Bolts and nuts shall confirm IS 1363 and IS 4218 (Part 5). Tech headed bolts may also be used where necessary.

### 9.11.3 Work tests

All valves shall be hydrostatically tested at the place of manufacture. The Contractor shall supply a certificate stating that the valves supplied have satisfactorily passed the specified tests and comply in all respect with this specification.

All valves shall be subjected test in accordance with IS 14846.

### 9.11.4 Packing

All valves shall be securely packed in crates or boxes for protection against damage during transit, and shall be accompanied by the materials necessary to secure all flanges to adjacent pipe-work. These materials shall also be suitably packed and shall be stored away from sunlight at all times.

### 9.11.5 Delivery

The materials subject of this Section shall be delivered to the Temporary storage buildings at site. Crates and other containers shall be opened as required by the Engineer as required at the store (and/or elsewhere) at an earlier stage of delivery to permit inspection of the contents. They shall then be resealed and stacked within the store as the Engineer directs. The Contractor shall place additional marks on the containers as the Engineer may direct, so that the contents of each can subsequently be ascertained without further disturbance of the stack.

### 9.11.6 Sluice valves

Sluice valves shall be of waterworks Standard to IS 14846 with inside non-rising spindles except that the body and bonnet shall be of Ductile Iron.

Sluice valves shall be of the double flanged ductile iron wedge gate type unless otherwise specified. They shall have a ductile iron body with renewable gunmetal faces on body and wedge and bolt on ductile iron bonnet.

The gland or stem seal housing shall be cast with an arrow on the upper side indicating the clockwise direction of closure of the valves.

Each sluice Valve shall be provided with a ductile iron cap secured by a non-corrodible set screw. No hand wheels are required. Gearing shall be supplied for Valve 350 mm dia. and above to ensure that the Valve can be operated by one man against the differential head for which it is designated.

Valve stems shall be of stainless steel, machined all over and with a machine cut robust trapezoidal or square form thread, operating a gunmetal nut.

Steam seals shall be of the stuffing box and gland from arranged for easy replacement of packing and shall be accessible for maintenance without removal of the Valve from service.

All nuts and studs subject to vibration shall be fitted with spring washers or locking tabs.

The Contractor shall provide work to avoid unair belt, both during closing and opening.

The following Tables indicate the valve sizes of Sluice Valves and Scour Valves that has been used in the works with respect to different diameters of DI pipes in the proposed distribution networks and clear water rising main (Not for UGR premisis). Besides, when sizing the components, the availability of the DI Fittings in accordance with the IS 9523 has been taken into consideration in order to avoid extra over loses with application of multiple fittings. Those guided principles shall be followed for the supply & laying of valves and fittings.

**Sluice Valves**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Distribution line Diameter ( mm) | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 |
| Recommended diameter of Sluice Valve | 100 | 150 | 200 | 250 | 300 | 300 | 300 | 350 |
| Type of Sluice valve | SVBG | SVBG | SVBG | SVBG | SVBG | SVBG | SVBG | SV+BV |
| | | | | | | | | |
| Line Diameter ( mm) | 500 | 600 | 700 | 800 | 900 | 1100 | 1300 | 1400 |
| Recommended diameter of Sluice Valve | 350 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 |
| Type | SV+ BV | SV+ BV | SV+ BV | SV+ BV | SV+ BV | SV+ BV | BFV+ BV | BFV+ BV |

Note: All valves must be double flanged types

**Legend:**

- **SVBG -** Sluice valve below ground installation without valve chamber

- **SV + BV –** Sluice Valve with bevel gear system below ground installation with valve chamber
- **BFV+BV –** Butterfly valve with bevel gear syatem below ground installation with valve chamber
- **DID**F - DI double flange
- **SAV** – Single orifice air valve
- **DAV** – Double orifice air valve

**Scour Valves/Washout Valves**

| Distribution line diameter ( mm) | 100 DI | 150 DI | 200 DI | 250 DI | 300 DI | 350 DI |
|---|---|---|---|---|---|---|
| Scour line Diameter (mm) - DIDF | 80 | 100 | 100 | 150 | 200 | 200 |
| Level Invert "T" (DI socketed T with flanged branch , dimension in mm) | 100x 80 | 150x 100 | 200x 100 | 250x150 | 300 x 200 | 350 x 200 |
| Scour Valve Diameter ( mm) | 80 | 100 | 100 | 150 | 200 | 200 |

| Distribution line diameter (mm) | 400 DI | 450 DI | 500 DI | 600 DI | 700 DI/MS | 800 DI/MS |
|---|---|---|---|---|---|---|
| Scour line Diameter (mm) - DIDF | 200 | 250 | 300 | 300 | 300 | 400 |
| Level Invert "T" (DI socketed T with flanged branch, dimension in mm) | 400 x 200 | 450 x 250 | 500 x 300 | 600 x 300 | 700 x 300 | 800 x 400 |
| Scour Valve Diameter (mm) | 200 | 250 | 300 | 300 | 300 | 400 |

| Distribution line diameter (mm) | 900 DI/MS | 1000 DI/MS | 1100 DI/MS | 1300 DI/MS | 1400 DI/MS |
|---|---|---|---|---|---|
| Scour line Diameter (mm) - DIDF | 500 | 500 | 600 | 700 | 800 |
| Level Invert "T" (DI socketed T with flanged branch, dimension in mm) | 900 x 500 | 1000x 500 | 1100x 600 | 1300x 700 | 1400x 800 |
| Scour Valve Diameter (mm) | 500 | 500 | 600 | 700 | 800 |

### 9.11.7 Butterfly Valves

Butterfly Valves shall comply with IS 13095 and relevant international standards and be of double flanged with metal or resilient seating. The body and disc shall be made of ductile iron.

Valve shall be drop tight at closure and be designated for drop tight shut-off of flow. The applicable tests in IS 13095 shall be applied at works to each butterfly valve.

The body end parts shall be circular and the diameter not less than that of the nominal bore of taper pieces.

The disc shall be of ductile iron with resilient seating ring in moulded rubber or other material to the approval of the Engineer located in a landing on the disc and secured by a gunmetal retaining ring fixed with screws made from homogeneous corrosion-resistant material.

Shaft-Stainless Steel shall be as per IS 6603. Sealing Ring shall be Resilient or equivalent type suitably as approved. Retaining Ring & Seat shall be of Stainless Steel complying to IS 6603.

The Contractor shall ensure that the Butterfly Valve gearing provides for sufficient closure time of the valve in order to minimize the development of water hammer pressure. As a minimum provision, the gearing shall provide for the time of closure to ensure at least two pressure waves reflections are accommodated within the time of closure. The above provision shall not absolve the Contractor in ensuing and providing valves having suitable time to ensure minimization of water hammer pressure.

The valves shall be made by reputed manufacturer as per the approved makes.

For acceptance of the make of the Butterfly valves by the Engineer, the Contractor shall furnish a certified statement (by recognized institution or laboratory) that proof of design test were carried out as described in IS 13095 and all requirements were successfully met.

### 9.11.8 Air Valves

Air valves shall be of single or the double orifice pattern complying to IS 14845 as specified with gray cast iron bodies. The inlet flanges shall be faced and drilled in accordance with IS specifications to the appropriate diameter and the pressure rating of the pipeline concerned.

The valves shall be capable of releasing air from the pipeline without restriction of rate of filling or flow due to back pressure and also to allow admission of air during pipeline emptying at a rate sufficient to prevent excessive depression of pressure in the pipe.

Valves shall be designed to prevent the operating element being in contact with the pipeline liquid by approved means such as the provision of an auxiliary float chamber sufficiently large to isolate the orifice valves and seats throughout the rated operational range.

Air valves shall be fitted with separate isolating sluice valve which shall be drop tight on closure and shall comply with the specification for sluice valves elsewhere herein.

Air valves shall be of a design which inhibits the entry of insects into the pipeline.

All air relief valves and associated isolating valves shall be works tested and capable of withstanding the test pressures specified above for valves generally.
All materials used in the manufacture of the valves shall conform to IS 14845.

The Air valve assembly shall be provided with a 12 mm tapping for draining purposes and the tapping shall be closed with a brass screw plug.

The design of the valve shall be such that there is no possibility of the ball of the large orifice being suddenly caught up in the escaping air stream during the filling of water main at high rates thereby closing the valve prematurely.

The size of the air valve provided for each location shall be such that air can be admitted at the rate necessary to prevent a vacuum developing when any washout is opened or when a burst occurs at a critical point. The Contractor shall provide the attested experimental data to confirm the adequacy of the air valves offered.

Air Valves used in the work:

All distribution networks other than gravity operating systems should have tamper proof Double orifice Air Valves (DAV) for its Secondary mains and Distribution mains. Distribution pipes could be with Single orifice (SAV) or air release valves. The gravity operated networks shall have SAV for its Distribution Mains and Distribution pipes but for Secondary mains where dia >= 350mm should have DAVs.

| Line Diameter (mm) | 100 DI | 150 DI | 200 DI | 250 DI | 300 DI | 350 DI | 400 DI |
|---|---|---|---|---|---|---|---|
| Gravity networks | 25mm SAV | 40mm SAV | 40mm SAV | 50mm SAV | 50mm SAV | 80 mm DAV | 80 mm DAV |
| Pumping Networks | 40mm D/AV | 40mm D/AV | 50mm D/AV | 50mm D/AV | 50mm D/AV | 80 mm D/AV | 80 mm D/AV |

| Line Diameter (mm) | 450 DI | 500 DI | 600 DI | 700 DI | 800 DI | 900 DI | 1000 DI |
|---|---|---|---|---|---|---|---|
| Air Valve for Gravity networks | 80 mm DAV | 100 mm DAV | 100 mm DAV | 150 mm DAV | 150 mm DAV | 200 mm DAV | 200 mm DAV |
| Air Valve for Pumping networks | 80 mm DAV | 100 mm DAV | 100 mm DAV | 150 mm DAV | 150 mm DAV | 200 mm DAV | 200 mm DAV |

### 9.11.9 Pressure-reducing Valves

Pressure-reducing valves shall automatically reduce valve inlet pressures, of magnitude of upto maximum working pressure, to the specified constant pressure at the valve outlet. Valves shall open immediately outlet pressure falls below the specified constant pressure and close drop tight when the outlet pressure rises to the specified constant pressure. Operations shall be controlled by means of water pressures at tapping located within the valve inlet and out let.

### 9.11.10 Service Connection Valves

House service connection valves shall be precision moulded ball valves manufactured and tested in accordance with ISO 4422-4, and with threads in accordance with ISO-7, BS 21 or IS 554. Valves shall be manufactured from high quality PVC resin or ABS, and the valve body

provided with threaded ends or compression couplings and adaptors to suit the service pipe and meter installation details. Whenever possible, the contractor shall provide and install the valves within the existing meter chamber at the consumer premises or as directed by the Engineer.

### 9.11.11 Nuts, Bolts, washers and Gasket

Unless otherwise specified, nuts, bolts and washers shall be galvanized and/or zinc electroplated to conform to the requirements of IS 1364. Bolts shall be of sufficient length so that at least one thread but not more than 3 threads shall protrude through the but ehn in fully tightened condition.

All gasket shall be manufactured from SBR rubber in accordance with IS 5382. The dimensions of flange gaskets shall comply with BS 4865.

### 9.11.12 Tee-keys spindles

The Contractor shall supply tee-keys of square form head.

Tee-keys shall be of mild steel and shall have uprights between 1000 and 1200 mm long and cross pieces between 600 and 800 mm long. Spindles shall be of galvanized mild steel, and fixed in secure galvanized steel trunnions secured to chamber walls by adequate galvanized hexagon raw bolts.

Extension spindles shall be provided of sufficient length to enable washout tees on large-diameter pipelines to be operated by a person standing on the roof of the chamber.

### 9.11.13 Installation of Valves, Fire hydrants and Marker Posts

#### 9.11.13.1 General

The contractor shall supply all labour, equipment and material required to install valves, fire hydrants and market posts, and construct valve chamber and surface boxes, as shown on the drawings and as specified herein. This work includes surface breaking excavation and backfill; sheeting and bracing on site forming; supply and installation of pipes, fittings, valves, fire hydrants and appurtenances; supply and installation of miscellaneous metal work, surface restoration and other work needed to complete the valve boxes.

Most of the components of work for above works are specified in other parts of this Specification. This section consolidates a description of the work required for above works in particular. The Contractor shall consult other parts for further details.

The Contractor shall prepare and submit a shop drawing for each installation. The shop drawings shall be based on the schematic arrangement shown on the drawings and include the dimensions of piping, appurtenance and other equipment to be installed and shall extend to the limits of the installation shown on the drawings or to the limit of special pipe construction. All supports, clearances and materials to be installed shall be shown.

#### 9.11.13.2 Materials

Cement, aggregate, water, admixture, reinforcing steel, concrete, form work, shall be in accordance with provision of “Concrete”, and the valves, fire hydrants, man holes, surface

boxes and appurtenances shall be in accordance with the specifications.

### 9.11.13.3 Location of Installation

The location of the fire hydrants shall be either under the pedestrian walkway or under the shoulder of the road, but shall not be under the carriageway. The location shall be approved by the Engineer before installation.

The location of the valves shall be a sufficient distance away from the road junctions that the installation is not adversely affected by future road widening or surfacing by the road maintenance authorities. The Contractor shall obtain the approval of the Engineer before installation.

### 9.11.13.4 Execution

Underground Utilities Interference

When underground utilities are shown on the drawings or anticipated to exist near the proposed location of the installation, the Contractor shall excavate test pits to make sure that the existing underground utilities will not interfere with the construction of the structure/laying of pipe line. On the other hand, if underground utilities are found to be actually existing, proper precautions shall be instituted so as not to disrupt service to the general public.

Manhole Frame and Cover

Manhole frame shall be set with the top conforming to the grade of the pavement or finished ground surface, or as indicated on the drawings, or as directed by the Engineer. Frames shall be set in full bed of mortar.

Valve Box

Valve Boxes shall be constructed with the top of the cover lower 0.2m from the grade of the payment or the manhole frame and cover shall be raised with its top conforming to the grade of the pavement or finished ground surface, or as indicated on the drawings, or as directed by the Engineer. The manhole frame and cover shall be raised with its top conforming to the grade of the pavement or finished ground surface.

Marker Posts

Marker posts shall be installed at the locations of all valves and meters of the distribution pipe lines and transmission mains and at the location of fire hydrants. The type location and diameter of the main shall indicate as specified in the relevant drawing, for the specified size of valves and pipe lines. Contractor shall obtain the approval of the Engineer regarding the location of marker posts, and also obtain the permission from the relevant authorities for the installation of the marker posts.

Marker Tapes

When the Engineer decided to introduce marker tapes for Transmission and Distribution pipelines then marker tapes (Caution Tapes, Warning Tapes) shall be installed in the pipe

trench, 500 mm above the crest of the pipe. Luminous blue colour tapes shall be used for transmission pipe lines and luminous pink colour tapes shall be used for distribution pipelines. The warning tape shall be of polyethylene, and should have performance details applicable to the 100 micron material of "Boddingtons underground warning tapes" or equivalent.

Minimum ultimate tensile strength at break (longitudinal and transverse) shall be 10MN/m2 as determined by BS2782 method 301E. Minimum elongation shall be 300% (Longitudinal) and 350% (Transverse) and shall be resistant to chemical attack from the ground condition with pH ranging from 3.0 to 9.0

The width of the tape shall be 100mm. Tapes shall be printed with the words, "WATER PIPE LINE BELOW- CAUTION- TRANSMISSION" for the transmission and "WATER PIPE LINE BELOW- CAUTION- DISTRIBUTION" for distribution pipe lines, on upper side of the tape in black block letters of 40mm size, in one row at an interval of 1m.

Marker tape shall be kept in position and care should be taken not to displace or twisted when backfilling.

## 9.12 Flexible Couplings and Flange Adaptors

Slip-on type couplings shall include the following couplings

- Straight flexible couplings
- Stepped flexible couplings
- Flange adaptors
- Dismantling joints

The pressure rating of the couplings shall be sutable for 16 bar working pressure and a test pressure of 24 bar.

The preparation of pipe ends for slip-on type couplings shall be in accordance with the requirements of and the tolerance specified by the joint manufacturer. Couplings shall be installed fully in accordance with the manufacturer's recommendations.

All couplings shall be supplied with transit protection.

### 9.12.1 Flexible Couplings

Flexible couplings shall be of the steel bolted compression ring type in accordance with AWWA C219.91, capable of allowing flexibility of the joint and removal of the attached pipework. Unless indicated all couplings shall be supplied without the central register.

Protection, both externally and internally, shall be a nylon coating in accordance with UK WIS 4-52-01: part 1.

### 9.12.2 Flange Adaptors

Flange Adaptors shall be of a bolted compression ring type in accordance with AWWA C219.91, allowing flexibility of the joint and removal of the attached flanged pipework.

They shall be given nylon coating in accordance with UK WIS 4-52-01: part 1.

## 9.13 Bulk Flow Meter

After a careful study of the system's requirements, bulk flow meters shall be proposed at strategic points in the system such as service reservoirs, DMAs and pumping stations to monitor the quantum of water being handled at those places. In addition, the priority consumers those who are having the service connection greater than 50mm dia shall also have bulk flow meter to obtain accurate flow records. Electromagnetic flow meters would be the preferred option but Ultra-sonic flow meters could also be used depending on suitability. Up to 63 mm dia mechanical flow meters with approved quality shall be used. Besides the Bulk flow meter readings at strategic locations of the overall water system with flow totalizing would be an integral element of the SCADA system.

Depending upon the pipe diameter and the design flow rates Bulk Flow meters could be selected but in the probable application in the networks considered it would be in the range from 50mm to 500 mm to register optimum flows from 80 m3/hr to 6600 m3/hr respectively. It is to be noted that DJB has already installed bulk flow meters at outlet of Water Treatment Plant & at UGR. However, bulk flow meters are still required to be installed to fulfill the design needs and also to facilitate accurate measurements for NRW assessment in the overall system. DMAs shall compulsorily have bulk flow meters at inlet and outlet points. The bulk flow meters installed at intermediate sections other than the UGR premises to monitor the inlet flows to DMAs, shall preferably be electro-magnetic or Inferential helix type meters with integration of flow registered by 7 digits cyclometer in cubic meters could be used for the meter diameter less than and equal to 50 mm or at non-critical locations where regular flow measurements are not required.

Specifications of bulk water meters shall be in line with the circular issued by the DJB in this regard (Circular No F15/DJB/Member (WS)/2014/2477, dated 08/01/2015). Some of the key points stipulated in that circular are highlighted below.

- Flow sensor should be electro-magnetic type and suitable for installation in a buried main. Connecting to the main of the sensor shall be through PN16 flanged connection.
- It should have an electronic display unit installed in an above ground cabinet enclosure, to be placed in a suitable & safe location.
- Meter shall be powered by batteries (with 03 year maintenance warranty) as an integral element to electronic display where current supply is not available.
- Real time clock, data logger, GPRS transmitters shall be incorporated and all installation should be weather protected and incompliance with IP68, IS 13947.
- Accuracy of the meters shall be in accordance with the quality requirements stipulated in ISO 4046 Class C to maintain ambient & liquid temperature up to 500 C.
- Pressure Sensor & Transducer should be an amalgamating requirement with bulk flow meter installation and shall have ability to operate over 130% of the full range.

## 9.14 Flow Meter for Service Connection

Each service connection whether domestic, commercial or industrial, billed or unbilled, including bulk or priority connections, stand pipes (including fire hydrants, if any) would compulsorily be metered according to the project policies and targeted service level benchmarks. Priority or bulk connections with connection diameter greater than 50mm could

be considered as large connections (or the design average flow > 15 m3/day) and the rest of the connections could be considered as general service connections. The meters for these connections would be volumetric & "dry dial type". Also they should be robust having high degree of accuracy of measurement at low flows as well and with replaceable working parts and cyclometer counters.

In general residential single-jet or multi-jet velocity type Class B water meters shall be used in available sizes of DN 15 to 20mm for domestic service connections and for Industrial, Institutional or commercial medium range service connections, Industrial & commercial Multi-jet water meters with diameter ranging from DN 15 to DN50 shall be used. The following are basic requirements for water meters.

- Shall be in quality compliance of ISO 4064
- Proven reliability on extra dry register & no parts of the register should come in contact with water
- Pre-equipped for communication
- Direct magnetic transmission

## 9.15 Pressure Gauge

Under each Booster Pumping Station (BPS), installation of pressure gauges and pressure transducers to monitor suction & delivery pressures would be an essential element. Also it shall be mandatory to provide tapping points at desired locations of transmission lines to facilitate pressure measurements whenever necessary. In addition, monitoring inlet pressures of DMAs would be necessary. For this purpose, pressure transducers shall be fitted at the inlet of each DMA, where not built into flow meters. This would be an integral component of pump automation. Pressure transducers shall also be provided at the critical point (furthest / highest point) or lowest residual pressure points of each DMA to provide feedback to the SCADA system, for pump control.

## 9.16 House Service Connections

The house service connection (consumer service connection) is defined as a portion of pipe and fittings from tapping point in providing distribution pipe to the consumer water meter. The specification of materials and workmanship shall conform to the guideline issued by DJB through its circular dated 8.12.2014 and explained as below.

### 9.16.1 General

1. The consumer service connection shall be replaced from ferrule point to the water meter installed at consumer premises irrespective of length of service pipe.
2. Tapping on the distribution pipe shall be provided with Saddle (DI or MDPE/HDPE composite). The bore size shall be maintained as 8 mm or as sanctioned with additional control through adopter of same (bore) size fitted in the saddle.
3. When tapping from HDPE pipes, regardless whether the line is under pressure, self-tapping ferule can be used. The self-tapping ferrule is a purpose designed product that incorporates its own cutter allowing under-pressure or dry conditions to be made without the need for ancillary tapping machines or other equipment. For tapping from DI/CI pipes the tapping method depends on whether the line is under pressure or dry condition. If the line is pressurized under-pressure tapping machine must be used, and if it is not pressurized a drill with suitable diameter can be used.

4. It is strictly prohibited to make holes by using welding equipment for metal pipes or heated steel stick for plastic pipes. It is also forbidden to weld a pipe to the main to make the branch from it.
5. The Medium Density Polyethylene Pipes (MDPE) of the required connection line size shall be used for underground portion of the service connection. The MDPE pipe shall be of minimum PE80 grade conforming to ISO specifications (ISO 4427 and BS 6730-1986) for carrying potable water.
6. GI pipe of class 'B' conforming to relevant IS shall be used for above-ground portion of service pipe up to consumer water meter.
7. Standard PE/GI or GI/PE coupler shall be used in each PE/GI or GI/PE connection point.
8. Center to center distance of any two tappings shall not be less than 50 cm.
9. If the available space is less than the minimum recommended C/C distance of 50 cm an additional service pipe (distribution pipe) shall be provided and HSC shall be given from this pipe.
10. After completion of tapping service connection, the service line should be protected from the pollution and flushed with water before installing the customer water meter.
11. Proper record of all such replacements of service connections shall be maintained along with consumers K-numbers, date of replacement, length of MDPE & GI portions of service pipe, status of water meter etc. The Contractor shall record the details and prepare a detailed as-built drawing of each HSC in AutoCAD (.dxf or .dwg) format showing the route of HSC from the tapping point to the consumer meter. The drawings shall be prepared in WGS 1984 coordinate system.

<u>Methodology for House Service Connection replacement where the distribution pipe is new</u>

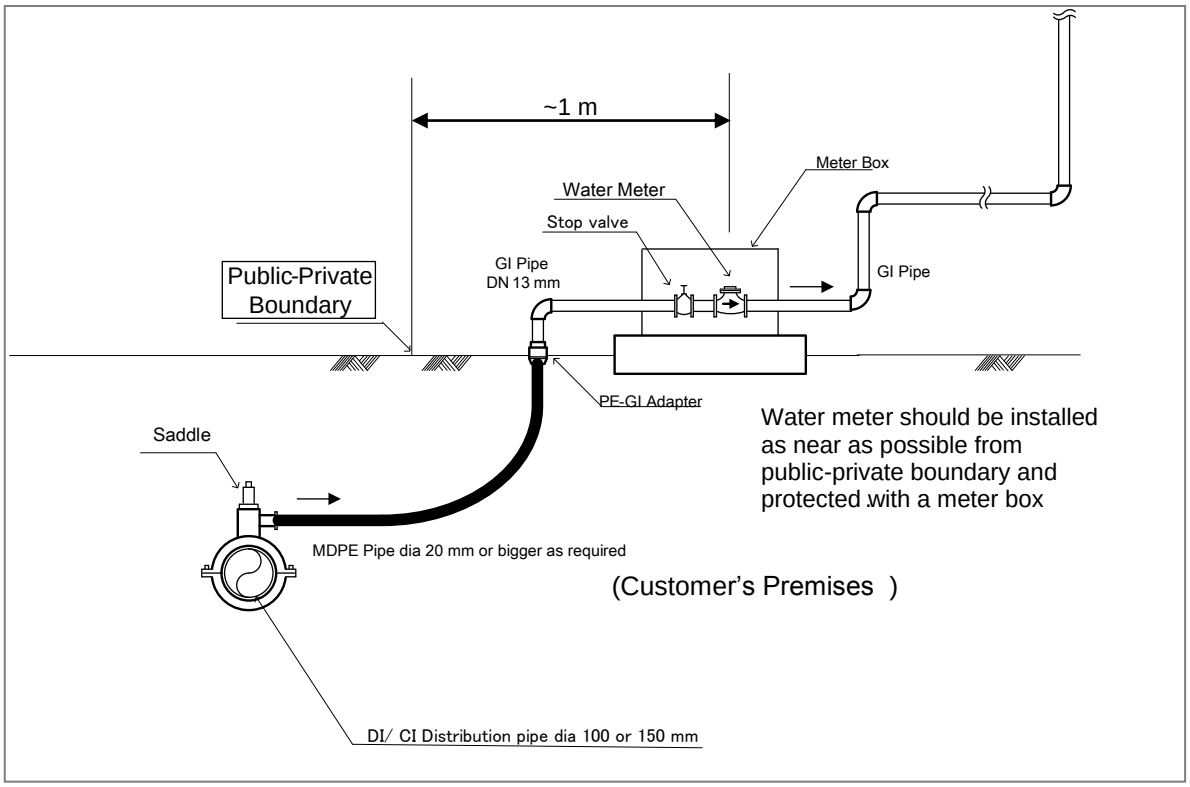
1. New HSC shall be connected from new distribution pipe before removing the existing HSC.
2. The existing HSC shall be dismantled and removed once the pressure test is satisfactorily conducted in the new HSC and the supply is started from the new distribution pipe.

<u>Methodology for House Service Connection replacement where the existing distribution pipe is to be used</u>

1. If the supply in the area is 24 hours, it may be necessary to stop supply during HSC work.
2. Most of the existing tappings are made with only ferrule but that shall be changed to saddle based tapping. The existing HSC shall be dismantled by removing ferrule. Care shall be taken not to allow water from surrounding area enter pipe through the whole of the ferrule point.
3. New saddle shall be positioned and fixed over the existing tapping hole in such a way that the opening in the saddle and existing tapping hole are aligned concentrically. New HSC shall then be laid connecting the saddle to the consumer meter.
4. Backfilling of the trench shall be done only after satisfactory pressure test.

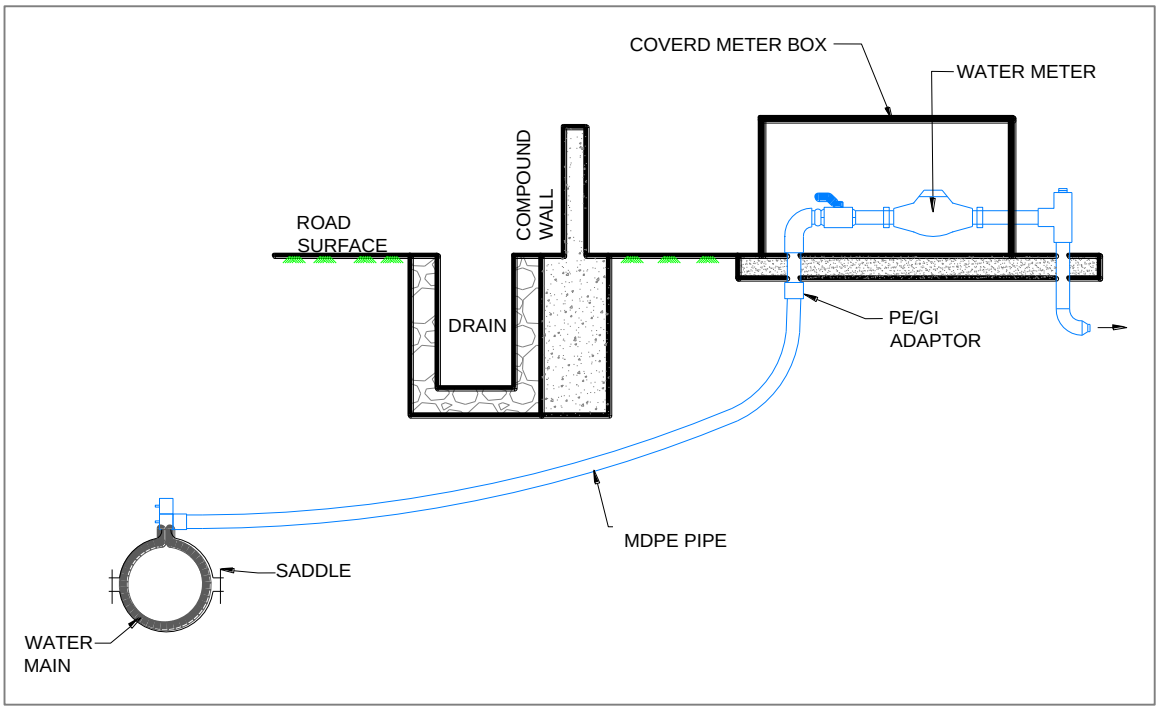
Use of existing distribution (service) pipe is not feasible if the existing tapping points are nearer than recommended 50 cm or if the tappings are not at the top of pipe. Creating new tapping points leaving old ones by plugging is not advisable as such locations become the potential source of leakage in future. In such cases the best alternative would be to replace the distribution (service) pipe.

The standard layout of HSC using MDPE/ GI pipe combination is illustrated in the following Figure.

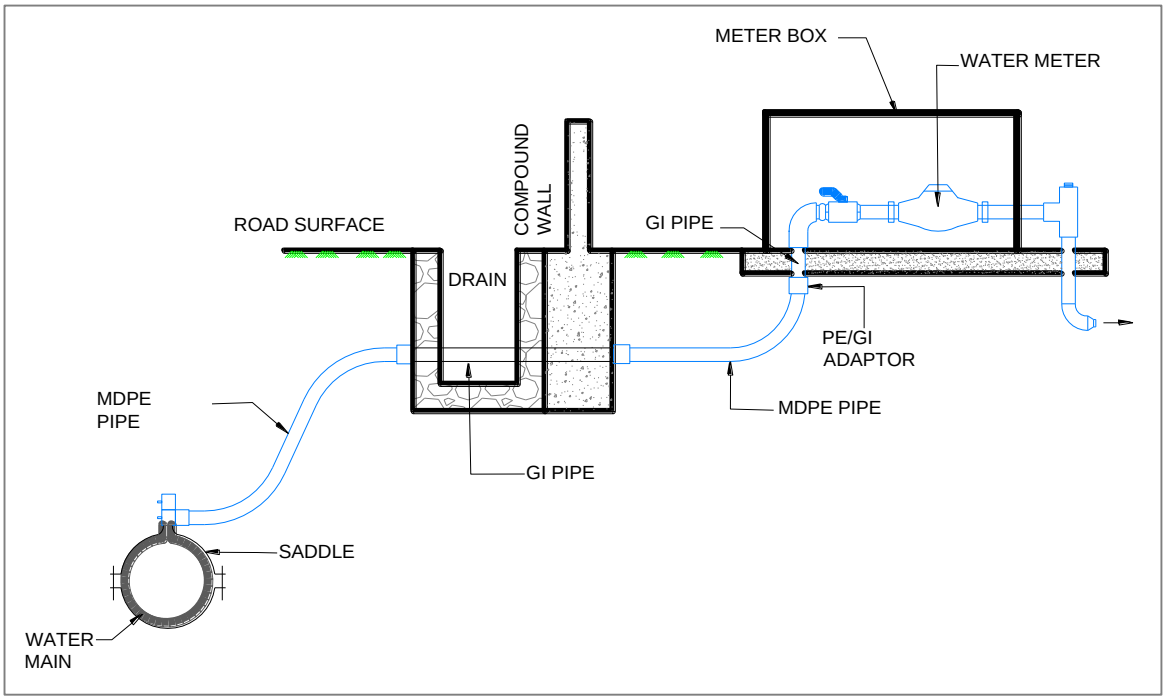



**Standard Layout of Single House Service Connection using PE/GI combination (Indicative Arrangement)**

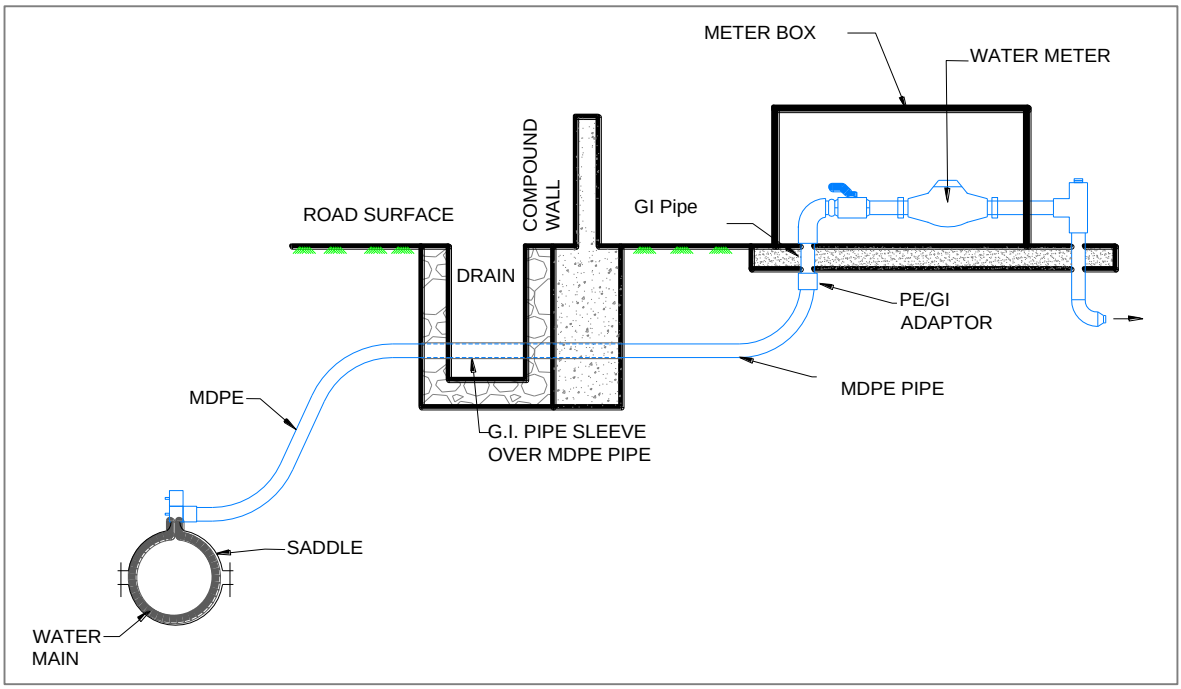
It is expected that the HSC will be required to cross drain in many locations. As per DJB guideline referred above, GI pipe shall be used at the exposed portion. It will require change over from PE to GI before and from GI to PE after the drain. In such situation the better option would be to continue with the MDPE pipe with GI sleeve pipe in the exposed portion. This would help avoid two PE/GI connections thereby reducing the chance of leakage. Cost of additional PE pipe in latter case would be more than compensated by the reduction of two PE/GI couplers. Schematics of such connections are shown in the following figures.




**Case 1: No exposed / drain crossings, all MDPE pipe (Indicative Arrangement)**

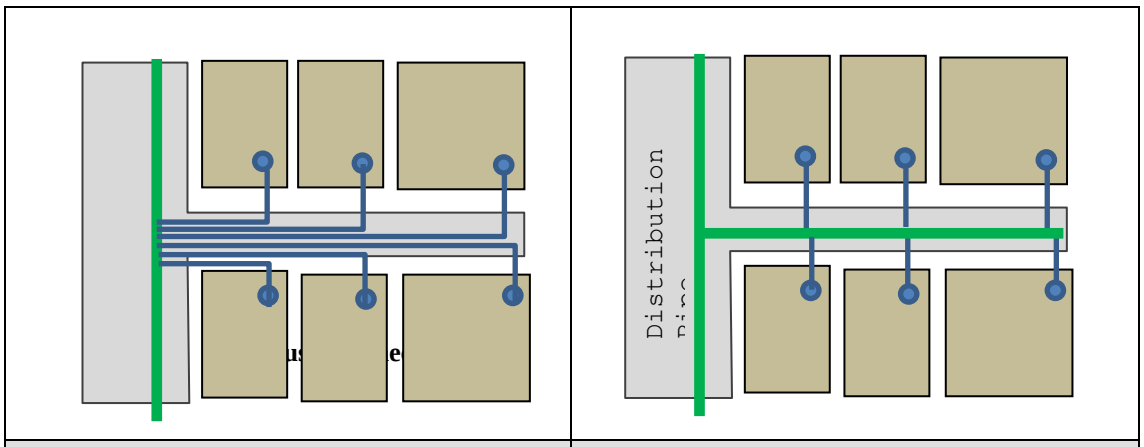



**Case 2: Drain crossings (or over ground section); MDPE / GI combination joined with adaptors (Indicative Arrangement)**




**Case 2 (Option): HSC pipe MDPE only upto meter connection but protected with GI sleeve at exposed locations (Indicative Arrangement)**

In existing situation, bundles of long house connection pipes are laid in many places due to non-availability of distribution main or insufficient water pressure in nearby distribution mains. This practice will be changed in this project; distribution mains will be planned in such a way that unnecessarily long house service connections will be avoided. This is schematically shown in the following Figure.




| Present: Inappropriate connections | Proposed modifications in new system |
|---|---|

**Schematic showing existing situation of house connection and proposed improvement**

### 9.16.2 Various Options for location of consumer water meters

As a rule, water meters should be installed in a location which is closest to the road boundary within the customer's premises, where meter-reading, inspection, and replacement work can

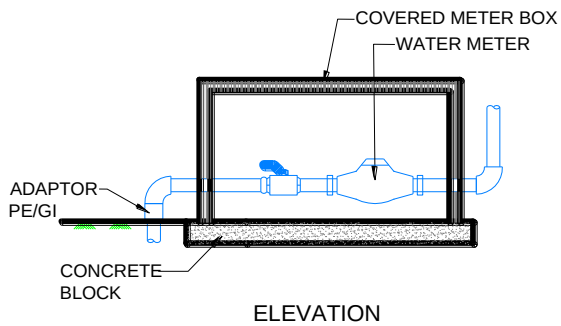
be undertaken easily. In addition, the location should be secure against damage from vandalism. The meter should preferably be installed within 1 m from the public-private boundary as shown in Figure above.

In case that water meters are installed underground, they should be placed in meter boxes with cast iron covers and with mechanism to prevent flooding. In addition, prevention of contamination by back water should be taken into consideration when removing the meter.

In case of highly congested areas like walled city, Pahar Ganj, Anand Parbat, Bapa Nagar etc enough space may not be available to installed water meters on the ground. In such cases, as it is commonly practiced, water meters may be installed on side walls of the building.

The meters should be protected with meter boxes wherever they may be installed. Depending upon the configuration of HSC near the meter, water meters may be installed as shown in the following figures. Consideration should always be given to the followings:

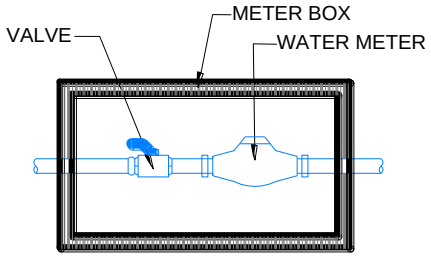
- to make sure that meters are installed horizontally (except the particular types of meters intended for vertical installation),
- to the provision of enough lighting for meter reading,
- securing of space for replacement work,
- securing of specified straight pipe distances before and after the meter depending on the type of meter,
- for back-flow prevention a check valve is recommended to be installed just before water meter, and
- it is not allowed to make any connection from the service connection line before the water meter.




ELEVATION
METER BOX ON GROUND
(OPT.-1)

Example (plan view)

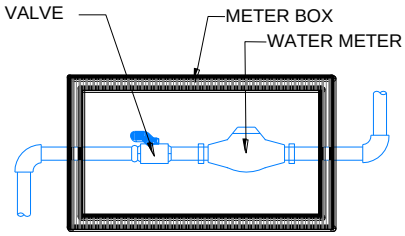
**Option 1 (on ground or horizontal surface):** This option is mostly applicable when the consumer premises have enough space. The meter box can be located on ground surface near compound wall at a slightly raised platform.




ELEVATION
METER BOX ON SIDE OF WALL
(OPT.-2)

Practical example from site with CI meter box

**Option 2 (on wall):** This option is applicable when enough space is not available for Option 1 but the HSC is still running horizontally along the wall of the building.



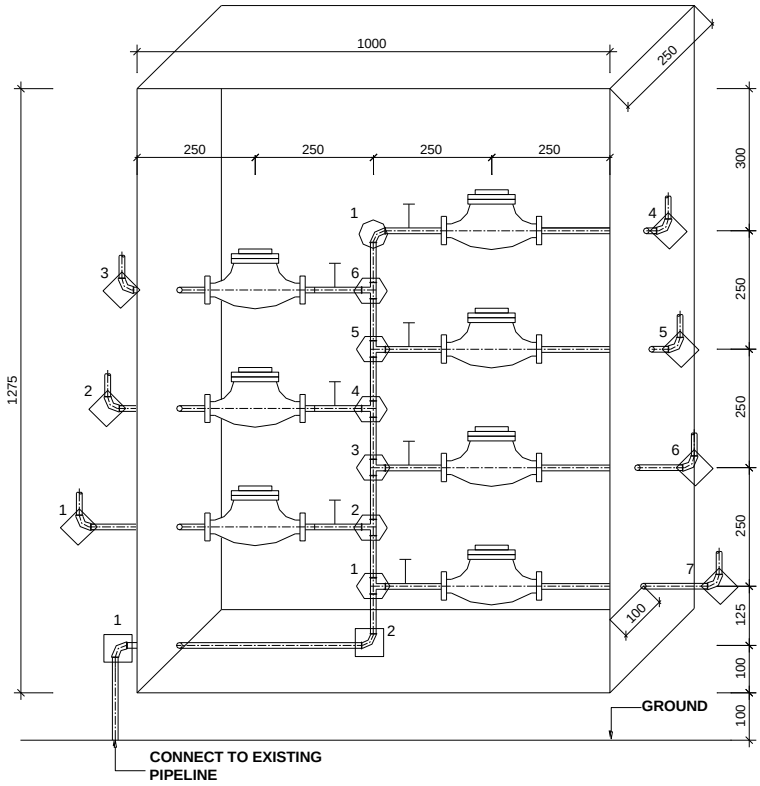

ELEVATION
METER BOX ON SIDE OF WALL
(OPT.-3)

Practical example from site (meter box cover not shown)

**Option 3 (on wall):** This option is applicable when the Options 1 and 2 are not possible due to space constraint and only feasible space is where HSC is running vertically. Since meters are not allowed to be installed in vertical position, some horizontal section should be created on HSC by 90 degree elbow for meter installation.

When several HSCs are to be taken from a single service pipe, the configuration of customer meters shall be as shown in the following Figure. In such cases the following guidelines should be observed:

1) Water meters should be installed with a vertical space of 25 cm or more.
2) Water meters should be installed horizontally without rotating.
3) For the ease of reading the height of meter cabinet should be lower than 1.7 from the ground level.




(Dimensions are in mm)

**Figure: Configuration of meters when multiple meters are required to be installed at a single location**

### 9.16.3 Strap/Clamp Saddle

Strap saddle for service connection from water distribution mains shall be of wrap around design, wide skirt and wide straps support, which shall reinforce the pipe while providing excellent stability to the saddle.

Saddles for service connections shall be fastened strap type with threaded outlet for service connection. The service connection threading sizes shall be conforming to IS 554.

Saddles shall be suitable for DI pipes of nominal size 100 to 300 mm with nominal service connection size from 15 mm to 40 mm.

The straps shall be elastomer coated (insulated) type for firm grip on pipe as well as to protect the coating on the pipe and to insulate the un-identical metals. The saddles shall be single strap type up to pipe sizes of NB 300 and service pipes of 25 mm, and double strap type when the service pipe is above 25 mm.

Fastners shall be of threaded nut-bolt-washer type. Nut-bolts of size M12 (1/2 inch) shall be used for saddles of size NB 100 MM and Nut-bolts of size M16 (5/8 inch) for higher sizes.

The sealing between the saddle and mains shall be obtained by using profiled elastomer seal matching to the curvature of the pipe. The seal shall be elastomer type, suitable for all potable water applications.

The material of construction of the body, straps, fastners etc.shall be non-corrosive material such as Engineering plastic (PE/PP) or stainless steel or a combination of both.

The design of saddle body should be such that the service connection outlet metal insert shall project out towards pipe side and align with the hole drilled on the pipe to ensure positive locking against rocking or creeping on the pipe, as might be caused by vibration, pressure or excessive external loading.

The clamp saddles shall be suitable for maximum working pressures up to 10 bars.

***Materials and Design Specifications***

**Saddle body**: Non-corrosive Engineering Plastic body moulded with Stainless steel threaded metal insert for taping outlet. Also, the stirrup metal plate shall be duly embedded in the plastic body, except at the place of nut-bolt lugs. Threading size and dimensions shall conform to IS 554. The body shall have retaining cavity housing for internal and external retention of the elastomeric seal. Sealing shall be achieved by pressure exerted by the body while fastening the saddle straps & body on the pipe.

**Saddle Strap**: Saddle strap shall be made of stainless steel 304 grade to prevent corrosion over the long service life.

**Strap Insultation**: Elastomeric (rubber) insulation/ lining shall be such that none of the stainless steel strap is in direct contact with the pipe. It shall ensure a firm non-slip grip mounting on the pipe to prevent the saddle from rocking or creeping on the pipe, as might be caused by vibration, pressure or excessive external loading.

**Saddle Seal**: It shall be virgin rubber SBR Grade 30/ NBR (NSF 61 approved). It shall be of type pressure activated hydro-mechanical design. It shall be contoured gasket to provide a positive initial seal which increases with increase in the line pressure. Gasket shall be gridded mat, with tapered ends, with the outlet section having O-ring contacting the saddle body.

**Nut-Bolts-Washer**: Stainless steel type 304, NC rolled thread, tightening torque for ½ inch nut-bolts: 14-15 kg.m and for 5/8 inch nut-bolts: 21-23 kg.m

## 9.17 Metering Public Tap

As a matter of principle, water distribution through public taps shall be discouraged. But it may not be possible to eliminate public taps altogether. In such a situation they shall be metered. Community approach shall be followed for metering public taps in which a caretaker committee shall be formed for each tap. These committees will be given responsibility of protecting meter and reporting leakage or misuse of water. Suitable secure location shall be identified in consultation with the committee for meter installation and the meter shall be protected with a meter box.

## 9.18 Pressure Zero test for DMAs

Once the DMA has been created, a pressure zero test should be carried out. This involves closing the supply to the DMA and checking that the pressure drops towards zero. All boundary and divisional valves should be sounded to check whether the valves are tight. If faulty valves are found, these should be rectified and the pressure zero test repeated.

A typical procedure for a pressure zero test will be as follows:

(1) It is expected that the PZT will be undertaken once the DMAs are isolated and start getting supply on continuous basis. If continuous supply is not possible before this test, then arrangement should be made with DJB to make sure that adjoining DMAs have supply during the PZT.
(2) Indicate boundary valves by marking valve covers (e.g. often by painting the valve cover red).
(3) Arrange for the test to take place between 01.00 and 05.00. Inform customers with special needs (hospitals, dialysis patients etc.) in advance.
(4) Ensure that the staff have maps indicating the DMA boundary, boundary valves, and the DMA inlet valve.
(5) Set up pressure loggers or gauges at pressure monitoring points (PMT) established earlier.
(6) Close the DMA inlet to isolate the DMA.
(7) Analyse the pressure data. If the pressure drops to zero then it is likely that the boundary is tight or at the very least, if there is an unknown connection, it is likely to be very small. However, if after 10 minutes, the pressure has not dropped, a second check should be made by simulating a consumption (e.g. opening a scour valve or fire hydrant within the DMA) to induce some flow, which should zero the pressure. If there are no unknown connections, the pressure should remain at the low level when the scour valve or hydrant is closed.
(8) If the test fails, i.e. the pressure creeps up; it is likely that there is an unknown connection. An assessment of the heads (pressure +ground level) at each of the monitoring points will allow the area of a potential inlet to be identified. Further investigation is then necessary, possibly with additional zoning of the DMA, to identify the unknown inlet.

On completion of the test, the supply valve is reopened. The pressure is monitored to ensure that supply has been restored to the DMA.

## 9.19 Measuring and Monitoring water loss level at DMA level

The formula to calculate Water Loss for a DMA will be as defined in Section 4.3.9

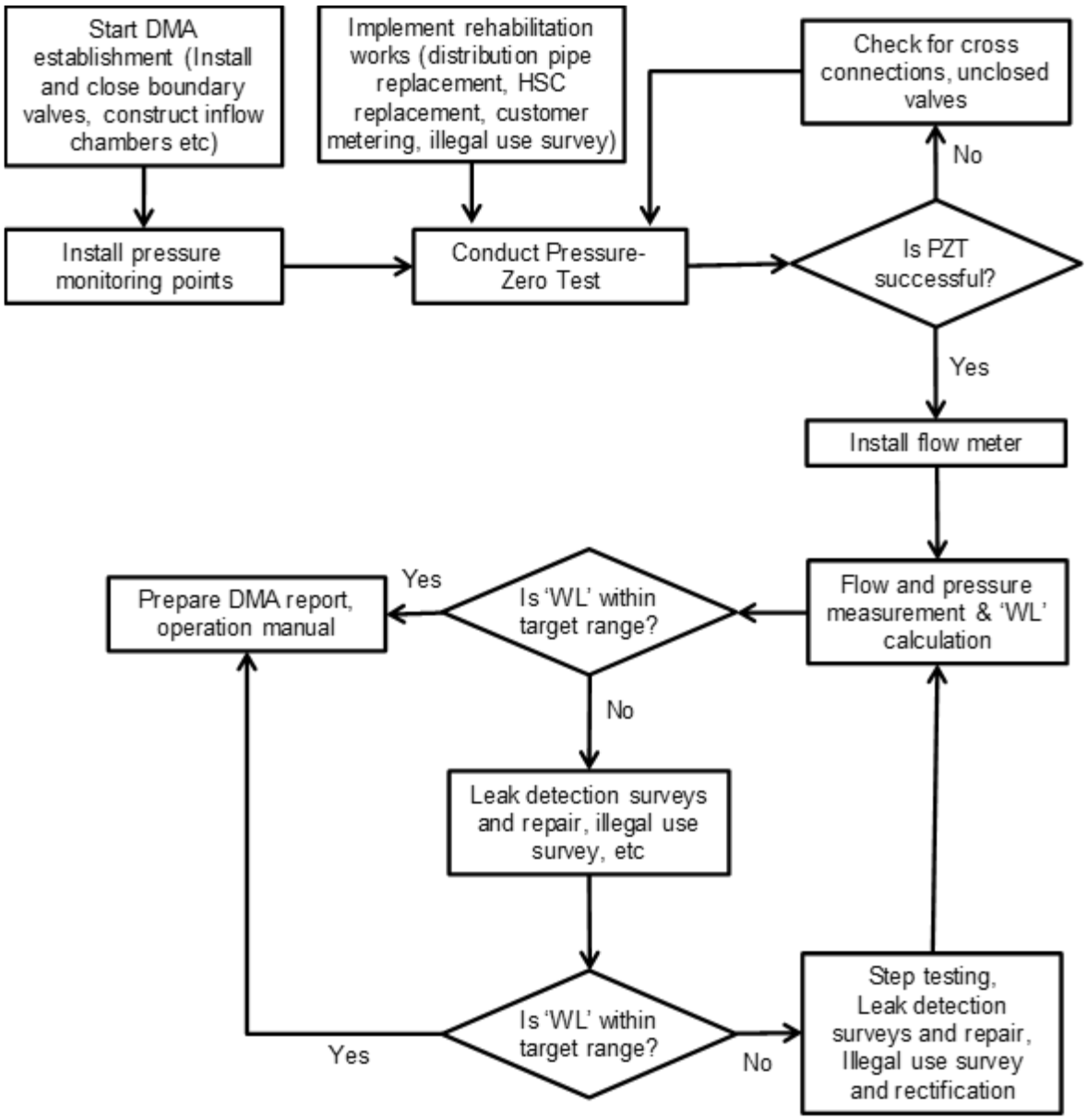
NRW for a DMA will be defined as:

$$\text{NRW (\%)} = \frac{X - (A + B + C + D)}{X} * 100\ \%,$$

Where:

X = Water input to the system (DMA) during the period (typically 1 month)
A = Water billed during the period
B = Water legally supplied but not billed (including slum and standpost consumption) during the period
C = Operational use (scouring, jetting, dust suppression, etc.) during the period
D = Tankers metered and billed/unbilled during the period

The flow diagram of DMA establishment and NRW management is shown below.




FLOW DIAGRAM FOR DMA ESTABLISHMENT AND WATER LOSS MANAGEMENT WORK

Once the Pressure-Zero test is successfully completed, isolation works such as installation of boundary valves, interconnections to improve the system etc. shall be completed and flow monitoring in each DMA shall be done. Water loss will be calculated on billing cycle basis as per the formula.

As shown in Figure above, if the Water Loss (WL) in any DMA is found to be equal or less than the target value (currently considered to be 14%), further WL reduction works may not be required in such DMAs.

Replacement of HSC and meters can be taken up in parallel to rehabilitation of network.

### (i) Estimating real losses

Physical losses within a DMA are effectively pipe leaks on the distribution system and customer connections. To estimate the level of leakage in the DMA it is necessary to calculate the system's Net Night Flow (NNF), which is determined by subtracting the Legitimate Night Flow (LNF) from the Minimum Night Flow (MNF). The MNF is the lowest hourly flow into the DMA over a 24-hour period, which generally occurs between1 to 4 AM in the morning when most consumers are inactive.

However, there might be some large water users such as factory, hospital, or night clubs etc. and legitimate night use by the remaining consumers during the test period is the legitimate night flow (LNF). For systems with complete metering, these large water users can be measured and the legitimate night use by the remaining consumers can be estimated (e.g. 1% or even less) and considered for deduction from MNF to obtain NNF.

To determine Net Night Flow (NNF) subtract the LNF from the recorded MNF.

**NNF = MNF – LNF**

Where LNF = Metered consumption by large water users and legitimate use (estimated) by the remaining consumer during the test period.

In a continuous (24×7) supply system customer demand fluctuates throughout the day with peak demands in the morning and evening, and a minimum demand at night when most customers are asleep and not using water. Water pressure decreases with increase in demand (flow) whereas water leak increases in direct proportion to water pressure. Hence the leakage rate is minimized at maximum demand period and vice versa. Therefore, extrapolating the night leakage value over 24 hours will tend to overestimate daily leakage. To take account of this fact, leakage estimates based on night flow measurements are multiplied by a Night-Day Factor (NDF).

The NDF for any DMA can be calculated by recording the hourly pressures at the AZP (average zone point) over 24-hour periods. Then if:

- The AZP pressure over the hour of minimum night flow is P,
- The AZP pressures corresponding to the hourly series of night flows $Q_0$ (00 to 01 hrs), $Q_1$ (01 to 02 hrs) etc, are $P_0$, $P_1$, etc, then the NDF can be calculated as

$$\mathbf{NDF = (P_0/P)^{N1} + (P_1/P)^{N1} + (P_2/P)^{N1} + ..... + (P_{23}/P)^{N1}}$$

Where N1 is the exponent in the FAVAD (fixed and variable area discharge) equation which relates leakage rate to pressure, i.e. Leakage $\alpha$ $(P)^{N1}$.

Pressure adjusted leakage rate ($m^3$/day) = NNF ($m^3$/hr) × NDF (hrs/day)
If any DMA has multiple inlet / outlets then the night flow from these locations should be taken at the same time and added together.

### (ii) Determining apparent losses

Apparent losses can best be calculated from the WL and real loss values, i.e.

**Apparent loss ($m^3$/month) = WL ($m^3$/month) – Real loss ($m^3$/month)**

If this approach is not possible due to difficulty in measuring real loss, apparent loss can be estimated based mainly on sample testing of meters. Recommended testing of at least 5% of working consumer meters representing all categories, class, age and make of the meters. This will yield commercial loss but water theft and billing anomalies can be estimated in consultation with DJB.

## 9.20 Replacement of house service connection on existing main and providing new service connections from newly laid distribution pipe

The house service connection (consumer service connection) is defined as a portion of pipe and fittings from tapping point in distribution pipe to the consumer water meter. The scope of work involves the following:

(a) Providing new connections from new distribution pipe for each legally existing connection and discarding the existing HSC.
(b) Replacement of existing service connection with new connections from existing distribution pipe for each legally existing connection from the tapping point (using the same existing tapping) on existing distribution pipe and discarding the existing HSC.
(c) Providing new connections from new or existing distribution pipe for newly sanctioned connections.
(d) The distribution system as-built drawings should contain the as built details of the service connection from tapping point to the location of consumer meter.

## 9.21 Methodology for providing House Service Connection where the distribution pipe is new

1. New HSC shall be provided from new distribution pipe. Stopcock shall be provided at the consumer premises and closed till the pipeline along with HSCs are hydro tested and disinfected before connecting to the system.
2. Once the water start flowing in the new pipeline, connect the new HSC to the old HSC before the meter point and disconnect the existing HSC.
3. After completion of laying, jointing, testing (hydro) of newly laid main along with new HSCs, the main shall be disinfected and cleaned thoroughly before putting into services. Care shall be taken to close the open ends of mains and services connections during the work period in order to avoid entry of dirt or any other items.

## 9.22 Methodology for House Service Connection replacement where the existing distribution pipe is to be used

1. Most of the existing tapings are made with only ferrule but that shall be changed to saddle based tapping. The existing HSC shall be dismantled by removing ferrule. Care shall be taken not to allow water from surrounding area to enter the pipeline.
2. New saddle shall be positioned and fixed over the existing tapping hole in such a way that the opening in the saddle and existing tapping hole are aligned concentrically. New HSC shall then be laid connecting the saddle to the consumer meter. If the existing tapping is too big, then that should be plugged and a new tapping near the same shall be drilled to connect the HSC.

The standard layout of HSC using MDPE/GI pipe combination is illustrated in the Drawing section.

It is expected that the HSC will cross existing storm water drains in many locations. As per DJB guideline referred above, GI pipe shall be used at the exposed portion. It will require change over from PE to GI before and from GI to PE after the drain. In such a situation, the better option would be to continue with the MDPE pipe with GI sleeve pipe in the exposed portion. This would help avoid two PE/GI connections thereby reducing the chance of leakage. Cost of additional PE pipe in latter case would be more than compensated by the reduction of two PE/GI couplers. Schematics of such connections are shown in the following cases:

In existing situation, bundles of long house connection pipes were laid in many places due to non-availability of distribution main or insufficient water pressure in nearby distribution mains. Therefore, it is considered to lay distribution mains in such a way that unnecessarily long house service connections will be avoided.

The specification of materials and workmanship shall conform to the guideline issued by DJB through its circular dated 8.12.2014 and explained as below: The details for replacements are as given below:

1. The consumer service connection shall be replaced from ferrule point to the water meter installed at consumer premises.
2. Tapping on the distribution pipe shall be provided with Saddle (DI or MDPE/HDPE composite). The bore size shall be maintained as 8 mm or as sanctioned with additional control through adapter of same (bore) size fitted in the saddle.
3. When tapping from HDPE pipes regardless that the line is pressurized, self-tapping ferrule can be used. The self-tapping ferrule is a purpose designed product that incorporates its own cutter and allows under-pressure or dry conditions to be used without the need for ancillary tapping machines or other equipment. For tapping of DI/CI pipes, the tapping machine method depends on whether the line is under pressure or dry condition. If the line is pressurized, under-pressure tapping machine must be used, and if it is not pressurized, a drill with suitable diameter can be used.
4. It is strictly prohibited to make holes by using welding equipment for metal pipes or heated steel stick for plastic pipes. It is also forbidden to weld a pipe to the main to make the branch from it.
5. The Medium Density Polyethylene Pipes (MDPE) of the required connection line size shall be used for underground portion of the service connection. The MDPE pipe shall be of minimum PE80 grade conforming to ISO specifications (ISO 4427 and BS 6730-1986) for carrying potable water.
6. GI pipe of class 'B' conforming to relevant IS shall be used for above-ground portion of service pipe up to consumer water meter.
7. Standard PE/GI or GI/PE coupler shall be used in each PE/GI or GI/PE connection point.
8. If the space is not available to tap connections then an additional service pipe (rider main) shall be provided and HSC shall be given from that pipe.
9. After completion of tapping service connections on the newly laid main, the service line should be protected from the pollution and flushed with water before connecting to the customer water meter.
10. Proper record of all such replacements of service connections shall be maintained along with consumers K-numbers, date of replacement, length of MDPE & GI portions of service pipe, status of water meter etc. The Contractor shall record the details and

prepare a detailed as-built drawing of each HSC in AutoCAD (.dxf or .dwg) or GIS format showing the route of HSC from the tapping point to the consumer meter. This drawing shall be part of the as built drawing of the distribution system. The drawings shall be prepared in WGS 1984 coordinate system.

11. After completion of laying, jointing, testing (hydro) of newly laid main along with new HSCs, the main shall be disinfected and cleaned thoroughly before putting into services. Care shall be taken to close the open ends of mains and services connections during the work period in order to avoid entry of dirt or any other items.

## 9.23 Leak Detection Survey and Leak repair

There are various methods for detecting water distribution system leaks. These methods usually involve using sonic leak-detection equipment, which identifies the sound of water escaping a pipe. These devices can include pinpoint listening devices that make contact with valves and hydrants, and geophones that listen directly on the ground. In addition, correlator devices can listen at two points simultaneously to pinpoint the exact location of a leak. Large leaks do not necessarily constitute the greatest volume of lost water, particularly if water reaches the surface where they are usually found quickly, isolated, and repaired. However, undetected leaks, even small ones, can lead to large quantities of lost water since these leaks might exist for a long time. Ironically, many small leaks are easier to detect because they are noisier and easier to hear using hydrophones. The most difficult leaks to detect and repair are usually those under stream crossings. Leak detection efforts should focus on that portion of the distribution system.

Active leak detection is crucial for identifying unreported water leaks in the distribution system. Night leak survey is necessary to identify the critical leak when the system pressure is high. The night survey will also alleviate the noise problem from Delhi's heavy traffic during day time.

The leak detection techniques will be chosen from the most suitable for Delhi's condition. Acoustic leak noise detectors with digital display of noise levels will be one of them. Use of tracer gas technology will also be considered.

The Contractor/Operator shall provide at his own cost all necessary equipment and tools for leak detection, step testing etc related to NRW reduction. The cost for these shall be deemed covered by the Performance Based fee. Ownership of such equipment shall remain with the Contractor and he will be at liberty to choose the method of disposal at the end of O&M period.

At the end of O&M period DJB with its own fund may buy the essential equipment / tools for leak detection and repair. The Contractor shall help DJB in identifying appropriate equipment / tools if required.

The leak detection survey as given below:

(a) Conducting routine survey for identification of visible leaks (walking along the pipe line)
(b) Conducting survey for identification of non-visible underground leaks in the Contract area using acoustic and non-acoustic methods. The operator can adopt gas tracer method to locate the underground non-visible leaks.
(c) Repairing all leaks found during the survey plus reported by public or any other person

within the stipulated period to avoid loss of water. Undue delay in arrest of leaks shall lead to strict action and may lead to penalty based on loss of water. The water loss shall be divided into two categories; the first category is leaks on HSCs and the second category is leaks on mains, and appurtenance. The penalty shall be applied for the leaks which are not attended for period of more than 2 days as given below:

- Penalty for one pending HSC leak beyond 2 day is Rs.500/per day for one week (7 days). Beyond 7 days, the penalty rate will be doubled.
- Penalty for one pending other leak (mains, appurtenance etc) beyond 2 day is Rs.1000/per day for one week (7 days). Beyond 7days, the penalty rate will be doubled.
- Response time will be counted after official record of the complaint.
- However, the identification of underground leaks by the operator, the response time shall start after the confirmation of the leaks.

There are various methods for detecting water distribution system leaks. These methods usually involve using sonic leak-detection equipment, which identifies the sound of water escaping a pipe. These devices can include pinpoint listening devices that make contact with valves and hydrants, and geophones that listen directly on the ground. In addition, correlator devices can listen at two points simultaneously to pinpoint the exact location of a leak. Large leaks do not necessarily constitute the greatest volume of lost water, particularly if water reaches the surface where they are usually found quickly, isolated, and repaired. However, undetected leaks, even small ones, can lead to large quantities of lost water since these leaks might exist for a long time. Ironically, many small leaks are easier to detect because they are noisier and easier to hear using hydrophones. The most difficult leaks to detect and repair are usually those under stream crossings. Leak detection efforts should focus on that portion of the distribution system.

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The leak detection techniques will be chosen from the most suitable for Delhi's condition. Acoustic leak noise detectors with digital display of noise levels will be one of them. Use of tracer gas technology will also be considered.

## 9.24 Step Testing

During the normal leak detection and rectification, if the real losses didn't reduce considerably, then it is required to narrow down the effort from entire DMA to leak prone area in the DMA by conducting Step Test. Sub-division of DMA by internal valving and identifying areas of higher leakage within a DMA by successively shutting off a part of the DMA (called 'leak detection block' or 'sub-DMA/sub-zone') by temporarily closing valve(s) in sequence is known as the step testing. Proper planning of pipe and valves to enable complete isolation of a particular section with the DMA is essential for this test.

Step tests are generally undertaken during the period of minimum night flow (often between 01.00 a.m. and 04.00 a.m.) to avoid causing supply problems to the customers. Therefore, the number of valves that need to be operated needs to be carefully considered. The size of the individual steps depends on the size of the DMA, configuration of pipe network, and availability of isolation valves. In a DMA of 1500 connections a step size of approximately 150 connections is recommended. It is advisable not to have more than 10 steps. There are two main

methods of conducting step test; 1) Isolation method, and 2) Close and open method.

**(A) Isolation Method**

This method involves the successive closing of valves starting from the furthest point from the meter resulting in less of the zone being supplied by the meter. The sequence of closing valves is progressively carried out working back to the meter where the flow should drop to zero. Whilst potential leak prone areas are identified by this method there is one major disadvantage that the entire DMA is de-pressurized for some time and this can cause back-siphonage or the risk of infiltration of ground water.

**(B) Close and Open Method**

This method involves closing valves to isolate each individual step and once the reduction of flow has been recorded the valves are reopened. This method does avoid parts of the system being without water for a longer period of time but it requires waiting time after each step till the flow is stabilized. Otherwise, the reduction in flow rate from some steps can be compensated by additional flow from recharging of previous steps, thus making interpretation of result more difficult.

Since part or parts of the network gets depressurized during step testing, water quality should be monitored to ascertain that no water from surrounding ground entered into the pipe during step testing.

# SUB-SECTION 10. PARTICULAR DESIGN CRITERIA AND REQUIREMENTS FOR RCC AND BUILDING WORKS

## 10.1 General

This chapter deals with the structural design criteria and requirements for the structures such as Underground Reservoirs, Booster Pumping Stations, Buildings and other civil structures. The design criteria shall apply for the structures which are to be designed by the contractor as specified in the contract. All the design and layout of the structures shall be done keeping in view of the land space available, ease in construction, aesthetics, operation and maintenance.

### 10.1.1 Structural Design Standard

All designs to be done by the contractor shall be based on the latest Indian Standard (I.S.) Specifications or Codes of Practice.

The adopted design standards shall follow the best modern engineering practice in the field based on any other international standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Engineer.

All reinforced concrete structural design shall generally conform to the following latest revisions of the Indian Standards Institution.

IS 456 : Code of Practice for plain and reinforced concrete,
IS 875 : Code of Practice for design loads for building and structures (Part I to V),
IS 3370 : Code of Practice for concrete structures for the storage of liquids (Part I to IV),
IS 1893 : Criteria for earthquake resistant design of structures (Part I to IV),
IS 2974 : Code of practice for design and construction of machine foundations (Part 1 to 4),
IS 13920 : Ductile Detailing of Reinforcement Concrete Structures subjected to seismic forces-Code of Practice,
IRC 6 : Standard specification and Code of Practice for road bridges Loads and Stresses

All structure steel design shall generally conform to the following publications of the Indian Standard Institution:

IS 800 : Code of Practice for general construction in Steel,
IS 806 : Code of Practice for use of steel tubes in general building construction,

### 10.1.2 Structural Design Criteria

#### 10.1.2.1 Concrete

Unless otherwise specified, concrete for all water retaining structures and pumping stations comprising reinforced non-prestressed, cast in place construction shall be grade M30, having a characteristic strength of 30N/mm². The structural concrete for all building structures /Non Water retaining structures shall be grade M25 (25 N/mm²). Concrete for prestressed elements,

if required, shall be factory controlled grade 40 concrete (40 N/mm²). Blinding concrete under footings and slabs of water retaining structures shall be grade M15 (15 N/mm²).

In general, the cement to be used shall be ordinary Portland cement; however, sulphate resisting Portland cement shall be used for foundations at locations where soluble sulphate content of ground water shall be excessive if confirmed by soil investigations.

#### 10.1.2.2 Reinforcement

Non-prestressed reinforcement shall be high strength deformed bars with a specified characteristic strength of 500 N/mm² or more.

#### 10.1.2.3 Analysis and Design

The structural designs shall be carried out according to Limit State of Serviceability and Ultimate limit state design philosophy.

The structures shall be checked for compliance with requirements for strength at the ultimate limit state using factored loading with maximum liquid levels.

The partial safety factor for retained water, surcharge and earth pressure shall be 1.5 for most at Ultimate limit state (ULS) and 1.0 at Serviceability limit state (SLS).

The structures shall be designed with a factor of safety of at least 1.2 against flotation during construction and service.

To ensure satisfactory serviceability, the limit states of crack-width and deflection shall then be checked with unfactored loading at normal working levels.

#### 10.1.2.4 Concrete Liquid Retaining Structures

Concrete liquid retaining structures shall be designed in accordance with the latest Indian Standard I.S. 3370.

#### 10.1.2.5 Other Concrete Structures

Other concrete structures shall be designed in accordance with I.S. 456, Code of Practice for plain and reinforced concrete and I.S. 875, Code of Practice for design loads for building and structures (Part I to V).

#### 10.1.2.6 Steel Structures

Steel structures shall be designed in accordance with I.S.800, Code of Practice for general construction in Steel and I.S.806, Code of Practice for use of steel tubes in general building construction.

Other equivalent codes or standards may be used as approved by the Employer.

#### 10.1.2.7 Crack Width

The maximum crack width at the serviceability limit state shall be limited to 0.2mm.

#### 10.1.2.8 Joints (Construction, Contraction and Expansion Joints)

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure. However, contraction joints shall be provided at specified locations spaced not more than 7.5m in both right angle directions for walls and raft.

Expansion joints of suitable gap at suitable intervals not more than 30m shall be provided in walls, floors and roof slabs of water retaining structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on convenience of construction.

To avoid segregation of concrete in walls, horizontal construction joints shall be provided at every 2m height and a dip tube shall be used during concreting of walls. PVC waterstop of 230mm width shall be used for walls & base slabs.

Expansion Joint shall be treated as follows.

Surface should be cleaned along the side walls of the expansion joint equal to the width of expansion joints on both sides with the help of mechanical means to remove all dirt, dust and debris. Fill the joint both sides with PE board or high density thermocol packing followed by Polyurathane 2 component gun grade sealant over the top of packing. Apply 2 component Sagemetal epoxy bonding on the side of the expansion joint, paste 1 mm thick TPO membrane over the bonding agent and cover the sides of the Expansion joint with Sagemetal bonding agent again. Finally provide aluminium non-corrosive material over the treated joint capable of accommodating joint movement.

### 10.1.3 Design Loadings

All building and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these shall include dead load, live load, wind load, seismic load, and stresses due to temperature changes, shrinkages, shrinkage and creep in materials, dynamic loads:

#### 10.1.3.1 Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipment and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding contents, shall be considered.

The following minimum loads shall be considered in design of structures:

| | | |
|---|---|---|
| (i) | Weight of water | 10.0 KN/m$^3$ |
| (ii) | Weight of soil (irrespective of Strata available at site and type of soil used for filling etc.). However, for checking stability against uplift, actual weight of soil as determined by field test shall be considered | 20.0 KN/m$^3$ |
| (iii) | Weight of concrete | 24.0 KN/m$^3$ |
| (iv) | Weight of reinforced concrete | 25.0 KN/m$^3$ |
| (v) | Weight of brickwork (exclusive of plaster) | 22.0 N/m$^2$ per mm thickness of brickwork |
| (vi) | Weight of plaster to masonry surface | 18.0 N/m$^2$ per mm thickness |
| (vii) | Weight of terrazzo and granolithic concrete finish or rendering screed, etc. | 24.0 N/m$^2$ per mm thickness |
| (viii) | Weight of sand (filter media) | 26.0 KN/m$^3$ |
| (ix) | Weight of Alum blocks | 24.0 KN/m$^3$ |
| (x) | Dead Load of Water Proofing | 2.5 KN/m$^2$ (Min Load on the roof slab). It can be more as per the actual loading. |
| (xi) | Weight of steel beams, steel plates and MS chequered plates | 78.5 N/m$^2$ per mm thickness of plates |

### 10.1.3.2 Live Load

Live Load (LL) shall include the superimposed loads due to the use/occupancy of the structure/building not including dead load, wind or earthquake load. Live loads shall be in general as per I.S. 875 part (II). However, the following minimum loads shall be considered in the design of structures:

| | | |
|---|---|---|
| 1 | Accessible/Inaccessible roofs | 1.5 KN./m |
| 2 | Floors supporting equipment such as pumps, blowers, compressors, valves, etc. (Entire Floor consisting of pumps, blowers, compressors, valves shall be designed for 10 KN/m$^2$ load apart from concentrated load of pumps, blowers, compressor, | 10.0 KN/m$^2$ |

| | | |
|---|---|---|
| | valves etc.) | |
| 3 | Live load on all other floors, offices, walkways, stairways and platform, general public access | 5.0 KN/m$^2$ |
| 4 | Floors accessible to trucks | Two axles of 9.5 tonnes each, at 1.2m centres with a minimum uniform load of 20 kN/m$^2$ |
| 5 | Electrical rooms | Actual weight but not less than 10 kN/m$^2$ |
| 6 | Laboratories and Chemical Rooms and control Rooms | 5.0 KN/ m$^2$ |
| 7 | Storage Rooms | 7.5kN/m$^2$ |
| 8 | Areas subjected to loading by cars | Minimum super loads of 3.0 kN/m$^2$ or minimum wheel load 1300 kg |
| 9 | Clear Water Reservoir Roof | 3KN/Sqm in addition to the load of soil cover if provided. |

In the absence of any suitable provisions for live loads in I.S. Codes or as given above for any particular type of floor or structure, assumptions made shall receive the approval of the Engineer prior to starting the design work. Apart from the specified live loads or any other load due to material stored, any other equipment load or possible overloading during maintenance or erection / construction shall be considered and shall be partial or full whichever causes the most critical condition.

### 10.1.3.3 Construction Loads

The design load shall accommodate loads from construction activities.

### 10.1.3.4 Loads on Buried Reservoir Roofs

Reservoir roofs shall be designed for the weight of saturated earth or 150 mm thick layer of white colour Dolomite/Calcite that shall be placed on the structure plus a live load (minimum of 3kN/m²) based on the use of the area. Consideration shall be given to loads from equipment and stockpiling that shall occur during the placement of the fill.

- ❑ Lateral Soil and Groundwater Loads

The structures shall be designed for loadings based on the interpretation of the data contained in the geotechnical report for each site, with the following minimum values:

| | | |
|---|---|---|
| 1 | Compacted soil density | 20.0 kN/m$^3$ |
| 2 | Active lateral soil pressure coefficient | 0.333 |
| 3 | At-rest earth pressure coefficient | 0.5 |
| 4 | Lateral surcharge from vehicles | 20 KN/m2 |
| 5 | Water head at bottom of walls | Groundwater level, if present or as stated below |
| 6 | Density of water | 10.0 kN/m$^3$ |
| 7 | Allowable bearing pressure | Based on soil investigation reports |

All Structures including water retaining structures shall be designed for groundwater at surface level.

Walls where vehicles shall approach within a distance equal to half the wall height shall be designed for a surcharge of 20kN/m2. Consideration shall also be given to any surcharge effects due to adjacent footings or the intended use of the area.

### 10.1.3.5 Load Combinations

The Structural Design shall be based on Limit State criteria as stated in I.S. 456 and IS 3370 Part 2 – 2009.

The load combinations shall be as stated in I.S. Code of Practice for design loads for building and structures IS-456. The effects of any load type (other than dead load) shall not be used to reduce the effects of another load type. A maximum of 90 percent of the dead load in any combination where it shall reduce the effects of another load type shall be used. Structures which contain liquids extend below grade, or both, shall be designed for the following load combinations:

- Liquid-containing compartments full, with no backfill for liquid containing compartments. No relief shall be given for any passive soil pressure on a structure on the face remote from a contained liquid unless otherwise approved.
- Backfill and groundwater, with liquid-containing compartments empty and full.
- Any liquid-containing compartment empty or full in combination.

#### 10.1.3.6 Flotation

All structures shall be designed to resist upthrust due to flotation during construction and in service.The water level shall be considered at the ground level for design of structures irrespective of the ground water level given in the geotechnical report. Pressure relief valves shall not be allowed in any structure.

#### 10.1.3.7 Handrail Loads

Handrails shall be designed to withstand whichever of the following live loads shall produce the most adverse effect:

- A force of 550 N acting outwards or downwards at any point on the top rail or post.
- A force of 330 N/m acting outwards or downwards on the top rail.

Handrail shall be made up of stainless steel (SS-304).

#### 10.1.3.8 Wind Load

Wind loads shall be as per IS 875 Part (III).

Structures shall be designed for a basic wind pressure as per IS 875 and the calculations shall be based on the IS 875-Part-III, Code of Practice for design loads for building and structures.

Wind forces on structures shall be based on the basic wind pressure and modifying factors based on the shape of a structure and its exposure.

#### 10.1.3.9 Earthquake Load

This shall be computed as per IS 1893.

An importance factor appropriate for the type of structure shall be considered for design of all structures. All Structures shall be design considering Zone-V as per Bureau of Indian Standards (IS 1893, Part 1:2002). The following parameters shall be used in the seismic design of Chandrawal WTPs:

- ✓ Zone : V.
- ✓ Zone factor (Z) : 0.36,
- ✓ Importance factor (q) : 1,5

Seismic constructive measures and provisions for anchorages and splices shall be adopted in conformity with the IS-13920.

#### 10.1.3.10 Dynamic Load

Dynamic loads due to working of plant such as pumps, blowers, compressors, switch gear, travelling cranes, etc. shall be considered in the design of structures.

### 10.1.4 Design Conditions for Underground/ partly Underground Liquid retaining Structures

Water level shall be assumed at the ground level for design of all the structures irrespective of water level given in the geotechnical investigation report. All underground or partly underground liquid containing structures shall be designed for the following conditions:

(i) Liquid depth up to full height of wall: no relief due to soil pressure from outside shall be considered;

(ii) structure empty (i.e. empty of liquid, any material, etc.): full earth pressure and surcharge pressure wherever applicable , shall be considered ;

(iii) partition wall between dry sump and wet sump : shall be designed for full liquid depth up to full height of wall;

(iv) partition wall between two compartments : shall be designed as one compartment empty and other full;

(v) structures shall be designed for uplift in empty conditions with the water table shall be considered at ground level;

(vi) walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads;

(vii) Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab. A minimum factor of 1.2 shall be ensured against uplift or floatation.

(viii) All the liquid retaining structures shall be design for maximum design crack widths of 0.2mm for direct tension and flexure.

### 10.1.5 Foundations

(i) The minimum depth of foundations for all structures, equipments, buildings and frame foundations and load bearing walls shall be as per IS 1904 but in any case this shall not be less than 1.0 meter in the original soil.

(ii) Safe bearing capacity of soil strata shall be taken as indicated in geotechnical report.

(iii) Special attention shall be drawn to danger of uplift being caused by the ground water table. All underground structural slabs shall be designed for uplift forces due to ground water pressure.

(iv) Maximum safe bearing capacity of soil strata shall be taken as indicated in geotechnical reports and contractor's independent Soil Investigation Report, whichever shall be less. For the foundation depths and types of footings other than those mentioned in the geotechnical reports, the maximum safe bearing capacity shall be appropriately computed from the parameters given in the geotechnical reports and got reviewed and

approved by the Engineer. Care shall be taken to avoid the foundations of adjacent buildings or structure foundations,

(v) If pile foundations shall be used, the bidder shall conduct the initial routine test as per IS 2911 at his own cost, to determine the safe load bearing capacity of piles.

### 10.1.6 Design Requirements

The following shall be the design requirements for all reinforced or plain concrete structures:

a) All blinding and leveling concrete shall be a minimum 100 mm thick in concrete grade M15.

b) For all liquid retaining reinforced concrete structures, concrete shall be of a minimum M-30 grade with a maximum 20 mm aggregate size for all structural member. For all other reinforced concrete structures/ Non Liquid retaining structures, reinforced concrete shall be of a minimum M-25 grade with a maximum 20 mm aggregate size for all structural members. If structure shall consist of water retaining structure along with buildings then entire structure shall be constructed in M-30 Grade of Concrete.

c) The reinforced concrete for reinforced concrete structures shall have a minimum cement content of 370 kg/m3 with a maximum 20 mm size aggregate.

d) The minimum clear cover to all reinforcement including stirrups and links shall be 50 mm for all water retaining structures on both faces of all structural members. As design consideration to control crack, though general requirements of IS 3370 shall be followed, permissible crack width shall be limited to 0.20mm for water retaining structures.

e) The amount of reinforcement in each of the two directions at right angles within each surface zone shall not be less than 0.35% of the surface zone cross section for all water retaining structures irrespective of the size of structure. For roof slabs, minimum of 10 mm dia bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.

f) The minimum cover to the main reinforcing bars for different members for non–water retaining structures shall be as follows unless stated otherwise:

| | |
|---|---|
| Slab (Floor, Roof, Canopy & Staircase) | 50mm |
| Beams (Sides, Bottom & Top) | 50 mm |
| Columns | 50 mm |
| Pedestals (in contact with earth) | 50 mm |
| Basement wall, retaining walls | |
| i) Face in contact with earth | 50 mm |
| ii) Interior face | 50 mm |
| iii) Foundations | 50 mm |

g) For reinforced concrete structures, reinforcement shall be TMT bars of grade Fe 500 or more.

h) All buildings shall have a minimum 1 meter wide, 100 mm thick plinth protection paving in M15 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well compacted strata.

i) All pipes and ducts to be laid below the structural plinth and road works shall be surrounded with concrete of grade M20.

j) Detailing of the reinforcement shall be done as per latest IS-13920 considering Zone-V.

k) Any structure or pipeline crossing below roads shall be designed for Class A of IRC loading.

l) Water tightness testing of water retaining structures shall be done in accordance with IS 3370 (Part I). The depth of water for testing shall be up to the soffit of the covering slab.

m) All water retaining structures shall be coated on water face (Wall, Base Slab & Roof slab (For Covered RCC Structures)) and other face as specified in the clause 4.14 of the civil specifications per the appoved by Engineer.

n) Any extra excavation shall be filled with PCC (M15). No Part of foundation of water retaining structure shall rest on filled up or compacted soil.

The following minimum thicknesses shall be used for different reinforced concrete members, irrespective of design thicknesses:

| | | |
|---|---|---|
| (ii) | Walls for liquid retaining structures | : 250 mm |
| (iii) | Roof slabs for liquid retaining structures | : 200 mm(Other than flat slabs) |
| (iv) | Bottom slabs/Raft for liquid retaining structures | : 250 mm |
| (v) | Floor slabs including roof slabs, walkways and canopy slabs | : 150 mm |
| (vi) | Column footings | : 300 mm |
| (vii) | Precast trench cover | : 150 mm |
| (viii) | Column Dimension | : 300 mm |

### 10.1.7 Hydraulic Testing of Liquid Retaining Structures

In addition to the structural test of structures, the liquid retaining structures shall also be tested for water tightness test at full supply level as described of latest revision of IS 3370 (Part I).

On completion of the structure and before its commissioning, the contractor shall carry out a water tightness test for the maximum water head condition i.e. with the water standing at Full Supply Level (FSL).

The water tightness test shall be carried out when the construction of liquid retaining structure shall be completed and when it shall be possible to fill the structure and ensure that uniform

settlement of the structure as a whole or as directed by the Engineer. Before the filling operations shall be started, the structure shall be inspected by the Engineer/Engineer's Representative and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted and it shall be ensured that the jointing material filled in the joint shall be in position and all openings shall be closed. The Contractor shall make necessary arrangement for ventilation and lighting of the structure by way of floodlights, circulators etc. for carrying out proper inspection of the surfaces and inner conditions if so desired by the Employer. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept.

If the test results shall be unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water retaining structures test procedures, at his own cost. If the re-test results still be unsatisfactory after the repairs, the structure shall be condemned and the Contractor shall dismantle and reconstruct the structure, to the original specification, at his own cost.

During testing and during defect notification period the impression marks created due to seepage shall be rectified and made good.

For all hydrotesting and disinfection works, the Contractor may obtain the required water from DJB upon payment as per the prevailing rates/cost of DJB.

### 10.1.8 Requirements for Buildings and Structures

All the building and structure works shall generally comply with the following requirements, unless otherwise specified elsewhere.

1. All building works shall be of reinforced concrete framework.
2. All external and internal walls shall be in 230 mm thick fly ash brick masonry or hollow fly ash concrete blocks as per IS-2572. Fly ash bricks shall have designation of 7.5 with cement mortar 1:6.
3. All internal masonry surfaces finish shall have 12 mm thick plain faced cement plaster in cement mortar (1:4) with neat cement finish on top. Over this, one coat of primer and two coats of plastic emulsion paint of approved quality and shade shall be provided. Ceiling Plaster shall be 6 mm thick in cement mortar (1:3).
4. All external masonry surfaces and concrete surfaces with rough board finish shall have 15 mm thick sand faced cement plaster in cement mortar 1:3. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.
5. All buildings shall have texture paint on the external surface as approved by Engineer. The coating in the concrete surfaces (internal, external and external below ground level) shall be done as specified in clause 4.14 of the General Specification.
6. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.
7. The Floor finishing of Plant room of Pump house & sub-station and other area of heavy loads shall be done as per below.

Kota stone with floor topping by MEB (Methyl epoxy blend) system of minimum 1000 microns laid over a prime coat of minimum 200 microns. The coat should be self leveling water based flooring complying to IS 101 (MORTH test).

8. Stairways with 1.5 m width shall be provided to permit access between different levels within buildings. All roof tops and overhead tanks shall be made accessible with ladder provision with hand rails. Vertical ladders fitted with landing point extensions shall be permitted where considered appropriate by the Engineer to access areas not frequently visited. Cast Iron/PVC rungs or steps shall be provided on the inner side walls of all the water retaining structures at 300mm spacing.

9. All floor cut-outs and cable ducts, etc. shall be covered with precast concrete covers in outdoor areas and GI/SMC plates of adequate thickness in indoor areas. All uncovered openings shall be protected with SS 304 hand railing.

10. All staircases shall be provided with Stainless Steel 304 hand railing for protection. All the platforms shall be provided with stainless steel hand railing.

11. The reinforced concrete roofs shall have waterproofing in brick bat coba on top as per the specifications of an approved specialist waterproofing company. Finished roof surface shall have adequate slope to drain quickly the rain water to R.W. down take inlet points.Crazy ceramic tile flooring shall be provided over the brick bat coba.

12. For roofing drainage, cast iron rainwater shall downtake with C.I/uPVC. Bell mouth and C.I./uPVC grating at top shall be provided. For roof areas up to 40 sq.m minimum two nos. 100 mm diameter downtake pipes shall be provided. For every additional area of 40 sqm or part thereof, at least one no. 100 mm dia. downtake pipe shall be provided.

13. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rain water.

14. Building plinth shall be minimum 450 mm above average finished ground level around building.

15. All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rain water splashing into the building. Chajja projection of minimum 750 mm for rolling shutters, 600 mm for doors and 450 mm for windows shall be provided to prevent the rain water splashing into the building. Chajja shall be projected 150 mm on either side from size of doors/windows/rolling shutters.

16. All windows and ventilators shall have 25 mm thick Granite stone sills bedded in cement mortar (1:3).

    Windows and ventilators shall be made of aluminium confirming to latest version of IS: 1948. All fixtures for doors, windows and ventilators shall also be of stainless steel and shall be provided as per IS specifications. Aluminium grills shall be provided in all the windows. Doors shall be in two panel and both panels shall be glazed/unglazed. All openable areas of Filter house shall be provided bird preventing aluminiumjalis and all doors shall be provided with automatic door closure.

17. Ventilator shall also be provided where height of floor is more than 3m. All windows and ventilators shall have SS wire mesh. Frame of doors, windows and ventilators shall be of aluminium of standard rolled section. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of Engineer. The minimum size shall be as per below:

    Door of opening size 1.2m x 2.1m
    Door of opening size 0.75m x 2.1m for toilets
    Glazed windows of minimum size 1.2m x 1.2m
    Ventilators of minimum size 0.6m x 0.6m

18. Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 3.5m wide x 3.5m high. Rolling shutter shall be provided wherever required.

19. All structural steel members shall be painted with two coats of enamel paint over one shop and one field coat of red oxide zinc chrome primer.

20. Kerbs to be provided below the hand railing on the catwalks/pathways shall be as per relevant sections of Factory Act.

21. All concrete channels and ducts to be used for conveying liquid shall have type U finish on the floor. The floor of the channels shall be finished smooth with screed concrete of thickness varying from 25mm to 100mm. All channels open to sky or with chequered plate covering shall be provided with SS handrailings.

22. Suitably designed forced ventilation arrangement shall be provided for underground structures and chlorine house.

23. Parapet wall of 500 mm high & 230 mm thick brick wall shall be provided for inaccessible roof and Parapet wall of 1000 mm high & 230 mm thick brick wall shall be provided for accessible roofs.

24. All the walkways shall have minimum 1.0 m width and shall be provided with chequered tiles of minimum 22 mm thick at top.

25. PVC encapsulated MS rungs shall be provided for access to the tanks, pits, sump, manholes etc.

26. The ground floor of pump house and all other such structures shall generally be made of 200 mm thick concrete grade slab on 230 mm thick rubble soling.

27. All non accessible roof tops of buildings and pump houses shall be provided with Cat ladder made of Stainless steel.

28. RCC staircases shall be minimum 1200 mm wide and maximum number of steps between two landings shall be 12. The size of tread and rise shall be 250 mm and 175 mm respectively.

29. Doors and frames shall be of uPVC as per IS-15931. Windows and ventilators shall be of Aluminium as per the relevant Indian standards. Doors, windows and ventilators as approved by Enginer shall be provided in all the buildings.

30. Hand railings shall be made up of Stainless Steel 304 confirming to ASTM A-240M. Height of railing not less than 1100mm.The distance between 2 vertical posts shall not be more than 1.5 metres. Mechanical properties of stainless steel Grade-304 shall be as follows:

| Grade | Tensile Strength (MPa) min | Yield Strength 0.2% proof (MPa) min | Elongation (% in 50 mm) min | Hard Ness | |
|---|---|---|---|---|---|
| | | | | Rockwell B (HR B) Max | Brinell (HB) Max. |
| 304 | 515 | 205 | 40 | 92 | 201 |

### 10.1.9 Rain Water Pipe

For roofing drainage, uPVC rainwater down takes with bell mouth and grating at top shall be provided. For roof areas up to 40sq.m minimum one no. 100 mm diameter down take pipes shall be provided. For every additional area of 40 sq.m.or part thereof, at least one no.100 mm dia. down take pipe shall be provided.

### 10.1.10 Cable and Pipe Work Trenches

Cable and pipe work trenches shall preferably be constructed in R.C.C. However, 500mm x 500mm size or smaller trenches, not resting on filled-up soil shall be constructed in 350mm thick brick masonry (1:4). The trenches shall be plastered internally in cement mortar (1:4) and externally in cement mortar (1:3).

Layout of trenches outside the buildings shall allow space for construction of future possible trenches where necessary with due consideration of planning for future developments. This aspect shall be brought to the notice of the Engineer while planning the works.

### 10.1.11 Water Supply and Sanitary pipes and plumbing installations in Buildings

In general, the entire piping and plumbing system shall be made of dual piping system, one shall carry the potable water and another reclaimed/reuse water. The reclaimed water shall be used for toilet flushing inside the building and may be for landscaping/horticulture purposes outside the building. The potable water piping system shall connect to the kitchen, sinks, showers, bathtubs and such other purposes that will come in contct with the human bodies. The roof top storage tanks shall also be installed separately for both the piping systems.

### 10.1.12 Storm Water Drainage

Storm water drains adjacent to the existing and proposed roads shall be sized for proper rainfall intensity, allowing for 100% runoff. Drains adjacent to roads shall be in RCC. Minimum Thickness of wall shall be 150 mm and slab thickness shall be 200 mm. Minimum size of drain shall be 300mmx300mm. The storm water disposal shall be inside the existing drain.

### 10.1.13 Aesthetic view and Landscaping

All the buildings should have aesthetically pleasant look and the buildings should be harmonious to each other. Bidder shall provide landscaping design for the entire complex considering requirements of the project's various units, interconnecting system, roads and pathways.

Large spaces particularly below the trees grove shall be planted with ground covers to provide aesthetics, to hide the barren soil which otherwise shall not be planted with grass or other shrubs control erosion of soil and to slow down the surface run-off effectively.

### 10.1.14 Landscaping

Landscapping work shall be done as per following and CPWD specifications. Contractor has to provide plants and lawn as per the Engineers approval.

### 10.1.15 Proposed methodology for Rehabiliation of Under ground reservoir:

Rehabilitation of UGR includes following works

(a) Replacement of corroded reinforcement: Zink Rich primer shall be provided for corroded reinforcement.
(b) Patch Repairs: Whereever there is corrosion of reinforcement & concrete is peeled off, repair shall be done using patch repair dual shrinkage companseted mortar.
(c) Shotcreting: once patch repair work is done, shotcreting of minimum 50 mm thicknee shall be done over wall & roof slab.
(d) Epoxy Coating: Once shotcreting shall be done, Epoxy coating of 400 micron thickness shall be provided.
(e) Wherever there is any leakage or dampness in the wall, injection grouting shall be provided.

### 10.1.15.1 Zinc Rich Primer

#### A) Application Areas

Product application is done where reinforcement is corroded and need to protect reinforcement against further corrosion.

If reinforcement bars dia have reduced >40% - Recommend a rebar application.

If reinforcement bars dia have reduced < 40% - Application of Zinc rich primer shall be done as per below details.

#### B) Item Description

Providing and applying Zinc rich primer over dry substrate free from dust. Providing and Applying anti-corrosive treatment to the exposed steel bars as well as the new bars after surface preparation as given above using two component, zinc rich epoxy primer with zinc content > 84%, Product shall meet the requirement of BS 4652 Type 2

**C) Technical Specifications**

**Key performance properties of the specified product**

| Sr No | Parameter | Results |
|---|---|---|
| i. | Volume Solid % | 57+- 3 |
| ii | Pot life | 120 mins |
| iii | Total Zinc content in dry film | >84% |

Application shall be done as per manufacturer specifications as approved by Engineer.

**D) Method of Application**

**STEP 1: Cleaning and Surface preparation**

Locate all location where spalling of concrete is happening. Hacking of concrete to expose reinforcement going 20mm beyond reinforcement. Remove all traces of corrosion by grit blasting/wire brushed/ sand paper as per site requirement. Cleaning of substrate with air/ water jetting are required to ensure loose concrete/particles to be removed.

**STEP 2: Primer Application:**

Providing and applying Zinc rich primer over dry substrate free from dust. Providing and applying anti-corrosive treatment to the exposed steel bars. Applying Zinc rich primer over dry substrate free from dust. Providing and Applying anti-corrosive treatment to the exposed steel bars.

**10.1.15.2 Dual Shrinkage Compensated Patch Repair Mortar**

**A) Application Areas**

Floors, columns, beams, walls and slab bottom shall be treated with 25mm average thick patch repair mortar. Application thickness shall be 12-50mm. Over the existing RCC at any point thickness shall not be less than 20mm at any point.

**B) Item Description**

Providing and repairing the distressed concrete in patches using single component, dual shrinkage compensated, fibre reinforced, thixotropic cementitious mortar containing PAN based fibers, tested for hardening shrinkage as per Coutinho ring test and achieves a minimum compressive strength of 15 MPa in 1day, 25 MPa at 3 days, 35 MPa in 7days and 45 MPa in 28days when tested as per ASTM C109 and capable of applying 50mm thickness in single layer initially by hand and final layer troweled in flush with existing surface using trowel inclusive of Manpower, Material and Equipment.

(Minimum thickness 15mm single layer upto 50mm, to increase further thickness can be done after 3 hours to achieve required thickness.)

**C) Technical Specification**

**Key performance properties of the specified product**

| Sr **No** | **Parameter** | **Test Method** | **Results** |
|---|---|---|---|
| i. | Compressive strength<br>1day<br>3 days<br>7 days<br>28 days | ASTM C 109 7cm cube | 15 MPa<br>25 Mpa<br>35 Mpa<br>45 MPa |
| ii | Shrinkage compensated | | Dual shrinkage compensated |

Application shall be done as per manufacturer specifications as approved by Engineer.

### 10.1.15.3 Water Tight Injection Grouting

**A) Application Area**

Damp walls, leakages

**B) Item Description & Methodology**

Fill the tank for 3 days. Mark the leaking or damp areas.

Providing and injecting 3 component water hydroswelling Vinyl ester metha acrylate based injection grouting or equivalent over dampness affected areas of walls. Such areas shall be treated by applying NRV parckers at every 250mm in staggered manner. The injection resin shall be low viscous and deep penetrative with density > 1.05kg/lit.

### 10.1.15.4 Waterproofing of Top Slab of Water Tank

**A) Item Description**

Solvent free, two component, high performance hybrid polyurea based protective coating at 1.5mm DFT shall be applied on the positive side of the base and walls of tanks/ swimming pools/water bodies for long term protection of concrete & masonry from aggressive atmospheric gases such as, carbon dioxide, sulphur dioxide and chloride ions. The mixed product should have 99% Solids Content as per ASTM D 2697, Tensile Strength more than 14 Mpa as per DIN DIN 53504, and Elongation of > 500% as per Din 53504. Protection system shall be fast curing- Sets in 30 seconds, seamless, food grade and resistance to wide range of chemicals.

Two Component spray applied Polyurea system consist of the following components as per sequence of application:

1] Mother Slab - Surface preparation, grinding the substrate treatment of pipe penetrations, cracks treatment, coving,

2] Primer - Moisture Insensitive epoxy primer for concrete

3] Sand Board Casting - Graded Quartz Sand

4] Waterproofing membrane - Spray applied two component polyurethane waterproof membrane

**Total thickness of system - Average 1.5 mm avg thickness**

5] Protection Minimum 50mm thick M 20 grade screed

**Performance properties**

| | | **Standard / test method** | **Value** |
|---|---|---|---|
| | **Solvent free, two component, high performance polyurea** | | |
| **1** | Shore A hardness | DIN 53505 | >85 |
| **2** | Tensile strength | DIN 53504 | 16 N/mm$^2$ |
| **3** | Elongation | DIN 53504 | >500% |
| **4** | Tear strength | ASTM D624 | >70 kg/cm |

**Application shall be done as per manufacturer specification as approved by Engineer.**

### 10.1.16 Proposed methodology for construction of UGR:

Existing water supply system needs to continue during the rehabilitation/construction of UGR hence two construction methodologies shall be proposed and construction methodology shall be selected as per the required capacity of proposed UGR & water demand. However contractor can propose for any other suitable method for construction of UGR considereing the requirement of maintaining water supply.

Method-1: Construction of UGR without dismantling of existing peripheral walls

Method-2: Construction of UGR with dismantling of existing peripheral walls

#### 10.1.16.1 Method-1: Construction of UGR without dismantling of existing peripheral walls:

In Most of the UGRs, there are two compartments, hence construction/rehabilitation of one compartment will be taken at a time and other partition will be utilized for supply. Hence piping arrangement (Inlet and outlet) of the compartment shall be done accordingly. However in case of only one compartment in any UGR, separate design methodology shall be given as per the available options.

After making the piping arrangement, dismantling of one of the compartment shall start. This will start with the dismantling of roof slab followed by dismantling of inner walls/columns. Exterior walls will not be dismantled and this will be used as formwork for the new RCC Walls.

Existing foundation has to be used as base of the proposed UGR foundation and footing of the new UGR has proposed to be constructed on existing foundation hence height of the proposed reservoir may be increased at certain location to get the required capacity of the reservoir. Water depth shall be decsigned as per functional requirement.

New RCC Walls shall be designed as propped cantilever wall with top hinged and bottom fixed. It will be designed for conditions mentioned below.

a. Water Pressure acting on the walls.

b. Soil Load acting on the wall from outside. The lateral soil coefficient shall be taken as 0.2.

1. Inside the reservoir, column along with foundation shall be constructed. Foundation of the walls and columns shall be resting on the existing foundation of the reservoir. Bearing capacity of the foundation can be assumed as 15 T/Sqm. However contractor shall be required to carry out soil investigation to verify the soil bearing capacity.
2. RCC Column, Beam and roof slab or column with flat slab shall be provided at the top of reservoir.
3. Intermediate walls shall be designed for full water load.
4. Epoxy coating of appropriate thickness shall be provided over the Walls, Columns, Beam and bottom of roof Slab.
5. Water Proofing shall be provided over the roof slab.

Structural design as well as construction drawings shall be submitted by contractor to DJB for approval.

**10.1.16.2 Method-2: Construction of UGR with dismantling of existing peripheral walls:**

If the capacity of the UGR with option-1 is less than the required capacity and Wherever two or more compartments exists in the UGR, existing peripheral wall along with the pitching needs to be dismantled and new reservoir shall be constructed. Required capacity can also be achieved by increasing the height of the reservoir. Height shall be increased upto such limit that energy consumption shall not be affected. Common wall between two compartments shall also be dismantled after completion of the construction of one compartment. Once one compartment is completely in operational condition then other compartment of the reservoir shall be dismantled. Foundation of the existing reservoir is not required to be dismantled. The foundation shall be provided over the existing foundation after providing a layer of PCC.

# Technical Specifications

# C2. Plant Materials and Workmanship

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## SUB-SECTION 1. MECHANICAL & ELECTRICAL DESIGN REQUIREMENTS

### 1.1 Introduction

This part of the Specification sets out the minimum standards of materials, workmanship and design to be used by the Contractor and reference to any specific material or equipment does not necessarily imply that such material or equipment is included in the Works.

All component parts of the Works shall, unless otherwise specified, comply with the provisions of this Chapter or be subject to the approval of the Engineer.

### 1.2 Standard specifications

All the Works under the Contract shall be carried out in accordance with the relevant quality standards, test procedures or codes of practice, collectively referred to as Reference Standards. Except where otherwise specified, all Plants, Equipment, Materials and Workmanship shall comply with the requirements of the relevant Indian Standards (hereinafter referred to as IS) issued by the Bureau of Indian Standards. If no standard is specified, the relevant Indian Standard or, in the absence of such standard, international standard shall apply. All Standards used shall be the current (latest updated) version.

Keeping in view of International Competitive Bidding (ICB) Contract and the JICA's Guidelines to use the recognized International Standards, extensive reference of British Standards (BS) is provided in the specifications for the easy and proper understanding of the Bidder on the nature and quality of the work. However, any material, methodology or workmanship prescribed herein in accordance with any International or other country's Standards may be substituted by the equivalent Indian Standards, if available, under the approval of the Engineer.

The Contractor may be asked to make copies of relevant standards available to the Engineer or the Engineer's Representative, together with, if necessary, English translations. He shall provide these as requested for prior assessment and for use during inspection and testing.

Reference is made in this section to the Standards listed below.

| | |
|---|---|
| ISO 10816-1:1995 | Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts. General guidelines. |
| BS EN 352-1:2002 | Hearing protectors. Safety requirements and testing. Ear-muffs. |
| BS EN 681-1:1996 | Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber. |
| BS EN 681-2:2000 | Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers. |
| BS EN 729-1:1995 | Quality requirements for welding. Fusion welding of metallic materials. Guidelines for selection and use. |
| BS EN 971-1:1996 | Paints and varnishes. Terms and definitions for coating materials. General terms. |
| BS EN 1092-1:2002 | Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges. |
| BS EN 1515-1:2000 | Flanges and their joints. Bolting. Selection of bolting. |

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| BS EN 1561:1997 | Founding. Grey cast irons. |
| BS EN 1563:1997 | Founding. Spheroidal graphite cast iron. |
| BS EN 1982:1999 | Copper and copper alloys. Ingots and castings. |
| BS EN 10029:1991 | Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above. |
| BS EN 10051:1992 | Specification for continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels. Tolerances on dimensions and shape. |
| BS EN 10297-1:2003 | Seamless circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Non-alloy and alloy steel tubes. |
| BS EN 12540:2000 | Corrosion protection of metals. Electro deposited coatings of nickel, nickel plus chromium, copper plus nickel and copper plus nickel plus chromium. |
| BS 1486 | Lubricating nipples. |
| BS 1710:1984 | Specification for identification of pipelines and services. |
| BS 3100:1991 | Specification for steel castings for general engineering purposes. |
| BS 3643-1&2:1981 | ISO metric screw threads. |
| BS 3692:2001 | ISO metric precision hexagon bolts, screws and nuts. Specification. |
| BS 4190:2001 | ISO metric black hexagon bolts, screws and nuts. Specification. |
| BS 4395-1&2:1969 | Specification for high strength friction grip bolts and associated nuts and washers for structural engineering. |
| BS 4800:1989 | Schedule of paint colours for building purposes. |
| BS 4871-3:1985 | Specification for approval testing of welders working to approved welding procedures. Arc welding of tube to tube-plate joints in metallic materials. |
| BS 4872-1:1982 | Specification for approval testing of welders when welding procedure approval is not required. Fusion welding of steel. |
| BS 4872-2:1976 | Specification for approval testing of welders when welding procedure approval is not required. TIG or MIG welding of aluminium and its alloys. |
| BS 4921:1988 | Specification for sherardized coatings on iron or steel. |
| BS 4933:1973 | Specification for ISO metric black cup and countersunk head bolts and screws with hexagon nuts. |
| BS 5252:1976 | Framework for colour co-ordination for building purposes. |
| BS 5493:1977 | Code of practice for protective coating of iron and steel structures against corrosion. |
| BS 5499-5:2002 | Graphical symbols and signs. Safety signs, including fire safety signs. Signs with specific safety meanings. |
| BS 7079 | Preparation of steel substrates before application of paints and related products. All parts thereof. |
| BS 7668:1994 | Specification for weldable structural steels. Hot finished structural hollow sections in weather resistant steels. |

## 1.3 Plant design and life

The Works as a whole shall be new, of sound workmanship and robustly designed for a long, reliable operating life and shall be capable of continuous operation for prolonged periods in the climatic and working conditions prevailing at the Site, with the minimum of maintenance.

The design shall take account of temperature changes, the stability of paint finish for high temperatures, the rating of engines, electrical machinery, thermal-overload services, cooling systems and the choice of lubricants for possible high and prolonged operating temperatures. The Contractor shall be called upon to demonstrate this for any component part, either by service records or evidence of similar equipment already installed elsewhere or relevant type tests.

The Plant shall be designed to provide protection against damage by the entry of vermin and dust, and to minimise fire risk and consequent fire damage. It shall be protected against damage due to dampness and condensation. Plant shall operate without undue vibration, and parts shall be designed to withstand the maximum stresses under the most severe conditions of service. Materials shall have a high resistance to change in their properties due to the passage of time or any cause which may have a detrimental effect upon the performance or life of the Works.

All manually-controlled Plant located outside a building shall be tamperproof. This is in addition to any requirements of the Specification for securing Plant under operational conditions.

All component parts of the Plant shall be manufactured to be interchangeable with the component parts of similar Plant.

The Plant shall be designed to have a high resistance to change in its operating characteristics due to passage of time or any other which may affect the performance or life of the Works. The Contractor may be called upon to demonstrate this for any component part either by service records of similar equipment, or by the records of extensive type tests.

Materials shall be selected taking into consideration their location and duty. For Plant in contact with water, the risk of electrolytic reaction between differing materials of construction and to the effects of corrosion and erosion shall be taken into account.

The plant shall be designed to provide easy access for replacement of component parts which are subject to wear, without the need to replace whole units. Except for consumable items requiring frequent replacement, no part subject to wear shall have a life from new to replacement or repair of less than five years. Where major dismantling is unavoidable to replace a part, the life shall not be less than ten years.

## 1.4 Substances and products

Substances and products used in the Works which may be in contact with water which is to be supplied for drinking, washing or cooking shall not contain any matter which could impart taste, odour, colour or toxicity to the water or otherwise be objectionable on health grounds.

All substances and products so used shall meet the requirements of relevant regulations and standards.

## 1.5 Workmanship

Workmanship and the general finish of plant installations shall be of first-class commercial

quality and in accordance with the best workshop practice, and shall be performed by persons skilled in their respective trades.

Pipework, fittings, cables, cable trays and the like shall be fitted in a neat, straight and symmetrical manner so as to present a pleasing appearance.

Indicating gauges fitted to machine assemblies or control panels shall generally be of similar style and grouped together.

External welds and flame cuts shall be finished smoothly by grinding.

Chequer plate coverings shall be fixed squarely in their frames with their patterns properly aligned. Hand railings shall be free from burrs.

## 1.6 Welding

Where welds may be highly stressed, the Contractor shall supply to the Engineer before welding starts detailed drawings of all weld preparations and procedures proposed. No welding shall be carried out before the Engineer has approved the procedures. No alteration shall be made to any previously-approved procedures without prior approval of the Engineer. Welders shall be qualified in accordance with the requirements of the appropriate section of BS 4871-3:1985, BS 4872-1:1982 and BS 4872-2:1976.

## 1.7 Castings

The structure of castings shall be homogeneous and free from non-metallic inclusions and other defects. Surfaces of castings which are not machined shall be carefully fettled to remove all foundry irregularities.

Minor defects which do not exceed 10mm in depth or 10% of the total metal thickness (whichever is less) and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Engineer shall be notified of larger defects and no repair welding of such defects shall be done without his prior approval.

If the removal of metal for repair should reduce the stress-resisting cross-section of the casting by more than 25%, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25%, then the casting will be rejected.

Castings repaired by welding for major defects shall be stress-relieved after such welding, or as otherwise instructed by the Engineer.

Non-destructive tests may be required for any casting containing defects whose effect cannot otherwise be established, or to determine that repair welds have been properly made.

## 1.8 Forgings

Major stress-bearing forgings shall be made to a standard specification which shall be submitted to the Engineer for approval before work begins. They shall be subject to internal

examination and non-destructive tests for the detection of flaws and shall be heat-treated for the relief of residual stress. The name of the maker and particulars of the heat treatment proposed for each major forging shall be submitted to the Engineer.

### 1.9 Non-metallic materials

The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated with a fungicide. Sleeving and fabrics treated with linseed oil varnish are not acceptable.

The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or similar hardwood which is resistant to fungal decay and other blemishes. All woodwork shall be treated to protect it against damage by any cause. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings on wood shall be non-ferrous. Adhesives shall be impervious to moisture and fungus growth. Only synthetic resin cement shall be used for joining wood.

### 1.10 Nuts, bolts, studs and washers

Nuts and bolts for pressure fittings shall be of high-quality steel, machined on the shank and under the head and nut. Bolts shall be dimensioned, so that, only one to three threads shall show through the nut when in the fully-tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy. These shall have the screwed portion of a diameter that will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt.

When there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material.

All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel or brass.

Bolts, nuts, screws and washers which may be submerged in a corrosive liquid shall be stainless steel.

The Contractor shall supply all holding-down, alignment and levelling bolts complete with anchorages, nuts, washers and packings required to attach the Plant to its foundation. The Contractor shall also supply all bedplates, frames and other structural parts necessary to spread the loads transmitted by the Plant to concrete foundations without exceeding the design stresses.

Isometric black hexagonal bolts, nuts and screws shall comply with BS 4190:2001 strength

grade 4.6.

Isometric precision hexagonal bolts, nuts and screws shall comply with BS 3692:2001 strength grade 8.8.

High-strength friction-grip bolts, nuts and washers shall comply with BS 4395-1&2:1969.

Black cup and countersunk head bolts and screws with nuts shall comply with BS 4933:1973.

Stainless steel nuts, screws, washers and bolts shall be manufactured from Grade 316S31 steel complying with BS 10250-4:2000 or BS 1515-1:2000.

Bolting for pipes and fittings shall comply with the relevant provisions of BS EN 1515-1:2000 except that spheroidal graphite iron bolts for use with ductile iron pipes and fittings shall be manufactured from metal complying with the provisions of BS EN 1563:1997 for grade 500/7.

## 1.11 Threads

All threads shall be of preferred metric sizes with the standard coarse form of medium fit to BS 3643-1&2:1982 except for special applications, for which the metric fine thread or other thread forms may be utilised, subject to the approval of the Engineer.

## 1.12 Guards for moving parts

All moving parts shall be protected by safety guards.

Guards shall be rigid, securely fixed and designed to allow normal operation, running maintenance and routine inspection on equipment without the need to remove the guard. Where this is impractical, guards shall be designed for easy fixing, dismantling and re-assembly.

## 1.13 Safeguarding of plant

The Contractor shall ensure that the whole of the Works as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise-suppression devices, written notices, safety colours and the like shall be provided where necessary during erection and permanently.

Plant layout shall provide easy and safe access to all operating devices, free from hazardous obstructions.

Nothing in this Specification shall remove the Contractor's obligation from drawing the attention of the Engineer to any feature of the Works which is not consistent with safety, or prevent him making proposals for incorporating equipment or designs which would increase the safety of the Plant.

## 1.14 Rating plates, name plates and labels

The Contractor shall ensure that each main and auxiliary item of Plant and equipment shall have permanently attached to it in a conspicuous position a nameplate and rating plate. Upon these shall be engraved the manufacturer's name, type and serial number of plant, details of the loading and duty at which the item of Plant has been designed to operate, and such diagrams as are deemed necessary. All indicating and operating devices shall have securely attached to them or marked upon them designations of their function and proper use. Provision shall be made to incorporate descriptive numbering codes as indicated on the layout drawings.

All valves shall have an identification plate bearing the valve number and a short description of valve function.

On major items of plant and valves, details of proposed plates, labels and inscriptions shall be provided by the Contractor for approval by the Engineer.

Nameplates, rating plates and labels shall be of a non-flame-propagating material, either non-hygroscopic or transparent plastic, with engraved lettering of a contrasting colour. Fixing shall be by means of non-corrodible screws.

Warning labels shall be provided where necessary to warn of dangerous circumstances or substances. Inscriptions or graphic symbols shall be black on a yellow background and to internationally recognised standards.

Instruction labels shall be provided where safety procedures (such as the wearing of protective clothing) are essential to protect personnel from hazardous or potentially-hazardous conditions. These labels shall have inscriptions or graphic symbols in white on a blue background.

## 1.15 Lubrication

### (a) General:

Plant shall be lubricated, as necessary to ensure smooth operation, heat removal and freedom from undue wear. Lubricated items shall be designed so that they do not require more than weekly lubrication, unless otherwise approved by the Engineer.

All grease nipples, oil cups and dip sticks shall be readily accessible, being piped where necessary to a convenient position.

The Contractor shall supply the first fill of oil and grease for Plant and maintenance equipment. The Contractor shall also provide the Employer with enough consumables for all equipment for the stipulated period as mentioned elsewhere in the specification.

A complete schedule of recommended oils and other lubricants shall be provided by the Contractor as part of the operating and maintenance manuals. The number of different types of lubricants shall be kept to a minimum. For grease-lubricated ball and roller bearings, lithium-based grease is preferred.

**(b) Oil lubrication:**

Gear boxes and oil baths shall be provided with adequately filling and draining plugs and oil level indication. Roller chain drives shall have oil-bath lubrication.

Drain points shall be positioned so that an adequately sized container can be placed beneath them. Where a large quantity of oil is involved or drainage to a container difficult, a drain valve and plug shall be provided at the point of discharge.

Bearings equipped with forced-feed oil lubrication shall be automatically charged prior to machinery starting up, and pressure monitored during operation with automatic shutdown of machinery and alarm on low oil pressure.

All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of water. Oil filling and drain points shall be arranged to avoid the risk of contamination of water by accidental spillage.

Access, without the use of portable ladders, to lubrication systems shall permit maintenance, draining and re-filling, without contamination of the charged lubricant.

The design of breathers shall take into account the conditions at the vent point, and include measures to prevent contamination of the lubricant.

**(c) Grease lubrication:**

Grease application shall be by steel lubrication nipples manufactured in accordance with BS 1486.

Anti-friction bearings requiring infrequent charging shall be fitted with hydraulic type nipples.

Plain bearings requiring frequent charging shall be fitted with button-head pattern nipples.

A separate nipple shall be provided to serve each lubrication point. Where a number of nipples supply remote lubricating points they shall be grouped together on a conveniently placed battery plate, with spacing in accordance with the recommendations of BS 1486-1:1959, Tables 9 and 10.

The Contractor shall provide a grease gun for each size and type of nipple installed. Where different types of grease are involved, separate grease guns shall be provided for each type. They shall be suitably labelled and, if possible, be of different styles to prevent incorrect greasing.

## 1.16 Gaskets and joint rings

Joint rings shall be manufactured to conform to BS EN 681-1:1996 and BS EN 681-2:2000. They shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80°C or greater, to suit the application.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used for rubber rings and these lubricants shall not contain any constituent soluble in the fluid conveyed. They shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

Graphite grease or similar shall be applied to the threads of bolts before joints are made.

## 1.17 Electroplating, galvanising and sherardizing

Parts to be galvanised, other than nuts, bolts and fasteners, shall be hot-dip galvanised to BS EN 729-1:1995, and associated parts thereof, to give a minimum average coating of 610g/m² of area covered and a zinc thickness of not less than 85 microns.

Where specified, nuts, bolts and fasteners to be galvanised shall be hot-dip galvanised to BS EN 729-1:1995 to give a minimum average coating of 305g/m² and a zinc thickness of not less than 43 microns. Where hot-dip galvanising is not practicable, nuts, bolts and fasteners shall be sherardized. Sherardizing shall be in accordance with BS 4921:1988, the thickness of zinc coating shall be not less than 30 microns.

Where chromium plating is used, it shall comply with the requirements of BS EN 12540:2000 including the following provisions:

- no blistering of any surfaces will be accepted;
- where the base metal is steel, plating shall be applied in accordance with Table 2;
- for all base metals, the service condition number 2 shall be used.

## 1.18 Noise

Except as provided for below, the noise emitted by any single item of Plant shall not exceed a sound pressure level of 85dB (A) when measured at a distance of 1m from the reference surface of that item in any direction and under the environmental conditions appropriate to the test requirements of ISO 3746 'Acoustic determination of sound power levels of noise services - survey methods' or the equivalent ANSI S12 36 - 1990 (R1997).

The Contractor shall be responsible for all noise tests on site. Sound pressure levels shall be measured in dB (A) using a calibrated sound meter with its response speed set to 'slow'.

For major items of Plant, the Contractor shall provide certificates from the manufacturer covering noise-level tests on the items or type test certificates for similar items of Plant.

If any item of Plant does not comply with the above requirement, the Contractor shall reduce the sound pressure level by providing improved or additional silencers or fitting sound-insulating materials until the requirement is met.

Plant such as compressors, blowers and the like, where reduction in noise to below 85dB (A),

shall be installed in separate rooms constructed in or containing sound-absorbing material. The noise level shall not exceed 75dB (A) when measured 1m from the outside of the room or structure. The Contractor shall provide hazard warning notices at the entrance to the room indicating that ear defenders must be worn. The Contractor shall provide a minimum of three pairs of ear defenders to BS EN 352-1:2002 which shall be stored in a dust-proof locker.

The background noise level at any point along the boundary of the site, arising from operation of plant shall not exceed 65dB (A).

No item shall have a sound level exceeding 85dB (A) at 1m distance unless that item and its actual sound pressure level is included in the Schedules of leading particulars, which form part of the Contract and is approved.

## 1.19 Vibration

All rotating elements shall be dynamically balanced so that the level of vibration at any point on any Plant item when operating at Site, either singly or with other Plant, and at any speed throughout the operating range, shall be within the limits of Class IV, grade B, as defined in ISO 10816-1:1995.

Pipework, valves and other connected equipment, or forming part of the operating system, shall be provided with adequate supports, brackets and fixtures, as necessary, to restrict any induced vibration to a minimum, under any operating condition.

Vibration measurements shall be taken on site by the Contractor at various points on each complete machine as defined above.

Measurements shall also be taken on connecting plant. If any item is found to be vibrating beyond the level considered by the Engineer to be a reasonable minimum, the Contractor shall reduce the vibrations to the required level.

## 1.20 Access steelwork

The Contractor shall provide adequate access to all Plant items to which access is necessary for routine maintenance and operation by means of ladders, platforms, covers and handrails to be supplied and fixed under this Contract.

Any small areas of chequer plating or other covering needed to cover gaps between items of Plant and the surrounding structure, and any access ladders, platforms and handrails that must be attached to items of Plant to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

All Handrails for structures and equipment shall consist of Stainless Steel of suitable grade.

## 1.21 Machinery, lifting and dismantling

Machinery bedplate design, packing and fixing shall minimise distortion and vibration.

Aligned machinery shall be mounted on bedplate or sole plates, permitting removal and reinstatement without a requirement to re-grout. Bedplates shall incorporate fine adjustment of the vertical and horizontal alignment between driver and driven Plant.

All machinery shall be fitted with lifting facilities. Large structures shall be provided with jacking points.

For Plant subject to frequent dismantling, tapped holes or other provision shall be made in all main castings, for the insertion of jacking screws or the fixing of drawing gear. Bolts or studs shall be used in preference to set screws.

## 1.22 Seals

### (a) General

The Contractor shall select a seal, compatible with his Plant and best suited for the worst conditions likely to be met when the Plant is in operation.

All seal materials shall be compatible with the fluid (including gases) being handled. For potable water, seal materials shall be subject to approval.

### (b) Soft-packed glands

Shafts shall be provided with renewable gland sleeves. Glands subject to abrasive liquids or negative pressures shall include lantern rings and a clean water continuous flushing system.

Gland adjustment nuts shall be readily accessible.

Gland drain pipework shall be provided, discharging to the nearest sump or drainage channel.

### (c) Mechanical seals

Mechanical seals which are subject to abrasive or corrosive fluids (including gases) or negative pressures shall be provided with a clean water gland flushing system. A back-to-back sealing arrangement with a flushing/cooling system will be accepted as satisfying the requirements of this clause.

## 1.23 Bearings

The Contractor shall select the most appropriate type of bearing for the Plant being supplied.

Single journal plain bearings shall be phosphor bronze or synthetic lubrication impregnated bushes with carbon or stainless steel journals respectively. Synthetic bearings shall be used only where bearing condition can be inspected readily.

Plain-type bearings shall be self-lubricating either by grease, forced oil or impregnation.

Ball and roller type bearings shall be adequately lubricated by oil or grease and sealed to prevent leakage of lubricant along the shaft. The dismantling of bearings shall be simple and

free from risk of damage.

Bearings fitted to gearboxes shall have a minimum design life of 100,000 hours at maximum loading.

### 1.24 Gearboxes

Gearboxes shall have a life of 100,000 hours, be selected in accordance with 'American Gearbox Manufacturers' Association recommendation for horsepower and service factor application. They shall employ a standard reduction ratio.

Gearboxes which have to be angle-mounted shall have a rating, choice of bearings, seals and lubrication system designed for such mounting.

Dependence on splash lubrication alone is not acceptable but it may be used in conjunction with a forced-feed method to reach all bearings and gears.

### 1.25 Safety signs

All signs providing health and safety information or instructions shall comply with BS 5499-5:2002 and equivalent local standards.

Signs shall be of durable quality and shall comprise a substrate of 22 gauge aluminium, pre-drilled for fixing and with radiused corners free of burrs or sharp edges. Symbols and lettering shall be screen printed.

### 1.26 Corrosion and erosion

Unless otherwise specified, the Contractor shall make proper provision for the prevention of corrosion and erosion in any part of the Plant. Provision shall include the use of suitable materials, choice of operating speeds, design of components and type of protective coatings and finishes.

### 1.27 Precautions against damp

Special precautions shall be taken to prevent corrosion due to humidity, rainfall and moisture.

All wall-mounted equipment shall be fitted with spacers to provide a minimum gap of 5mm. All holes in equipment shall be effectively sealed against the ingress of water. All items exposed to the weather or water shall be free of water traps; where necessary, drain holes shall be provided to prevent the accumulation of water.

All fixings, fastenings and spacers which may be submerged in a corrosive liquid shall be galvanised or sherardized, unless otherwise specified.

All electrical equipment which is not sealed against free movement of air shall be protected from condensation with anti-condensation heaters. In general, heaters shall be thermostatically-controlled and switched off when enough heat is generated by operation of the Plant.

## SUB-SECTION 2. PAINTING AND PROTECTION

### 2.1 Scope

Protective coatings shall comply with BS EN ISO 12944, Part 1 to 8 and BS EN ISO 14713 or IS 9172. All items of the Plant shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials of the Plants. The thickness of coatings stated in this section of the specification is the minimum allowable thickness. Where the paints that are available do not provide dry-film thickness as specified, additional coatings shall be applied. Protective coatings for surfaces of tanks and other plant in contact with chemicals or otherwise in conditions not foreseen in this section of the specification or in BS EN ISO 12944 shall be suitable for those conditions. They shall be the subject of design submissions supported by evidence proving satisfactory experience of the proposals elsewhere.

Where dissimilar metals are in contact, the Contractor shall provide insulation to prevent electrochemical corrosion.

### 2.2 Surface to be painted

In general following surfaces are to be painted:

(i) All exposed piping and metal surfaces, interior or exterior,
(ii) All submerged metal surfaces.
(iii) All structural and miscellaneous steel, including Tanks,
(iv) The interior of process Tanks, Channels, launders etc.
(v) The interior of structures
(vi) Equipment furnished with and without factory finished surfaces, except as specified below.
(vii) All interior and exterior exposed surfaces of buildings.

### 2.3 Surfaces not to be painted

The following surfaces in general shall not be painted:
(i) Concrete surfaces subject to pedestrian traffic
(ii) Plastic surfaces
(iii) Non-ferrous metal unless otherwise noted or indicated (Galvanized metal shall not be considered a non-ferrous metal)
(iv) Piping which is specified as galvanized.

In no case shall any concrete, wood, metal or any other surface requiring protection be left unpainted even though not specifically defined herein.

### 2.4 Submittals

Material specifications, surfaces preparation and application instructions, and colour sample

cards shall be submitted to the Engineer for approval.

## 2.5 Protective Coating and Painting- General

The protective coating system shall have a minimum 10-year life to first maintenance. A five-year minimum performance warranty shall be given in respect of the paint as applied.

For coatings, exterior conditions shall be assumed to be 'polluted inland' conditions and the interiors of buildings shall be assumed to be 'frequently damp or wet' except for control rooms.

All coatings applied to any part of the plant in contact with water to be used for drinking, washing or cooking shall be non-toxic, non-carcinogenic, shall not impart taste, odour, colour or turbidity to the water or foster microbial growth and shall be approved in the same manner as substances and products in clause 1.4.

No manufacturer's name-plate identification, vented filler plugs in gearboxes or grease nipples shall be painted over.

To avoid the possibility of the presence of carcinogenic poly-aromatic hydrocarbons all bituminous paints and coatings shall be manufactured from petroleum or asphaltic bitumen and not from coal tar bitumen.

Lead based paints shall not be used.

All machined, polished or bright surfaces shall be given suitable protection against corrosion, damage and deterioration.

The Contractor shall ensure that, before despatch from the manufacturer's works and after completion of erection, all plant has received suitable preparation followed by the protection system listed in tables A and B attached.

The Contractor shall liaise closely with the plant manufacturer who shall provide full facilities for him to inspect and check the preparation and painting during all stages. The Contractor shall report on his inspections to the Engineer.

All paint materials shall be stored and applied strictly in accordance with manufacturers' instructions. Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paint shall not be applied under adverse conditions. Air temperatures shall be above 5°C and relative humidity less than 55% or as otherwise specified by the paint manufacturer.

The Contractor shall ensure that, for the materials specified, application conditions are in accordance with the specification and manufacturer's instructions. Paint shall be applied only to surfaces that have been cleaned and prepared in accordance with these instructions.

Where local climatic conditions make the specified requirements difficult to achieve, the

Contractor shall provide temporary protection during painting.

The dry paint-film thickness shall be measured by Elcometer or other approved method.

All manufacturing processes shall be complete prior to galvanising with all erection markings clearly legible afterwards. Surfaces shall be adequately degreased before the applications of any coating, pre-treated with a brush application of etch primer or T washes.

Steel subject to hydrogen embrittlement through galvanising shall not be used.

All iron and steelwork to be painted shall be blast cleaned to all parts. Following blast cleaning, steel surfaces shall be zinc metal sprayed where specified.

Aluminium structures and fittings shall not be painted.

The painting procedure shall be submitted by the contractor in the following format:

(i) Surface Preparation
(ii) Reference Standard
(iii) Conditions of Work
(iv) Type of Materials
(v) Tests and inspection methods and sequence, thickness (DFT)
(vi) Colour in final coat
(vii) Total thickness of coats (DFT)
(viii) Other necessary data and information

## 2.6 Painting at Site

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer's works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast iron parts received at site shall be provided with adequate number of further coats of coal-tar epoxy polyamine coating to a total dry film thickness of 275 microns including the primer coats. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint before application of each coat of epoxy based coal-tar paint giving a total dry film thickness of at least 275 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Engineer, full details of the paints he proposes to use together with colour charts for the gloss finishes.

After erection, such items which are not finish painted shall be finish painted, items finish painted at the Manufacturer's works shall be touched up for any damaged paint work.

## 2.7 Protective Coating

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval.

Protective coating systems shall generally fall into one of the following basic systems:

(i) Protective Coatings;
(ii) Galvanising;
(iii) Galvanising plus painting;
(iv) Multi-coat painting;
(v) Bitumen enamel;
(vi) Others as proposed by the Contractor and approved by the Engineer.

Coating systems and minimum thickness shall be provided as per relevant codes.

## 2.8 Chromium plating and items to be Chromium plated

Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of BS EN 12540 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be bright. Where the base metal is steel, plating shall be applied in accordance with relevant Table of BS EN 12540. Other base metals shall be plated in accordance with relevant Tables of BS EN 12540 as appropriate. For all base metals the service condition table number 2 shall be used.

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipework, oil level gauges and fittings, small bore pipes, valves and fittings, plugs and grease nipples etc., which are sited in architecturally finished areas of the station and selected by the Engineer shall be chromium plated. Damage to chromium plating shall be made good before Taking Over.

External Screws, Bolt heads, Nuts and Washers shall be chromium plated, sherardised or made of stainless steel.

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect. They shall all have chromium plated cases, bezels, cocks and fittings.

## 2.9 Galvanized Parts

All materials to be galvanised shall be shown on the approved drawings or specified. All punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified in the relevant codes. Such parts shall be galvanised not more than four hours after commencement of shot blasting.

All galvanising shall be done by the hot dip-process in accordance with BS EN ISO 1461. Minimum thickness of 120 microns shall be ensured with coating thickness gauge. No alternative process may be used without the approval of the Engineer. No components shall be galvanised which are likely to come into subsequent contact with oil.

The zinc coating shall be uniform, clean smooth and free from spangle as far as possible. In the case of component parts the zinc coating shall weigh not less than 610 g/sq.m of area covered and shall not be less than 120 microns in thickness.

Where hot-dip galvanising is not practicable bolts and nuts shall be sherardized, which shall conform to BS: 4921. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit.

All galvanised parts shall be protected from injury to the zinc coating due to differential seration and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be touched up with approved zinc-dust paint or other approved flake metallic compound as approved by the Engineer.

## 2.10 Fusion-bonded epoxy powder coatings

All fabricated steel pipework and other Plant where specified, shall have a lining and coating, not less than 250 microns thick, of 100% solids, thermosetting fusion-bonded, dry power epoxy coating.

All grit and dust shall be removed and coating shall be started before formation of visible oxidation of the surface. The metal shall be pre-heated to a temperature recommended by the manufacturer and the epoxy powder applied by immersion in a fluidised bed, after which excess powder shall be removed. The powder shall be allowed to flow out completely before curing.

The thickness of the coating, including any repaired areas, shall be checked with a calibrated tester. Spark testing, for pinholes, voids, contamination, cracks and damaged areas, shall use a high-voltage spark generator.

Repairs due to coating imperfections or damage shall be done using a brush-applied compatible two-pack liquid epoxy compound.

The area to be repaired shall be cleaned to remove dirt, grease, scale and damaged coating, which shall be feathered. Pinhole surface preparation is not required other than removal of detrimental contaminants which could impair the adhesion of the repair material.

The surface coating shall be applied by an approved applicator.

## 2.11 Coating system for electrical enclosures

Enclosures shall be given protective coating at the place of manufacture and before installation of any electrical fittings.

Electrical panels, including switchboards, control panels and instrument panels, installed within buildings shall be prepared as follows:-

(i) Thoroughly clean surfaces to remove rust, scale, dirt, loose paint and the like and degrease by the use of solvents which are compatible with the paint finish to be applied. If rust-proof steel has not been used in the construction, the surfaces shall be treated with a passivating agent such as phosphoric acid.

(ii) Internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved priming coat. The final coat shall be an opaque gloss white enamel.

(iii) External surfaces shall have a minimum of five coats of paint of which the first shall

be an approved priming coat, the second and third a suitable undercoat, all of which shall be rubbed smooth when dry before application of the next coat. The colour of undercoat paints shall be different from priming and finishing coats.

(iv) The final coats shall be of stove enamel paint to a finish and colour as Engineer's Requirements. The dry-film thickness shall be not less than 100 microns.

Electrical panels which are to be installed in exposed positions or in damp conditions shall receive a surface preparation containing zinc prior to application of the primer undercoat and finishing coats.

A 500 ml tin of matching touch-up paint shall be supplied with each panel.

## 2.12 Defects

Defects are defined in BS EN 971-1:1996 'Glossary of paint terms'.

The Contractor shall ensure that all coatings are free from defects and adequate in all respects for the purpose intended.

The painting system shall be deemed to have failed if:-

(a) after painting, damage has been caused by handling, impact, abrasion or welding;
(b) any portion of the paint film separates from any other or the parent metal;
(c) after painting the total dry-film thickness is less than that specified.

Failure shall not include:-

(a) loss of gloss;
(b) variation of shade, not affecting the anti-corrosive properties of the system.

## 2.13 Colour coding

Unless otherwise specified, colour coding for plant, equipment and pipework shall be as per standard practice and the relevant codes. The contractor shall obtain Engineer's approval on this matter. Steel pipes shall be painted and hoses and thermoplastic pipes shall be colour banded in accordance with BS1710. When using colour bands on thermoplastic pipes the Contractor shall ensure that the adhesives used on colour bands do not contain agents which will cause deterioration of the pipes. Colour bands shall be applied on straight lengths of pipes at no more than 3m spacing. Bands shall be applied, at all junctions, both sides of valves, Plant, fittings and wall penetrations.

Finishing coats shall be applied as specified in the relevant code.

Pipeline contents shall be identified by name and the direction of flow by arrows.

Where two or more pipes in a duct or gallery convey the same fluids, each pipe shall display a separate number, with contents named at each point of entry or outlet.

## 2.14 Air pipework

Pipework conveying air shall be identified throughout its length in accordance with BS1710.

For steel pipework, the finish colour of the protective coating system generally shall be the basic identification colour, blue 2O-E-51 to BS 4800. Where this is precluded by use of high temperature paint finishes and/or the application of thermal insulation and cladding, then banding shall be applied in appropriate materials. The banding shall be 150 mm wide and in the same basic identification colour.

For non-steel pipework such as instrument air supply branches, identification shall be by means of banding generally as above except that the width of banding shall be limited to 50 mm.

# Technical Specifications

# C3. Mechanical Works

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## SUB-SECTION 1. PARTICULAR SPECIFICATIONS

### 1.1 Scope and Applicability

This section deals on the particular specification/ requirement for the Mechanical works related to the Plants at BPSs and UGRs which shall be designed, as required, and constructed by the contractor. Further details on the materials, methodology and workmanship are explained elsewhere in the specification as a standard technical specification for the respective works. In case of any differences on the requirement or design criteria, the details furnished under this sub-section shall prevail.

Any materials or workmanship for Mechanical works referred to the International codes and standards (BS, BS EN, EN, ISO, IEC etc.) may be executed by employing equivalent Indian Standards, if available, subject to the approval of Engineer.

### 1.1.1 Design- General

The bidder shall design the plant to be included in the treated water pumping station considering the existing conditions and the future requirements given under this contract. The arrangement shall be generally as shown on the drawings.

The exact total head for treated water pumping plant will depend on head losses in the intake system and delivery pipe work designed by the Contractor, and the final levels chosen by the Contractor at the incoming and on the receiving reservoir location and levels. This therefore cannot be given precisely in this Specification. Figures quoted in this Specification are approximate only and shall be confirmed or amended by the Contractor following the detailed design.

The duty point at which best efficiency is required is at the design head as indicated, is based on the minimum water levels in the treated water reservoir and at the inlet to the balancing reservoir. Pump guaranteed performance required is to be chosen as applying at these levels.

### 1.1.2 Mechanical plants included at BPSs and UGRs

Mechanical plant to be installed at or associated with the BPSs and UGRs shall include:

- Inlet to reservoirs and Outlets from the water storage reservoir, with isolating valves;
- Water pumps, with valves and pipe work including suction and delivery manifolds; delivery main isolating valve;
- Electric overhead travelling crane;
- Ventilation fans;
- Gates at inlet, outlet and partition wall

***The detailed requirements of mechanical works/components at each of the Reservoir sites are given in the Scope of Works under section VI - A.***

## 1.2 Pumps for Treated Water

### 1.2.1 General requirements

The bidder shall design the pipe work and pumping station, and the pump mounting proposals in such a way that the pumps, they provide will operate satisfactorily as specified in all possible operating conditions, including any possible water level with any combination of pumps running. The design and execution shall be carried out in accordance with latest codes and standards.

Water pumps shall be of the horizontal-shaft, split-casing, driven by horizontal directly-coupled induction motors at a speed as specified under relevant Standards.

The system has to be designed for continuous supply i.e 24x7 system of direct distribution. In view of this, and to meet with fluctuating demand variations it is proposed to install variable speed drives for all the proposed pumps. VFD details are given under section VI – C4.

The Contractor shall also confirm the pump duty parameters when operating at lowest and highest water level as per Schedule of Technical Particulars, VOL. II. The guaranteed best efficiency for selected pumps at the duty point conditions needs to be proven. Minimum efficiency shall be not less than 84% for rated configuration of each pump.

The pumps shall be of High efficiency type and vendor shall give life cycle analysis. No degradation of pump efficiency for first two years of operation. Efficiency of the pump shall be tested at the end of each year of operation and loss of pump efficiency during the next 8 years of operation shall not exceed 0.25% per year. In case, it is found that the loss of efficiency has become more than the stipulated value, the additional power cost shall be borne by the vendor.

## 1.3 Valves and Pipe work

### 1.3.1 General

Pipe work shall be ductile iron for the delivery side and also for the suction side. The deliveries shall be connected to the Ductile Iron / MS delivery manifold. Dismantling joints shall be incorporated at both suction, delivery and in header mains to facilitate removal of pumps and valves. Provision shall be incorporated for resisting end thrust on each manifold section. The inter pedestal distances for pumps shall not be less than 1500 mm. Pipeline of 700mm and above diameter shall be of Mild Steel.

### 1.3.2 Valves

Each pump shall be provided with an suction isolating valve, and a delivery non-return valve and isolating valve. Suction valves and delivery valves shall be sluice valves. Non-return valves shall be of swing type check valves, designed for rapid closing when forward flow stops.

Pump suction valves and delivery valves shall be fitted with electric actuators. The delivery main shall be provided with a isolating valve, and a swing type check valve.

Pipe work shall be protected from corrosion as specified for exposed steel pipes elsewhere in the Specification.

Design criteria for the components of these systems shall be as follows.

### 1.3.3 Common inlet manifold with valves and connections to clear water reservoir

- Maximum velocity: 0.9 m/s
- Design pressure: 10 bar

### 1.3.4 Pump suction branches including valves

- Maximum velocity: 1.2 m/s
- Design pressure: 10 bar

### 1.3.5 Pump delivery branches including valves

- Maximum velocity: 1.8 m/s
- Design pressure: 1.5 times pump shut valve head, or PN 1.0/PN 1.6 whichever is applicable

### 1.3.6 Common delivery manifold and isolating valve

- Design pressure: 1.5 times pump shut valve head, or PN 1.0/PN 1.6 whichever is applicable
- Maximum velocity: 1.7 m/s for rising main

## 1.4 Electric overhead travelling crane

An electric overhead travelling crane complying with the standards shall be provided in the pumping station, designed to serve all the plant equipment installed in the pump house.

The Contractor shall determine the maximum Safe Working Load required for the crane, based on the plant he provides.

The pendant control shall be designed for operation from the motor hall floor. Crane operating speeds shall be limited to as specified in codes and standards and complied with:

A fixed ladder with safety hand railing shall be provided for access to the crane for servicing, and to gain access to the maintenance platform for use when servicing high-level lighting and ventilation units mounted in the roof.

## 1.5 Electric Monorail Hoist

An electrically operated monorail hoist complying with the standards shall be provided in the pumping stations identified and shown in General Arrangement.

The Contractor shall adopt the hoist capacity as the maximum Safe Working Load required

for the hoist based on the plant design.

### 1.6 Ventilation system

The pumping station shall be provided with a ventilation system designed to limit the air temperature rise not more than 7 deg. C. when the plant is under operation. The system shall be designed to provide uniform ventilation throughout the pumping station to promote plant cooling and eliminate pockets of stagnant air.

The system shall be sized based on the maximum number of motors operating together, with all the lights switched on, and with all operating personnel present, but the design air extraction rate shall not be less than 6 air changes hourly for the complete pump hall.

The system shall comprise a number of roof-mounted air extraction fans. The fans shall be fitted with non-corrodible protective cowls and any other protection needed to make them weatherproof in the climatic conditions at the Site, including monsoon winds combined with heavy rainfall.

Fans shall be controlled from wall-mounted contactors, accessible from pumping station floor level. The air extraction units shall be designed so that routine servicing can be from the maintenance platform on the crane and access from the roof is not needed.

### 1.7 Submersible pumps

A portable dewatering submersible pumps shall be provided for emptying the reservoirs and sumps. The pumps shall each be sized to deliver flows of not less than 10 l/s to discharge at suitable location.

Submersible type sump pumps complete with all associated pipe work, valves and fittings shall be supplied and installed in the pump house to pump leakage water to the suitable discharge system.

The sump pumps shall be complete with hard wired level controls for automatic start/stop. An alarm shall be raised if the level in the sump becomes high.

### 1.8 Access platforms and ladders

Steel access platforms and ladders with hand railing shall be provided wherever needed. The arrangements shall ensure that all parts of the plant requiring maintenance and observation are made readily accessible in safety. Each pump and motor assembly shall have dedicated access.

Plant requiring access includes the pumps and their valves and the ventilation fans.

If step irons are provided, for example for access to valve chambers, they shall be fitted with approved safeguarding arrangements to protect personnel.

### 1.9 Surge study and provision of surge protection installation for treated water main

The Contractor shall make a surge analysis for pumping systems at his own cost and the study shall analyse the performance of pumping station and its associated delivery and rising main

pipelines.

On completion of his design, the Contractor shall study any possible transient conditions arising with operation of his plant and the pipeline, and shall design and provide any surge protection measures needed. The Contractor shall provide a surge study report to the Engineer as soon as the study is completed. Details of surge protection to be provided shall be subject to approval.

If an air vessel for surge protection is provided, it shall be installed near to the water pumping station.

A fabricated-steel, equal-tee piece, provided initially with a bolted-on blank flange, shall be provided in the delivery main for connection of the surge protection device.

## 1.10 Service Water System

The Contractor shall provide a complete service water system.

A covered service water storage tank shall be mounted on the roof of the pump house & in case of UGR, a service water line shall be taken from the UGR directly.

The service water storage tank shall be filled by service water pumps ( with 100% standby arrangement ) located suitably. The storage tank shall provide at least one hour storage of service water at average usage rates.

## SUB-SECTION 2. PUMPING PLANT

### 2.1 Definitions

For this Specification the following definitions shall apply:-

| | | |
|---|---|---|
| (a) | Design duty: | The total head to be developed and the quantity of fluid to be discharged when the pump is running at rated speed; |
| (b) | Static head: | The difference between free water surface level on the suction side of the pump and the delivery level; |
| (c) | External friction head: | The head required to overcome friction external to the Works (Frictional loss in the transmission main) and the velocity head at the outlet of the pumping main; |
| (d) | Station losses: | The friction losses in valves and pipes within pump room; |
| (e) | Internal losses: | The frictional losses in the pump suspension main and head bend up to the delivery flange of vertical wet well pumps |
| (f) | Total head: | The sum of (b), (c), (d) and (e); |
| (g) | NPSHa : | Net positive suction head available at site |
| (h) | NPSHr: | Net positive suction head required for the pump |
| (i) | LWL: | Low Water Level at free water surface level on the suction side of the pump. |
| (j) | HWL: | High Water Level at free water surface level on the suction side of the pump. |

'Pump set' where used in this specification and the schedules including the price schedules, shall mean the complete assembly of pump, motor, driving arrangement, and supporting headpiece or base plate as appropriate.

### 2.2 Pump design and layout

#### 2.2.1 General

The head/quantity characteristics of pumps shall be stable at all rates of flow between closed valve and fully-open valve, and the characteristics shall be steep enough for satisfactory operation in parallel under all conditions specified.

Pump efficiency shall be well maintained over the whole of the specified duty range.

Lubrication arrangements shall be designed to avoid any contamination of the pumped fluid.

Pumps and associated pipe work shall be arranged so that air can be completely removed, using air-release valves at high points, and complete drainage is provided from low points by drain valves.

Pump suction and discharge flanges shall each be provided with 2 opposed plugged tapping for fitting pressure gauges and the like. The tapping shall be fitted with suitable metallic plugs for transport.

Arrangements for the easy handling of all pumping machinery shall be provided, by using lifting lugs or eyes as appropriate.

### 2.2.2 Driving arrangements

Unless otherwise specified, pumps shall be driven by electric motors and be directly coupled. Motors shall provide a power margin of not less than 10% above the maximum power absorbed by the pump in any possible operating condition.

All the driving arrangements shall be equipped with overload protection system.

### 2.2.3 Seals, glands and sleeves

Pumps shall be fitted with mechanical seals with the seals have a proven record of satisfactory running when fitted to the pump design in question, and with prior approval. Mechanical seals shall be readily adjustable and replaceable.

### 2.2.4 Bearings

Pump bearings shall have a design running life of not less than 50000 hours. Bearings shall be designed for loadings 20% in excess of calculated maximum loading and shall be suitable for reverse rotation at 150% of rated speed or the maximum reverse speed the pump can reach in installed conditions when driven backwards by reverse flow if this is greater.

Bearing cooling arrangements shall use closed circuits. Open discharge of cooling water into the pumping station drainage system is not permissible. The coolant flow shall be easily visible and local indication of bearing metal temperature shall be provided. Excessive metal temperatures shall result in safe shutdown of the pump.

### 2.2.5 Balancing

Rotating assemblies shall be statically and dynamically balanced in accordance with ISO 1940–1. They shall be designed so that the first critical speed of the pump and its drive is at least 30% higher than the maximum operating speed. If rotating assemblies are small and out-of-balance forces are negligible, the Engineer may waive this requirement. For each pump, the manufacturer shall state whether or not balancing has been completed.

### 2.2.6 NPSH

The NPSH requirements of pumps, based on the 3% output drop criterion, shall be at least 1m less than the NPSH available at every working condition at site maximum ambient temperature.

### 2.2.7 Velocities in pump branches

Unless otherwise specified, the water velocity in the suction branches of a pump shall not exceed 1.2 m/s and in the discharge branch shall not exceed 1.8 m/s when the pump is operating within its specified working range. There shall be no discernible noise due to hydraulic turbulence or cavitation within the pump or its associated pipework and valves.

Taper pipes shall be designed to reduce velocity progressively using profiled internal contours which contain no steps or angles from which turbulence or cavitation can be generated. The taper pipes shall be considered as part of the pump and be included in performance calculations and tests.

### 2.2.8 Priming

Unless otherwise approved, pumps shall be set at levels which ensure they will be flooded suction at the lowest water level of UGR which is possible in normal operation. Priming arrangement is not acceptable for pump in proposed pumping stations.

### 2.2.9 Base plates

If pump and motor are mounted on a combined plate, the plate shall be a substantial fabricated-steel construction. Holes for holding-down bolts shall be included, and all packing for levelling, and all holding-down bolts and the like shall be provided. Steel dowels shall be fitted after final alignment of pump and motor to facilitate dismantling and reassembly.

### 2.2.10 Pump performance

Pump performance guarantees shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's works. Verification of factory test results shall form part of the Site Tests on Completion.

Pumps shall operate at design duty within the acceptance tolerances for flow and total head laid down in ISO 3555 or IS 10981 with no negative tolerance on Pump efficiency.

Unless otherwise specified, at the time of tender the Contractor shall supply the performance curves for the pumps is providing. The curves shall show total head, pump efficiency, power absorbed by the pump, and NPSHr plotted against flowrate for the full operating range required. The curves shall be extended to show shut valve conditions, and to show performance at flowrates at least 20% in excess of the maximum flowrate expected in

normal operation at site conditions.

Where appropriate, curves shall also be included to show the variations in station losses and internal plant losses plotted against flowrate, to enable the complete pump performance curves to be shown.

If the Purchaser's estimated system curves for head against flow have been provided, the Contractor's pump curves shall be superimposed on the system curves to show conveniently the expected performance in site conditions.

Power consumption details needs to be furnished and guaranteed for each pump assembly for the loading conditions as required to be operated. The details should be furnished under Technical particulars.

## 2.3 Double Suction Centrifugal Pumps

### 2.3.1 Description

The Contractor shall furnish and install the specified horizontal double suction centrifugal pumps complete with motors and appurtenances as specified herein.

### 2.3.2 Scope

Each pumping unit shall consist of a horizontal double suction centrifugal pump, couplings, squirrel cage induction motor and all necessary appurtenances to provide complete pumping systems. The Contractor shall require that a single manufacturer supplies the pumping units specified herein. The Contractor shall supply install commission and hand over all equipment to the satisfaction of the Engineer.

### 2.3.3 Type

Each pump shall be of the horizontally split volute casing, enclosed impeller, double suction centrifugal type, designed so that the impeller shaft and bearings can be removed without disturbing the connecting piping or bottom casing. The pump and motor shall be mounted on a fabricated common steel base.

### 2.3.4 Quality Assurance

The equipment to be furnished shall be new and as a standard product of a manufacturer experienced in the design, fabrication and construction of pumping equipment. The pumps shall be the product of an experienced manufacturer and:

1) Must demonstrate equal or larger capacity installations using similar equipment and equipment installed and successfully operating for at least 5years;
2) Provide names and phone numbers of contacts at referenced installations to verify

performance;

3) Demonstrate to satisfaction of Engineer that equipment to be provided is equal to that specified;
4) The pump manufacturer's machining and assembly shops must be ISO 9002 certified in order to assure conformance to the highest quality standards.

### 2.3.5 Unit Responsibility

The Contractor shall cause all equipment specified under this contract to be furnished by the pump manufacturer who shall be responsible for the adequacy and compatibility of all pumping unit components. Any component of each pumping unit not provided by the pump manufacturer shall be designed, fabricated tested and installed by factory authorized representatives experienced in design and manufacture of such components. This requirement, however, shall not be construed as relieving the contractor of the overall responsibility for this portion of work.

### 2.3.6 Design Requirements

The arrangements shown on the drawings is based upon the best information available to the Engineer at the time of design and is not intended to show exact dimensions peculiar to any specific equipment unless otherwise shown or specified. Therefore, it may be anticipated that the structural supports, foundations connecting piping and valves shown in part or whole, may have to be changed in order to accommodate the pumping equipment furnished. Any such changes shall be submitted to the Engineer for his approval. Pumping units shall be designed to operate without cavitation or damaging vibration at the specified speed, flow and head conditions.

The pump base shall be designed for anchor bolting to a concrete foundation, assuming that the pump, without restraint at the suction and discharge connections, is subjected to a displacing force equal to that developed by an internal pressure equal to three times shut-off head at the operating-speed. The motor shall be connected to the pump by a flexible coupling. The complete pumping unit shall be designed to operate without overload on any component at any point along the pump curve at the specified speed.

### 2.3.7 Factory Testing

1) Materials

   Melt and strength tests of the cast iron used in the manufacture of the pumps major components shall be performed in accordance with the applicable BS standards as indicated in the specification. The contractor shall furnish the Engineer is with certified copies of the results of all tests.

2) Hydrostatic Tests

   Each pump shall be hydrostatically tested. Test pressure shall not be less than 1.5 times the maximum working pressure as shown the approved head-capacity curve or twice

the rated pressure which ever is higher. At no time during this test shall the casing show undue deflection or signs of weakness at any point nor shall the external surface surfaces of the casing show sweating through porous metal or leaking through gasket or cracks or other detects. The contractor shall furnish the Engineer with certified results of the tests.

3) Performance Tests

Pumps shall be factory tested for performance in accordance with BS EN ISO 9906 or IS 8034 and IS 1710 by a testing agent approved by the Engineer and shall be to accuracy class C. The supplier shall submit these test curves prior to shipment of the equipment. These test curves shall include Head. Efficiency, Power absorbed and NPSH required against Capacity. The Engineer may witness these tests. Pumps with motors of higher than 30 kW shall be tested with its distinctive contract motor, unless otherwise approved by the engineer.

4) Vibration Tests

Vibration tests shall be carried out in accordance with ISO 10816-7 or IS 3483.

5) Motor Tests

Motors shall be tested in accordance with NEMA and IEEE Procedures. The tests shall include.

- Routine Tests
  - No load current
  - Locked Rotor Current
  - Winding Resistance
  - High Potential Test
- Complete Tests
  - Rated Load Temperature Rise
  - Slip.
  - Locked Rotor Torque
  - Break down Torque.
  - Efficiencies at 100,75 and 50 percent of Full load
  - Power factor at 100,75 and 50 percent of Full Load.

The Contractor shall furnish the all certified test results before shipment.

### 2.3.8 Submittals

The Contractor shall submit complete information including fabrication, assembly, foundation and installation data together with detailed specifications arid performance information covering materials of construction, power drive assembly, parts, devices, wiring diagrams and all other accessories of the equipment furnished. The submittals shall include but not be limited to the following:

1) Manufacturer’s product data
2) Shop Drawings to and describe pump construction and materials

3) Motor data including:
   - Manufacturer
   - Minimum guaranteed efficiency
   - Power factor at full load, 3/4 load and 1/2 load
   - Locked rotor current
   - Motor speed
   - Mounting details
4) Pump characteristic curves
   - Plot flow, total dynamic head, brake power, shut off head, efficiency and net positive suction head required for full operating range of pump
   - Show recommended limits of continuous operation
5) Certificates of compliance
6) Certified test reports
7) Operation and maintenance manuals
8) Training program

### 2.3.9 Information to be provided

The Contractor shall provide the following details in three copies at least 14 days before handing over of the equipment.

1) Certified copies of all performance tests of pumps and motors
2) Manufacture's Certification that all pumping units and motor control equipment is fully in conformance with the specification
3) Operation and Maintenance manuals of Pumps and Motors Control wiring diagrams for Electrical Panels
4) Spare Parts Manuals

### 2.3.10 Products

#### 2.3.10.1 General

Pumps and drives shall be rated for continuous duty and shall be capable of pumping the specified flow range without surging, cavitation, or vibration. The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation and vibration throughout the entire pump operating range. The service factors for the motors shall not be applied when sizing the motors. To ensure vibration-free operation, all moving components of each pumping unit shall be statically and dynamically balanced. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided. In any case, the amplitude of vibration as measured at any point on the pumping unit shall not exceed the limits set forth in the latest edition of the Hydraulic Institute Standards. All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation. The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and oil or water leaks over the range of operation. All units shall be so constructed that dismantling and repairing can be accomplished without difficulty. The Contractor shall be responsible

for proper operation of the complete pumping system, which includes pump and motor. Each pump shall be provided with a name plate indicating the details: Design capacity, Total head, Speed, Motor rating, Model number, Manufacturer's serial number, Weight of equipment, and Tag number.

### 2.3.10.2 Pumps

Pumps shall be of horizontal shaft driven, single stage, volute casing, double suction and horizontally split casing centrifugal type.

1) Design conditions

Pumps shall be designed and constructed to satisfactorily meet the design conditions and requirements specified in the Particular Specifications. Pumps are required to deliver treated water with specific gravity of 1.0,

Materials

| | |
|---|---|
| Pump shaft | Stainless Steel conforming to AISI 431 |
| Impeller | Stainless Steel casting conforming to SS 316 / SS CF8M |
| Casing | Cast Iron conforming to IS 210 FG 260 |
| Shaft sleeves | Stainless Steel conforming to AISI 410 (hardened) |
| Casing wear rings | Zinc free bronze / SS |
| Bearing Housing | Cast Iron conforming to IS 210 FG 260 |
| Bolts, Studs & Nuts | Stainless Steel conforming to SS 316 |

2) Speed

Nominal operating speed of the pumps shall be as per the requirements specified in the Particular Specifications. However, the pumps speed shall be limited to not exceeding 1500 rpm.

3) Efficiency

Minimum pump efficiency expected at the duty point for each pump shall be as per the requirements specified in the Particular Specifications. The efficiency at the duty point will be a consideration in the evaluation of the offer, as both capital and operational costs will be taken into consideration in evaluating bids. Pump efficiency of minimum 84% shall be considered for evaluation purpose.

4) Construction of Pumps

- Castings, fabrications, machined parts and drives shall conform to the industry standards for strength and durability and shall be rated for continuous duty over the entire operating range. Service factors, where applicable shall be assumed to be 1.0. Pumps shall be horizontal shaft driven volute casing, single stage, double suction horizontally split casing centrifugal type with suction and delivery flanges positioned in the fixed half of the housing.
- Couplings between pump and motor shall be flexible type and shall have sufficient

capacity to develop the full strength of the shafting, which they connect.

- Suction and delivery flanges shall be drilled in conformity with BS/ DIN 2527 / BSEN 1092 standards and other equivalent standard as applicable and incorporate two tappings in each flange for mounting suction and delivery pressure gauges, the spare tapping being plugged. Flange shall be machined on face and edge and spot faced at seating surfaces of the bolt heads and nuts.
- Casing shall be of close-grained Cast Iron free from crack impurities and any other casting defect and shall incorporate replaceable casing wear rings made bronze casting/ SS. The surfaces of all water passages shall be smooth and free from and projections, which might cause undesirable turbulence. Lifting lugs or eye bolts shall be provided at well balanced positions and also tapings shall be available for priming, gland lubrication and drainage connections and air releasing cocks shall be provided on pump casings to permit air release during priming.
- Pump shaft shall be of a diameter sufficient to prevent distortion from stresses imposed on them and shall be machined all over. The areas in contact with water and also over the full length of the stuffing box, protected with shaft sleeves (as applicable) keyed or properly shrunk fitted onto the shaft. Fine ground finished surfaces shell be made for bearing seats. Pump shaft shall be mounted on ball or roller thrust bearings at top, with static grease lubricated in rigid bearing housings properly seated to prevent ingress of moisture and designed for a continuous (24Hrs/day) duty life of not less than 50,000 Hrs (L10 type bearing). Provisions shall be available for external grease lubrication of the bearings. The shaft shall be of ample size and rigidity to ensure low working stress under all conditions of operation. The shaft shall be protected from wear corrosion by removable sleeves (as applicable) made of stainless steel. The sleeves (as applicable) shall extend from the impeller to the outside of the stuffing boxes for gland packed pumps.
- The bearing shall be an anti-friction ball bearing, and suitable lubrication system shall be provided. For horizontal pumps there shall be a deflector fastened to the shaft at the inner end of each bearing-housing.
- Impeller shall be enclosed double suction type of one piece construction and shall be dynamically balanced including coupling, shaft and wear rings prior to final assembly up to 130% of the operating speed. The flow passage shall be smooth and free from hollows, cracks, pinholes and projections, which might incite or encourage cavitation. All exterior surfaces shall be accurately machined. The impeller shall be tightly mounted on the pump shaft with a key so that it will not become loose.
- Pressure gauges (A compound gauge of 100 mm diameter ) shall be fitted to each pump with operating cocks.
- All bolts, cap screws, anchor-bolts nuts and washers shall be stainless steel.

Centrifugal pumps shall have stable & rising head/flow characteristics with maximum pressure at shut-off condition. The rotating parts of pumps shall be balanced properly to prevent undue vibration of noise. The design of the pumps shall be such that no thrust is transferred to the driving motor. The thrust and journal bearings shall be capable of carrying at least 10% more than the maximum calculated design load and shall be capable of reversed rotation at 130% of full speed. The shut off head of pump should not be less than 115% of the duty point head.

Pumps of a particular category shall be identical. Identical pumps shall be suitable for parallel operation, with equal load division. Components of identical pumps shall be

interchangeable. Suction and delivery ends of all pumps shall have flanged ends.

The rating of the pump motor shall be 110% of the maximum power required by the pump over the entire operating range. The casing shall be of robust construction. Liquid passages in the casing shall be finished smooth. Casing drain and vent connection shall be provided. Casing shall withstand the usual moments and thrust without expansion joint. The impeller shall be properly balanced so as not to cause any vibration during operation. Impeller shall be made in one piece and securely keyed to the shaft. Means shall be provided to prevent loosening during operation including rotation in reverse direction. Impeller fastening nuts (if provided) shall be of cap type and shall tighten in the direction of normal rotation.

Wearing rings shall be of renewable type. These shall be held in place by screwing against rotation, press fit and locked with pins. Opposed wear surfaces or hardenable material shall have a hardness difference of at least 50 BHN. The rotary components shall have higher Brinell hardness. The pump shall be provided with removable and renewable labyrinth profile casing ring.

Replaceable shaft sleeves (if applicable) shall be provided to protect the shaft where it passes through stuffing boxes.

In order to avoid waste of water through continuous gland leakage of soft packed pumps, the casing stuffing box/ seal chamber shall be designed to facilitate externally removable shaft/sleeve mounted, non-split, self-aligning cartridge type Mechanical seal of any reputed make.

Pumps shall be furnished complete with an approved type of flexible coupling. Spacer type couplings shall be provided when required to permit dissembling the pump without removing the pipe connections or to permit. Both halves of the couplings shall be furnished by the pump supplier. Coupling halves shall be bored and keyed to fit shafts of the pump and the motor. Both halves of the coupling shall be match marked.
Coupling guards, made of expanded metal and bolted to the base plate shall be furnished for all coupled pumps.

The common base plate for pump and motor shall be in one piece. Suitable holes shall be provided for grouting and they shall be so located that they base can be grouted in place without disturbing the pump and motor. All pumps and motors shall be properly aligned, bolted to the base plates. Between pump drain connections and base plate of a minimum 15mm drain piping shall be installed for gland packed pumps.

Tapping for pressure gauges shall be provided on suction and delivery side of pumping system. All incidental pipe (including valves) required for sealing, lubrication and cooling for stuffing box packing and or bearing or pump shall be provided.

A. The supplied pumps shall offer low operation cost by way of sustained efficiency with no degradation for first two years and thereafter by maximum 0.25% every year up to economical life i.e. 10 years. Periodic energy audits will be conducted to check on efficiency degradation.

B. Operator shall submit an undertaking from pump manufacturer confirming that the

offered pump offers" Lowest cost of ownership to DJB" and the pump is

1. Designed for low life cycle cost
2. The supplied pumps shall offer low operation cost by way of sustained efficiency with no degradation for first two years and thereafter by maximum 0.25% every year up to economical life i.e. 10 years.
3. Low maintenance cost by way of access to the parts to be serviced (removal/ fitment of mechanical seal and bearings without opening casing).

C. In order to avoid bare metal casing from getting oxidized and to reduce the relative surface roughness of the pump casing, a Coating with properties of good erosion and corrosion protection including protection against cathodic action shall be applied on casing internal surface coming in contact with water. The coating applied should be suitable for potable water application and certified by Authorised National Lab.

Pump shall be tested in the Manufacturer's Works with job motors. Pumps shall be given running test over the entire operating range covering from the shut off head to the run-out flow. A minimum of five readings approximately equidistant shall be taken for plotting the curves.

D. For pumps having discharge below 350 Cu. Mt./Hr, specifications at A, B, & C of this clause shall not be applicable. Also efficiency of these pumps shall not be less than 80%.

### 2.3.11 Execution

#### 2.3.11.1 Installation

The Contractor shall provide the complete pumping system and factory – trained personnel to supervise installation and initial operation of all components. The pumps shall be aligned, connected and installed at the locations shown and in accordance with the manufacture's recommendations. Contractor shall certify that the equipment is installed in a manner to ensure proper operation.

#### 2.3.11.2 Testing

1) Each assembled pump shall be shop tested by the manufacturer to determine the following characteristics. All tests shall be performed in accordance with the latest Hydraulic Institute Standards or BS ISO 9906 or JIS B 8301 and 8302/IS standard as applicable.
   1. head-capacity curve
   2. power curve
   3. efficiency curve.

   Each motor shall be shop tested by the manufacturer in accordance with the requirements of General Provisions for Electrical Installations.
2) Each major component of the pumping equipment shall be performed to a complete site test to ensure compliance with the performance requirements as specified herein, witnessed by the Engineer if so desired. All costs for the site tests shall be borne by the Contractor.

### 2.3.11.3 Certification

Manufacturer shall supply certified pump performance curves demonstrating compliance with the performance specified herein.

## 2.4 Submersible sump drainage pumps

Sump pumps shall be of the open / semi open-impeller centrifugal-type, vertically-mounted and close coupled to their fully-submersible electric motors.

Sump pumps of 1.5kW and under shall incorporate an integral level detector, control and motor starter and shall be powered only with a suitably-fused three-phase or single-phase low-voltage supply and with supply isolation at the supply point.

Sump pumps over 1.5kW shall be controlled and started from the supply point. Control shall be by means of adjustable float level switches mounted near the pump.

Pumps shall be supplied with all necessary pipework to discharge to surface drainage. Each pump shall be provided with delivery reflux and isolating valves, and suitable lifting arrangement for lowering and lifting the pump from the sump.

Pumps weighing 40kg or more shall be lowered into the sump on guide rails and be located to their respective discharge pipework with an angle flange connection and self-locating clamps.

Pump impellers shall be designed to pass solids of the sizes which pass through the inlet ports of the pump and shall be capable of pumping solids of up to 25 mm diameter.

Provide submersible, corrosion resistant, industrial quality pump complete with electric motor of submersible design IP 68 protection, discharge piping, mercury switch actuated controls, power cord, control panel, cover, and other accessories required for proper installation and operation.

The impeller shall be open / semi-open statically, dynamically, and hydraulically balanced, accurate machined and filed for smoothness.

Shaft shall be of Double mechanical seal with Tungsten-Carbide carbon ring with stainless steel parts and Oil filed chamber to lubricate running faces.

**Materials**

| | | |
|---|---|---|
| 1) | Pump Casing : | Cast iron |
| 2) | Impeller: | CF8M |
| 3) | Shaft: | Stainless steel confirming to AISI 431. |
| 4) | Fasteners: | Stainless steel. |

## SUB-SECTION 3. PIPEWORK

### 3.1 Pipework within structures

The term pipework shall include all necessary supports, saddles, slings, fixing bolts and foundation bolts required to support the pipes and associated equipment.

Pipework layout within pumping stations shall be agreed with the pump manufacturer.

Pipes and fittings up to 600mm within building shall be DI and over 600 mm diameter and shall be MS including specials and fittings.

Pipework shall be laid out and designed to facilitate the erection, painting in situ and dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum of head loss. Where steel pipework is used, the number of flanges shall be kept to a minimum and the size of each length of pipework shall be determined by the ease of handling, installation and general appearance of the completed pipe system. Positions of flanges shall take account of any concrete pipe supports or thrust blocks needed.

Flexible joints shall be provided where needed to facilitate removal of Plant or to allow for differential settlement of the building. Wherever practical, flexible joints shall be provided with tie-bolts or other approved means to transfer thrust or tension axially along the pipework.

Where steel and cast flanges are to be bolted together, the steel flange shall be machined over its full face after welding to the pipe is completed. Flanges shall be finished truly vertical with the pipe axis. Wherever possible, standard fittings shall be used in preference to special fittings.

Facilities shall be provided for draining the pipe system and releasing air. The drained fluid shall be piped into the appropriate drainage system and the time for drainage shall not exceed 30 minutes.

Valves, strainers and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.

Flanges shall be drilled in accordance with the appropriate pressure rating.

Where a pipe passes through a wall, a retaining wall, or is subject to end thrust, it shall incorporate a puddle flange. Puddle flanges shall be undrilled.

Unless otherwise approved, steel pipework in pumping stations shall be internally and externally coated with an approved two-component solvent-free, spray-applied epoxy coating.

## 3.2 High-pressure pipes and fittings

High-pressure pipework shall be of seamless or welded steel, complying with API Specification 52/ IS 3589 for line pipe.

Pipes and fittings shall be specified by nominal diameters.

The process of manufacture shall be as stated by the Contractor in the Form of Tender. Test and test certificates will be required for the pipework supplied under this Contract in accordance with Clauses 3.3 and 3.5 of API Specification 5L/ IS 3589 including ladle and check analyses of the steel. The pipework manufacturer shall perform fracture toughness tests in accordance with API Specification 5L and shall provide test certificates to show the pipe is suitable for use under the operating conditions specified at temperatures between –5°C and 45°C.

Steel specials for butt-welding shall comply with IS 816 or ANSI B16.9. All specials shall have the same strength and be compatible in all other respects with the line pipe with which they are to be used.

Carbon steel pipes shall be in accordance with BS EN 10216 or IS 3589-01. Carbon steel fittings shall comply with IS 3589-01.

Pipework and fittings shall be completely fabricated and corrosion-protected at the maker's works.

Welding shall be in accordance with IS 816 and IS 1216. All welding and fabrication operatives shall be coded and tested by an independent inspection authority. The work shall be done manually by welders qualified for all-position welding to BS 2633 and the Contractor shall submit to the Engineer details of all welders whom he proposes to employ. The Engineer's approval for any welder will be given only after the welder has satisfied the requirements of the welder tests prescribed by BS EN 287-1. The welder shall perform the relevant tests, and test certificates shall be provided by the Contractor for examination by the Engineer. The Engineer reserves the right to visit the premises where fabrication is taking place, to examine procedures, to inspect fittings, and to spot check where relevant all certification of materials and operatives employed on work being done for the Engineer.

The internal and external surfaces of the pipe shall be smooth, clean and free from grooving and other defects which might impair its functional properties. The ends of the pipe shall be cleanly cut square with the axis and free from deformity. The pipe shall be homogeneous throughout and uniform in colour, opacity, density and other physical properties.

The pipe shall be delivered in the longest lengths possible to keep site jointing to a minimum.

## 3.3 Dismantling joints, flexible couplings and flange adaptors

Pressure ratings shall match the pressure rating of the pipework in which they are installed, and materials used and methods of protection shall not be inferior to those used for the pipework.

Where needed, joints and couplings shall be provided with tie bolts to restrain the maximum

axial thrust arising when in service.

Detachable flexible couplings shall be suitable for the angular deflections specified below without leakage. Flange adaptors shall be suitable for half the angular deflection stated.

| **Nominal pipe diameter** (mm) | **Angular deflection** (degrees) |
|---|---|
| Up to 600 | 5 |
| 601 to 750 | 4 |
| 751 to 900 | 3 |
| 901 to 1200 | 3 |
| 1201 to 1800 | 2 |
| 1801 upwards | 1 |

Flexible couplings for each size of pipe shall also be capable of withstanding the shear force applied by the weight of a 4m length of pipe of that diameter full of water suspended between two couplings.

Detachable flexible couplings shall be provided with central registers or location plugs only where specified or detailed in the Drawings.

Flange adaptors shall have flanges as specified for flanged joints. Bolts, nuts and washers shall comply with the requirements for bolts, nuts and washers for flanges.

The metal components of flexible couplings and flange adaptors shall be protected by thermoplastic polyamide or fusion-bonded epoxy coatings unless otherwise specified or detailed in the Drawings.

- Horizontal piping shall be run parallel to the building walls and sloped to permit drainage where practical, except where shown or specified otherwise. Intermediate low points in a run are not allowed.

- Parallel lines shall be grouped on the same horizontal or vertical plane wherever possible.

- Vertical piping shall be plumbed, and the entire piping configured to allow clearances for convenient access for painting and preventive maintenance of valves.

- Obstructions shall be cleared, headroom preserved, and openings and passageways kept clear. Long-radius flanged elbows shall be provided unless otherwise noted. Eccentric reducers shall be installed with the straight side at top of piping system, unless otherwise indicated.

- Hubs, spigots, and flanges shall be provided at right angles to the axis of the opening, and openings at the exact angle specified. Isolating valves shall be provided at each piece of equipment or appliance on both the supply and return lines. Valves shall be located to be easily accessible to the operator of equipment.

- Slab, floor, wall and roof penetrations and closures:

  - Wall sleeves shall be used for all piping penetrations of slabs, floors, walls and roofs unless otherwise noted on the Drawings. The size and location of all building and structure penetrations shall be verified prior to pouring concrete. Holes drilled with a suitable rotary drill will be considered in lieu of sleeves.
  - Material orders shall be placed early so they are available for placement in concrete forms.
  - The annular space between the pipe and the sleeve in exterior walls shall be caulked, or a modular mechanical closure unit used. The mechanical closure unit is preferred and shall be installed where possible.
  - Wall pipes and sleeves shall be supported by formwork to prevent contact with reinforcing steel.

### 3.4 Piping Thrust Protection

- Thrust protection shall be provided for all unrestrained pipe joints except expansion joints. Pipe thrust protection data shall be submitted for each piping system as part of the requirements for submittals.
- No references to thrust protection details have been shown on the Drawings unless special details are required. The absence of detail references on any Drawings does not relieve the Contractor of the responsibility for providing thrust protection throughout the plant.
- General details referenced show acceptable methods for piping thrust protection. Alterative thrust restraint systems may be used by the Contractor only where approved by the Engineer. Structural design shall incorporate a factor of safety of three against yield of thrust restraining elements. Systems incorporating anchor studs placed perpendicular to the longitudinal axis of the pipe are unacceptable.
- On steel piping, thrust ties and welded or flanged tie rod lugs shall be provided for protecting unrestrained joints.
- On flanged ductile iron piping, thrust ties attached to the pipe with flange lugs shall be provided for protecting unrestrained joints.
- On ductile iron piping with mechanical or push-on joints, restrained mechanical joints or mechanical or push-on joints, restrained by tie rods shall be provided for thrust protection. Retainer gland type thrust protection systems shall be used only where shown on the drawings or specified in the applicable detail piping specification or where approved by the Engineer.
- All unrestrained joints in nonferrous exposed and submerged piping shall be thrust protected as specified herein,
- A sufficient number of screw unions, flanged joints, or mechanical couplings shall be provided to allow any section or run of pipe to be disconnected without taking down adjacent runs and on runs into non-flanged valve or equipment connections.
- Transition couplings shall be provided to connect pipes with small difference in outside diameter.
- If couplings are to be encased in concrete, sleeve type couplings shall be used. Grooved end type couplings are not acceptable.

### 3.5 Expansion joints:

- Expansion joints shall be provided where pipe work crosses expansion joints in the

structure, where shown on the drawings and where required to prevent undue strain on the pipe, or connecting equipment.

- Piping shall be installed to allow for thermal expansion due to the differences between installation and operating temperatures. Anchor walls shall be installed to withstand the hydraulic thrust and thermal forces and to direct and control thermal expansion.
- Grooved-end piping:
    i. Couplings shall be installed on 6m maximum centres to provide for piping expansion.
    ii. Couplings and end caps shall be set so that half of the total axial movement in a run of piping is available for pipe expansion and half of the total axial movement is available for pipe contraction.
    iii. Half of the couplings shall be installed with no end gap and half with maximum end gap; or all coupling end gaps shall be set at the center of their travel.
    iv. The end gap shall be set before the final pipe segment is cut and installed, Screwed, Soldered, and Socket-weld Piping:
- Expansion joints shall be used to provide for expansion of rigid piping systems.
- Alignment guides shall be used at each support.
- Oversize pipe sleeve guides shall be provided to maintain clearance of 3 mm minimum at each support.
- For piping 20 mm and larger, formed U-bolts shall be provided with double nuts to provide 6 mm minimum clearance around the pipe.
- Process pipe work shall be provided with flexible couplings or expansion joints and at connections to equipment where shown. The Contractor may install additional flexible couplings to facilitate piping installation, provided that complete details describing location, pipe supports, and hydraulic thrust protection are submitted.
- Dielectric joints shall be provided at connections of dissimilar metals and joints shall be tested to verify non-conductivity. For buried piping, flexible mechanical compression joint couplings or concrete closure collar shall be provided, as directed by the Engineer.
- For exposed piping, materials and ratings of insulating flanges, couplings and unions shall be in accordance with the appropriate Specification.

Cast iron and spun iron pipework shall be manufactured and tested to IS 1536, 1537 and 1538 or BS EN 598, 545 & 969 and IS 8329 (Ductile) as applicable unless specified otherwise.

Flanges shall be as per DIN 2527 and equivalent or IS 6392, and shall be machined over the whole face and edge. After machining, flanges shall be flat and normal to bore of the pipe to within 0.125 mm over the flange diameter.

The process of manufacture shall be as stated by the Contractor in the Form of Tender. Test certificates will be required for the pipework supplied under this Contract in accordance with Clauses 3.3 and 3.5 of API Specification 5L including ladle and check analyses of the steel. The pipework manufacturer shall perform fracture toughness tests in accordance with API Specification 5L and shall provide test certificates to show the pipe is suitable for use under the operating conditions specified at temperatures between –5°C and 45°C.

Steel specials for butt-welding shall comply with BS EN 10253-2 or ANSI B16.9 or IS 5822. All specials shall have the same strength and be compatible in all other respects with the line pipe with which they are to be used.

Carbon steel pipes shall be in accordance with BS EN 10216-1 or IS 1239-1. Carbon steel

fittings shall comply with BS EN 10252-1 or IS 1239-I&II.

Pipework and fittings shall be completely fabricated and corrosion-protected at the maker's works.

Welding shall be in accordance with IS 816 arc welding. All welding and fabrication operatives shall be coded and tested by an independent inspection authority. The work shall be done manually by welders qualified for all-position welding to BS 2633 and the Contractor shall submit to the Engineer details of all welders whom he proposes to employ. The Engineer's approval for any welder will be given only after the welder has satisfied the requirements of the welder tests prescribed by BS EN 287-1 or IS 816. The welder shall perform the relevant tests, and test certificates shall be provided by the Contractor for examination by the Engineer. The Engineer reserves the right to visit the premises where fabrication is taking place, to examine procedures, to inspect fittings, and to spot check where relevant all certification of materials and operatives employed on work being done for the Engineer.

### 3.6 Pipe protection

The internal and external surfaces of the pipe shall be smooth, clean and free from grooving and other defects which might impair its functional properties. The ends of the pipe shall be cleanly cut square with the axis and free from deformity. The pipe shall be homogeneous throughout and uniform in colour, opacity, density and other physical properties.

The pipe shall be delivered in the longest lengths possible to keep site jointing to a minimum. Pipes shall be given external and internal protection as per relevant BIS/ IS codes. Testing of pipe protection shall be done as directed by the Engineer using elcometers, coating thickness gauges, bond test and holiday detectors.

All underground pipe work having a cover more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around. All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns. No internal and external painting to be given to SS pipes.

## SUB-SECTION 4. VALVES

### 4.1 General

Valves shall be suitable for use with the fluid being conveyed at the temperatures and pressures required for the application. Unless otherwise approved, pressure designation shall not be less than PN 10.

Valves shall have integral flanges drilled as specified in relevant codes where applicable. Flanges to other standards shall be used only if approved and provided that any differences do not affect mating dimensions.

Sluice valves and butterfly valves shall be suitable for flow in either direction.

Sluice valves shall comply with BS EN 1171 or IS 14846 as appropriate

Butterfly valves shall comply with BS 5155 / AWWA-C-504/1980 / IS 13095

Reflux/check valves shall conform to BS 5153 / IS 5312

Valves shall be suitable for frequent operation, and for infrequent operation after long periods of standing either open or closed.

Rubber used in valves shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR). It shall comply with the requirements of Appendix B of BS 5155, be suitable for making a long term flexible seals, and be resistant to anything causing deterioration of the flexible seal.

### 4.2 Gate valves (Sluice valves)

Gate Valves shall conform to the provisions of AWWA C509; JIS B 2062; DIN 3352 Part 4A & B, BS 5150, BS 5163, IS 14846 or approved equivalent and as further specified herein. Valves shall be of non rising stem, clockwise closing, wedge, gate valves suitable for above ground use and flow in both directions. Valves pressure rating shall be equal to, or greater than the adjoining pipe or fitting but a minimum of 10 bars.

Valves shall be designed for the "Closed End Test" and shall be of metal (above 300 mm) / resilient seal design ( up to 300 mm) with bolted bonnet connection and straight-through port. Wedges shall be low clearance- guided in the body and shall have an inner core. They shall be encapsulated with a synthetic EPDM rubber covering on the inside and outside by vulcanizing up to 300 mm. The rubber covering shall have a minimum thickness of not less than 2.5 mm on both flow sides and 2.0 mm on sealing surfaces with nobody- metal exposed. EPDM wedge rubber shall be approved to be used for potable water and be selected to meet the chemical properties and temperatures of the fluid being handled by the valves. Flanges shall be in accordance with NP 10 of BS 4504/ IS 1538.

Stems shall be non-rising and manufactured of stainless steel, Stem threads shall be of the rolled type. Sealing and bearings (up to 600 mm) shall be gland less corrosion proof and maintenance- free and shall be designed in the form of a series of 'O' –rings of synthetic

rubber. Stem bearing gap shall be sealed against entry of dust by a wiper ring. Stem sealing should be replaced when required. Stem nuts shall be of zinc-free bronze.

The body and bonnet shall be of ductile iron and shall be internally and externally fusion bonded epoxy coated/ Liquid coated 250 microns as specified here-in. Prior to assembly, the entire valve body and bonnet shall be holiday tested internally and externally.

Gear operated valves shall be provided with operating nuts as specified. Gear cases shall be totally enclosed and equipped with indicators to show valve position and designed for full differential pressure of 10 bars.

Valve spindles shall be of the non-rising type. The valve spindle seal shall be replaceable with the valve fully open and the main under pressure. Valves used with potable water shall not use any brasses which contain more than 5% zinc. Valves less than 250mm diameter may be of the resilient-seated type unless otherwise specified. Valves 450mm and over shall be fitted with integral by-passes and gate jacking screws. Valves below 80mm NB shall comply with BS 5154.

Material of Construction

| | | | |
|---|---|---|---|
| a. | Body | : | Ductile Iron IS 1865 Gr 400/15 or 15/ GGN 40 |
| b. | Wedge | : | Ductile Iron IS 1865 Gr 400/15 or 15/ GGN 40 |
| c. | Spindle | : | AISI 410/ AISI 420/ SS 304 |
| d. | Seat Rings | : | St. Steel to CF – 8 / AISI 304 |
| e. | Spindle Nut | : | High Tensile Brass to IS-320 HT2/ Gun metal IS 318 Gr LTB 2 |

## 4.3 Reflux /Check valves

Reflux/check valves shall be designed for rapid closing without slamming no later than the moment forward flow stops. The valve size and design shall be chosen to give the best performance possible, taking account of the system where the valve is installed. The effect of any surge vessel in the system as well as the static and dynamic heads shall be included in the assessment.

If self-closing without slamming cannot be achieved, external mechanisms may be used to control the closure rate. Details of mechanisms shall be subject to approval. Valves shall preferably be fitted with metal resilient faces or seats.

Check valves used in raw water systems shall not be installed vertically, or positioned so that water-borne solids can settle against the valve flap when the flap is closed.

Valves shall be installed and commissioned in accordance with manufacturer’s instructions. The Contactor shall co-ordinate the valve requirements with those of the actuators and instrumentation to ensure compatibility of control interfacing and operations.

All valves shall be tested to the appropriate test pressure at the manufacture’s works, and shall be supported by a test certificate from the manufacturer. Work tests on all valves shall be witnessed by an approved independent testing agency at no extra cost to the Employer. The Contractor shall supply original manufacturer's test certificate endorsed by the approved

independent testing agency for each valve supplied. The certificate shall relate to the individual number cast on each valve and shall give the date of test. The manufacturer shall factory test each valve for performance, leakage and hydrostatic pressure in accordance with AWWA C500/ IS 5312.

Non-return valves on the pump delivery branches shall possess high speed closing characteristics, with minimum shock on closing. The body and door shall be of ductile iron, the seats and faces shall be of zinc-free bronze and the hinge pins shall be of stainless steel Grade 431 S29.

Material of Construction

| | | |
|---|---|---|
| a. | Body & cover | : Ductile Iron IS 1865 Gr 400/12or 15/ GGG 40 or 500/7 |
| b. | Door | : Ductile Iron IS 1865 Gr 400/12 or 15/ GGG 40 or 500/7 |
| c. | Hinge Pin | : SS AISI 420/ SS 304 / SS AISI 410 |
| d. | Seat Rings | : Integral Nickel weld overlay, microfinished/ SS304 |
| e. | Shaft sealing (if applicable) | : EPDM Rubber |
| f. | Surface Protection | : Epoxy powder/liquid coated inside and outside, Min 250 microns, colour RAL Blue |

## 4.4 Butterfly valves

Butterfly valves shall be of double flanged and short body type complying to IS 13095 code or AWWA suitable for installation with the valve shaft in any position. Butterfly valves shall comply with BS 5155 / AWWA-C-504/1980. The body and disc shall be of ductile iron.

Valves shall be fitted with indicators to show the position of the disc, clearly marked with ‘open’ and ‘closed’ positions. Valves shall not contain any brasses containing more than 5% zinc. Gunmetal to BS 1400 Grade LG2, aluminium bronze, or nickel components may be used for internal components.

Resilient-seated valves shall have nitrile rubber seals / EPDM.

The disc shall rotate through 90 deg from the full open to the tight shut position. Suitable stops shall be provided inside the body so as to prevent further rotation beyond fully open or fully closed position. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation. The driving end sealing shall preferably be of the gland and stuffing box type. The stuffing box shall be easily accessible for adjustment and replacement of packing without disturbing any other part of the valve or operator assembly. The depth of the stuffing box shall not be less than 50 mm or the diameter of the shaft, whichever is lower. As an alternative, ring type sealing may be provided at the driving end. The gear unit of the valves shall be grease-lubricated with proper sealing and packed with grease for lifetime service.

The valve shaft shall have a minimum shaft diameter extending through the valve bearings and into the valve disc and specified in the relevant codes. The shaft should also be sized to withstand the maximum torque that will be imposed by the operator. Stub shaft construction, if offered, shall have each stub shaft inserted into the disc hub for a distance of at least 1½ times the shaft diameter.

Butterfly valves for electrical operation shall be fitted with actuator and limit switches for auto operation. Time of opening and closing of valves shall be between 10-30 seconds.

Each valve shall be provided with lifting lugs. Butterfly valves shall be installed into the pipe works in such a manner that they can easily be removed from the line for dismantling and replacement of the seats which shall be of rubber unless otherwise specified. For the rubber seated valves, the valves shall be air tight in the closed position with a disc differential pressure as specified.

Hand wheels of butterfly valves shall be made of malleable iron / steel fabricated with arms and rims of adequate strength. The hand wheel diameters shall not be more than 600 mm. Hand wheels of diameter 300mm or less shall be of cast iron of rugged casing and shall provide positive grip on the chain even under the most severe operating conditions. The operator shall be complete with chain guides. The chains for the chain wheels shall be of endless type.

Material of construction

| | |
|---|---|
| Body/ Disc | Ductile Iron IS 1865 Gr 400/15 / GGG 40 |
| Shaft | SS 420 / SS 431/SS 304 |
| Body seat | Integral (Monel 60) Ni-Cu alloy weld deposited / Ni-Cr weld deposited./ |
| Disc seal & O ring | EPDM |
| Disc seal Retainer ring | Ductile Iron / SS AISI 304 (CF 8) |
| Surface Protection | Epoxy powder /liquid coated inside and outside, Min 250 microns, colour RAL Blue |

## 4.5 Pressure and flow control valves

### 4.5.1 General

Pressure-control valves and flow-control valves shall be designed for the operating conditions specified.

Valves shall be capable of controlling the required flow or pressure within plus and minus 5 percent of the set value. The rate of response of opening and closing of the main valves shall be controllable at the valve. External indication of the position of the valve element shall be provided.

Hydraulic control systems shall include isolating valves to allow maintenance or replacement without interrupting the supply.

### 4.5.2 Flow-control valves

Flow-control valves shall be designed to prevent the flow downstream rising above that specified for the particular application, regardless of the operating pressures in the system upstream or downstream of the valve.

### 4.5.3 Pressure-relief valves

Pressure-relief valves shall be designed to prevent the pressure in the pipeline upstream of the valve rising above a preset level. The valve shall remain closed at lower pressures.

The pressure at which the valve opens shall be adjustable. A pressure gauge shall be provided to indicate upstream pressure over the operating range of the valve.

Safety valves shall comply with BS 6759: Part 1. They shall be designed to open at the specified pressure and re-close and prevent further release of fluid after normal pressure has been restored. The pressure / temperature rating shall be in accordance with Table PE–1 in BS 1560: Part 2.

Shell material shall be from the materials listed in Table PE–1 BS 1560: Part 2.

Flanged ends shall be Class 900, raised-face type complying with ANSI B16.25 or Table PE–1 or BS 1560: Part 2. Butt-welded ends shall be in accordance with Section 8 of BS 1868.

### 4.5.4 Pressure-reducing valves

Valves shall be capable of maintaining a constant downstream pressure from a higher upstream pressure and they shall be drop-tight under no-flow conditions.

A pressure gauge shall be provided to indicate downstream pressure over the operating range of the valve.

Valve operation shall be controlled by the interaction of the inlet pressure, outlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the outlet pressure on its underside and a constant pressure on its upper side, derived either from weights or from a spring.

Valves shall be flanged and drilled to BS 4504/ IS 1538 for the operating pressure required. Materials for valves shall be as follows:—

| Component | Material |
|---|---|
| Body and cover | Cast iron |
| Internal valve | Gunmetal with bronze liner, cups and facing rings in leather |
| Relay valve | Bronze with stainless steel shaft and nylon valve face |
| Diaphragm | Reinforced synthetic rubber |
| Loading spring, If employed | Spring steel |
| Cylinder & weights, If employed | Cast iron |
| Lever | Steel with gunmetal pins and links |

| | |
|---|---|
| Connecting pipework to cylinder | Copper |
| Cylinder | Mild steel epoxy lined with internal working parts gunmetal bushed |

### 4.5.5 Automatic air-relief valves

The size of valve shall be as per CPHEEO manual and capable of exhausting air from pipe work automatically when been filled. Air shall be released at a sufficiently higher rate to prevent the restriction of the Inflow rate. Placing of air valves shall be on pipe and hydraulic gradient peaks and as required by surge analysis / hydraulic design. Similarly the valve shall be capable of ventilating pipe work automatically when being emptied. The air inflow rate shall be sufficiently high to prevent the development of a vacuum in pipeline. The valve shall automatically release air accumulating in pipe line work during normal working condition. The valve shall be of single chamber, double orifice with Triple action (Venting, admitting and venting during operation), Tamper proof in one piece construction (both large and small orifice housed in the housing itself)

All branched outlets including air valve tee's will be provided with one ½"BSP coupling duly plugged for measurement of pressure in due course. The closing plug will be in Stainless Steel (AISI 304 or equivalent) with Hex. Head and will be provided with copper washer for sealing.

1. All flanges will be drilled as per I.S. 1538 , Table IV and VI
2. Each valve shall be provided with an isolating valve.

**Material of Construction**

| | |
|---|---|
| Body | Ductile Iron to GGG 40/ IS 1865 Gr 400/ 12- 15 or 500/7 |
| Float | SS 304/ SS 316, |
| Internal Shell | Stainless steel/ SS 304/ Hostaflon |
| Gasket & Seal | EPDM Rubber |
| Screws | SS 304/ Carbon steel |
| Surface Protection | Epoxy powder coating min. 250 microns thickness |

### 4.5.6 Ball float valves

Ball float valves shall be designed for installation on the inlet to a storage tank and shall automatically shut off when the water reaches a predetermined level. They shall be of the single beat type with balancing piston, resilient seatings, and direct float and lever operation.

Ball float valves shall be suitable for long-term operation when partly open.

### 4.5.7 Ball valves

Ball valves shall conform where applicable to BS5159.

Multi-piece bodies shall be used where work on the ball and seats when installed may be needed. If valves need removal for servicing, one-piece bodies may be used.Seat materials shall be chosen for long life, with erosion and corrosion resistance.

Ball supports shall be of the floating ball or trunnion type. If line pressure is too low to ensure a positive leak-free seal, built-in seat loading devices, or specially shaped seatings shall be used to ensure sealing.

**Ball Valves for Alum/PAC services:- Stainless Steel**

Full bore ball valve, 2 piece, Screwed / Flanged (above 50m) with latch locking handle & PVC sleeve; seat / seals; PTFE (Teflon). Ball & Stem in SS (CF 8M) tested to 100 kg.m2 Hyd for body and seat. Body shall be of stainless steel – SS 316 / equivalent.

## 4.6 Penstocks (Sluice gates) and headstocks

### 4.6.1 General

a) Design Requirements and Construction Features

(i) The construction of sluice gates shall be in accordance with the Specification and generally as per AWWA C501 or IS: 13349.

(ii) The sluice gates shall be capable of performing the duties set in this Specification without undue wear or deterioration. They shall be constructed so that maintenance is kept to a minimum. All parts of sluice gate, including lifting mechanism components shall be designed for the heads specified with a minimum safety factor of five.

(iii) All sluice gates shall be of the non –rising spindle type.

(iv) All gates shall be flush bottom closure type only. However conventional bottom closure type may be used where flush bottom type is not applicable.

b) Frame

(i) The frame shall be of ample section and cast in one piece. All surface forming joints and bearings shall be machined. The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

c) Guide

(i) Guide shall be bolted to the frame or cast integrally with it and shall be machined on all bearing and contact faces.

(ii) The length of guide shall be such that it should support the gate upon the horizontal line of stem nut pocket.

(iii) Arrangement shall be made to prevent lateral movement of bolted on guides. They

shall be capable of taking the entire thrust produced by water pressure and wedging action. Wedges or wedge facings shall be attached securely to the guides at points where, in the closed position, they will make full contact with the wedging surfaces on the slides.

d) Seating Faces

(i) Seating faces shall be made of full width, solid section, They shall be secured firmly by means of counter sunk fixings in finished grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

(ii) The faces shall be of ample section and finished smooth. The maximum clearance between the seating surfaces, with the slide in the closed position shall not exceed 0.10mm

e) Wedging Devices

(i) Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required to provide contact between the slide and frame facing when the gate is in closed position. All faces shall be machined accurately to give maximum contact and wedging action. Wedges shall be fully adjustable with suitable adjusting screws and locknuts and so designed that they will remain in the fixed position after adjustment.

f) Gate Slides

(i) The slide shall be with strengthening ribs where required and a reinforced section to receive the seating faces.

(ii) The slide shall have tongues on each side extending its full length, and the tongues shall be machined accurately on contact surfaces. Surfaces of the slide that come in contact with the seat facing and wedges shall be machined accurately. The maximum allowable clearances between the slide and the slide guide shall be 1.6mm.

(iii) An integrally cast stem nut pocket with reinforced ribs shall be provided above the horizontal centerline of the slide. The stem nut pocket shall be provided with drain.

g) Stem Nut and Lift Nut

(i) Gate shall be provided with a lower fixed stem nut for connecting the stem to the slide and a revolving lift nut located in the lifting mechanism in the head stock. They shall be of ample design to endure the thrust developed during gate operation under maximum gate operating condition loads in opening and closing direction. The stem nut and slide shall be constructed to prevent turning of the stem nut in the pocket in the slide. The stem be threaded and keyed or threaded and pinned to the stem.

h) Stem

The operating stem shall be designed for a tensile strength to withstand a 90kg effort on the crank and for a critical buckling compressive load assuming a 36kg effort on the crank.

The threads of the stem shall be machine cut or rolled and of the square or acme type. The number of threads per inch shall be such as to work most effectively with the lift mechanism used. The top of the stem be provided with a stop collar.

i) Stem Coupling

The coupling shall be threaded and keyed or threaded and bolted, and shall be of greater strength than the stem.

j) Stem Guides

(i) Stem guides shall be cast, with bushings and mounted on cast brackets. Guides shall be adjustable in two directions and shall be so constructed that when properly spaced they shall hold the stem in alignment. Number of stem guides shall be such that unsupported length of stem shall not exceed one hundred times its diameter.

k) Lifting Mechanism

(i) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate electric actuators and suitable gearing if required. All gates will be with electric actuators unless otherwise specified.

(ii) Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

(iii) The design of the lift mechanism for gates shall be such that the slide can be operated with a torque of not more than 7 kg-m on the operator after the slide is unseated from wedges based on the operating head. The maximum crank radius shall be 380mm.

(iv) All gears and bearings shall be enclosed in a cast iron housing with labyrinth seals. The lifting mechanism shall be with a cast iron pedestal, machined and drilled to receive the gear housing and suitable for bolting to the operating floor. The direction of rotation to close the gates shall be indicated on the lift mechanism.

(v) A suitable means shall be provided for lubricating the stem threads directly adjacent to the lift nut. An inspection cover shall be provided to access the lift nut and gearing.

(vi) Stem shall be provided with a polycarbonate tube cover shall be fixed to the head stock.

l) Fasteners

All anchor bolts, assembly bolts, screw, nuts, etc shall be of ample section to safely withstand the forces created by operation of the gate.

m) Wall Thimbles

(i) Wall thimbles shall be made of cast iron and shall be supplied along with the gate. The wall thimbles shall provide a rigid mounting, designed to prevent warping of the gate frame during installation.

(ii) The cross section of the thimble shall have the shape of the letter 'F'. The front, or mounting flange, shall be machined and shall be drilled and tapped to the same template used for its particular gate frame. The frame shall be attached to the thimble with bolts of studs. The depth of the wall thimbles shall not be less than 300mm.

(iii) To permit entrapped air to escape as the thimble is being encased in concrete, holes not lesser than 35mm diameter at not more than 600 mm span, shall be cast or drilled in each entrapment zone formed by the reinforcing ribs or the flange and water stop.

n) Lifting lugs

(i) Lifting lugs shall be provided for all gates.

**Material of Construction:**

| | | |
|---|---|---|
| i) | Wall Thimble | Cast Iron : IS 210 Gr. FG 200 |
| ii) | Frame and Slide | Cast Iron : IS 210 Gr. FG 200 |
| iii) | Seating faces | Stainless Steel : ASTM Countersunk fixing A276 type 316 |
| iv) | Wedge | Stainless Steel : ASTM A743 CF8M or SS316 |
| v) | Stem | Stainless Steel: ASTM extension A276 type 316 |
| vi) | Stem nut | Stainless Steel : ASTM A743 CF8M |
| vii) | Stem Coupling | Stainless Steel : ASTM A276 type 316 |
| viii | Fasteners, anchor bolts & nuts | Stainless Steel : ASTM bolts and nuts A276 type 316 |
| ix) | Lifting mechanism, Pedestal gear house cover and stem guide | Cast Iron : IS 210 Grade FG 200 |
| x) | Lift nut | Bronze : ASTM B 148 (CA952, CA954 or CA958) |

### 4.6.2 Headstocks

Where remote operation of penstocks, gate or butterfly valves is required they shall

generally be as shown on the Drawings, using headstocks or headstocks with operating shaft extensions.

Headstocks for direct connection to valves or penstocks shall be for use with rising stem valves. They shall be cast iron and fitted with position indicators. Stem bearings shall be gunmetal bushed.

If operational conditions require, hand wheels shall operate through bevel gears.

If the installation requires, extensions shall be provided between penstock or valve and headstock. Extension lengths shall be adjustable during assembly on Site. Universal couplings shall be fitted next to the valve and the headstock, and the two couplings shall be arranged to give linear transmission of rotational movement between headstock and penstock shaft.

## 4.7 Valve Operation

### 4.7.1 Shafts and caps for tee-key operated valves

Operating and extension shafts for valves operated by tee key shall be capped.

Extension shafts shall be circular section. For valves installed in chambers, extension shafts shall be provided with split bearings, rigidly held on brackets spaced no more than 1,500 mm apart. For buried valves, the shaft shall be supported inside a protecting tube held on a purpose-made support, which shall be fixed to the top of the valve and provided with a shaft guide.

Bearings and shafts shall be suitably protected against corrosion.

Extension shaft couplings shall be provided with locking arrangements.

### 4.7.2 Manual operating mechanisms

Manual closing of valves shall be by the clockwise rotation of a tee key or handwheel.

Tee-key operated valves shall be provided with detachable cast iron shaft caps, with keys to match the cap. One key shall be supplied for every five valves installed, with a minimum requirement of two keys in any one size.

Handwheels shall be shaped to give a safe grip without sharp projections, clearly marked with the direction of opening and closing and shall be fitted with integral locking devices. A padlock and chain will not be acceptable for locking.

Manually-operated valves and penstocks shall be capable of being opened and closed by one person, when the specified maximum unbalanced pressure is applied to the valve or penstock. Under this condition the total force required at the rim of the handwheel or at the tee key to open the valve or penstock from the closed position shall not exceed 30 kg (15 kg each hand). Where necessary, gearing and bearings shall be provided and the handwheel sized to fulfil this requirement.

Gearboxes shall be totally enclosed oil bath lubricated. Thrust bearings shall be provided so that the gearcase may be opened for inspection or be dismantled without releasing the stem thrust or taking the valve or penstock out of service. Oil and grease lubricated gearing, bearings and glands shall be protected against the ingress of dust and moisture.

Operating mechanisms shall be of the weatherproof type and those parts subject to submergence shall have a degree of protection IP68 to BS 5490 at a depth of submergence of 5 m. Where practicable, operating mechanisms shall be fitted with mechanical position indicators clearly visible from the operating position.

Headstocks of the rising shaft type shall each have an index pointer working over a graduated, open-to-closed position indicator fixed to the side of the pillar.

### 4.7.3 Electric actuators

Electric actuators shall operate valves and penstocks at opening and closing rates that will not impose unacceptable surge pressures on the pipework.

Actuators shall be rated at not less than 20 percent in excess of the power required to operate the valve or penstock under maximum working conditions.

Actuator enclosures shall have a minimum protection IP 68 to BS EN 60529.

Actuator electric motors shall comply with BS 4999. For non-modulating type actuators, the motor short-time rating (STR) shall allow the successive full travel operation of the travel from open to closed and vice versa but shall be not less than 15 minutes. For modulating type actuators the motor shall have a duty-type rating (DTR) to meet the varying cyclic load requirements of the valve.

Electric motors shall be provided with built-in thermal protection complying with BS 4999: Part 111.

Actuators shall be complete with:

(a) An alternative system for manual handwheel and reduction gear operation which shall be lockable.

(b) An interlock, to prevent engagement of the handwheel whilst the actuator is being power driven and to disengage the manual drive positively when the power drive is started.

(c) Reversing type motor starter complete with isolating switch.

(d) Local and remote control selector switch when specified, which shall be lockable.

(e) Open, stop and close push-buttons.

(f) Potentiometer for remote valve position indication when remote control is specified.

(g) Torque switches for mechanical disengagement of the drive at the extremes of valve

operation to limit excess torque.

(h) Supply failure and remote control available monitoring relays. The supply failure relay shall operate under single phasing and phase reversal conditions.

(i) Auxiliary and interposing relays as necessary.

(j) Voltage-free changeover type contacts for the remote indication of:

-Motor tripped on overload
-Fully open
-Fully closed
-Operating
-Supply failed
-Remote control available

The rating of volt-free contacts shall be not less than 15 A at 240V a.c. and 2 A at 50V d.c. unless otherwise specified. The contacts shall be suitable for inductive load switching.

(k) Anti-condensation heater

Separate or segregated terminal boxes shall be provided for the connection motor, heater and control cables.

## 4.8 Valve packaging and installation

### 4.8.1 Marking and packing

Each valve shall be indelibly marked with the diameter and pressure rating and shall carry a unique reference number to enable each item to be clearly identified with works fabrication records, works test certificates, delivery notes and the like.

Wherever possible, the identification marks shall be painted on the outside of the item but where there is not enough smooth surface area for the identification marks they shall be put on rust-proofed metal tags secured to the item with galvanised wire or chain (not through flange holes).

Valves shall be packed in the `closed' position except that uncrated resilient seat gate valves for transport to tropical areas shall be in the `open' position.

### 4.8.2 Valve handling

The Contractor shall provide all equipment needed to handle and install valves and associated equipment without damage. The equipment shall include lifting beams, reinforced canvas slings, protective padding, cradles and the like. Unprotected wire rope or chain slings shall not be used for handling.

Temporary packing, coverings or crates provided for protection in transit shall not be

removed (except for inspections, after which they shall be replaced) until immediately before installation.

### 4.8.3 Valve installation

Valves shall be installed and commissioned in accordance with the manufacturer's instructions. After installation, valves shall be cleaned, and gates, discs, seats and other moving parts closely inspected, foreign matter removed, and the valves checked for ease of operation. Moving parts shall be lightly greased or otherwise treated in accordance with the manufacturer's recommendations.

Unless otherwise specified or directed by the Engineer, butterfly valves shall be enclosed in chambers, installed with the shaft horizontal, and supported as detailed on the Drawings. They shall be installed so that when the valve is opening the lower portion of the disc moves in the direction of the main or normal flow.

Unless shown otherwise on the Drawings, gate valves shall be installed with their shafts vertical.

Gate valves without external gearing, and not otherwise required to be in a chamber, may be buried. The buried part of the valve shall be protected as specified. Unless otherwise specified, backfilling shall be to just below the top of the valve or shaft shroud, and a surface box shall be provided.

Jointing, sleeving, external wrapping, anchor and thrust blocks, valve chambers, valve marker posts and the cleaning and disinfection of valves shall be executed as specified for the associated pipeline.

# SUB-SECTION 5. LIFTING DEVICES

## 5.1 General

### 5.1.1 Scope

This Section specifies the requirements for the design, manufacture, construction, installation, testing and commissioning of hoists, monorails, bridge cranes trolley assemblies.

### 5.1.2 Reference Standards

IS 875 , IS 3177 , IS 3832 , IS 3938 , IS 2266 , IS 15560
Other applicable standards referred to in this section are listed below:

| | | |
|---|---|---|
| BS | 302 | Stranded steel wire ropes or equivalent standard |
| BS | 466 | Power driven overhead travelling cranes, semi Goliath and Goliath chain for general use or equivalent standard |
| BS | 2573 | Rules for the design of cranes or equivalent standard |
| BS | 2853 | The design and testing of steel overhead runway beams or equivalent standard |
| BS | 2903 | Higher tensile steel hooks for chains, slings, blocks, and general engineering purposes or equivalent standard |

## 5.2 System Description

Lifting equipment shall be provided as required to remove equipment for replacement and/or maintenance purposes. The design shall ensure safe access is provided for the operation of the lifting equipment. Overhead cranes will also be required to grant access for maintenance of roof mounted equipment such as light fittings or fans, etc., and shall be designed.

## 5.3 Submittals

The Contractor shall furnish the following data:

1) Complete structural calculations of crane and monorail member and component sizing and design, shall be submitted, as required by BS 2573, BS 2853.
2) Shop drawings shall be submitted. Layout drawings shall clearly show the lifting height of the equipment and clearances in relation to other equipment and structures where the largest items are lifted.
3) The Contractor shall include all the documentation required on the lifting equipment in the operation and maintenance manuals. A copy of the design data, factory and site tests shall be included in the manuals.

## 5.4 Product

### 5.4.1 General

1) Hoist crane shall include all equipment, appurtenances and auxiliaries to make the lifting equipment fully operation and capable of performing under the specified load conditions.
2) Lifting systems, including hoists, as far as feasible, shall use the standard components of one manufacturer to simplify maintenance.
3) Nameplates shall be permanently attached to the monorail hoist and bridge, crane hoist assemblies. The lifting capacity shall be stencilled in tonnes on each side and shall be clearly legible from the working level.
4) The term 'crane' shall be deemed to include gantry rails, platform with handrails for maintenance use, down-shop conductors, end stops, holding-down bolts and all other items required for complete installation. Cranes shall be prominently marked with their SWL on both sides of the crane bridge girders. Crane hooks shall be fitted with safety latches and the hook block shall incorporate fully-guarded rope sheaves.
5) The maintenance platform shall be designed to provide safe access to the crane machinery and all high-level lighting and roof-mounted ventilation plant. Access to the platform shall be by fixed stairway from a convenient point in the pump hall. Enough slings, ropes, shackles, lifting beams and the like shall be supplied to handle all the plant to be served by the crane. They shall be labelled or marked with the safe working load (SWL) and the purpose for which they are intended.
6) All movements shall be electrically powered and be suitable for operating with the hook fully loaded. Motors shall be of the quick-reversing type with electro-mechanical brakes suitable for the duties specified. Limit switches shall be incorporated to prevent excess travel, or over-hoisting and over-lowering of the crane hook. Facilities shall be provided for the accurate location of the hook by means of 'inching' all the motions. Crane operation shall be from ground floor level by bridge-mounted pendant push-button controls. Controls shall be mechanically and electrically interlocked to prevent inadvertent operation of opposing motions. The pendant shall be supported independently of the electric cable and shall be arranged for extending for operation when necessary
7) Down-shop conductors shall be of the fully-insulated shrouded bus bar type. The current collectors shall have renewable contact pieces. Festoon cables may be used for cross travel. A crane isolator, lockable in the 'off' position and incorporating a warning lamp, illuminated when the supply is 'on', shall be provided at the bottom of the access ladder. A second isolator shall be provided at the control cubicle located on the crane platform.
8) The Contractor shall supply all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail-safe protection if the power supply fails. All electrical equipment shall be fully tropicalized. Motors and switchgear shall be provided with anti-condensation heaters, which shall be energised when the crane is at rest, and suitable warning notices shall be provided.
9) Warning signs shall be provided to the approval of the Engineer and affixed to the bottom lift blocks or pendant controllers.

### 5.4.2 Design Conditions

1) Cranes and lifting equipment shall be suitable for indoor or outdoor installation, as shown and designated. The high ambient temperature in which lifting equipment and

particularly cranes may be required to operate shall be taken into consideration, particularly with respect to the electrical load ratings of motors, switchgear, resistors, cables and wiring, as well as mechanical heat sources such as brakes, bearings and gearing. Due allowance shall be made for possibly higher temperatures than the maximum recorded shade temperature near the roofs of buildings, if the lifting equipment is mounted in a building, or for the effect of direct sunlight if mounted externally.

2) Design of travelling hoist crane and incidental accessories will be based upon the use of a factor of safety of 5, structural beams shall have a factor of safety of 2 with capacity load on all mechanical parts of the system. The factors of safety shall be based upon the ultimate strength of the material used.
3) Lifting equipment shall be rated for the load of the heaviest installed item of plant, and designed such that one man can operate it without difficulty.
4) Hook and load wire shall reach to the floor of the lowest level.
5) The crane and hoist shall conform to IS: 3177, IS: 3832 and IS: 3938, class 2, medium duty and meet specified operational requirements.
6) The crane shall be of single/double girder type (as per requirements)
7) All the cranes shall be electrically operated.

## 5.5 Electrically Operated Over Head Travelling Crane / Electric Hoists

1) The hoist rope drum shall be of high quality seamless pipe with left and right hand spiral grooves to accommodate the hoist rope in one layer. As far as possible, the drive gearing shall be fixed directly to the rope drum to obviate high torsional stress in the drum shaft. The rope shall be securely clamped to the drum.
2) The hoist drum shall incorporate a wire rope, rewind system and guides to prevent the hoist rope skipping and damaging the lay.
3) The bridge structure shall be formed by a single cross girder or double girder as per design requirement with the hoist units traveling along the lower flange of the bridge girder. The end carriages shall be fabricated adequately stiffened throughout their length to produce a section with high torsional resistance designed to eliminate and tendency for the bridge to cross whip. The carriage wheel base shall be adequately proportioned in relation to its span to give a widely distributed load on the crane rails and ensure freedom from cross working.
4) The hoist braking system shall be of the automatic electro-mechanical fail safe type which, when the current is cut off or fails will automatically arrest the motion and hold at rest any load up to and including the rated load. The system shall safely control the lowering of the same load form the highest to the lowest point of lift and shall not allow any slippage of the suspended load to occur when the 'Raise' motion is initiated.
5) The hoist rope shall be a flexible wire rope specially designed for usage with cranes and in accordance with BS 302, with a safety factor of not less than six times the maximum tension induced by the safe working load.
6) The crane hook shall be of high-grade forged steel trapezoidal section in accordance with BS 2903/ IS 15560, ‘C’ type. The hook shall be supported on a ball thrust bearing to allow free swiveling under full loads and shall also be fitted with a safety catch. The safe working load shall be marked in the hook in accordance with BS 2903/ IS 15560.
7) All the hoist functions shall be controlled from a single pendant push button station. The pendant unit shall be suspended from a special track spanning the bridge length using a non-metallic cord and not the control cable. The pendant shall operate on a low voltages (typically 110 volts AC) source, incorporated with a key operated switch to prevent unauthorized operation and indicators to indicate all crane or hoist movements

including start and stop. The hook shall have a safety latch to prevent rope coming off the hook.

8) The electric hoist shall be fitted with right and left handed spiral grooved seamless pipe with a rope hoist arrangement with spring loaded rope bands and guards to ensure accurate rope guidance and location. Hoist rope shall be extra flexible, improved plough steel rope with well lubricated hemp core and having six stands of 36 wires per strand with an ultimate tensile strength of 160/180 kg/sq.mm Electromagnetic brake shall be provided to hold suspended load instantly, securely and automatically in the event of the electric current being cut off whether intentionally, accidentally or due to power failure.
9) Power feed to the crane shall be from a shrouded conductor rail system and that to the hoist shall be through close looped flexible cable suspension system with carriers sliding along a wire across the full span of the crane. Flood lights of an approved design shall be fitted to the end carriages and arranged to illuminate the entire area under the crane.
10) The sheaves of the hook block shall be guarded to prevent a hand or fingers from being trapped between the sheaves and the in-running rope.
11) A limit switch shall be fitted to prevent over hoisting. This shall be self-resetting, closing automatically when the hoist motor is put in reverse.
12) Brakes shall be well protected from oil and grease leakage or spillage, and from adverse effects of atmospheric condensation or dust. A simple and easily accessible means of carrying out adjustment for wear of the shoes or linings shall be provided for all brakes.
13) Automatic brakes, operating when the drive motor stops shall be supplied for the long and cross travel motions.
14) Long-travel, cross-travel and slow and normal speed hoist motors of each crane shall be controlled from the lowest level by a pendant push button station.

| | | |
|---|---|---|
| Lifting speed | Low | 0.9 m/min |
| | High | 2.5 m/min |
| L.T. speed | | 10 m/min |
| C.T. speed | | 2.5 m/min |

### 5.5.1 Factory Inspection and Testing

1) The Contractor shall secure from the lifting equipment manufacturer certification that the following inspections and tests have been conducted on each crane or hoist system at the factory, and submit to the Engineer prior to shipment.
2) Cranes shall be inspected and tested in accordance with the requirements of BS 466/ IS 3177/ IS 3938/ IS 3822/ IS 2266 and shall also be carried out in the manufacturer's works and witnessed by the Engineer.
3) The works tests shall include overload tests during which a 25 percent overload shall be lifted by the hoist at the middle of the crane span and sustained under full control whilst it is moved up and down at both normal and creep hoist speeds. Whilst still under overload the crab unit of each crane shall be operated from end to end of its travel and in both directions.
4) The mechanism and controls for the long travel motions shall be tested under light running conditions without moving the crane.

## 5.6 Execution

### 5.6.1 Installation

Lifting equipment shall be installed in accordance with the requirements and instructions of the manufacturer. The lifting equipment manufacturer shall provide a representative to supervise the installation and testing.

### 5.6.2 Site Tests

After erection cranes and hoists shall be inspected, tested and certification provided by a qualified independent crane-testing specialist in accordance with the requirements of BS 466 and the tests witnessed by the Engineer. Site tests shall be done by the Contractor who shall supply the necessary materials for the test loads. The test loads shall be removed from Site by the Contractor after successful tests have been completed.

## SUB-SECTION 6. FANS

### 6.1 General

Unless otherwise indicated, the requirements of this Section shall not apply to individual fans having a duty air flow rate of 0.7m³/s or less.

The make and type of fan shall be subject to approval. Fans shall be type-tested in accordance with the requirements of BS 848 and shall be selected to give the air flow rate and sound power level specified.

Fans shall be built to a fully-developed design and shall be capable of withstanding the pressures and stresses developed during continuous operation at the selected duty. Belt-driven fans shall be capable of running continuously at ten per cent in excess of the selected duty speed.

The Contractor shall provide fans capable of delivering the required air volume when operating against the actual total system resistance.

Where fans are supplied with noise attenuators, full details shall be provided. Fan drives shall be as detailed elsewhere in this Specification.

Fans shall be installed using bolts, nuts and washers with all 'as-cast' bearing surfaces for bolt heads and washers counter faced. Holding-down bolts for fans and motors shall be provided with means to prevent the bolts turning when the nuts are tightened. Anti-vibration mountings shall be as detailed elsewhere in the Specification. Fans heavier than 20kg shall be provided with eyebolts or other purpose-made lifting facilities.

Wherever specified, or as necessary, fans shall be fitted in with variable inlet vanes which shall be matched to fan performance to give stable control. Vanes shall be interlocked to ensure movement in unison. Operation shall be manual or automatic as specified. Where manual control is specified, the operating device shall facilitate positive locking in at least five different positions.

Vane blades shall not vibrate or flutter in any possible operating condition, and the construction of the linkage system shall minimise friction and lost motion.

Unless otherwise specified, the shaft and impeller assembly of all fans shall be statically and dynamically balanced. All propeller fans shall be statically and dynamically balanced where the impeller diameter is 750 mm or greater. Where indicated, limits of vibration severity shall be in accordance with BS 4675: Part 1.

Fan bearings shall be suitable for the installed altitude of the fan. They shall be grease/oil ball and/or roller type or oil-lubricated sleeve type. All bearing housings shall be precision-located and arranged so that bearings may be replaced without the need for realignment. Bearing housings shall be protected against the ingress of dust and, where fitted with greasing points, they shall be designed to prevent damage from over-greasing. For grease-lubricated systems, the bearings shall be provided initially with grease recommended by the bearing manufacturer. For oil-lubricated systems, the housings shall provide an adequate reservoir of oil and shall

include a filling plug and be oil-tight and dust-proof. Systems other than total-loss types shall include an accessible drain plug. All bearing lubricators shall be located to facilitate maintenance.

## 6.2 Ceiling fans

Ceiling fans shall comply with BS 4934 for safety and BS 5060 for performance.

Fans shall be speed-controlled in at least five discrete steps, using a separate surface-mounted controller. The controller shall use a tapped auto-transformer for speed control.

Motors shall be capacitor start/run type, with inner wound stator and rotating outer body and incorporating ball-type bearings.

Motors shall be suitable for use in a tropical environment.

## 6.3 Centrifugal fans

Centrifugal fans for high-velocity high-pressure systems (defined within the HVCA Specification DW/141) shall be backward-bladed type.

Unless otherwise specified, centrifugal fans of more than 7.5kW at the fan shaft shall be of the backward-bladed type having a fan total efficiency not less than 75%.

Fan casings shall be built to allow withdrawal of the impeller after installation. Fans other than those in air-handling units shall be provided with flanged outlet connections and spigoted inlet connections unless otherwise specified, except that, for negative pressures greater than 500Pa, inlet connections shall be flanged. A plugged drain point shall be fitted at the lowest point in fan casings. Permanent indication shall be provided showing the direction of rotation of the fan impeller. Fan casings shall be provided with removable access panels incorporating purpose-made air seals. The sizes of access panels shall facilitate cleaning and maintenance.

Impellers shall be of mild steel or aluminium alloy, of riveted, welded or other approved construction, with spiders or hubs of robust design.

## 6.4 Axial-flow fans

Axial-flow fan casings shall be rigidly constructed of mild steel or aluminium alloy, stiffened and braced where necessary. Mounting feet shall be provided where necessary for bolting to a base or to supports. Inlet and outlet ducts shall terminate in flanges to facilitate removal. For in-duct mounting fans, the length of the fan casing shall be greater than the combined length of the impeller(s) and motor(s) and electrical connections to the motors shall be through an external terminal box secured to the casing.

Impellers shall be of steel, aluminium or plastics and the blades shall be secured to the hub or the blades and the hub shall be formed in one piece. The hub shall be keyed to the shaft. Blades shall be aerofoil or laminar section, capable of pitch adjustment where specified.

For axial-flow fans driven by motors external to the fan casing, the requirements for drives and guards mentioned elsewhere in this Specification shall be met. Unless otherwise indicated, a guard is not required for any part of a drive which is inside the fan casing. An

access panel with purpose-made air seals shall be provided in the fan casing. The access panel shall be sized to facilitate maintenance.

Where axial-flow fans of the bifurcated type are specified, the motors shall be out of the air stream. Motors may be placed between the two halves of the casing in the external air or may be placed within the fan casing, provided that effective ventilation is given to the motors.

## SUB-SECTION 7. ELECTRO - CHLORINATORS

### 7.1 General

Under this package one set of Electro Chlorination System (ECS) with a standby unit is proposed to be installed at NARAINA (6 DMA's) as well as at NEW RAJINDER NAGAR (3 DMA's) UGR – BPS. The minimum capacity of Electro Chlorinators shall be 5 kg/hr. The System shall be skid mounted, comprising Brine, Hypo & Acid tanks, pumps, blowers and various associated pipes and fittings, including Flow meters, sensors & analysers

The operation of Electro Chlorinator shall be based on SCADA. The ECS shall work on input from the chlorine analysers installed in DMAs. SCADA system shall take input from chlorine analysers. To make up the right amount of residual chlorine in the network the chlorine shall be dosed off in the pumped main by ECS.

The chlorination system to be provided at the proposed locations of NARAINA and NEW RAJINDER NAGAR, UGR – BPS, is to supplement the anticipated reduction in residual chlorine value in the distribution system down stream of these units. The chlorination system provided at treated water reservoir (WTP) is of capacity 20 kg/hr for 477 MLD 24x7 water supply. The transmission main from Clear water reservoir (WTP) up to UGR's is approximately 13 Kms and 16 kms in length, while length of distribution pipe up to the farthest point is approximately 2 kms and 3 Kms respectively.

# Technical Specifications

# C4. Electrical Works

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## SUB-SECTION 1. GENERAL

### 1.1 Regulation and Standards

The electrical installation shall comply with all relevant statutory regulations and standards current at date of tender, unless otherwise indicated within this Specification. In general, the following shall apply:

(a) Indian Electricity Act and rules thereof;
(b) National Electrical Codes of Practice;
(c) Fire Insurance regulations;
(d) Rules laid down by the Chief Electrical Inspector of the Delhi State;
(e) Any other regulations laid down by local authorities;
(f) International Electro-technical Commission (IEC).

If no standard is specified, the relevant Indian Standard or, in the absence of such standard, international standard shall apply.

For the benefit of bidders, a few Indian Standards and Codes of practices and other international standards are listed below. Unless otherwise noted, equipment/devices/accessories/installations/testing etc. shall comply with relevant standards/codes mentioned herein. Where Indian Standards are not available equipment/ devices etc. complying with relevant British or IEC standard shall be proposed. While referring to any standard, the latest revision/edition shall govern. Bidders are advised to include in their bid a list of equipment/devices and corresponding standards to which they confirm. Translation in English of standards, which are available in other languages, shall be furnished during detail engineering, in such cases the English translation shall govern. Unless otherwise approved motors, transformers, generators, switchgear, control gear and associated equipment shall comply with the relevant IEC, ISO, PD, HD, EN and BIS Standards.

| | |
|---|---|
| IS 732:1989 | Code of Practice for Electrical Wiring Installations. |
| IS 5 | Colors for ready mixed paints and enamels. |
| IS 325 | Three phase induction motors. |
| IS 374 | Electric ceiling type fans and regulators. |
| IS 1248 | Direct acting indicating analogue electrical measuring instruments and their accessories. |
| IS 1293 | Plugs and socket outlets of rated voltage up to and including 250V and rated current up to and including 16A. |
| IS 11171 | Dry Type Transformers |
| IS 2223 | Dimensions of flange mounted AC induction motor. |
| IS 2419 | Dimensions for panel mounted indication and recording electrical instrument. |
| IS 2544 | Porcelain post insulators for system with nominal voltages greater than 1000V. |
| IS 2551 | Danger notice plates. |
| IS 2705 | Current transformers. |

| | |
|---|---|
| IS 2713 | Tubular steel poles for overhead power lines. |
| IS 2834 | Shunt capacitors for power systems. |
| IS 3156 | Voltage transformers. |
| IS 4029 | Guide for testing 3 phase induction motors. |
| IS 4889 | Method for determination of efficiency of rotating electrical machines. |
| IS 5216 | Guide for safety procedures and practices in electrical works. |
| IS 5578 | Guide for marking for insulated conductors. |
| IS 6875 | Control switches (switching devices for control and auxiliary circuits, including contractor relays ) for voltage up to and including 1000V AC. |
| IS 7098 | Cross - linked polyethylene insulated PVC sheathed cables. |
| IS 828 | Circuit breakers for over current protection for house hold and similar installations. |
| IS 10322 | Luminaries. |
| IS 12729 | General requirement of switchgear and controller. |
| IS 13032 | MCB boards for voltage up to and including 1000V AC. |
| IS 13947-2:1993 | Low voltage switcher and controller. |
| IS 732 | Code of practice for electrical wiring installations. |
| IS 3043 | Code of practice for earthing. |
| IS 3646 | Code of practice for interior illumination. |
| IS 1271 | Thermal evaluation classification of insulating material. |
| IS 722 | AC electricity meters. |
| IS 2309:1989 | Protection of Buildings and Allied Structures Against Lightning - Code of Practice. |
| IS 3231 | Specification for Electrical Relays for Power System Protection. |
| IS 3961 | Recommended current rating for cables. |
| IS 6701:1985 | Specification for Tungsten Filament Miscellaneous Electric Lamps. |
| IS 8686:1977 | Specification for Static Protection Relays. |
| IS 13947-2:1993 | Specification for Low Voltage switchgear and Low Voltage-Part 2: Circuit Breakers. |
| IS/IEC 309-1:1988 | Plugs, Sockets-Outlets and Couplers for Industrial Purposes-Part 1: General Requirements. |
| IS/IEC 309-2:1989 | Plugs, Sockets-Outlets and Couplers for Industrial Purposes-Part 2: Dimension Interchangeability Requirements for Pin and Contact Tube Accessories. |
| IEC 60034-5:2000 | Rotating electrical machines. Degrees of protection provided by the integral design of rotating electrical machines (IP code). Classification. |
| IEC 60034-6:1991 | Rotating electrical machines. Method of cooling (IC code). |
| IEC 60034-9:1997 | Rotating electrical machines. Noise limits. |

| | |
|---|---|
| IEC 60051-1:1997 | Direct acting indicating analogue electrical measuring instruments and their accessories. Definitions and general requirements common to all parts. |
| IEC 61439 | Low Voltage Switchgear and Control Gear Assemblies |
| IEC 60073:2002 | Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators. |
| IEC 60085:1984 | Method for determining the thermal Classification of electrical insulation. |
| IEC 60136:1986 | General requirements for rotating electrical machines. Specification for dimensions of brushes and brush holders for electrical machinery. |
| IEC 60137:1995 | Insulated bushings for alternating voltages above 1kV. |
| IEC 60188:2001 | High pressure Mercury Vapour Lamps. Performance Specifications. |
| | |
| IEC 60255 | Electrical Relays. |
| IEC 60269-1:1998 | Low-voltage fuses. General requirements. |
| IEC 60287-1-1:2001 | Electric cables - Calculation of the current rating - Part 1-1: Current rating equations (100 % load factor) and calculation of losses – General. |
| IEC 60404-1:2001 | Magnetic Materials. Classification. |
| IEC 60439-1:1999 | Specification for low-voltage switchgear and control gear assemblies. Specification for type-tested and partially type-tested assemblies. |
| IEC 60470:2000 | High-voltage alternating current contactors and contactor-based motor starters |
| IEC 60726:2003 | Dry-type power transformers. |
| IEC 60947-1:2004 | Specification for low-voltage switchgear and control gear. General rules |
| IEC 60947-2:2003 | Specification for low-voltage switchgear and control gear. Circuit-breakers. |
| IEC 60947-3:1999 | Specification for low-voltage switchgear and control gear. Switches, disconnectors, switch-disconnectors and fuse-combination units. |
| IEC 60947-4-1:2001 | Specification for low-voltage switchgear and control gear. Contactors and motor-starters. Electromechanical contactors and motor-starters. |
| IEC 60947-4-2:2000 | Specification for low-voltage switchgear and control gear. Contactors and motor-starters. A.C. semiconductor motor controllers and starters. |
| IEC 60947-4-3:2000 | Specification for low-voltage switchgear and control gear. Contactors and motor-starters. Contactors and motor-starters. AC semiconductor controllers and contactors for non-motor loads. |
| IEC 60947-7-1:2002 | Specification for low-voltage switchgear and control gear. Ancillary equipment. Terminal blocks for copper conductors. |
| IEC 61000 | Electromagnetic Compatibility (EMC). |
| ISO 1000:1992. | Specification for SI units and recommendations for the use of their multiples and of certain other units. |

| | |
|---|---|
| ISO 1461:1999 | Hot dip galvanised coatings on fabricated iron and steel articles. Specifications and test methods. |
| ISO 2112:1990 | Specification for aminoplastic moulding materials. |
| ISO 3046-1:2002 | Reciprocating internal combustion engines. Performance. Declarations of power, fuel and lubricating oil consumptions and test methods. Additional requirements for engines for general use. |
| ISO 3046-4:1997 | Reciprocating internal combustion engines. Performance. Speed governing. |
| ISO 5657:1986 | Fire tests on building materials and structures. Method of measuring the ignitability of products subjected to thermal irradiance. |
| PD 5304:2000 | The safe use of machinery. |
| SP 30:1985 | National Electric Code. |
| HD 21.1 S4:2002 | Cables of rated voltages up to and including 450/750 V and having thermoplastic insulation - Part 1: General requirements. |

## 1.2 Power Supply Information

The proposed power supplies are as follows:

| | | | |
|---|---|---|---|
| (i) | 11 kV AC System | Voltage variation +10 to -10% Freq. Variation +5 to -5% | Three Phase, 50 Hz, effectively earthed AC System. |
| (ii) | 415V AC System | Voltage variation +10 to -10% Freq. Variation +5 to -5 % | Three Phase and neutral, 50 Hz, effectively earthed system. |
| (iii) | 240V AC System | Voltage variation+10% to -10% Freq. Variation + 5% to -5 % | Single phase and neutral, 50 Hz, effectively earthed system |
| (iv) | 24V DC Supply | Voltage variation +/- 10% | Unearthed two wire system |

All equipment shall have rated withstand capacity based on above criteria.

## 1.3 General Electrical Requirements

### 1.3.1 Abbreviations of Electrical Terms

For the purpose of this Specification, the following abbreviations of electrical terms have been used:

R = red phase
Y = yellow phase
B = blue phase
N = neutral
ac = alternating current

| | | |
|---|---|---|
| dc | = | direct current |
| A | = | ampere |
| mA | = | milliamp |
| V | = | volt |
| kW | = | kilowatt |
| kWh | = | kilowatt hour |
| kVAr | = | kilovolt ampere reactive |
| kVA | = | kilovolt ampere |
| MVA | = | megavolt ampere |
| Hz | = | hertz (cycles per second) |
| CT | = | current transformer |
| SP | = | single pole |
| SPN | = | single pole and neutral |
| DP | = | double pole |
| TP | = | triple pole |
| TPN | = | triple pole and neutral |
| SPSwN | = | single pole and switched neutral |
| TPSwN | = | triple pole and switched neutral |
| LSF | = | low smoke and fumes |
| MCB | = | miniature circuit breaker |
| MCCB | = | moulded-case circuit breaker |
| RCD | = | residual current device |
| MCC | = | motor control centre |

### 1.3.2 Workmanship

Bidders shall ensure workmanship of good quality and shall assign qualified supervisor/ engineers and competent labour who are skilled, careful and experienced in carrying out similar works. DJB shall reserve the right to reject non-competent person/s employed by the contractor, if the workmanship is found unsatisfactory.

### 1.3.3 Contractor's License

It shall be the responsibility of the contractor to obtain necessary license/authorization/ permit for work for his personnel from the licensing board of the state. The persons deputed by the contract's firm should also hold valid permits issued or recognized by licensing board.

### 1.3.4 Units of Measurement

All information, dimensions and tolerances of layouts and terminal points shall be presented in Metric System to a degree of accuracy which permits the precise matching of existing components.

### 1.3.5 Environmental Conditions

All Plant shall be designed and manufactured for continuous operation under the specified climatic and environmental conditions as detailed elsewhere within the specifications.

### 1.3.6 Electrical Safety

(a) The Contractor shall be responsible for the electrical safety of all equipment supplied and installed. While any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on Site. If necessary, this shall include fencing of areas in which a risk is considered likely to exist, and erecting warning notices.

(b) The Contractor shall be responsible for ensuring that the electrical installation is carried out by competent personnel and that the work is carried out in accordance with standard procedures and test requirements. Before any piece of apparatus is energised, it shall be thoroughly examined to ensure that it is free of dirt, water, vermin or other foreign matter.

(c) The Contractor shall provide adequate safety labels for the safe operation and maintenance of all electrical equipment.

(d) An A1 size laminated single line diagram shall be provided on each switchroom wall.

(e) Each electrical switchroom shall be provided with all necessary safety equipment including operating gloves, full length rubber safety mat, a minimum of 2 Nos., CO2 portable fire extinguishers, fire bucket and any other equipment deemed necessary by the Contractor. An emergency first aid kit and safety procedure shall be provided in each switchroom.

## 1.4 Design Criteria for Electrical Equipment/ System

The Design Criteria described below covers the electrical equipment/system for the proposed Water Supply Project as follows:

The following assumptions have been made to arrive at the estimated load of the different sites.

### 1.4.1 Load Factor

| | | | |
|---|---|---|---|
| (i) | Motor | : | 0.9 |
| (ii) | Auxiliary motor | : | 0.9 |
| (iii) | Auxiliary load, valve motors, etc. | : | 0.9 |
| (iv) | Lighting load | : | 1.25 |

### 1.4.2 Diversity Factor

| | | | |
|---|---|---|---|
| (i) | Main and auxiliary motor | : | 1.0 |
| (ii) | Auxiliary load, valve motors, etc. | : | 1.5 |
| (iii) | Lighting load | : | 1.2 |

### 1.4.3 Power factor of LV Motors:

As per Manufacturer's Catalogue

### 1.4.4 Efficiency of LV Motors:

Premium Energy Efficient Motors (Energy efficient eff 3)

Energy efficient, high performance motors shall be provided for optimum utilization of energy.

### 1.4.5 Design Criteria- Miscellaneous

The capacity of the transformers are decided based on 100 % standby (redundancy) i.e. in the event of outage of any one of the transformer, other transformer can supply the complete load of the plant.

All electrical equipment will be rated for $50^0$ C design ambient temperatures.

All power cables shall be sized based on continuous current capacity, permissible voltage drop and short circuit current rating. The voltage drop shall be limited to 3 % at rated equipment current rating.

The other rating factors for variation in ground temperature, variation in ambient air temperature, grouping of cables, depth of laying, etc. shall also be considered for cable sizing.

The illumination levels proposed for various areas are as follows:

| Area | | Lux Level |
|---|---|---|
| • Pump House | : | 200 |
| • Switch Gear Room / area | : | 250 |
| • Control room | : | 300 |
| • Store Room | : | 150 |
| • Office | : | 250 |
| • Stair Case, Coridor, walkway | : | 100 |
| • Bathroom / Toilet | : | 100 |
| • Street Lights | : | 30 |
| • Parking Area | : | 50 |
| • Chlorination Room | : | 200 |
| • Battery Room | : | 150 |

For all indoor and outdoor areas LED fittings to be provided. Decorative fixtures/ receptacles shall be used for office areas and industrial type fixtures/ receptacles shall be used for remaining areas. Street/ area lighting shall be controlled by time switch for automatic switching off luminaries.

The values of fault level for designing the electrical system shall be based on transformers capacities, its impedance and system fault level. Fault clearing time for sizing of earth conductor will be taken as one second.

The material of earthing conductor shall be hot dip Galvanized Steel. All connections between the earth conductors buried in earth/concrete and between earth conductor and earth leads shall be of welded type. While sizing the buried earth conductor, a corrosion allowance of at least 20% shall be taken. Plant earthing system shall be designed such that the overall earthing grid resistance is maximum one (1) ohm.

Main earthing conductors outside and inside the building shall be planned in such a manner that various equipment is connected to earthing system by two connections in a reliable manner.

## 1.5 Inspection and Test at Manufacturer Works:

(a) The responsibility for inspection, certification, etc. of all materials, parts lies with the Contractor.

(b) The Contractor shall specify all of the inspection and testing requirements in the quality plan which shall identify the activities requiring the DJB approval, review, witnessing etc.

(c) All Equipment shall be inspected for compliances with:
- Requirement of DJB specification & correspondence therefore.
- Applicable codes, standards and specifications, which shall also include sub-referenced standards therein.
- Test and Inspection Plans produced by the Contractor. Inspectors have the right to request additional inspections or tests to ensure that the equipment complies with the specification and all relevant codes & standards.

(d) Contractor shall furnish valid Type Test Certificates of similar ratings along with the QAP. Fresh type tests for the equipment are not needed, provided the Manufacturer can submit certificates that the equipment complies with all type tests as prescribed by IEC/IS Standard specifying the test requirements for that equipment.

(e) Routine tests on the equipment shall be carried out as per the relevant IEC/IS in presence of DJB / PMSC representative. Equipment offered for final inspection shall be complete and ready for shipment, with the possible exception of the final paint finish.

(f) Routine Test certificates to be submitted for Equipment and its all auxiliaries.

(g) Vendor to furnish required copies of test certificates, Ref Documents, Drawings, and Instruction Manuals before equipment are dispatched.

(h) Any defects found by the DJB / PMSC representative shall be rectified in their presence. Where this is not possible or practical, check lists shall be prepared and signed by the QAP inspector stating all “pending items”. Copies of these lists shall be sent to the Client to enable their subsequent checking. The equipment shall not leave the Vendor factory before all defects have been rectified and without the written permission of the Client.

(i) All cost for all inspection shall be paid by Contractor, Contractor will arrange proper inspection schedule for witness at Manufacturer works.

(j) Contractor shall intimate 7 days before in writing to DJB and PMSC for inspection schedule at Manufacturer works.

(k) All spare parts shall be subjected to the same inspection standards and full material certification as the main order.

(l) Any acceptance or release of equipment following an inspection or test activity shall in no way relieve the Vendor of his contractual responsibility to provide guarantees as to the suitability of the materials, workmanship and performance of the equipment in accordance with this specification.

(m) Client / Consultant reserve the right to waive the inspection at any Item / stage. Inspection shall be carried out only on receipt of Vendor's internal test report of the equipment offered and scrutiny of the same.

## SUB-SECTION 2. POWER TRANSFORMER

### 2.1 General

(a) Transformers shall be of dry type, encapsulated, cast resin, air cooled for indoor installations. Dry type transformers shall be with class F insulation and temperature of winding shall be limited to Class 'B'. The noise level for all transformers shall be in accordance with NEMA TR-1. Transformers shall be designed for over-fluxing withstands capability of 110% continuous125% for at least 1 minute and 140% for 5 seconds.

(b) Overloads shall be allowed as per IEC 354. Under these conditions, no limitations by terminal bushing, tap changers or other auxiliary equipment shall apply.

(c) Transformers impedance shall be suitably chosen considering fault current limitation of Switchgear and voltage drop limitation of motors.

(d) Dry type transformer shall be suitable for operation of maximum 115°C temperature and shall be enclosed in sheet steel enclosure of at least IP 23 degree of protection, complete with door and interlocking facility.

(e) The transformer shall be suitable for continuous operation at rated load for maximum ambient in summer temperature of 50 deg C. The maximum humidity shall be considered as 100%. The maximum temperature and humidity however shall not occur simultaneously.

(f) Transformer shall be suitable for cable/ bus duct termination with disconnect chambers as required.

(g) All the transformers shall be designed to withstand without injury, the thermal and mechanical stress of short circuit current at its terminal with full voltage maintained behind it for a period of 3 seconds for HV transformers and 2 seconds for LV transformers.

(h) The transformers shall be capable of continuous operation at the rated output under the following conditions without injurious heating at that particular tap.
- The voltage variation of ± 10% of rated voltage of that particular tap
- Frequency variation of -5% to +5% of rated frequency
- Combined voltage and frequency variation of 10% (absolute sum).

(i) The transformers shall be sized for total working load and 20 % design Margin.

(j) Transformer shall be designed and supplied with 100 % redundancy and each transformer shall be designed to cater complete plant load.

### 2.2 Construction Features

#### 2.2.1 Base

(a) The transformer base shall be a made of separate rigid steel, capable of supporting the core and coil assembly and enclosures. Construction shall include provisions for lifting as well as for jacking and skidding or rolling in both directions.

(b) Two stainless steel ground pads with two tapped holes for attaching ground leads shall be provided, one in each diagonally opposite corner of the base. Lifting provisions shall be designed for lifting the transformer and the core --and-coil assembly, separately or together

#### 2.2.2 Primary & Secondary Coils, Core and Coil Assembly

(a) The high voltage and the low voltage coils shall be wound with high conductivity copper conductors and then cast separately in moulds. Coils shall be separated by a uniform air

space that permits free circulation of cooling air between the coils. Winding shall be properly sized, insulated in operation, including short circuits, when the transformer is properly installed and adequately protected.

(b) The transformer core shall consist of thin, individually insulated sheets of high permeability grain-oriented, non-aging silicon steel. They shall be miter-corner-cut without burs and hand stacked, to provide a cross section most nearly resembling the circular cross-section inside low voltage coil. The core should be CRGO material for high permeability.

(c) Construction shall be consisting of separate high and low voltage coils for each phase, mounted coaxially, with air space between high and low voltage coils adequate for the rated voltage levels. Coils shall be mounted concentrically and supported in place on the transformer core so as to restrain movement in shipping and services. Each coil shall be supported on epoxy blocks, top and bottom, with resilient pads to retain the coils while permitting thermal expansion under loading. The core-and-coil assembly shall be designed and manufactured to withstand without damage the short circuit testing as defined in IS 11171, IS 2026 (part 1)- 1977.

### 2.2.3 Windings

(a) The windings shall be of high conductivity copper, wire.

(b) The amount of insulation shall be determined not only by normal voltage per turn, but also by due consideration of the line voltage and the service conditions, including impulse phenomena caused by lightning strokes on the transmission line and surges during switching operation of circuit breakers and other associated fault conditions.

(c) In case of graded insulation winding, the insulation of the turns shall be reinforced between turns or provided with suitable means to protect the winding against surges and transients on the basis of result of study for voltage distribution in coil against impulse injection.

(d) The primary and secondary windings shall be so placed that they remain electrically balanced with their magnetic centers coincident under all conditions of operation. The windings shall be so arranged and so firmly clamped in position that they will withstand the mechanical stresses to which they might be subjected on short circuit.

(e) Low voltage winding shall be placed next to the core and high voltage winding shall be placed concentrically over it. Individual coils shall be built, impregnated and lowered on the core legs and after top yoke filling the coils shall be clamped by pressure bolt. Winding shall be crossover/helical/continuous disc type with multiple conductor to maintain the desired eddy currents.

(f) Provision shall be made for taking up any contraction of windings due to shrinkage of insulation materials in order to eliminate movement of any coil due to short circuit, vibration or other sources of disturbance.

(g) All windings, after being wound, all fibrous and hygroscopic material used in the construction of the transformers shall be dried under vacuum, and be impregnated with purified.

(h) The general design and construction of the transformer and the bracing of the windings shall be such that no mechanical movement of the coil is possible as a result of the dead short circuit on any side of the transformer. The transformer shall withstand, without injury, the dead short circuit for duration of at least two (2) seconds.

- One number of winding temperature scanner (digital) with alarm/trip contacts to be provided.
- One number of PT-100 type RTD sensor per LV winding to be provided.

### 2.2.4 Rating and Connection Plates

Rating and connection plates shall be securely fitted to the transformer and for enclosed transformers, on the outside of the enclosure. The plates shall be of non-corrodible and durable material.

### 2.2.5 Fittings

(a) Transformers shall be fitted with bi-directional rollers and earthing terminals
(b) Bushings
- The bushings shall conform to the IS 2099 and applied standard.
- All porcelain parts shall be one piece. Porcelain parts constructed or assembled segments will not be acceptable. Threaded studs shall be furnished on all bushings.
- The bushings for the terminals including neutral shall be of oil filled type or solid single-piece porcelain type.
- The porcelain of each busing shall be glazed and the glaze shall be uniform throughout the surface.
- The neutral terminal shall be connected with a copper conductor bar or rod or pipe, which shall run down to ground, supported by insulators on the transformer tank. The neutral conductor shall be fitted with a terminal for earthing with proper size copper strip.

### 2.2.6 Terminal Connectors

Expansion-type terminal connectors shall be furnished and equipped with an alignment guide. The size of conductor and method of take-off will be furnished when shop drawings are submitted by the Contractor for approval.

### 2.2.7 Terminal Cabinet, Duct and Wiring

The Contractor shall furnish and install where practicable, metal conduit and duct for wiring of the accessories. The conduit duct shall be suitably connected to the transformer.

The terminal cabinet shall be mounted on a terminal board to facilitate the wiring for external circuits.

The Contractor shall furnish and install, wherever necessary, the cable and wire required for connecting the accessories and terminal board. The bottom of the terminal cabinet shall be equipped with removable blank cover plates.

### 2.2.8 Protection of Transformer (Marshalling Box)

Protection as winding temperature scanner shall be provided.

### 2.2.9 On Load Tap Changer (OLTC)

(a) On Load Tap changer shall be provided for transformer 800 KVA and above ratings.
(b) OLTC gear shall safely carry and withstand through fault current of the transformer and shall incorporate protections to prevent tap change operation during flow of such fault current.
(c) Tap changing once initiated should be completed irrespective of status of the initiating devices or loss of control supply.
(d) Taps shall be provided + 5% to -10 % in steps of 1.25 % .

(e) OLTC driving mechanism and its associated control equipment shall be mounted in a weatherproof cabinet having degree of protection of at least IP 42. The cabinet shall incorporate the following:
- Driving motor with associated switch and fuse (or MCB) and raise and lower contactors with overload and single phasing protection
- Remote / local selector switch
- Control switch for raise / lower operations
- Over current blocking device
- Limit switches to prevent over travel and final mechanical stops
- Manual operating device with interlocking switch
- Tap position indicator and operation counter
- Break or clutch to permit only one tap change at a time
- Auxiliaries such as terminal blocks, space heaters, interior lighting, etc.
- Anti Condensation heater with switch.

(f) Voltage sensing and regulating device for automatic control including a time delay relay for delaying the indication of tap changing shall be provided. Settings shall be adjustable at site.

(g) A remote control panel shall be provided in the electrical room and shall include, but not be limited to following:
- Voltage regulator (solid state)
- Control switches for raise / lower
- Tap position indicator
- Alarm annunciator with 'Acknowledge', 'Sound Cancel', 'Reset' and ‘Lamp test' push buttons
- Audio signal for 'Tap Change in progress’'
- Winding temperature indicator
- Indicating lamps for upper and lower limit of taps and for 'Tap Change in Progress’
- Auxiliary relays as required for remote annunciation, control
- Auxiliaries such as terminals, fuses, space heaters, interior lighting, etc.

### 2.2.10 Off Load Tap Changer

(a) The Tap-changer shall be capable of operating under no-voltage condition from the outside of the transformer which is installed at convenient level for easy operation. The position must be clearly indicated. All taps shall be rated for full output. suitable locking mechanism to avoid operation for tap changing during transformer energizing or to avoid charging on incomplete tap position shall be provided by utilization of transformer disconnecting switch auxiliary contact, etc

(b) Off circuit tap changer shall be comprise of
- + 5% to – 5 % in steps of 2.5%
- Operating handle or wheel accessible from ground level
- Tap position indicator
- Padlocking arrangement with padlock.

## 2.3 Performance Requirement

(a) Core type, two windings cast resin dry type transformer for indoor type shall be suitable for operation on11KV/0.433KVvoltage system having rating to take care of full working load. The transformers shall be loaded up to 80% of full working load capacity. The rated

power of the transformer shall be so designed to take full working load, where one transformer is in service mode.

(b) The No load voltage in the primary will be 11KV and in secondary will be 0.433KV. Number of phases shall be (3) three at 50 Hz. The percentage impedance as per IS code, in Vector group Dyn11 type of cooling natural Air with winding of electric grade copper.

(c) Ambient temperature 50º C & Average winding temperature over ambient temperature 90 ºC Rated HV bushing suitable for 12KV, with accessories earthing terminals, rating & diagram, Lifting lugs winding temperature scanner.

(d) Transformer shall be capable of delivering the rated current at a voltage equal to 105% of the rated voltage without exceeding the limiting temperature rise.

(e) The transformer shall be designed with particular attention to the suppression of harmonic voltage

## 2.4 Rejection

(a) The Engineer reserves the right to reject the transformer under the following condition:
- Voltage ratio at no load not within the limits of tolerance over the guaranteed value.
- Impedance voltage at principal tapping not within the limits of tolerance over the guaranteed value.
- No load and load losses exceeding the guaranteed loss value by more than 15%

(b) If the commissioning of the pumping station is likely to be delayed by rejection of a transformer, DJB reserves the right to accept the rejected transformer until the replacement of new transformer. Transportation of rejected and replaced transformer, as well as installation and commissioning of both the transformers shall be at contractor's cost.

## 2.5 Transformer Compounds

(a) The transformers shall be housed in a transformer room located in sub-station building. A minimum clearance as per IER shall be provided to all sides of the transformer. Transformers shall stand on reinforced concrete plinths.

(b) The name plate shall be provided at the room wall identifying the transformer number and rating. The name plate shall be plastic laminate or other material approved by the Engineer and the size of characters and numerals shall be not less than 50mm. The name plate shall be fixed to the access gate using stainless steel fixings.

(c) Each transformer rooms shall be provided with adequate portable fire fighting equipment.

## 2.6 Tests & Test Reports

(a) For all the type tests as per relevant IS standard, type test certificates which are not older than five (5) years from the date of bid submission shall be submitted for Client review. If valid test certificates are not available then type test shall be carried out on each type of transformer.

(b) All routine tests as per IS 11171 standard shall be carried out at manufacturer's works in presence of Client or his representatives. In addition, Temperature rise test shall be conducted, in presence of Client or his representatives, on one Transformer of each rating.

## SUB-SECTION 3. MOTORS

### 3.1 General

(a) Premium energy-efficient type motors shall have to be considered for this project and shall have maximum efficiencies at rated output as per latest norms. Motors shall be of the AC Squirrel Cage type suitable for running with Variable Frequency Drive (VFD) which will have compatibility with Instrumentation and SCADA system.

(b) They shall be suitable in all respects for service in extreme climate conditions. Motors intended for use with VFD are to be provided with improved, stronger insulation as compared to standard motors. These motors typically have increased winding slot insulation, increased first-turn insulation and increased phase-to-phase turn insulation, as compared to standard motors. Motors shall be manufactured with "VPI" (Vacuum Pressure Impregnation) process.

### 3.2 Premium Efficiency LV Motor

(a) Motors shall be of Squirrel Cage induction motor. The Degree of protection shall be IP: 55. The insulation shall be Class 'F', however the temperature rise shall be restricted to that of 'B' class.
(b) Motor of rating 30 kW and above shall be provided with space heater suitably located for easy removal or replacement and winding shall be suitable for continuous heating from 230V, single phase 50 Hz supply.
(c) Maximum power required by the driven equipment over the entire range of operation. (In case of pumps from shut off to run off)
(d) The superior design and higher quality of material shall be used to reduce the heat generated into in the motors and make motors Premium Energy Efficient (identical to efficiency class IE3 according to IEC 60034-30) to draw lower power from the system as per IS 12615 -2011. The motors are to be operated at nominal voltage and with VFD and / or frequency with tolerance as per IS 325**.**

### 3.3 Specific Requirements

#### 3.3.1 Starting Characteristics

(a) The motor characteristic shall be coordinated with VFD starter as per requirement. For other motors it shall be coordinated with respective starters.
(b) The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.
(c) Motor shall be capable of three equally spread starts per hour, two starts in succession, with motor initially at rated load operating temperature.
(d) Pump motor subject to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at 125% rated speed in reverse direction.

#### 3.3.2 Locked rotor withstand time

(a) The locked rotor withstand time under hot condition at 110% rated voltage shall be more than motor starting time at least 2.5 seconds for motors starting time up to 20 sec and by 5 seconds for motor of starting time more than 20 seconds.
(b) Starting time mentioned is at minimum permissible voltage of 80% rated voltage,
(c) Hot thermal withstand curve shall have a margin of at least 15% over the full load current of the motor to permit relay setting using motor rated capacity.

### 3.3.3 Running requirements

(a) Motor shall run continuously at rated output over the entire range of voltage with ± 10 % of the nominal value and at any frequency with ± 3 % of the nominal value.
(b) The motor shall be capable of operating satisfactorily at full load for 5 minutes without injurious heating at 75% rated voltage at Motor terminals.
(c) The Motor shall be capable of resuming normal operation after a system disturbance causing temporary loss of supply voltage for a period up to 0.2 sec. (fault clearing time) followed by sudden restoration to 70% rated voltage. From this voltage the motors shall be capable of accelerating and ultimate recovery under the most arduous load conditions.

## 3.4 Construction Features

### 3.4.1 Enclosure

(a) All motor enclosure shall conform to the degree of protection IP-55 unless otherwise specified, Motor for outdoor or semi outdoor service shall be of weather proof construction.
(b) For hazardous area, approved type of increased safety enclosure shall be furnished.
(c) Motor shall be designed on 50 deg. C ambient temperature.
(d) Motor shall be suitable for bi-directional rotation.

### 3.4.2 Cooling

The motor shall be totally enclosed fan cooled (TEFC). IS: 6362 : 1995/ IEC Pub 34-6 : 1991.

### 3.4.3 Winding & Insulation

(a) All insulated winding shall be of copper.
(b) Motors shall have Class F insulation but limited to Class B temperature rise.
(c) Winding shall be impregnated to make them Non-hygroscopic and oil resistant.
(d) Insulation level of appropriate level shall be considered.
(e) Electrical joints and connections shall withstand the mechanical and thermal stresses under normal and abnormal operating conditions. Stator end windings shall be blocked and braced to provide high rigidity
(f) Completed windings, including connections, shall be subjected to a minimum of two cycles of vacuum impregnation with solvent-free resin varnish followed by curing, so as to fill effectively the gaps between individual conductors, to enhance mechanical strength and to provide a high resistance to moisture, oil and chemical contamination.
(g) The insulation of cables connecting stator windings to terminal boxes shall be of the chloro sulphonated polyethylene (CPS) or ethylene propylene rubber (EPR). Natural rubber insulated cables shall not be used. Cables shall be securely fixed to the stator frame.
(h) The winding insulation materials and cable insulation shall be resistant to flame propagation.

### 3.4.4 Tropical Protection

(a) All motors shall have fungus protection involving special treatment of Insulation and metal against fungus, insects and corrosion.
(b) All fittings and hardware shall be corrosion resistant.
(c) Fans and blades external to the enclosure shall be protected against contact by means of guards.In case of motors with VFD, excess heat may be generated at lower speed and to overcome the temperature rise, extra cooling may be envisaged.

### 3.4.5 Bearings

(a) Motor shall be provided with anti-friction bearings unless sleeve bearings are required for

particular application.

(b) Bearings shall be capable of accepting the mechanical & electrical forces imposed on them by the rotor and external forces due to VFD drive method.

(c) Bearings shall be provided with seals to prevent leakages of lubricants or entrance of foreign matters like dirty water etc. into the bearing area and shall be designed to permit the easy removal of bearings. Oil-lubricated bearings shall be fitted with a breather.

(d) Sleeve bearings shall be split type, ring oiled with permanently aligned, close running shaft sleeve.

(e) Grease lubricated bearings shall be pre lubricated for low rating motors and re-grease able for higher rating motor and shall have provision for in service position

(f) Lubricant shall not deteriorate under all service conditions. The lubricant shall be limited to normally available type with oil companies

(g) Bearings shall be insulated as required to prevent shaft current to flow through bearings result in damage. They shall be connected to earth at one point via a link. The link shall be removable to permit testing of the bearing insulation.

(h) Oil and water pipes, direct-driven oil pumps and any other ancillary equipment shall be insulated as necessary to maintain the integrity of the bearing insulation. The insulation shall not be short-circuited by the application of electrically- conducting paint

### 3.4.6 Noise and Vibration

(a) The Noise level shall not exceed 75 dB (A) at 1.5m from motor at no load condition.

(b) The peak amplitude of vibration shall be as per IS:12075- 1987 specified limits.

### 3.4.7 Motor Terminal Box

(a) Motor terminal box shall be detachable type and located in accordance with IS1231: 1974. clearing the motor base plat/ foundation.

(b) Terminal box shall be capable of being turned 360° in steps of 90° unless otherwise approved.

(c) The terminal box shall be split type with removable cover with access to connections and shall have the same degree of protection as motor.

(d) Terminal shall be stud, solidly constructed and thoroughly insulated from the frame.

(e) The terminals shall be clearly identified by phase markings with corresponding direction of rotation marked on the driving end of the motor.

(f) The terminal box shall be capable of withstanding maximum system fault current for duration of 0.02 sec,

(g) Motor terminals box shall be furnished with suitable cable lugs and double compression brass glands to match the cable being utilized. The details of the cable will be intimated by the Contractor during detailed engineering stage.

(h) The gland plate for single core cable shall be non-magnetic type.

(i) Additional epoxy insulator with bus bar shall be provided for connection of two more. Cables per phase if required during detail engineering without any extra cost.

### 3.4.8 Grounding / Earthing

(a) The frame of each motor shall be provided with two separate and distinct grounding pads complete with tapped hole, G.I. Bolts & washer etc.

(b) The cable terminal box shall have separate grounding terminal.

### 3.4.9 Rating Plate

In addition to minimum information required by I.S. Code, the followings shall be shown on the Motor rating plate:

- Temperature rise in Deg. Centigrade under rated condition and method of measurement.
- Degree of protection.
- Bearing identification No. & recommended lubricant.
- Location of Insulated bearings.
- Confirmation "Suitable to be used with VFD" for VFD motors.

### 3.4.10 Accessories

General Accessories shall be furnished as listed or otherwise needed by the driven equipment specification or application.

(a) Space Heater

- Motor shall be provided with space heater suitably located for easy removal or replacement.
- The space heater shall be rated 230V, single phase 50 Hz and sized to maintain the motor internal temperature above low point when the motor is idle,
- The motor winding shall be suitable for continuous heating from 230V, single phase 50 Hz supply.

(b) Accessory Terminal Box

- All accessory equipment such as space heater, temperature detector, and current transformers shall be wired to and terminated in the terminal boxes, separate from and independent of motor terminal.
- Accessory terminal box shall be complete with double compression Brass glands and pressure type terminals to suit user's cable connections

(c) Lifting Provisions
Motor weighing 25 kg or more shall be provided with eye bolt or otherwise adequate provision of lifting.

(d) Painting

Motor including fan shall be painted with corrosion proof epoxy paints

### 3.5 Tests

(a) All routine & acceptance tests as per relevant IS shall be conducted on motors shall be carried out in presence of DJB Engineers and its representative. .
(b) For all motors Type Test certificates shall be furnished. If the test reports are not found in order by Client then these tests shall be conducted by the Contractor without any cost implication.
(c) Efficiency and loss measurements shall be done for all LT motors as per relevant standard (Being energy efficient motors.) as routine test.

## SUB-SECTION 4. 11 KV SWITCH BOARD

### 4.1 Intent of specification

This specification is intended to cover the design, manufacture, assembly and testing at manufacturer's works, supply & delivery, properly packed for transport to site of HV Switchgear –11 KV complete with all accessories for efficient and trouble-free operation.

### 4.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

| | | |
|---|---|---|
| IS : 3427 | : | Metal enclosed switchgear and Control gear for voltages above 1000V but not exceeding 11000V |
| IS : 2147 | : | Degrees of protection provided by enclosures for switchgear and Control gear. |
| IS : 2516 | : | Alternating Current Circuit Breakers |
| IS : 10601 | : | Dimensions of terminals of high voltage switchgear andControlgear |
| IS : 4710 | : | Switches and Switch Isolators above 1000 V but not exceeding 11000 V. |
| IS : 2705 | : | Current Transformers |
| IS : 3156 | : | Voltage Transformers |
| IS : 3231 | : | Electrical relays for Power System Protection |
| IS : 375 | : | Switchgear bus bars, main connections and auxiliary wiring, marking and arrangement |
| IS : 7098 | : | Cross linked Polyethylene insulated PVC sheathed cables for working voltages from 3.3KV upto and including 33KV. |
| IS : 3043 | : | Code of practice for Earthing |
| IS : 6875 | : | Control Switches Push Buttons |
| IS : 8686 | : | Specification for static protective relays |
| IS : 9046 | : | AC contactors for voltages above 1000 volts and upto and including 11000V. |
| IS : 9921 | : | AC dis-connectors (isolators) and earthing switches for voltages above 1000V |
| IS : 13118 | : | Specification for high voltage AC circuit breakers. |
| IS : 9385 | : | High voltage fuses |
| IS : 9224 | : | Low voltage fuses |
| IS : 2544 | : | Porcelain post insulator for voltage above 110 V |

The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

## 4.3 Design Criteria

(a) Switchgear and its components and accessories shall conform to relevant IEC/IS Standards amended up to date.
(b) The switchgear shall be indoor, metal clad, floor mounted, draw out type. Design and construction shall be such as to allow extension at either end.
(c) The switchgears will be located in a clean but hot humid and tropical atmosphere.
(d) For continuous operation at specified ratings, temperature rise of the various switchgear components shall be limited to the permissible values stipulated in the relevant standards and this specification.
(e) The switchgear and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short circuit current without any damage or detoriation of material.
(f) Circuit breaker shall not produce any harmful over voltage during switching of induction motors.

## 4.4 Specific Requirements

### 4.4.1 Construction:

(a) Metal clad switchgear and control gear shall comprise metal enclosed switchgear and control gear in which components are arranged in separate compartments with metal enclosures intended to be earthed. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits.

(b) The metal clad switchgear and control gear shall have separate compartments for the following components:
   i. Each set of busbars
   ii. Current transformers
   iii. Voltage transformers on incomer side
   iv. Each main switching device
   v. Cable chambers suitable for heat shrinkable type cable
   vi. Metering and relaying devices.

(c) Degrees of Protection:
   Protection against approach to live parts or contact with internal moving parts not less than IP4X class for all the above compartments.
(d) Switchgear shall comprise indoor, metal clad, Draw out type Vacuum circuit breaker. The circuit breaker shall be fully horizontally draw out type. The circuit breaker shall have distinct service and test positions. In the test position the circuit breakers shall be capable of being tested for operation without energizing the power circuits. Four normally open auxiliary contacts shall be provided for each of the service and test limit position switches.
(e) The test position should preferably be obtained without the need to disconnect normal control connections and use of extension cords for testing.
(f) The switchgear shall fully house the breaker both in the service position as well as in the test position.
(g) Switchgear shall be dust, moisture and vermin-proof.

(h) Separate removable gland plates with minimum thickness of 3 mm shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.
(i) All doors, panels, removable covers shall be provided with all around neoprene gaskets. All louvers shall have screens and filters. Vent openings shall be covered by fine mesh on the vertical face. The screens and grills shall be made of either brass or galvanized iron wire mesh.
(j) Metal clad unit shall comprise rigid welded structural frame enclosed completely by metal sheets, minimum 2.5 mm thick (hot rolled) or 2.0 mm thick (cold rolled), smooth finished, leveled and free from flaws.
(k) The current transformers shall be mounted on the fixed portion of the switchgear and not on the breaker truck.
(l) Each switchgear cubicle shall be fitted with a label in the front and rear of the cubicle. Each switchgear shall also be fitted with label indicating the switchgear designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

(m) Safety Interlocks

Switchgear shall be provided with following interlocks:

- Operation of an isolator shall not be possible unless the associated circuit breaker is in the open position.
- Compartment door of a breaker or an isolator shall not open unless the associated breaker or an isolator is in open position.
- Caution name plate, 'Caution Live Terminals' shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incoming terminals of main isolators.
- Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the exposed live parts when the breaker is withdrawn.

(n) Bus and Bus taps:

- Main busbars shall be of electrolytic grade copper alloy of high conductivity and non-segregated type.
- Busbars shall be located in air insulated enclosures and segregated from all other compartments of the cubicle. Direct access or accidental contact with busbars and primary connections shall not be possible. To provide a seal between adjacent cubicles, busbars shall be taken through seal-off bushings or insulating pads.
- All busbars joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections are required, suitable bimetallic connectors or clamps shall be used.
- Busbars shall be rated in accordance with the service conditions and the rated continuous and short time current ratings specified in the Data sheet / SLD. Maximum temperature of the busbars and busbar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 85 deg. C.
- Busbars shall be adequately supported on insulators, to withstand dynamic stresses due to short circuit current. Busbar support insulators shall conform to relevant standards.
- The busbar clearances in air shall be suitable for the short circuit levels.
- Busbars shall not be painted and all performance characteristics specified shall be obtained with unpainted busbars.
- Busbars shall be fully insulated for highest system voltage of 12 kV with heat shrinkable sleeves.

### 4.4.2 Circuit Breaker:

4.4.2.1 General

(a) Circuit breakers shall be VCB type. These shall conform to relevant standards specified and shall be of draw out type. Circuit breakers shall comprise three separate identical single pole units operated through a common shaft by the operating mechanism.
(b) Isolating plugs and sockets for power as well as control circuits shall be of robust design and fully self-aligning. Plugs and sockets for power circuits shall be silver faced and shall be insulated with PVC or other insulating material shrouds.
(c) The circuit breakers shall be complete with surge arrestors to provide protection to the equipment controlled by the breaker, against switching surges. The surge arrestors shall be 'rotating machine class type' suitable for use with motors.
(d) Breaker internal wiring up to the plug shall be similar for all breakers.

4.4.2.2 Operating Mechanism

(a) Circuit breaker shall be power operated, by a motor charged spring operated mechanism. Main poles of the breakers shall be such that unless otherwise specified, the maximum difference between instants of contacts touching during closing shall not exceed half cycle of rated frequency.
(b) Operating mechanism shall be provided with non-pumping feature, electrically and mechanically. Electrical anti-pumping feature shall be obtained by means of an auxiliary relay.
(c) Main poles of the breaker shall operate simultaneously. There shall be no objectionable rebound and the mechanism shall not require any critical adjustment. It shall be strong, rigid, positive and fast in operation.
(d) Mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and will not cause tripping or closing operation of the power operated closing devices. When the circuit breaker is already closed, failure of any auxiliary spring shall not cause damage to the circuit breaker or endanger the operator.
(e) The circuit breakers shall be fully draw-out type, having SERVICE, TEST and DISCONNECTED positions with positive indicators for service & test positions.
(f) A mechanical indicator shall be provided to show open and closed positions of breaker. It shall be located in a position where it will be visible to the operator standing on the front of the switchgear with cubicle door closed.
(g) The closing coil shall operate correctly at all values of voltage between 80 % and 110 % of the rated voltage. A shunt trip shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and all values of supply voltage between 50 % and 110 % of rated voltage.
(h) Mechanical trip and close devices shall be provided for manual operation of the breaker. Access to mechanical closing device shall be only after opening the cubicle door. However, the mechanical trip device shall be brought out to the front of the cubicle door.
(i) Working parts of the mechanism shall be of corrosion resisting material. Bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned and locked to prevent loosening or changing adjustment with repeated operation of the breaker.
(j) Auxiliary switches mounted on the fixed portion of the cubicles and directly operated from the breaker operating mechanism on each breaker having 8 'NO' and 8 'NC' potential - free contacts rated for 10 amps. 240V AC and 10 amp (inductive breaking) 24 V DC shall be provided. The contacts shall be in addition to those utilized in the control circuit of each

breaker and shall be exclusively meant for the Purchaser's use in external interlocks and controls.

4.4.2.3 Spring Operated Mechanism

(a) Spring operated mechanism, shall be complete with motor, opening spring, closing spring with limit switch for automatic charging and all necessary accessories to make the mechanism a complete operating unit.
(b) As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply to the motor, at least one open- close - open operation of the circuit breaker shall be possible.
(c) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring.
(d) Closing action of the circuit breaker shall compress the opening spring ready for tripping.
(e) When closing springs are discharged, after closing a breaker, closing springs shall automatically be charged for the next operation.
(f) Motor shall be such that it requires only about 30 sec. for fully charging the closing spring. Motors shall be rated for 240V AC and shall operate satisfactorily at all values of voltage between 80 % to 110 % of rated voltage.
(g) Mechanical indicators to indicate charged and discharged condition of spring shall be provided.

### 4.4.3 Control & Indication

(a) Breaker control supply shall be of 24V DC. Breaker closing and tripping shall be suitable for 24 V DC.
(b) The circuit breaker shall be wired up for local & remote operation. Each breaker shall be equipped with following :
- One no of TEST-NORMAL selector switch stayput type with pistol grip handle and key interlock
- All indicating lamps shall be preferably LED types.
- Breakers shall be controlled locally and / or remotely as per plant operational requirement. Breaker signals, protection relay operated condition and necessary current, voltage and power signals shall be routed to PLC / SCADA in addition to local indication.
- Each switchgear shall be provided with one DC fail relay and DC fail indicating lamp for each DC incomer. Further a common DC failure alarm contact shall be wired up for remote annunciation to indicate failure of DC supply to any breaker panel.

### 4.4.4 Auxiliary Switches

(a) Control switches shall be rotary, multi-position, cam-operated, multi-stage type with dust cover and silver-to-silver contacts rated 600 volt and 20 amperes. Breaker control switches and selector switches shall have "pistol grip" handles.
(b) Meter switches shall all have "knurled knob" handles. Lockout switches shall have "oval" handles.
(c) Each circuit breaker unit shall be provided with a breaker control switch and two indicating lights, red (breaker closed) and green (breaker open). Control switches shall be three-position (close-off-trip) with spring return to center. Pistol grip handles to be provided.
(d) Each incoming line main circuit breaker, bus tie circuit breaker, and feeder circuit breaker unit shall be provided with a Truck Operated Cell (TOC) auxiliary switch.

(e) The TOC switch shall operate when the circuit breaker is racked into the connected position only. The Mechanism Operated Contact (MOC) auxiliary switch shall operate when the breaker closes and in either the connected or test positions.
(f) The TOC switch shall have a minimum of two normally open and two normally closed contacts rated at 10 amperes and 24 VDC. The MOC auxiliary switch shall have a minimum of five normally open and five normally closed contacts rated 10 amperes. All auxiliary switches shall be wired to terminal blocks located in the breaker compartment.

### 4.4.5 Current Transformers

(a) Current transformer shall be cast – resin type. All secondary connections shall be brought out to terminal blocks wherever or delta connections will be made. Current transformers shall conform to IS : 2705 and comply with the specification.
(b) They shall have sufficient thermal and mechanical capacity to withstand the maximum momentary current rating of the breakers. The secondary terminals shall be of the solder-less clamp type. All current transformers shall be properly identified for polarity with standard marking symbols. The minimum acceptable accuracy class for metering and relaying shall be in accordance with the list.
(c) CT's shall be mounted over stationary primary disconnects. If multi-ratio CT's all leads shall be wired out to shorting type terminal strips.
(d) Magnetization curves and the secondary resistance shall be provided for each type and rating of current transformer. Also all technical details, routine test reports of CTs shall be furnished with the offer.

### 4.4.6 Voltage Transformer

(a) HV Switchgear shall have 3-phase voltage transformer with HRC type primary and secondary fuses. In addition to all buses and incoming feeders, for tie feeders also voltage transformers shall be provided as required.
(b) The voltage transformers shall be of cast resin insulated type. The voltage transformers shall be of draw-out type and provided with secondary fuses which will be capable of disconnecting the transformer fuses from their voltage source and removing them from the structure.
(c) This drawout mechanism shall be so arranged that full access to the transformers cannot be accomplished until the fuses are disconnected from the structure. When moved to a full out position, the transformer fuses and VT windings shall be automatically grounded. VT mounted on circuit breaker trolley is not acceptable. The voltage transformers shall have an accuracy class 0.5 for metering and class 3 P for protection. Secondary voltage of voltage transformer shall be 110 V AC.
(d) Fuse failure relay (97) shall be provided on the secondary side of all voltage transformers to monitor failure of LV fuses.
(e) Voltage transformers and their primary fuses shall be mounted in separate steel compartments. Primary connections to the transformers shall be insulated and enter the compartment through porcelain bushings. Each set of voltage transformers and fuses shall be mounted on the draw-out steel carriage Low voltage fuses, sized to prevent overload, shall be installed in all ungrounded secondary leads. Fuses shall be suitably located to permit easy replacement while the switchgear is energized.

### 4.4.7 Relays

(a) All protective relays, unless otherwise specified, shall be multifunction, numerical (microprocessor based type) comprehensive relays capable of measuring all electrical parameters like voltage, current, power, power factor, frequency etc.

(b) The relays shall be capable of communicating all analogue and digital signals with PLC / SCADA. All protective relays shall be of draw-out type, suitable for flush mounting and fitted with dust tight covers. All relays shall have built-in testing facilities. Small auxiliary relays may be of non-draw-out type and mounted within the cubicle.
(c) Each feeder shall be complete with necessary auxiliary relays, timers, etc., to meet the circuit requirement. . All protection /supervision/trip relays shall have necessary contact for PLC / SCADA system.
(d) The programmable type numerical protection relays, conforming to IS, shall be used. The relays used shall only be from the approved manufacturer.
(e) The numerical relay unit shall be suitable for use in the tropical climatic conditions as mentioned in specification.
(f) It shall be possible to select required type of over current and earth fault protection of IDMT characteristics.

### 4.4.8 Measuring Instruments

(a) The indicating meters shall be of at digital type. The accuracy class shall be 1.0. The scale shall be provided with a red mark at the rated current value of the circuit. The accuracy class of Energy meters shall be 0.5.
(b) Each incomer shall be provided with ammeter, voltmeter and multifunction meter having accuracy class of (0.5) shall be provided on the incomers of all the switchgears.
(c) Transducers for indication to PLC / SCADA shall be provided in incoming & outgoing feeders for the measurement of voltage, current, power and energy. Transducers for measuring 3 phase bus voltages shall also be provided. All transducers shall be dual output type.
(d) Wherever multifunction numerical relays having measurement and communication capabilities with PLC / SCADA are used, separate indicating instrument and transducers may not be required.

### 4.4.9 Secondary wiring

(a) Inside the cubicles the wiring for control, signaling, and protection and instrument circuits shall be done with 1100 V grade PVC (FRLS) insulated stranded copper conductor of size 1.5 $mm^2$ (minimum). For CT circuits, cable size shall not be less than 2.5 $mm^2$ copper.
(b) Each switchgear line up shall be completely assembled, wired and tested at the factory, including all buses, connections, insulators, terminals, and terminal blocks to ensure proper functioning of control, protection, transfer and interlocking schemes.
(c) Secondary wiring shall be firmly laced and secured and terminated in approved molded-type terminal blocks conveniently located with respect to shipping splits and control conduit terminals.
(d) Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
(e) Each wire shall be identified, at both ends, with permanent markers bearing wire numbers.
(f) Wire terminations shall be made with crimping type connectors with insulate sleeves. Wire shall not be spliced between terminals.

### 4.4.10 Terminal Blocks

(a) Terminal blocks shall be of 1100 V grade, stud type with marking strips. Sufficient terminals shall be provided on each terminal block to ensure that not more than two outgoing wires are connected per terminal. All spare contacts of auxiliary relays, timers etc. shall be wired up to the terminals. 10% spare terminals shall be provided on each terminal block. Terminals for

CT secondary leads shall have provision for easy shorting, earthing and shall be suitable for connecting 2 cables of 2.5 mm2 copper.

(b) Terminal blocks shall be mounted such that the wires to them can be grouped and laced together in a neat and workmanlike manner.
(c) Marking system identifying the "from-to" wire designation.
(d) Two-pole, pullout disconnecting fuse blocks (with fuses) to be provided for each breaker to protect trip and close circuits.
(e) Terminal blocks shall be located to allow easy access. Wiring shall be grouped such that the individual wires of an cable can be connected to consecutive terminals.

### 4.4.11 Cable termination

(a) Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection.
(b) Terminals shall be suitable for heat shrinkable type / push on type cable termination with provision for earthing the armour if armoured cables.
(c) All provisions and accessories shall be furnished for termination and connection of cables, including removable gland plates, cable supports, crimp type tinned copper/aluminum lugs, brass compression glands with tapered washers (Power cables) and terminal blocks.
(d) Gland plates shall be minimum 4mm thick. The gland plate and supporting arrangement shall be such as to minimize the flow of eddy current.
(e) Sufficient space shall be provided between the power cable termination (end-boxes)and gland plate. Core balance CTs wherever required shall be accommodated within this space.

### 4.4.12 Ground Bus

(a) Switchgear cubicles shall be connected to an earth bus bar rated to carry maximum fault current running throughout the length of the switchboard. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing bus bar to the plant-earthing grid at two distinctive ends.
(b) Each stationary unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw-out type VT unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
(c) CT and VT secondary neutrals shall be earthed through removable links.

### 4.4.13 Name Plates

(a) Black engraved perspex sheet or PVC of 3-mm thick nameplate with the switchgear designation shall be fixed at the top center of the panel.
(b) Separate nameplate giving feeder details shall be provided at front and both halves of rear for each panel.
(c) Nameplates shall be provided for each equipment (lamps, PBs, switches, relays, auxiliary contactors etc.) mounted on the switchboard. Special warning plates shall be provided at the back of each vertical panel.

### 4.4.14 Space Heaters

(a) Each cubicle shall be provided with thermostat controlled space heaters suitable for operation from single phase, 50 Hz supply and 5A,240V AC, 3 pin plug socket and cubicle lamp.
(b) The space heaters shall be located at the bottom of the switchboards. Cubicle heater, plug/socket/lamp circuits shall have individual switch fuse units.

### 4.4.15 AC / DC Power Supply

(a) The following power supplies will be made available to each switchgear:
   1. A.C. supply : Single Feeder
   2. D.C. supply : Double Feeder with auto changeover facility from external DC supply.

(b) Isolating switch fuse units shall be provided at each switchgear for the incoming supplies, 4-pole, single throw & off for A.C. and 2-pole, double throw & off for D.C.

(c) Bus-wires of minimum 2.5 Sq.mm copper shall be provided to distribute the incoming supplies to different cubicles. Isolating switch fuse units shall be provided at each cubicle for A.C/D.C. supplies.

### 4.4.16 Push Buttons

(a) All push buttons shall be heavy duty, spring return type suitable for flush mounting on sheet steel cubicle doors.

(b) The push buttons shall have two (2) Nos. 'NO' and two (2) Nos. 'NC' contacts. The continuous current and breaking capacity of the contacts shall be adequate for the duty involved.

### 4.4.17 Control /Selector Switches

(a) Circuit breaker control switches shall be 3- position (TRIP/NEUTRAL/CLOSE) with spring return to neutral. Local/remote selector switch shall be of stay put type lockable in “remote” position.

(b) Ammeter selector switches shall have make before break feature on its contacts.

(c) The selector switch shall have four positions. Voltmeter selector switches shall be suitable for selection of all ‘Phase to Phase’ and ‘Phase to Neutral’ voltages.

### 4.4.18 Painting

(a) All metal surfaces shall be thoroughly cleaned, sand blasted, pickled and degreased to remove mill scale, rust, grease and dirt.

(b) After cleaning, the under surface shall be prepared by applying two coats of high quality zinc rich polyurethane enamel based primer.

(c) After preparation of the under surface powder coated with two coats of final polyurethane enamel paint of approved shade shall be applied.

(d) Painting shade shall be subject to owner’s approval.

## 4.5 Test

Routine test and temperature rise test shall be carried out in presence of DJB and Consultant representative as per IS / IEC. Following Type Test Report shall be provided, in case type test report is not available, same shall be carried out.

(a) Lightning Impulse Voltage Tests. (b) Verification of degree of protection.
( c ) Power Frequency Tests. (d) Partial Discharge Tests
(e) Short time and peak withstand current

## SUB-SECTION 5. SOLAR POWER SYSTEM

### 5.1 Solar Power and Accessories

(a) Solar power systems shall typically comprise the following configuration:

- Solar Panel Array and Structure
- Solar Inverter
- Earthing and Lightning Protection
- Cables and all other Accessories

(b) The specification of Solar Power System shall comply with the regulation, guidelines or other requirements of DERC (Delhi Electricity Regulatory Commission), electric supply company, Bureau of Indian Standards (BIS) or IEC 61215 or other international standards and MNRE approved test centers.

(c) Before installing the PV solar system, it shall be ensured that sun path is clear and not shaded by trees, roof gables, chimneys, buildings or other features of plant.

(d) Solar Power System shall be grid connected to the 3 phase, 50 c/s, 415V bus in the pumping station.

(e) The solar power shall be supplied to the load of the plant normally. But when the generated power is exceeded the power of the load of the plant, the solar power shall be supplied reverse to the grid of the electricity company as per their guidelines.

(f) The Solar System shall provide complete information of Solar Power Generation on PLC Screen. Graphical presentation of Solar Generation shall be available in Control Room SCADA Screen.

(g) The type of solar panel, no. of the solar panels, and connection of the solar array and the nos. of solar inverter shall be decided by the contractor in consideration of manufacturers design and the following conditions.

- Space of the underground reservoir of plant , environment and the maintenance space
- Applicable solar inverter output
- Inverter input DC voltage
- Average ambient temperature (shall be taken as 50°C if not otherwise given in the particular specification);
- Number of peak sun hours in Delhi, 24–hour period;

(h) Solar System shall be provided with Surge Protection System, Interlocking Panel, Isolation transformer and other protection devices.

### 5.2 Solar System Operation

(a) Solar System shall be installed for power generation (minimum capacity as per SLD). In day time for normal operation of plant, energy generated from Solar System shall be used for operation of the plant load and balance power shall be drawn from grid supply by Power Supply Company.

(b) It is the Contractor's responsibility to install and operate the Solar System in such a way that maximum utilization of solar energy for operation of the plant.

(c) The protection system shall be such that there is no problem in main grid system in case of any malfunctions in solar system or vice versa.

(d) Necessary energy meters and protection system shall be installed. All the input or output data shall be transmitted to SCADA system.

(e) In case power generated by Solar system is more than requirement of Plant, excess energy shall

be fed to the grid as per "Renewable Energy Regulation of Net Metering, Guideline of DERC", and Guidelines issued by Power Supply Company from time to time.

(f) The output generated power and the status and failure of the system shall be transmitted remote alarm system on the Monitoring Equipment installed in the pumping station/SCADA system.

(g) Weather sensors, Irradiance, temperature, wind speed sensors and safety equipment etc. shall be provided.

### 5.3 Solar Panel and Structure

(a) The solar panel array shall comprise a series of high-power photovoltaic type polycrystalline silicon cell panels mounted in a sturdy aluminium frame. The whole structure shall be installed on top of underground reservoir of Pumping Station and shall be constructed in a manner appropriate to the environment in which it is to be installed. The cells shall be encapsulated in a protective, easily cleanable, weather-proof coating. The coating shall not affect the efficiency of the solar cells.

(b) The Contractor shall pay particular attention to the requirements of the local planning authorities, particularly in areas of environmental sensitivity.

(c) The Mounting structure shall be so designed to withstand the speed for the wind zone of the location where a PV system is proposed to be installed (Delhi-wind speed of 150 kM/ hour). It may be ensured that the design has been certified by a recognized Lab/ Institution in this regard.

(d) Hot dip galvanized iron mounting structures may be used for mounting the modules/ panels/arrays. The mounting structure steel shall be as per latest IS 2062: 1992 and galvanization of the mounting structure shall be in compliance of latest IS 4759.

(e) The structure shall be designed so that the tilt angle can be adjusted in order to obtain the optimum operating conditions (manually operated). The cable-connection facilities at the panel array shall be provided in marshalling enclosures protected to a minimum of IP55.

(f) Each solar panel certified peak power output shall be guaranteed for a minimum of 15 years.

(g) All solar cells/panel shall be works tested for peak power output and for voltage and current at peak power output at an illumination level of 1kW/m² at a spectral density of AM 1.5.

(h) This test shall be carried out at the normal operating temperature of the cell. This shall be taken as the ambient temperature required by the specification.

### 5.4 Solar Inverter

(a) The type of the solar inverter shall be 3 phase, 50 c/s, 415V and the grid connecting type.

(b) The solar inverter can be operated only when the 415V bus is energized by the grid line.

(c) The solar inverter shall have automatic operation mode and MPPT function.

(d) The solar inverter shall be provided in the outdoor/indoor metal enclosed wall-mounted panel or free standing panel and with output terminals to warn of the fault of solar inverter for Monitoring Panel.

(e) The solar inverter shall have necessary protections which will be required by DERC and the electricity company.

(f) This test shall be carried out at the normal operating temperature of the cell. This shall be taken as the ambient temperature required by the specification.

(g) Over-voltage protection shall be provided by using Metal Oxide Varistors (MOVs) on DC and AC side the inverter.

(h) The degree of protection of the indoor inverter panel shall be at least IP 31 and that of outdoor at least IP-55

### 5.5 Power and Control Cables

(a) Power Cables of adequate rating shall be required for interconnection of :

- Modules/panels within array
- Inverter and loads.

(b) The power cable shall be 1.1 grade, heavy duty, stranded Al/Cu conductor, XLPE insulated, galvanized steel wire/strip armoured, flame retardant low smoke (FRLS). The cables shall, in general conform to IS-1554 P+I & other relevant standards.
(c) The control cable shall be 1.1 grades, heavy duty, stranded copper conductor, XLPE insulated, galvanized steel wire/strip armoured, flame retardant low smoke (FRLS). The cables shall, in general conform to IS-1554 P+I & other relevant standards.
(d) The permissible voltage drop from the SPV Generator to the Charge controller shall not be more than 2% of peak power voltage of the SPV power source (generating system). In the light of this fact the cross-sectional area of the cable chosen is such that the voltage drop introduced by it shall be within 2% of the system voltage at peak power.
(e) All connections should be properly terminated, soldered and/or sealed from outdoor and indoor elements. Relevant codes and operating manuals must be followed. Extensive wiring and terminations (connection points) for all PV components is needed along with electrical connection to lighting loads.

### 5.6 Earthing Equipment/Material

(a) Earthing system shall be provided for the Solar System and Panels.
(b) To prevent the damage due to lightning the one terminal of the lightning protection arrangement is also earthed. The provision for lightning & surge protection of the SPV power source & Charge controller is required to be made.
(c) In case the SPV Array cannot be installed close to the equipment to be powered & a separate earth has been provided for SPV System, it shall be ensured that all the earths are bonded together to prevent the development of potential difference between two earths.

### 5.7 Junction Boxes and Combiners

(a) Dust, water and vermin proof junction boxes of adequate rating and adequate terminal facility made of fire resistant Plastic (FRP) shall be provided for wiring. Each solar shall be provided with fuses of adequate rating to protect the solar arrays from accidental short circuit.

### 5.8 Communication Interface

(a) Monitoring Equipment shall have the interface for the SCADA system.
(b) The communication system must be able to support :
- Real time data logging
- Event logging
- Supervisory control
- Operational modes
- Set point editing

(c) The following parameters shall also be measured and displayed continuously:

- Solar system temperature
- Ambient temperature

- Solar irradiation/isolation
- DC current and Voltages
- DC injection into the grid (one time measurement at the time of installation)
- Efficiency of the inverter
- Solar system efficiency
- Display of I-V curve of the solar system
- Any other parameter considered necessary by supplier of the solar PV system based on prudent practice.

(d) Data logger system must record these parameters for study of effect of various environmental & grid parameters on energy generated by the solar system and various analyses would be required to be provided through bar charts, curves, tables, which shall be finalized during approval of drawings.

(e) The communication interface shall be an integral part of inverter and shall be suitable to be connected to local computer and also remotely via the Web using either a standard modem or a GSM / WI-FI modem.

## SUB-SECTION 6. PACKAGE SUB STATION

### 6.1 General

The Packaged Sub-Station (PSS), with 100 % redundancy should be designed to feed the construction power to Main LT Panel Pumping Station. The PSS is to supply power at 415V. It should essentially include:

The enclosure of the packaged substation having 03compartments like:

- HV compartment (Ring Main Unit type)
- Distribution transformer (11kV/433VDry Cast Resin Type)
- LV switchboard,

### 6.2 Standards

The equipment should be designed, manufactured and tested in compliance with

| | | |
|---|---|---|
| i | Common clause for high voltage switchgear and low voltage switchgear | IEC62271-200 |
| ii | Self-contained medium voltage apparatus | IEC298 |
| iii | AC switches and earthing switches | IEC129 |
| iv | Switches and disconnectors | IEC265 |
| v | Combined switch/disconnectors | IEC420 |
| vi | High voltage fuses | IEC420 |
| vii | High voltage test procedures | IEC60 |
| viii | Distribution Substation | IEC1330 (1st editionNov.95) |
| ix | Classification of degrees of protection for enclosures | IEC529 |
| x | Transformer | IEC76 |
| xi | LV switchboard | IEC439-1 |

### 6.3 General Characteristics

| | Unit | Rating |
|---|---|---|
| Operating Voltage | KV | 11 |
| Rated withstand voltage at power frequency | KV | 12 /28/75 |
| LV Rated Current | A | - |
| Rated Short Time Current | Amp / Sec | 18.6 |
| LV side rated voltage | V | 433 |

In accordance with IEC recommendations, these characteristics should be valid for:

- Altitude : Less than1000 meters above sea level
- Temperature : from -25$^0$C to+50C

## 6.4 Construction Features

(a) The enclosure should be made of hot dip galvanized steel Sheet. Steel tropicalized to Indian Weather Conditions.
(b) The colour should be : As per approval of drawing
(c) The metal base should be made of 4mm hot dip galvanized steel and ensures rigidity for easy transport and installation.
(d) The enclosure should be made of hot dip galvanized steel Sheet. Steel tropicalized to Indian Weather Conditions.
(e) The structure of the substation should be capable of supporting the gross weight of all equipment.
(f) Intermediate ceiling roof should be provided . A minimum clearance should be left between the top of any component installed in the substation and there of the substation.
(g) Protection degree of the enclosure for MV and LV compartments should be not less than IP54 in accordance with IEC recommendation.
(h) Ventilation apertures should be sufficient for natural ventilation(Class K10)
(i) MV and LV compartments should be accessible on the sides of the substation through double doors equipped with key lock, and rubber seals. The doors can be padlocked and/or lock protected.
(j) All metallic compartments to be earthed to a common earthing point for the whole package.
(k) Internal lighting to be activated by associated switch for each compartment.
(l) Three (3) compartments should separate the different components (MV/Transformer / LV for safe operations.
(m) The package substation should passed internal arching withstand test 18.4 kA / 1 sec.

### 6.4.1 MV Switch Board

(a) Type of Proposed RMU : with internal arc withstand 18.6 KA 1SEC(MIN) The RMU should be “Vaccum” switchgear range with built-in functions and reduced dimensions.
(b) The self-contained totally insulated unit should constitute the MV component of the MV/LV transformer substation or the branching point of an MV network. The RMU should provide, in a single Epoxy enclosure, all the medium voltage functions enabling transformers to be connected, supplied and protected. The RMU to be equipped with 2 Isolators and1 Circuit Breaker.

### 6.4.2 Transformer:

Cast Resin Dry Type transformer shall be provided, transformer shall be designed to meet complete plant running load with 20 % design margin. For detail specification of transformer refers Section No. 2. In PSS all transformers shall be provided with Off Load Tap Changer.

### 6.4.3 LV Compartment

The PSS to be provided with LV Distribution System consisting of ACB / MCCB.

## 6.5 Tests:

All routine tests shall be carried out as per IEC / IS standards in presence of DJB. Type test report shall be submitted.

## SUB-SECTION 7. 415 V SWITCHBOARD

### 7.1 Intent of Specification

This specification is intended to cover the design, manufacture, assembly and testing at manufacturer's works, supply & delivery, properly packed for transport to site of LV switchgear of rating 415 V. The equipment shall be offered under this specification shall be complete with all accessories for efficient and trouble-free operation.

### 7.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

| | | |
|---|---|---|
| IEC 61439 -1 & 2 | : | Low Voltage Switchgear and Control Gear Assemblies |
| IEC 60044 | : | Instrument Transformers |
| IEC 60255 / IS : 3842 | : | Electrical Relays |
| IEC 60228 | : | Conductor of Insulated Cable |
| IEC:60255 / IS : 3231 | : | Electrical relays for Power System Protection |
| IS : 375 | : | Switchgear bus bars, main connections and auxiliary wiring, marking and arrangement |
| IS : 3043 | | Code of practice for Earthing |
| IS : 6875 | | Control Switches Push Buttons |
| IS : 8686 | | Specification for static protective relays |
| IEC 60947 / IS: 13947 | : | Contactors and Motor Starters |
| IS : 9224 | | Low voltage fuses |

The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

### 7.3 Design Criteria

(a) Switchgear and its components and accessories shall conform to relevant IEC/IS Standards amended up to date.
(b) The switchgear shall be indoor, metal clad, floor mounted. Design and construction shall be such as to allow extension at either end.
(c) The switchgears will be located in a clean but hot humid and tropical atmosphere.
(d) For continuous operation at specified ratings, temperature rise of the various switchgear components shall be limited to the permissible values stipulated in the relevant standards and this specification.

(e) The switchgear and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short circuit current without any damage or detoriation of material.
(f) Circuit breaker shall not produce any harmful over voltage during switching of induction motors. If required surge protective devices shall be included to limit over voltage.
(g) All the 415 V AC, devices / equipment like bus support insulator, circuit breaker, VTs etc mounted inside the switchgear shall be suitable for continuous operation and satisfactory performance under the following supply conditions:

- Variation in supply voltage : ± 10 %
- Variation in supply frequency : ± 5 %
- Combined voltage / frequency variation : ± 10 %
- System Earthing : Solidly Earthing

(h) The fault level on the 415V buses shall be calculated based on transformer contribution and motor contribution and shall be limited to 35 kA inclusive of 10 % margin. The minimum short time current rating shall be 35 kA for 1 second.
(i) It is the responsibility of the Vendor to co-ordinate operation of all the ACBs and MCCBs for short circuit condition so that discrimination in operation is provided. Co-ordination and relay setting is in Contractor scope.

## 7.4 Specific Requirements

### 7.4.1 General

(a) The LV switchboards shall be Type Tested Assemblies (TTA) all type tests as defined in latest IEC 61439-1/2 built up from compartments housing circuit breakers, Control gear, relays, bus bars, controls and other equipments.
(b) The LV main switchboards and the associated equipment, including switchgear, control gear and bus bar assemblies shall be certified for the category of duty specified. The main circuits of the LV main switchboards shall have an insulation voltage of 1100 V AC.
(c) Where armoured multicore cables terminate inside the switchboard enclosure, glanding plates or glanding brackets shall be provided for securing the cables to the switchboard. Glanding plates, glanding brackets and extension boxes shall be removable and shall be of adequate size for the particular cables to be terminated. Separate current transformers shall be provided for each protection device and for instrumentation. The switchgear assembly/sub-assemblies or panels shall be termite and rodent proof. The sub-assemblies of similar equipment shall be interchangeable.
(d) 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:43/ IP: 55 and IP unless otherwise stated. Ventilating openings and vent outlets, if provided, shall be arranged such that same ingress protection of IP 43 is retained.
(e) Switchboards shall also have test certificate for Seismic withstand.
(f) The switchboard along with ACBs and connections should have been be type tested design at CPRI/ERDA/Independent international test house for short circuit, temperature rise, protective earth short circuit test and dielectric tests of the ratings required.
(g) 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.

### 7.4.2 Construction Features

(a) The switchboard shall be form 3b/ 4b . For form of separation only metallic covers shall be used.

Hylem / PVC sheets shall not be allowed.

(b) Circuit breakers, instrument transformers, bus bars, cable compartments, LV chamber relays and instruments shall be housed in separate metal / insulated partitioned compartments within the cubicles. Metal barriers where employed shall be effectively earthed and insulated barriers shall be arc proof to ensure operator safety. Power and control cable entry into the switchgear panel shall be totally segregated.

(c) Protection against shock in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of all live parts. Control cables shall be segregated from primary conductors.

(d) The Switchboards shall be metal clad totally enclosed, floor mounted free standing type of modular extensible design suitable for indoor mounting.

(e) Incomer and bus section panels or sections shall be separate and independent and shall not be wired with sections required for feeder. The incomer panel shall be suitable for receiving bus trunking or MV / LV cable of size specified.

(f) Switchboards shall be made up of requisite vertical sections, which when coupled together, shall form continuous dead front switchboards.

(g) Switchboard shall be readily extensible on both sides by addition of vertical sections after removal of the end covers.

(h) The switchboards shall be designed for use in high ambient temperature and humid tropical conditions as specified. Ease of inspections, cleaning and repairs while maintaining continuity of operation shall be provided in the design.

(i) Metal based neoprene gaskets between all adjacent units and beneath all covers shall be provided to render the joints dust and vermin proof. The unused openings within the switchboards shall be closed using suitable grommets.

(j) Special care to be taken to ensure effective earthing of the frame and doors of the switchboards.

(k) Each vertical section shall be provided with a rear chamber housing the cable end connections and power/control cable terminations. There should be generous availability of space for ease of installation and maintenance with adequate safety for working in one vertical section without coming into contract with any live parts. The design of the switchboard shall allow standard extension chambers if required to accommodate cables.

(l) Some switchboards may be required to be installed against the wall, for such application-documented designs shall be available.

(m) All panels and covers shall be properly fitted and square with the frame. The holes in the panel shall be correctly positioned.

(n) Switchboard shall be provided with "Danger Notice Plate" conforming to relevant Indian Standards.

(o) VFD shall be mounted in separate cubical with proper ventilation system.

### 7.4.3 Bus and Bus taps

(a) All Main buses and connections bars shall be of electrolytic grade copper or aluminium with uniform cross- section sized to carry continuously, the specified current without exceeding temperature limits.

(b) The short time withstand current rating shall be at least 35 kA for 1 sec.

(c) Busbar, busbar connection, conductor forming part of the equipment of switchgear shall comply IEC 61439-1 on current carrying capacity and temperature rise.

(d) Busbars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for busbars and cast-resin shrouds for joints shall be provided.

(e) Bus insulator shall be flame-retardant, non-hygroscopic, track resistant type with high creepage surface. This shall be of non-carbonising material such as epoxy bonded fiberglass. Bus bars shall be color coded for easy identification.
(f) The bus bar supports shall be able to withstand stresses due to maximum short circuit and also take care of any thermal expansion.
(g) Clearance between phase – phase, phase – earth/ neutral should be in line with IEC.
(h) Busbar chamber shall be provided with inter panel barrier with epoxy cast seal off bushings through which the buses will pass through so as to prevent fire from one panel to another.

### 7.4.4 Air Circuit Breaker ( ACB)

(a) Air Circuit Breaker ( ACB) shall be confirmed to IEC 60947 / IS 13947 (Part 1 & 2) .
(b) Air circuit breakers shall be electrically draw out type with microprocessor based release having numerical inbuilt protection.
(c) ACBs in AC circuits shall be of 3 / 4 pole construction arranged for simultaneous 3 / 4 pole electrical / manual closing and opening and for automatic instantaneous tripping on short circuit. Operating mechanism shall be quick make, quick break and trip free type. The ON, OFF and TRIP positions of the ACB shall be clearly indicated and visible to the operator when mounted as in service. Front of board operating handle shall be provided. It shall have communication port for interlinking with SCADA and PLC system.
(d) If switchgear contains, ACB feeds module, there shall be two numbers 24 DC control supply for each switchgear. Auto and manual changeover scheme of changeover of supply- 1 to 2 and vice versa shall be provided. Necessary voltage monitoring contactors (for remote alarm) and indication lamps shall be provided.
(e) All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.
(f) Incommer breaker, where ACB has been provided shall have motor wound spring mechanism, 24 V operated closing and tripping coils.
(g) Feeders of rating 630A and above shall have ACBs with inbuilt numerical relays for protection. Feeders of rating less than 63A shall be SFU / MCB / MPCB.

### 7.4.5 Moulded Case Circuit Breaker ( MCCB)

(a) The MCCB shall confirm to the latest applicable standards.
(b) MCCB in AC circuits shall be of FP / TPN construction arranged for simultaneous FP / TPN Auto / manual closing and opening. Operating mechanism shall be quick-make, quick-break and trip free type. The ON / OFF and Trip position of the MCCB shall be clearly indicated and visible to the operator. Operating handle for operating MCCBs from door of board shall be provided.
(c) MCCBs provided in Main Incommer of Panel shall be microprocessor type release with overload, short circuit and earth faults protections.
(d) MCCB provided for motor feeder (55 KW and above) shall have microprocessor type release with overload, short circuit protections.
(e) MCCB provided for motor feeder (below 55 KW) shall have thermal magnetic release protection.
(f) It shall be with communication port for interlinking with SCADA and PLC system.
(g) The instantaneous short circuit releases shall be so chosen to operate at a current in excess of the peak motors inrush current and a range of setting shall be provided for selection.
(h) MCCB terminal shall be provided with thermal magnetic release for protection against overload, short circuit and earth faults.
(i) MCCB shall incorporate time delay devices to ensure that it will tolerate harmless transient overload unless this will in excess of 25% of its rated value for a sustained period.

(j) The circuit breaker shall be provided with additional 2 NO + 2 NC ( specially for Client / Contractor use) of auxiliary potential free contacts required for indication, remote control, interlocking and other purposes. All contacts shall be wired to a terminal block.

### 7.4.6 Contactor

(a) The power contactor used in the switch board shall be of air break, single throw, triple pole, and electromagnet type. Contactors shall be suitable for uninterrupted duty and rated for class AC3 duty.
(b) Operating coils of all contactors shall be suitable for operation on 230 V, single phase, 50 Hz supply.
(c) Contactor shall be provided with NO and NC contacts.
(d) Contactors shall not drop out at voltage down to 70 % of coil rated voltage. All motor Contactors and their associated apparatus must be designed to operate for a period not less than 5 minutes at a voltage of 20 % below the nominal value and at a frequency without injurious overheating.
(e) Overload relay and reset button shall be independent of the 'Start' and 'Stop' push button. All Contactor shall be provided with single phase protection.

### 7.4.7 Miniature Circuit Breaker

(a) Miniature Circuit Breaker shall comply with IS-8828-1996. Miniature circuit breaker shall be quick make and break type for 230 / 415 V AC, 50 Hz application with magnetic thermal release for over current and short circuit protection. The breaking capacity shall not be less than 10 kA at 415 V AC.
(b) MCB shall be DIN mounted. The MCB shall be current limiting be type (class-3). MCBs shall be classified (B,C,D ref IS standard) as per their tripping characteristic curves defined by the manufacturer. The MCB shall have the minimum power loss (watts) per pole. defined as per IS / IEC and the manufacturer shall publish the values.
(c) The housing shall be hear resistant and having impact strength. The terminal shall be protected against finger contact to IP20 degree protection. All DP, TP and TPN MCB shall have a common trip bar.

### 7.4.8 Measuring Instruments

(a) Indicating instruments shall be flush mounted, back connected with anti parallel circular scales with black pointer, black markings. Measuring instruments shall be digital type.
(b) Incommer of all panel shall be provided with MFM. Ammeter and voltmeter.
(c) All motor outgoing feeders shall have MFM and Ammeter.
(d) Outgoing feeder for other panel shall be provided with MFM.
(e) Current transformer shall be cast – resin type. All secondary connections shall be brought out to terminal blocks wherever or delta connections will be made. Current transformers shall conform to IS : 2705 and comply with the specification.
(f) 4-20 mA output transducer for current, power and voltage.

### 7.4.9 Motor feeder control

(a) All motor shall be operable from Remote i.e. from PLC / SCADA.
(b) Remote control commands i.e. start / stop, generated from PLC / SCADA shall be wired to switchgear through interposing relays housed in respective switchgear.
(c) Under locked position, the drive operation is inhibited from remote. The emergency stop push button shall be wired directly to Switchgear.
(d) Motor rating more than 55 KW and above shall be provided with motor protection relay.
(e) Motor rating less than 55 KW shall be provided with overload relay.

(f) Necessary electrical protection for drive shall be realized at switchgear, whereas process interlocks and protections are realized in PLC / SCADA.
(g) All electrical operated actuator shall have PLC / SCADA control for START / STOP and CLOSE.
(h) Following signal exchange shall take place between Switchgear and PLC / SCADA:
- Drive start & stop commands.
- Drive status feedbacks by means of ON & OFF contacts.
- Switchgear disturbance (control power supply failure, trip coil unhealthy,
- Emergency Local PB operated, Switchgear. In test position, protection operated.
- Switchgear available (Breaker in service position, Switchgear selected in remote and Breaker spring charged, trip coil healthy, protection not operated).

(i) Electrical Trip
Current transducers 4-20 mA type or multifunction meter shall be mounted in the SWGR for monitoring the motor current in PLC / SCADA. Auxiliary power supply to these transducers shall be from the control supply of the respective switchgears. These Current Transducers shall be 4-20 mA dual output type.

### 7.4.10 Control Transformer

(a) Control transformers shall be of the double-wound, air-cooled and chassis-mounting type designed. An earthed metallic screen shall be provided between the primary and secondary windings.
(b) The rated secondary voltage shall be 230V unless otherwise specified. One end of the secondary winding shall be earthed. Primary windings shall be connected phase-to-phase on three-phase power systems.
(c) The transformer rated output shall be not less than 20% greater than the total standing load. The combination of the inrush VA of the largest contactor plus the total hold-in VA of all devices shall not result in the transformer secondary voltage falling below 80% of its rated value. Control transformers shall be provided with primary and secondary winding protection devices.

### 7.4.11 Indicating Lamps and Push Buttons

(a) These shall be switchboard type, low power consumption, LED cluster type lamps complete with necessary accessories. Lamps shall be provided with screwed translucent covers to diffuse light. The lamp covers shall preferably be unbreakable, moulded and heat resistant material and shall be provided with chromium plated bezels.
(b) Push buttons shall be heavy duty, push to actuate type with colour button and inscription marked with its function. Each push button shall have minimum 2 NO + 2 NC contacts or as required, rated 10 A at operating voltage.
(c) Push button shall be shrouded type except for emergency trip button (if provided) which shall be mushroom type for easy identification. Push button colour shall be as follows:
- STOP /OFF - Red
- START / ON - Green
- Reset - Yellow
- Test - Black
- Spring Charging - Blue
- DC supply supervision - Violet

### 7.4.12 Relays

(a) All protective relays, unless otherwise specified, shall be multifunction, numerical type comprehensive relays capable of measuring all electrical parameters like voltage, current, power, power factor, frequency etc. Incommer of main LT panel shall be provided with

supervision and master trip relay. The relays shall be capable of communicating all analogue and digital signals with PLC / SCADA. All protective relays shall be flush mounting and fitted with dust tight covers. All relays shall have built-in testing facilities. Small auxiliary relays may be mounted within the cubicle.

(b) Each feeder shall be complete with necessary auxiliary relays, timers, etc., to meet the circuit requirement. . All protection /supervision/trip relays shall have necessary contact for PLC / SCADA system.

(c) The programmable type numerical protection relays, conforming to IS, shall be used for incomer and motors rating more than 55 KW. The relays used shall only be from the approved manufacturer.

(d) The numerical relay unit shall be suitable for use in the tropical climatic conditions as mentioned in specification.

(e) It shall be possible to select required type of over current and earth fault protection of IDMT characteristics.

### 7.4.13 Control wiring

(a) Stud type terminal with identification ferrules shall be used. Local dependent marking as well as remote and dependent marking may be indicated in the ferruling at terminal blocks. Interlocking type ferrules shall be used. All wires carried within the switchgear enclosure shall be LSZH insulated and neatly arranged so as to be readily accessible and to be easily replaceable. Wherever necessary the wires should be run in cable through and the wiring should be routed so that the same remains away from areas where electrical flame or flash over may occur. No conduit or cables shall be carried through the busbar chamber.

(b) The voltage transformer wiring shall be done by LSZH insulated, 1100V grade multi stranded flexible copper conductor of size 1.5 Sq.mm and all the current transformer and DC control wiring shall be of the same type of cable as specified above with conductor size of 2.5 Sq.mm. The colour coding shall be as per IS 5578 /11353.

(c) AC and DC wiring are to distinguishable function wise. AC and DC terminals are to be separated by shrouded terminals separators.

(d) All spare contacts of switches / relays shall be wired upto the terminal blocks.

(e) 20 % extra spare terminal shall be provided.

(f) All CT wiring shall be terminated on shorting and disconnecting type terminals.

### 7.4.14 Cable termination

(a) Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection.

(b) Terminals shall be suitable for heat shrinkable type / push on type cable termination with provision for earthing the armour if armoured cables.

(c) All provisions and accessories shall be furnished for termination and connection of cables, including removable gland plates, cable supports, crimp type tinned copper/aluminum lugs, brass compression glands with tapered washers(Power cables) and terminal blocks.

(d) Gland plates shall be minimum 4mm thick. The gland plate and supporting arrangement shall be such as to minimize the flow of eddy current.

(e) Sufficient space shall be provided between the power cable termination (end-boxes)and gland plate. Core balance CTs wherever required shall be accommodated within this space.

### 7.4.15 Bus Duct Connection

(a) Bus duct (NPSBD) connection if specified in specification shall be furnished along with transition panel if required. Bus duct connection shall be generally from top of the switchgear.

(b) All connection bus work shall have the same continuous rating as associated switchgear bus and shall be fully braced for the short circuit current mentioned in specification.
(c) All provision such as matching flange and other accessories shall be furnished for connection to busduct.

### 7.4.16 Ground Bus

(a) An earth bus of requisite section shall be provided. It shall extended throughout and solidly connect all panels in a line with proper terminals, at the end to connect the station earthing system. The terminal arrangement at the ends shall be suitable for connection to Earth fault and shall be complete with bimetallic washers etc.
(b) CT secondary neutrals shall be earthed through removable links.

### 7.4.17 Name Plates

(a) Black engraved perspex sheet or PVC of 3-mm thick nameplate with the switchgear designation shall be fixed at the top center of the panel.
(b) Separate nameplate giving feeder details shall be provided at front and both halves of rear for each panel.
(c) Nameplates shall be provided for each equipment (lamps, PBs, switches, relays, auxiliary contactors etc.) mounted on the switchboard. Special warning plates shall be provided at the back of each vertical panel.

### 7.4.18 Space heaters

(a) Panel shall be provided with thermostat controlled space heaters suitable for operation from 240 V single phase, 50 Hz, supply and 5A, 240V AC, 3 pin plug socket and cubicle lamp.
(b) The space heaters shall be located at the bottom of the switchboards. Cubicle heater, plug/socket/lamp circuits shall have individual switch fuse units.

### 7.4.19 Power Factor Correction

(a) It is preferred that power factor improvement capacitor banks are connected across the main 415 V, MCC Panel so as to improve the circuit power factor at full load to a minimum of 0.98 lag even up to unity but it shall not exceed the magnetizing current to Transformer and motors. The use of VFD may also provide power factor of the order of 0.98. Hence while calculating the compensating capacity this shall be considered.
(b) The overall plant power factor shall be improved up to the statutory limit imposed by the Current Electric Authority. The firm has to provide inbuilt APFC (Automatic Power Factor Control) panel as per approved makes on unity incoming panel in standard construction for making power factor correction up to 0.98 for maximum load and also at no load. Static capacitors for No - Load losses shall be installed.
(c) LT capacitor bank shall be provided with automatic power factor correction system. Its panel shall incorporate timer circuit to allow capacitor to discharge at minimum 50V before re-energisation of any individual bank.
(d) Capacitor bank shall consist of many small capacitors so that banks can be in circuit as per system p.f requirement with the help of Automatic Power Factor Correction relay. Minimum 0.98 p.f will be maintained at power distribution agency meter on H.V. Side. Capacitor bank calculations shall also take into consideration the transformer impedance. Each capacitor should be able to switch ON either in manual or auto mode independently with override facility of manual operation.
(e) Each capacitor shall have reactor to avoid the inflow of the harmonic current.

### 7.4.20 Painting

(a) All metal surfaces shall be thoroughly cleaned, sand blasted, pickled and degreased to remove mill scale, rust, grease and dirt.
(b) After cleaning, the under surface shall be prepared by applying two coats of high quality zinc rich polyurethane enamel based primer.
(c) After preparation of the under surface, powder coating painting shall be applied.
(d) Painting shade shall be subject to owner's approval.

### 7.4.21 Test

(a) All routine test shall be carried out as per IEC- 61439 1 & 2 in presence of DJB representative as per relevant IS / IEC standard.
(b) Type test report of following tests shall be submitted as per IEC-61439-1&2. In case not available shall be done in presence of DJB and its representative without extra cost.

(i) Temperature Rise Test on assembly and bus bars.
(ii) Dielectric Properties Test.
(iii) Short Circuit Resistance.
(iv) Clearance and Creepage Distance.
(v) Mechanical Operation Check.
(vi) Degree Of Protection
(vii) Strength Of Material and Parts

## SUB-SECTION 8. BUS DUCT

### 8.1 Non-Segregated Phase Bus Ducts [NSPBD]

(a) 1.1 kV class non-segregated phase bus duct with accessories shall be provided for connection between transformers and their respective 415V switchgear.
(b) The continuous rating of the bus duct shall be same as the rated current of respective switchgear bus.
(c) The short time and momentary current ratings of the bus ducts shall be same as that of associated 415V switchgear.
(d) The busbars in the bus-duct shall be sleeved with FRLS heat shrinkable, colour coded XLPE sleeves.

### 8.2 Specific Requirements

(a) The bus conductor shall be of Aluminium alloy grade 63401 as per IS: 5082.
(b) Enclosure for NSPBD shall be of CRCA sheet.
(c) Flexible expansion joints shall be provided for the conductor and enclosure along the run of the bus duct length to take care of expansion. Also flexible joints shall be provided at the termination points.
(d) Inspection covers for periodic inspection of the insulators shall be provided.
(e) There shall be no joints in the enclosure through which water can seep.
(f) The outdoor portion (at bolted joints of the bus duct shall be provided with a continuous rain hood of non-magnetic material suitably supported from the bus duct support structure.
(g) The bus conductors shall be given a coat of matt black paint to facilitate heat dissipation. However the sizing of the bus conductor shall consider the conductor as unpainted.
(h) The adjacent sections of the bus conductor shall be welded or bolted.
(i) The joints along the conductors shall be of highest quality and the temperature rise test shall be conducted including the joints.
(j) The bus support insulators shall be of 1.1 kV class for non-segregated phase bus ducts and shall be mounted on resilient pads. The material of insulator shall be epoxy resin cast.
(k) The spacing of the bus support insulators shall be considered by giving due factor of safety to withstand the forces due to the momentary short circuit current assigned for the bus duct.
(l) Wall frame assembly and FRP sealing plate shall be provided for NSPBD where the bus duct passes through walls (indoor to indoor).
(m) The support structures shall be hot dip galvanized.
(n) Thermostatically controlled space heaters shall be provided along the run of bus duct.
(o) Silicagel breathers shall be provided at both end, if required.

### 8.3 Technical Requirement

Non-segregated phase bus ducts shall be designed as per following criteria:

| | Description | Particular |
|---|---|---|
| (a) | Type of cooling | Natural Air |
| (b) | Maximum temperature rise of conductor over 50 deg. C ambient | 40 deg C |
| (c) | Maximum temperature rise of enclosure over 50 deg C ambient | 20 deg C |

## 8.4 Test

(a) All the routine and the following special tests shall be conducted on NSPBD.

- Air tightness test
- Temperature rise test

Routine tests shall be conducted on all the pieces of NSPBD as applicable. Also, test certificates shall be furnished for bought out items. Valid type test certificate shall be submitted. In case valid certificate is not available than type test shall be conducted on NSPBD.

## SUB-SECTION 9. VARIABLE FREQUENCY DRIVES

### 9.1 Supply System

(a) The frequency converter shall operate from a 415V, 3-phase, 3-wire supply system at any frequency between 47.5 Hz and 52.5 Hz. and with a voltage variation of +/- 10 % from nominal value. The complete drive system shall produce rated output under the above supply conditions.
(b) The complete drive system shall also continue to function, with a ±10% voltage fluctuation. The supply system neutral point will be solidly earthed and the supply fault level will be specified.
(c) The load reactors shall be provided if required and the details shall be mentioned.
(d) If the primary voltage of any frequency converter transformer is 415V, then the transformer shall be housed within the frequency converter enclosure.
(e) The harmonic current spectrum of each frequency converter generated at the point of common coupling shall be stated in the schedule of Particulars and Guarantees when running at maximum duty.

### 9.2 Design Criteria

(a) The frequency converters shall either be mounted as part of the LV switchboard or in free-standing enclosures compatible in appearance with the LV switchboard.
(b) The frequency converters shall be designed to feed a squirrel cage induction motor. The motor stator may be wound to accept maximum inverter output voltage at maximum duty speed, provided that an emergency bypass facility is not required.
(c) The frequency converter shall be selected suitable type for this electrical system and shall be taken proper measures to keep the harmonic current generated by frequency converter. If necessary the active IGBT rectifier type frequency converter or matrix converter shall be provided.
(d) The type of frequency converter, type of power semiconductors and type of motor offered shall be clearly stated in the data sheet of VFD.
(e) The motor and frequency converter shall be compatible in all respect. In particular, the following points will be addressed:

- the drive motor shall be rated to produce 110% of the maximum load power when frequency converter fed;
- the motor shall be sized to allow for continuous running under all load conditions throughout the specified range taking into account particularly the higher machine losses when inverter-fed and the reduction of cooling fan output at reduced speeds, although the possibility of using a separate drive for the motor cooling fan may be considered where appropriate;
- the drive system shall be designed to achieve the highest practicable overall efficiency, taking into account the motor efficiency degradation when inverter-fed and the losses in any power factor correction / harmonic filter networks;
- the drive system shall develop sufficient starting torque to start the driven equipment under any operating conditions;
- the Contractor shall ensure that any torque pulsations produced by the drive system do not cause resonance in the shaft system at any point in the whole speed range;
- the drive control system (for pump applications) shall be such that over-current trips do not occur during any hydraulic conditions, irrespective of the pump characteristics, so that in the case, for example, of a pump exhibiting a rising-power run-out curve, the motor speed shall automatically be reduced until the drive reaches a stable operating point within the continuous

capability of the motor-inverter system.

- The drive shall have provision for PLC / SCADA communication and control facility.

## 9.3 Construction Features

(a) Incoming triple-pole load-break, fault-make MCCBs with over-current trips or ac isolators complete with suitably-rated HRC fuses, either type of device being mechanically interlocked with cubicle door. A minimum of 2 sets of auxiliary changeover contacts shall be fitted to the incoming devices.

(b) Main contactor to IEC 60947-4-1:2000, feeding the input bridges, intermittent duty class 0.1, utilisation category AC3, electrical endurance 300 000 operations minimum. The contactor shall also meet the requirements of the eight-hour duty as defined in IEC 60947-4-1:2000.

(c) MCCBs or MCBs for isolation of reference, excitation and control supplies.

(d) Three-phase input bridges, dc-link component, inverter bridges and all necessary control equipment.

(e) Surge-suppression devices and device snubber networks. The surge suppressors to clip the peak voltage wave form near the motor shall be provided if required to relieve the motor insulation from severe voltage stress.

(f) To dissipate heat generated in the VFD panel, exhaust fan / heat sinks / louvers shall be provided as per requirement. Isolator, fuses (or MCCB), contactor and thermal-overload protection for ventilation fan motor.

(g) Total load ammeter.

(h) Speed (or, if speed signal not available, inverter output frequency).

(i) Hours-run meter.

(j) Local / off / remote and manual / auto control selector switches as required.

(k) Emergency stop button operational in all control modes - latching mushroom type, coloured red and lockable in the stop position. The push-button shall be of the key reset type. An emergency stop shall also be located at the plant. Emergency stops shall be connected in series to directly break the main contactor control supply and open the main contactor.

(l) Stop and start push-buttons.

(m) Speed limit pre-setting potentiometers or programmable controls shall be provided to enable the minimum and maximum speeds to be set. The setting of these shall determine the variable range within which the speed of the motor can be controlled.

(n) The above controls (and any other controls that can be expected to be adjusted on site) shall be easily accessible, without the need for special extension cards or modules not integral with the basic drive control electronics. Speed-adjusting facilities shall be provided for each of the following:

- Manual Control - by adjustment of a speed setting potentiometer or programmable control externally mounted on the drive.
- Auto Control - this shall be capable of accepting a proportional 4mA to 20mA instrumentation speed-reference signal and shall not present an impedance greater than 500 ohms. The signal will be arranged such that:

  4mA = Low-duty speed.
  20mA = High-duty speed.

(o) Anti-condensation heaters and thermostats for the enclosure. Circuitry for 230V motor anti-condensation heaters, with fuse and switching contactor.

(p) Test facilities for operation / testing of the inverter under no-load conditions: with motor disconnected when switched to test mode.

(q) Internal lighting and an RCD-fed 16A, 230V, 50Hz switch socket outlet shall be incorporated for testing and maintenance purposes.

## 9.4 Protection

(a) The frequency converter shall incorporate as a minimum, the following protection:

- instantaneous and inverse-time over-current protection for frequency converter and motor protection;
- high-speed fuses for protecting converter/inverter semiconductor devices with intertrip;
- phase failure or reversal;
- over-voltage;
- under-voltage;
- earth fault;
- for all motors a thermostat protection relay shall be included.

(b) The operation of voltage-sensitive protection relays shall be time-delayed to prevent unnecessary tripping of the controller in the event of transient supply-voltage variations and be suitable for distorted supply voltage waveforms.
(c) The facilities listed are the minimum foreseen. Any additional facilities which the Contractor considers necessary for the satisfactory operation and maintenance of the controllers shall be provided.
(d) Indication of the reason for failure shall be by lamps or LEDs which shall be visible from the outside of the enclosure without the need to open the enclosure.
(e) Such lamps or LEDs shall 'latch' once a fault has been indicated and be reset by a reset push-button.
(f) VFD shall be provided by DOL by pass arrangement.

## 9.5 Power Factor Correction / Harmonic Filters

(a) Each drive system shall operate with an input power factor more than 0.98 at 100 % load. The reactors within harmonic filters shall be fitted with extra core clamps, anti-vibration mounts, or any other features the Contractor considers necessary to limit the propagation of noise.
(b) The above precautions concerning reactor noise shall also apply to all other reactors within the drive system, such as line reactors and dc link chokes.

## 9.6 Radio Frequency Interfaces

(a) Under all conditions of operation, the frequency converter shall not emit signals that may interfere with radio transmission or reception.
(b) Values of radio interference voltage shall meet the requirements of current Indian Standards and any local statutory requirements. In the event of there being differences between Standards or Regulations, the most stringent shall apply.

## 9.7 Interlocks

(a) Electrical interlocks shall include the following in addition to any others considered necessary by the Contractor for the safe operation and protection of the equipment:-

i. Thermal protection of the power semiconductor devices of converter and inverter bridges for naturally and force-ventilated bridges.
ii. The power semiconductor bridge cooling air flow switch interlocks (if force-ventilated

bridge).

iii. A minimum of one normally-open and one normally-closed contact corresponding to the following control relays/functions shall be wired to the main cubicle terminal rail for future interlocking:

- 'Drive Healthy', meaning it is in a state ready to start if called to do so;
- 'Drive Running', meaning main contactor is closed, all electronic and inhibits released and no fault conditions are present. Preferably this contact will detect motor rotation;
- 'Drive Tripped', meaning drive has stopped due to a fault condition within the drive system.

## 9.8 Harmonics and Waveform Notching

(a) The Contractor shall ensure that the harmonic current generated at the Electricity Supply Authority point of common coupling are not exceeded the limit specified in IEEE Std.519-2014.

(b) Furthermore, the Contractor shall demonstrate that the addition of the new variable-speed drive equipment shall not adversely affect any part of the existing plant and is not likely to affect proposed new items of plant. This assurance shall be gained by a process including, but not confined to, the following points:

- The total harmonic voltage distortion at any point on the LV-distribution system shall not exceed the levels. The voltage distortion is to be calculated under the condition where all drives that may operate simultaneously are running at full load.
- Harmonic current generated by the frequency converter shall be remedied not to adversely affect to the electrical system of this plant including the emergency generator.
- Frequency converters that incorporate a line-commutated converter input bridge, produce notching of the mains sinusoid. The size of these notches shall be limited to the values in IEEE Std519-2014, General System Class unless otherwise specified, or by raising the effective pulse number of the drive systems or by other means.

## 9.9 Noise

When running at any combination of speed and load, the frequency converter system shall not create a sound pressure level greater than 85dBA measured at a distance of one metre in any direction from the surface of the frequency converter enclosure. The noise measurements shall be carried out in a similar manner to that described in IEC 60034-9:1997.

## 9.10 Tests

All routine tests shall be carried out on VFD as per IS / IEC standards. Type test reports shall be provided.

## SUB-SECTION 10. SOFT STARTER

### 10.1 General

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.

### 10.2 Design and Construction

(a) For LV System FCMA / HFSR / Electronic Soft Starter may be used.

(b) As the motor get full speed Soft Starter shall be by pass.

(c) Soft Starter shall have DOL by pass arrangement.

(d) Soft starter panel shall be indoor, metal clad with separate metal enclosed compartment for:

  (i) Control, metering and current transformers for differential protection.

  (ii) Shorting (by pass) arrangement

  (iii) Power cable termination

  (iv) Push button with indicating lamps

(e) Starting current shall be limited to 1.5 to 2.0 times the rated current of the motor. The soft starter manufacture shall co-ordinate with motor manufacturer for this purpose.

(f) 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.

(g) Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

(h) Contractor shall furnish the losses of the soft starter and any clearance required for adequate cooling.

(i) Soft Starter compartment shall have proper ventilation system and space for workmanship.

### 10.3 Control

(a) Control Voltage shall be 24 V DC and alarm shall be generate in case of failure of DC supply. DC failure indication and alarm shall be provided.

(b) Digital Input

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

(c) Soft Starter shall have Ammeter showing clearly starting current.

(d) 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.

(e) 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.

(f) Galvanic Isolation

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

(g) 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.

(h) Keyboard lock

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

**10.4 Tests**

All routine tests shall be carried out on Soft Starter as per IS and type test report shall be submitted for same or above ratings.

## SUB-SECTION 11. DIESEL GENERATOR SET

### 11.1 Intent of Specification

(a) This specification is intended to cover the design, manufacture, assembly, testing at manufacturer's works, supply & delivery, properly packed for transport to site of Emergency Diesel generator complete with all accessories for efficient and trouble-free operation.

### 11.2 Codes and Standards

(a) All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and / or supplemented by this specification.

| | | |
|---|---|---|
| IS:4722/IEC:60034 | : | Generator |
| IS:3977 | : | Diesel Oil System |
| IEE: 446 | : | Recommended practice for emergency and standby power system for commercial and industrial application. |
| BS:5514 | : | Reciprocating Internal Combustion Engine. |

(b) Material conforming to other internationally accepted standards, which ensure equal or better quality than the standards mentioned above, would also be acceptable. In case the Contractors who wish to offer material conforming to other standards, the Contractor shall clearly bring out the salient points of difference between the standards adopted and the specific standards in relevant schedule. Four copies of such standards with authentic English translations shall be furnished along with the offer.

### 11.3 Codes and Standards

(a) DG sets shall be rated for continuous duty. Rating of each DG set shall be suitably sized for safe shut down of the respective unit and also to meet complete plant running load in the event of total black out.
(b) DG sets shall automatically come into operation in the event of total AC power failure in the station. DG sets shall be capable of starting the highest rated motor while supplying the other base loads. The maximum voltage drop at motor terminal during motor start shall be within the specified limit.
(c) Contractor shall submit DG sizing calculation for approval of DJB / PMSC engineer
(d) Diesel engines shall be suitable for HSD oil. In the foundation, suitable drain off system for oil shall be provided.
(e) The transformer shall be free from annoying hum or vibration. The design shall be such as not to cause any undesirable interference with radio or communication circuits
(f) DG set shall be provided with AMF Panel.

### 11.4 Specific Requirements

#### 11.4.1 Starting & Control

(a) The DG Set shall have integrated control with automatic starting sequence from the manually initiated command from a single push button. It shall also have auto initiation through a 'No volt relay' and Auto position of auto/manual selector switch. The DG set shall also issue automatic closing command to its breaker on achieving rated voltage and frequency on its terminals.
(b) The starting time required from the initiating signal until the operating speed and voltage is attained and the engine and generator are ready to take load, shall not be greater than 30 seconds. Three attempt starting facility shall be provided using two impulse timers and a summation timer. The DG shall be capable of being stopped manually from remote and local. Interlock shall be provided in DG control panel to prevent shutting down operation as long as the circuit breaker at its generator output is closed.
(c) If electrical self starting system is provided, the source of energy shall be batteries backed up by battery chargers.
(d) DG sets shall incorporate compressed air starting system, which shall be capable of six (6) consecutive starts of all DG sets without refilling. To meet compressed air requirement 2 x 100% air compressor shall be provided. One compressor shall be of motor driven and other one shall be diesel engine driven with hand cranking facility.
(e) The starter motor shall conform to IS : 4722 or any relevant standard.
(f) Suitable thermal insulation together with jackets shall be provided on all exposed hot pipes and equipment to limit the surface temperature to 60deg. C.

### 11.4.2 Battery & Battery Charger

(a) The battery shall conform to the requirements of IS:7372 or relevant standard.
(b) The battery charger shall be suitable to charge required numbers of batteries at 12V/ 24 volts complete with, transformer, rectifier, charge rate selector switch, indicating ammeter & voltmeter etc. Connections between the battery charger & batteries shall be provided with suitable copper leads with lugs etc.
(c) The battery or compressed air system for starting the engine shall be capable of performing six (6) normal starts without recharging or refilling. In any case, continuous cranking for at least one minute shall be possible.

### 11.4.3 Engine Rating

(a) The engine shall be of standard design of the original manufacturers. It should be 4 stroke cycles, water cooled, naturally aspirated/ turbo charged (as per manufacturer standard), diesel engine developing suitable BHP for giving a power rating as per ISO 8528- Part-1 in KVA at the load terminals of alternator at 1500 rpm at actual site conditions.
(b) The engine shall be capable for delivering specified Prime Power rating at variable loads for PF of 0.8 lag with 10% overload available in excess of specified output for one hour in every 12 hours. The average load factor of the engine over period of 24 hours shall be 0.85 (85%) for prime power output.
(c) The engine shall conform to IS;10000/ ISO 3046/ BS;649 /BS 5514 amended up to date.
(d) Necessary certificate indicating the compliance of the DG set capacity requirement for the engine model so selected along with compliance of Noise and Emission norms as per latest CPCB guidelines for DG set capacity up to 1000KVA, should be furnished from the manufacturers along with the data sheet. However above 1000 KVA DG set, manufacturers shall furnish certificate that the Engine for the DG set complies with the CPCB Emission norms.
(e) The engine shall be fitted with following accessories subject to the design of the manufacturer:
   i. Dynamically balanced Fly wheel
   ii. Necessary flexible coupling and guard for alternator and engine (applicable only for double bearing alternator)

iii. Air cleaner( dry/ oil bath type) as per manufacturer standard,
iv. A mechanical/ electronic governor to maintain engine speed at all conditions of load
v. Daily fuel service tank fabricated from M.S. sheet with inlet, outlet connections air vent tap, drain plug and level indicator (gauge) M.S. fuel piping from tank to engine with valves, unions, reducers, flexible hose connection and floor mounting pedestals, twin fuel filters and fuel injectors. The location of the tank shall depend on standard manufacturers design.
vi. Dry exhaust manifold with suitable exhaust residential grade silencer to reduce the noise level.
vii. Suitable self-starter for 12 V/ 24 V DC.
viii. Battery charging alternator unit and voltage regulator, suitable for starting batteries, battery racks with interconnecting leads and terminals.
ix. Necessary gear driven oil pump for lubricating oil, priming of engine bearing as well as fuel systems as per manufacturer recommendations.
x. Naturally aspirated/ turbo charger (as per manufacturer standard)
xi. Lubrication oil cooler
xii. Lubrication oil filters with replaceable elements.
xiii. Crank case heater as per manufacturer recommendations.
xiv. Fuel injection: Engine should have suitable fuel injection system in orderto achieve low fuel consumption.
xv. Fuel control solenoid
xvi. Fuel pump with engine speed adjustment.
xvii. Engine Control Panel: fitted and having digital display for following:-
(a) Start/stop key switch. (b) Lube oil pressure indication
(c) Water temp. Indication (d) RPM indication
(e) Engine Hours indications (f) Battery charging indication
(g) Low lub. Oil trip indication (h) High water temp. indication
(i) Over speed indication.
xviii. All moving parts of the engine shall be mechanically guarded in such a manner that a human finger cannot touch any moving part.
xix. Radiator/ Heat Exchanger System/ Remote Radiator(delete whichever is not applicable)
xx. Any other item not included/ specified but is a standard design of the manufacturer

### 11.4.4 Governor

(a) Mechanical governor of class A2 for up to and including 200 KVA capacity and Electronic governor of class A1 for capacity above 200KVA, as per ISO 3046/BS5514 with actuator shall be provided as per standard design of manufacturer.
(b) Governor shall be a self contained unit capable of monitoring speed.
The engine speed shall be so maintained that frequency variation at constant load including no load shall remain within a band of 1% of rated.

### 11.4.5 Fuel System

(a) It shall be fed through engine driven fuel pump. A replaceable element of fuel filter shall be suitably located to permit easy servicing. The daily service tank shall be complete with necessary supports, gauges, connecting pipe work etc.
(b) In case of top mounted tanks, non return valves are must in fuel supply and return line of specified value. Pipe sealant should be used for sealing for all connections. No Teflon tape to be used. If piping length is more than 10 meters, detail engineering is required in consultation with OEM/ Manufacture.

### 11.4.6 Lubricating oil system

It shall be so designed that when the engine starts after a long shut down lubrication failure does not occur. Necessary priming pump for the lubricant oil circuit as per recommendation of manufacturer shall be installed, to keep bearings primed. This pump shall be normally automatically operative on AC/ DC supply available with the set.

### 11.4.7 Piping Work

(a) All pipe lines and fittings and accessories requirement inside the room/ enclosure and outside for exhaust piping shall be provided by the contractor. This shall include necessary flexible pieces in the exhaust, fuel, lub. oil and water lines as are necessary in view of the vibration isolation requirement in the installation.
(b) Piping of adequate size shall be used for lub. oil of the material as per manufacturer standard. However, only M.S. pipes for the exhaust shall be used. For fuel lines within the acoustic enclosure, PVC braided pipe as per manufacturer recommendations can be used.However, for fuel lines outside the acoustics enclosure only MS pipe be used.
(c) The pipe work shall be inclusive of all fittings and accessories required such as bends, reducers, elbows, flanges, flexible connections, necessary hardware etc. The installation shall cover clamps, supports, hangers etc. as are necessary for completing the work. However, the work shall be sectionalized with flanged connections as are necessary for easy isolation for purposes for maintenance of unit as approved by Engineer-in-charge.

## 11.5 Constructional Requirements

(a) Diesel engine shall be mounted on visco damper type vibration dampening system and shall be complete with integral air intake through dry type air filters and exhaust systems, metering facility, speed regulation system, fuel injection system, lube oil system, primary cooling water system along with necessary filters, silencers, ducts, piping and fittings, valves, instruments, etc.
(b) The generating unit shall be complete with all auxiliaries and its performance, torsional vibration, materials and workmanship, etc. shall be in accordance with the standard practices of diesel engine manufacturer's association in BS-5514or equivalent. The engine shall be properly balanced so as to transmit only small unbalanced forces to the foundation.

## 11.6 Diesel Oil System

(a) The diesel oil system as provided shall be complete with duplex type filters, hoses, piping, fittings, relief valves, supports, control and instrumentation and all other accessories to make it complete.
(b) The fuel consumption of the engine at full and three quarters of its rated power output shall be indicated.
(c) A day oil tank of adequate fuel capacity ( As per CPWD Guideline) shall be provided, mounted on fabricated steel platform. The tank shall be complete with level indicator marked in litres, two nos. of level switches, filling inlet with removable screen, an outlet, a drain plug, an air vent and necessary piping. The fuel tank shall be painted with oil resistant paint. All pipe joints shall be brazed/ welded.

## 11.7 Lubricating Oil System

(a) Automatic pressure lubrication shall be provided by a shaft driven gear type pump through an oil cooler and fine mesh filters to the end bearing, camshaft bearings, camshaft chain and gear drives, governor, air starting, distribution, auxiliary drive gears etc.
(b) If pre-lubrication is required before starting of the DG set, than one (1) no. electrically operated and one (1) no. standby DC operated lube oil pump shall also be provided for the purpose.
(c) All necessary accessories like pressure gauges, temperature and oil level indicators, pressure relief valves, bypass valves, pressure switches for alarm and control shall be furnished together with all inter connecting piping, fittings, supports, valves, etc.

### 11.8 Cooling System

(a) Totally air cooled type DG sets are preferable. However, in case jacket water cooling system is offered, the same shall be in closed cycle and have radiator located in front of the engine with a fan driven mechanically from the engine shaft. Forced water circulation by means of pump driven by the engine shaft shall be employed.
(b) As an alternative to radiator located in front of the engine with a fan driven mechanically from the engine shaft, separately located radiator (which will be located outside the DG room) with motor driven fan by 415V DG MCC directly fed from alternator terminals. The radiator tube shall be of copper with sufficient transfer area. Heat exchanger/ cooling tower arrangement shall also be acceptable.

### 11.9 Ancillary Equipment

The following minimum equipment's shall be provided:

- Flywheel
- Fuel piping
- Tachometer/RPM indicator
- Lubricating oil cooler (if applicable)
- Exhaust silencer and piping
- Fuel and lubricating oil filters, air filters.
- Temperature gauges for water and lubricating oil and pressure gauges for lubricating oil.
- Hand barring gear.
- Necessary foundation bolts and base channels for the engine, alternator, fuel service tank and for all other equipment included in this package.
- Base frames
- Platforms and hand railing and access ladder (if applicable)
- Starting equipment
- Protective equipment preferably in the form of fuel cut-off solenoid and suitable relays to protect the engine against low lubrication pressure.
- Lifting attachment for lifting the complete set or the engine alternator separately.
- Radiator/Heat Exchanger.

### 11.10 Generator

#### 11.10.1 General

(a) The generator shall be of totally enclosed or screen protected drip proof and self air cooled type. The generator shall be driven by the diesel engine specified above and shall match the same in all respects. The generator shall conform to IS-4722, IEC-60034.
(b) AC generator shall be supplied along with excitation system, AVR and include all necessary auxiliaries.

(c) The Generator shall be star connected, 3-phase, 50Hz synchronous generator and shall have a continuous rating. The operating conditions shall be as follows:
- Voltage 415V
- Frequency 50Hz (+3 to -5%)
- Power factor 0.80

(d) The generator stator and rotor windings core insulation and all connections including main and neutral leads shall have suitable class of insulation meeting the temperature rise limitation set forth for air cooled machines in IS: 4722 or relevant standard.

(e) The generator shall withstand without mechanical injury an over speed of 20% for a period of 2 minutes.

(f) Resistance element temperature detector shall be installed at the following locations :
- 6 nos. duplex or 12 nos. simplex RTD's in stator windings.
- 1 no. RTD element in each bearing.

(g) Suitably rated single phase, space heaters located in lower part of alternator shall be provided to maintain the internal temperature above the dew point to prevent moisture condensation on the insulation when the set is not running.
- Separate terminal boxes shall be provided for phase and neutral side of leads.
- The terminal boxes shall be dust proof, weather proof phase segregated double walled (metallic as well as insulated barriers) having degree of protection of IP-54 as per IS: 13947.
- The terminal box shall be of sufficient size to conveniently terminate the size and number of cables. Suitable tinned copper pads shall be provided for power cable termination along with all necessary hardware and cable lugs. For single phase cables, gland plate shall be of nonmagnetic material and shall be removable type. The necessary CT's for differential protection shall be provided on neutral side.
- Alternator vibration level shall not exceed the values as defined in IS:12075.Alternators in case driven by diesel engine shall be able to withstand vibration level of 9 mm/sec. as per BS 5000 Part III,

### 11.10.2 Stator

(a) The stator laminations shall be designed and assembled as to minimize noise and offer minimum resistance to the cooling air flow. Coil ends and stator supports shall be designed as to withstand abnormal operating conditions.

(b) The stator windings shall be brought out to six insulated terminals in two separate terminal boxes. The alternator shall, be provided with three separate terminal boxes i.e. for the live and neutral stator connections and for control connections.

(c) The star connection shall be formed in the neutral terminal box. Terminal box shall be capable of withstanding short circuit current for 1 sec. All terminals shall be of stud type. The terminal boxes shall be complete with lugs and double compression cable glands.

### 11.10.3 Rotor

(a) The rotor shall be built in accordance with the best modern practice and shall be designed to withstand safely all stresses due to overload and over speed.

(b) The necessary inertia as required for proper regulation including at heavy rush loads shall be realized by the rotor design.

(c) The rotor shall be designed to have a large margin between the running and critical speeds. The critical speeds of all rotating parts as well as the rigidity against vibrations shall be checked together with the Diesel engine manufacturer and must be confirmed by calculations.

### 11.10.4 Bearings

(a) The bearing(s) shall be antifriction/sleeve bearings as per manufacturer's standard.
(b) Safe lubrication during start-up must be ensured to prevent bearing damages. Suitable precautions (i.e. bearing insulation) shall be taken to prevent harmful flow of shaft Currents.

### 11.10.5 Excitation System

(a) The generator shall be provided with complete excitation system capable of supplying the excitation current of the generator under all conditions of output from no load to full load and capable of maintaining voltage of the generator constant at any value with (±)10% of the rated voltage. It shall be possible to set the same from remote also. The type of insulation of the armature field winding of the exciter shall be class-B and the temperature shall not exceed the values specified in IEC-60034 Part-I for different parts.

### 11.10.6 Automatic Voltage Regulator

(a) The regulation system shall be provided with equipment for automatic and manualcontrol. Necessary equipment shall be furnished for the following:
(b) To prevent automatic rise of field voltage in case of failure of potentialsupply.
(c) To initiate transfer from automatic to manual control of excitation on fusefailure in the generator potential signal.
(d) The regulator shall regulate from generator current and potential signals.
(e) The above equipment shall be housed in self standing sheet metal cubicle, andshall be completely tested and wired.
(f) The regulation equipment shall function correctly between the frequency variation of -5% & +3% and shall ensure a voltage variation not more than (±) 1% of the set point in steady operating condition between no load to full load.

### 11.10.7 Generator Neutral Grounding

(a) The generator neutral shall be grounded as per manufacturer's recommendation; taking into consideration that single phase to ground fault current shall be limited to less that 3-ph fault current.

### 11.10.8 Control, Measuring & Protection System

(a) The Diesel generator set shall be equipped with a local control board. It shall consist of the following panels:
    - Engine Control Panel
    - Generator Control and Relay Panel
(b) All equipment shall be clearly arranged, and may be visualised by LCD or similar displays
(c) The necessary measuring transducers for transmission of generator parameters to the PLC / SCADA System shall be included in the scope of supply and shall be mounted and wired in the relay panel. For the remote control a serial interface to the PLC / SCADA System shall be provided.

### 11.10.9 Engine Control Panel

(a) The engine control panel shall be equipped with all instruments and control devices etc. necessary for operation and supervision of the Diesel engine and its auxiliaries at different modes of operation. It shall also be equipped with the fault annunciation device for the Diesel Engine set including all auxiliaries.

(b) Following alarms and instruments / gauges shall be provided in the engine control panel as minimum.

i. Measuring Instrument
- lubrication oil temperature gauge
- cooling water temperature gauge
- charge air temperature gauge
- cylinder and turbo-charger temperature gauge
- starting air pressure gauge
- lubrication oil pressure gauge
- speed indicator gauge
- operation hours counter gauge.

ii. Generator Control & Relay Panel

- The Control & Relay panel for the generator set with the provision for local starting shall comprise protection and metering equipment, indicating instruments. The panel shall be free standing; sheet steel enclosed having a degree of protection of IP 54. Sheet steel thickness shall not be less than 2 mm.
- All auxiliary devices for control, indication, measurement, protection and alarm shall be mounted on the front door of the panel. Alarm/indications shall also be annunciated in central control room. Remote start /stop operation facility shall be provided from central control room.
- Wiring for control and signaling indicating/metering circuits shall be done with PVC insulated copper conductors having 1100 V grade insulation.
- An adequately sized earth bus shall be provided in the panel for connection to the main earth grid. All non-current carrying metallic parts of the mounted equipment shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.
- Engraved nameplates shall be provided for all devices mounted on the front of the panel.
  Control panel shall be complete with space heater, cubicle lamp, 5/15A socket along with switch and fuse.
- The final paint shade and the identification tag shall conform to the specific requirement.
- The panel shall be provided with adequate number of tripping & alarm facias annunciator and buzzer. The devices shall include but not limited to:

- AC voltmeter with selectors switch , 144mm square.
- AC Ammeter with selector switch, 144Sq.mm.
- □KW Meter , 144 Sq.mm.
- Power factor meter with full circle 4 quadrants marking 144mm. squre.
- Frequency meter.
- Mains ON/OFF switches.
- Pilot lamps.
- DC Voltmeter.
- DC Ammeter
- Manual/Auto/test selector switch.
- Emergency Stop push button.
- Generator overload annunciation
- Engine failed to start annunciation

- Engine tripped on fault annunciation
- High engine temperature annunciation.
- Acknowledge/Test/Reset push buttons
- Abnormal voltage (under and over voltage) (Alarm).
- Charger ON/OFF (Alarm)
- Low air pressure in receiver (Alarm)
- Alternator stator temperature high (Alarm)
- Electrical protective relays operated (Trip)

### 11.11 Test

All routine tests on DG sets as per Standards shall be carried out at manufacturer works in presence of DJB / PMSC representative.

## SUB-SECTION 12. EARTHING AND LIGHTING PROTECTION

### 12.1 Earthing System

#### 12.1.1 General

(a) The Contractor shall provide all required material and carry out main earth grid, treated earth pits, raisers and inter connections, equipment earthing etc for the following areas and all areas/buildings/structures covered with in the battery limit of this package.

i. Pumping Stations
ii. Switchgear Rooms
iii. Control Rooms
iv. Transformer Yard at Pump House Area
v. All Plant equipments.

(b) For Transformer neutral and body shall be earthed with separate plate earthing.
(c) Earthing system shall consist of earth grids and electrodes buried in soil in the plant area, to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons.
(d) Separate earth pits shall be provided for PLC / Electronic panels.
(e) The earthing system shall conform to relevant IS/IEC standards. Contactor shall do soil resistivity test in presence DJB engineers and submit the soli test report for eathing design.

### 12.2 Design and Standards

(a) Earthing system shall be design as per IEEE-80 and submit the complete design of earhing system for approval.
(b) Earthing grid design shall be done in such a manner that the grid resistance is less than one ohm.
(c) The submission of Earthing layout, drawings and obtaining Electrical Inspector final clearances & approval shall be within the responsibility of the Contractor. If the resistance is observed to be not less than 1 ohm. The Contractor shall provide additional earth pits such that resistance is less than 1 ohm.
(d) The earthing system & Lightning system design and installation shall generally comply with the following standards.

| | | |
|---|---|---|
| IS-3043 | : | Code of practice for Safety Earthing |
| IS-2309 | : | Code of Practice for the Protection of Buildings and Allied Structures against Lightning. |
| CBIP | : | CBIP manual on Earthing of AC Power system (Publication No. 302) |
| IEEE-80 | : | Guide for safety in Alternating current sub-station grounding |
| IEEE-665 | : | Guide for Generating Station Grounding |
| IEEE-1100 | : | IEEE recommended practice for Powering and Grounding Electronic Equipment |
| | | Indian Electricity Rules |

(e) The contractor shall submit the earthing drawing / layouts to electrical Inspector for his approval. Necessary modification wherever required shall be carried out by the contractor and got approved by the Inspector at no extra cost to the Client. After installation the resistance of

the ground grid shall be tested in presence of Client / Consultant as per the IE rules. After the test, report shall be submitted to Electrical Inspector for approval.

## 12.3 General Requirement

### 12.3.1 General Requirement of Earthing

(a) Metallic frames of all current carrying equipment, supporting structures adjacent to current carrying conductors, structures, lightning protection system conductors and neutral points of various systems shall be connected to a single earthing system.
(b) Earthing conductors in outdoor areas shall be installed at a minimum depth of 600 mm.
(c) All cable trays in the plant buildings as well as inside the trenches shall be connected to earth grid at an interval of about 10 m. Fence shall be earthed.
(d) Neutral earthing of Transformers shall be done using 2 leads. All equipment terminal boxes shall be earthed separately through 2 leads.

### 12.3.2 Earthing Conductor inside the building

(a) The earth grids of buildings shall be interconnected through test pits to enable measurement of earth resistance for each area separately. Main earthing conductors shall be buried in earth around the building.
(b) Minimum two taps-off from this earthing loop shall be taken inside the building and connected to the earthing grid embedded in the soil with approximately 50mm concrete cover.
(c) Each RCC / Steel column of the building shall be interconnected to the floor earthing grid in the ground floor.
(d) Cable trays, steel pipes / conduits, steel columns, etc. shall not be used as earth continuity conductors.
(e) Maintenance Free earthing pit shall be provided.
(f) Earthing grids of all the buildings, outdoor yards shall be interconnected to form a single grid for the plant.

### 12.3.3 Conductors Material

The Earthing system conductors and accessories shall be as follows:

| Type Of Installation | | Material |
|---|---|---|
| Main Earth Grid | : | MS Rod ( buried) |
| Upto 11 KW | : | 4 SWG GI Wire |
| 11 KW to 37.5 KW | : | 25 X 6 GI Flat |
| 37.5 KW to 55 KW | : | 40 X 6 GI Flat |
| 55 KW to 200 KW | : | 50 X 6 GI Flat |
| 200 KW and Above | : | 50 X 10 GI Flat |
| HT Panel | : | 65 X 10 GI Flat |
| LT Panel ( Above 2000 Amp) | : | 65 X 10 GI Flat |
| LT Panel ( Less than 2000 Amp) | : | 50 X 6 GI Flat |
| LDB, PDB | : | 25 X 6 GI Flat |
| Welding Socket, Switch Board, Power Socket | : | 4 SWG GI Wire |
| Lightning Protection system | : | 25 X 6 GI Flat |
| Transformer Body and Neutral | : | 65 X 10 GI Flat |
| Bus Duct | : | 65 X 10 GI Flat |
| UPS / Battery Charger | : | 50 X 6 GI Flat |
| Cable Trays | : | 25 X 6 GI Flat |

| | | |
|---|---|---|
| DG Set | : | As per manufacturer recommendation |

The CONTRACTOR shall undertake the soil resistivity measurements at site and select suitable size of MS Rod for Main Grid.

### 12.3.4 Earthing System Installation

(a) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.
(b) Earthing conductor running exposed on column, walls, etc., shall be supported by suitable cleats, at intervals of 750 mm.
(c) The earthing conductor crossing the road / track shall be laid in hume pipe or laid at a greater depth to avoid damage.
(d) When earth conductor passes through floors, walls, etc., suitable pipe sleeves shall be provided and the same shall sealed after installation.
(e) The connection between earthing pads / terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.
(f) Metallic conduits, and pipes shall not be used as earth continuity conductor.
(g) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
(h) The cable sheaths, screens armour shall be earthed at both ends for multicore cables. For single core cables the same shall be done at one end (switchgear end) only.
(i) All bimetallic connections shall be treated with suitable compound to prevent moisture ingression.
(j) Flood light poles & towers, their junction boxes shall be connected to the earthing conductor to be run along with supply cable. This earth conductor shall be in turn connected to earth grid at two extreme points.
(k) Flexible earth conductors shall be provided at expansion joints for earthing the gates, operating handles, etc.
(l) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint / compound.

### 12.3.5 Earthing of Extraneous Metal Work

(a) Metallic fences, including plastic-covered chain-link fencing, associated metallic support posts, stays, gates and anti-climbing fittings, shall be earthed as per IS.
(b) Metallic fences which are situated within the area of the electrical earthing system or cannot be separated from it by a minimum distance of 2m, shall be bonded to the electrical earthing system.
(c) All structural steelwork within the Site, including handrailing, ladders, walkways and the like, shall be bonded to the electrical earthing system.

## 12.4 Instrumentation Earthing System

(a) An instrumentation earthing system shall be provided throughout in accordance with the requirements of relevant IS. The instrument earthing system shall be isolated from the main electrical earthing system except at their point of connection which shall be at the main earth terminal in the relevant process area.
(b) Instrumentation earth cables shall be segregated from other power and earth system cables in order to reduce electrical interference on the instrument earthing system.

(c) The instrument earthing system shall be used for the connection of any signal system zero-volt point and all communications and instrumentation cable screens. Cable screens shall be earthed at one end only. Instrument cable armours shall not be used as protective screens. Instrument cable armours shall be earthed to the electrical earth system at one end only.

(d) Each instrumentation, control, communications and telemetry panel shall be provided with an:
- electrical system earth bar bonded to the metalwork of the panel and providing earth connections for all cable armours and power circuit protective conductors;
- instrumentation earth bar insulated from the panel metalwork for connection of signal system zero-volt connections and connection of all signal cable screens.

(e) The design of the instrument earthing system shall be incorporated as part of design of the overall earthing system for the works.

## 12.5 Lightning Protection System

Lightning protection system shall consist of vertical air termination rods, horizontal roof conductors, down conductor and pipe electrodes.

### 12.5.1 Need for Protection

The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309/IEC and any building whose risk index is above the value specified in IS shall be provided with lightning protection. Contactor shall submit lightning protection system design and layout for approval.

### 12.5.2 Lightning Protection System Layout

(a) The lightning systems design and installation shall generally comply with IS: 2309/IEC code of practice for the protection of building and allied structure against lightning.

(b) Each down conductor shall be connected to a rod electrode, which in turn shall be connected to the station earthing system through test links.

### 12.5.3 Lightning Protection System Installation

(a) Conductors of lightning protection system shall not be connected with conductors of safety earthing system above ground level.

(b) The down conductors shall be welded to steel structures at 1000 mm interval or cleated to wall at 750 mm interval. Wherever welded, the weld locations shall be treated to provide rust protection.

(c) Each down conductor shall be provided with a test link at a height of about 1000mm above ground level.

## SUB-SECTION 13. CABLING

### 13.1 Type of Cables

#### 13.1.1 MV Cable

11 KV cables shall be 11 KV (E) grade suitable for use in medium resistance earthed system, stranded & compacted aluminium conductor, extruded semi conducting screen over conductor, XLPE insulated, semi conducting followed by copper tape screened, extruded PVC Type ST-2 inner sheathed, aluminium / GS wire armoured, overall FRLS PVC outer sheated, conforming to IS 7098(Part II),IEC 502 for construction details and tests.

#### 13.1.2 LV Cable

LV Power cables shall be 1100 V grade, single / multi core, stranded aluminium conductor, XLPE insulated with PVC inner sheath, armoured overall FRLS PVC outer sheated, generally conforming to IS 7098 (for XLPE). The cables used for DC System shall be of single core type. Minimum conductor cross section of power cables shall be 6 Sq.mm for aluminium cables. Power cable less than 6 Sq.mm shall be Cupper.

#### 13.1.3 Control Cable

Control cables shall be 1100 V grade, multicore, minimum 1.5 Sq.mm cross section, stranded copper conductor having minimum 7 strands, PVC insulated, PVC inner sheathed / galvanised steel wire armoured overall FRLS PVC outer sheathed generally conforming to IS 1554 Part-I. In situations where accuracy of measurement or voltage drop in control circuit warrants, higher cross sections as required shall be used.

### 13.2 Design Criteria For Cable Sizing

#### 13.2.1 Power Cables

(a) Power cable sizes shall be selected on the following basis :

(b) Power cables shall carry the full load current of the circuit continuously under site conditions considering the conditions listed below :

- Ambient design temperature 50 deg C.
- Maximum allowable temperature under normal full load condition and under short circuit condition based on material selected (XLPE).
- Maximum short circuit fault current.
- Ambient temperature for underground cables,50 deg C.
- De rating factors as per IS/IEC and manufacturer's standard catalogues.

(c) Power cables shall withstand the fault current of the circuit for the duration not less than the maximum time taken by the primary protective system to isolate the fault.

(d) For the cables to 415 V motors and feeders protected by fuses, the cross section shall be chosen according to the cut-offf current of the fuse and its fusing time.

(e) Voltage drop from transformer secondary to motor terminals during starting of motors will be limited to the following values :

- For LV Motors : 15% of the rated voltage

(f) Voltage drop in feeder cables shall be limited to 3% during full load running condition. Voltage drop from transformer secondary to motor terminals during full load running of motors shall be limited to 3 % of rated voltage.
(g) For power supply to valve actuator motors, actuators of various isolating and and exhaust fans, 3/4 core 2.5 Sq mm stranded copper conductor cable may be used in view of ease of termination.
(h) Project and Client Name shall be mentioned on cable.
(i) Design calculation for arriving at cable size shall be submitted for DJB approval.

### 13.2.2 DC System Cables

(a) 1100 V grade single core cables as specified in LT power cables shall be used from batteries / battery chargers to main DCDB, between main distribution board, from main distribution board to sub distribution board, main DC supply to various system cabinets / panels, switchgears etc and for critical auxiliaries. Flexible cables with PVC insulation shall be used where termination of XLPE / PVC insulated cables is difficult.
(b) Voltage drop in cables between battery to DCDB and battery charger to DCDB shall be limited to 2%. Voltage drop in cables between DCDB and loads shall be limited to 3%.
(c) Design Calculation for arriving at cable size shall be submitted for purchaser's approval.

### 13.2.3 Control Cables

(a) Current transformer leads shall be checked for the lead burden vis-à-vis the current transformer VA capacity. In case 2.5 Sqmm conductor impose unacceptably high burden on CTs, 4.0 Sqmm conductor shall be used. The conductor material shall be copper.
(b) Voltage transformer leads shall be checked for voltage drop which shall be limited to within 1% for all cases other than tariff metering. For tariff metering the voltage drop shall be limited to 0.2%. In case the voltage drop with 2.5 sqmm conductors exceeds this value, higher conductor sizes shall be used.

## 13.3 Cable Termination

(a) Cables shall be laid in trays / trenches / conduits by the Contractor. Joint markers shall be provided at each joint.
(b) All 11 KV termination kits shall be of heat shrinkable type and suitable for XLPE insulation and the same shall have been tested for a system short circuit value.
(c) All 1100 V termination for XLPE / PVC power cables and control cables shall be done by double compression weather proof type cable glands. Heavy duty, tinned, long barrel copper / alluminium lugs shall be used for termination.

## 13.4 Cable Joints

Cable joints shall be avoided to the extent possible. If joints are unavoidable due to circuit length, in excess of permissible maximum drum length, they shall be heat shrinkable types having a short circuit withstand capacity value as specified in clause 10.4 above. Lugs shall be heavy duty, tinned copper, long barrel type. All cable glands shall be double compression, weather proof.

## 13.5 Cable Tray

Cable tray size shall be designed in such a manner that there is no overlapping of cables,20% spare shall be provided.

### 13.5.1 Perforated Cable Tray

(a) Cable tray shall be heavy-duty hot-dip galvanised steel. Wherever possible, galvanised steel cable trays shall be installed in full lengths without cutting. Cut edges shall be treated with an approved zinc-based paint.
(b) Cable trays shall be installed using proprietary accessories and MS angle support at the distance of 1000 mm.
(c) All cables shall be firmly clamped to the tray using approved purpose-made fixings.
(d) Cable tray shall be mounted not less than 25mm from the face of the structure.

### 13.5.2 Ladder

(a) Cable ladders shall be heavy-duty hot-dip galvanised steel. Wherever possible, galvanised steel cable ladders shall be installed in full lengths without cutting. Cut edges of steel ladders shall be treated with an approved zinc-based paint.
(b) Cable ladders shall be installed using proprietary accessories and MS angle support at the distance of 1000 mm.
(c) All cables shall be firmly secured to ladders using approved purpose-made fixings.

## 13.6 Cable Carrier System

(a) The cable carrier system shall be designed considering the following :

- Facility for easy laying of cables.
- Access to maintenance.
- Neat and aesthetic appearance.
- Safety of equipment & personnel.
- Ground water seepage.
- Drainage system for oil and water.

(b) Cables shall be laid in prefabricated ladder (for power) / perforated (Control and instrumentation) type trays and in conduits. Also joint markers shall be provided at each joint.
(c) Cable trays and supporting structures in chemically corrosive area like battery room shall be mild steel painted trays finished with chlorinated rubber based paint / epoxy paint.
(d) No direct underground burial cables shall be laid except lighting tower, street lighting. For some exceptional case like isolated individual equipments it shall be allowed after approval by the client /consultant.

## 13.7 Cable Installation System

(a) All material and accessories required for cable installation like cable trays, tray covers, support steel, etc., shall be hot dip galvanized. Conduits / pipes shall also be hot dip galvanized steel. The racks/trays, conduits/pipes, trenches required to route the cables to individual equipment shall be supplied and installed by the Contactor.
(b) Separate trays shall be provided for HV Power / LV Power (AC&DC) / Control & Instrumentation cables.
(c) After laying all the cables, Contractor shall dress all cables by clamping at every metre, so that the cables are securely held and aesthetically good.
(d) All cable entries to the buildings to be sealed by fire proof & water proof cement after cable installation.
(e) All outdoor cable trays are to be provided with covers. All vertical cable tray race ways are to be provided with covers all round. Cable trays shall be of ladder / perforated type complete with all

necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories. Cable trays of ladder and perforated types and the associated accessories such as coupler plates, tees, elbows, etc., shall be fabricated from 12 gauge (2.5 mm thick) mild steel sheets. Cable tray covers shall be provided for all cable trays and raceways.

### 13.8 Fire-Proof Sealing Of Cable Penetration

Cables / cable tray openings in walls and floors or through pipe sleeves from one area to another or one elevation to another, between the units and within the same unit, shall be sealed by a fire-proof sealing system. The fire proof sealing system (FPSS) shall effectively prevent the spread of fire from the flaming to the non-flaming side, in the event of a fire. The FPSS shall conform to the following requirements:

(a) FPSS shall have a fire rating of two hours.
(b) The FPSS shall be subjected to fire endurance test, hose stream test, temperature measurement of non-flaming side as per ASTM-E119. 'Standard method of fire tests of building construction and materials'.
(c) The FPSS will also conform to the in-combustibility test carried out in accordance with IS: 3144-1992.
(d) Under fire condition, the FPSS material shall not emit excessive smoke or any corrosive or toxic fumes.
(e) FPSS shall have minimum life of 25 years.

### 13.9 Tests

(a) All routine tests as per relevant standard shall be performed on each size of cable. If same size is supplied in different lots, inspection shall be done for each lot. These tests shall be carried out as per relevant standards as applicable.
(b) Type test certificates for type tests conducted on identical design and size of the Cables shall be submitted for review. If type tests have not been done or the certificates are found to be not in order by Contractor then these type tests shall be conducted on Cables to be supplied for this project at no extra cost to Contractor.

## SUB-SECTION 14. LIGHTING SYSTEM

### 14.1 Intent of Specification:

Illumination levels shall be provided for indoor/outdoor area of pumping station and roads as per the recommendations covered in relevant Indian Standards shall be proposed. Contractor shall be required to measure levels of llumination after completion of lighting installation work. Shortfalls in illumination levels shall be made good by the contractor as required.

### 14.2 Lighting System Design

(a) The lighting system design shall be submitted on lates version of lighting software. All internal and external light fitting shall be LED type. All fitting shall be provided with electronic ballast.
(b) The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of lighting specified in following paragraph.
(c) The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

### 14.2.1 Illumination Level

**Note: -** All Internal and External lighting shall be LED lights only and shall be as per following lux level.

- Pump House : 200
- Switch Gear Room / area : 250
- Control room : 300
- Store Room : 150
- Office : 250
- Stair Case, Corridor, walkway : 100
- Bathroom / Toilet : 100
- Street Lights : 30
- Parking Area : 50
- Chlorination Room : 200
- Battery Room : 150

### 14.2.2 Indoor Lighting

The recommended values of illumination level for various areas in the plant are indicated in the Table above. Following factors shall be considered while arriving at the utilisation factor to determine the number of fixtures for each area/buildings in the plant.

<u>Maintenance Factor:</u>

(a) Air-conditioned clean interiors like office rooms, control room : 0.8
(b) Industrial areas with normal interiors such as store, pump room : 0.7
(c) Industrial areas with dusty interiors : 0.6

<u>Reflection factor for wall/ceiling</u>

(a) White and very light colours : 0.7
(b) Light colours : 0.5

(c) Middle tints : 0.3
(d) Dark colours : 0.1

Utilization factor considering the room index at applicable surface ref lection factors. The working plane shall be considered at 0.85 m from the floor level.

### 14.2.3 Outdoor Lighting

(a) The recommended illumination levels for outdoor areas are indicated in the above table.
(b) Mounting height, spacing of flood lights shall be based on lamp wattage, uniformity of illumination and vertical angles. Ratio of minimum to average illumination shall not be less than 0.3 and for minimum to maximum shall not be less than 0.2.
(c) Maintenance factor shall be generally 0.6 under average conditions.
(d) Flood lights for area lighting shall be mounted on towers/poles/building structures.
(e) Automatic switching ON/OFF shall be provided for outdoor lighting. For road illumination inside the battery limit lighting poles shall be provided every 30m.
(f) Approach road lighting near the pumping station area shall be provided with suitable street light poles as per IS.

## 14.3 Switches, Receptacles

(a) In the plant area, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area, separate switches shall be provided. For cabins, rooms, etc., separate switches shall be provided for each point. Similarly for entrances, building periphery lighting separate switches shall be provided.
(b) 240V, 50 Hz, 3 pin Power Receptacles (5A and 15A) shall be provided in all building/areas of the plant. Inside a building, receptacles shall be provided at interval of 30m or part there of for hand tools, water coolers, exhaust fans etc. Inside each cabins atleast two receptacles shall be provided and the same shall be indoor/outdoor/flameproof as per the location.
(c) Minimum 2 nos of 5A and 1 no 15A receptacles shall be provided in each room.
(d) 20A sockets shall be used for AC & ventilation and shall be controlled through MCBs.
(e) 2 Nos. welding sockets shall be provided in pumphouse, switchgear room, transformer room. Separate Welding DG shall be provided.

## 14.4 Lighting Distribution Panel

(a) The Main Lighting Distribution board ( MLDB) shall be fed through 415V/433V lighting transformers with off circuit taps ± 5% in steps of 2.5%. The lighting transformer shall be cast resin dry type and shall be housed in a suitable enclosure. The main lighting distribution boards shall consist of incoming MCCB and required number of out going triple pole and neutral MCCBs. MLDB shall be designed for the required short circuit level of 20 kA.
(b) Lighting Distribution Board ( LDB) shall have three / single phase incomer controlled by ELCB+MCB and a number of single phase outgoing circuits controlled by MCBs. The All the distribution boards shall be sheet steel clad, dust and vermin proof, cubicle type with degree of protection conforming to IP-52.
(c) Outdoor panels shall be weather proof type with IP-55 protection. The thickness of sheet steel enclosures shall be 2 mm minimum for load bearing and 1.6 mm for other members. In all the lighting distribution boards 20% spare feeders of each type and rating shall be provided.

(d) Number of outgoing feeders in LDB's shall be provided as per requirement including the spare feeders and feeders for "CLIENT USE". Each outgoing MCB in LDB's shall be of 15 A, but load to be limited to 2 kW or maximum 10 nos. fittings to be connected to one MCB.

(e) External area lighting shall be fed from separate boards located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers.
(f) In high bays, walkway shall be provided for maintaining light fittings. At other places suitable ladder / platform / approach shall be provided for maintaining / replacement of light fittings.
(g) Each of the LDBs shall be provided with voltmeter and ammeter along with selector switches, 'SUPPLY ON" indicating lamps, etc. The switch boxes, receptacle boxes etc. shall be made up of 18 SWG sheet steel.
(h) Two ground pads with bolts and nuts shall be provided on each board for connection to 25 X 6 mm GI flat.
(i) Painting : All sheet steel enclosures of panels, switchboards & receptacles shall be chemically cleaned rinsed, phosphated & dried. After the treatment steel surfaces shall be given two coats of finished enamel paint of approved shade.
(j) The distribution of lighting fixtures/receptacles shall be such that the loading on each phase of the LDB is approximately equal.
(k) Bus and Busbar Connection
Panel busbar shall be electrolytic grade hard drawn Cupper colour coded for easy identification of required size.

## 14.5 Cable and Wiring

(a) Heavy duty AYWY cables with FRLS, XLPE shall be provided for the following connections:

- Incoming feeders to all LDBs, receptacles, lighting panels.
- Feeders connecting area lighting panels to outdoor lighting panels, etc. shall be of 3 core x 2.5 sq.mm, 1100 V grade FRLS, PVC stranded cable of copper.

(b) Wiring from lighting DBs / panels to individual fixtures, plug points, fans, etc. shall be of single core, 2.5 sq.mm, 650 V grade PVC stranded copper conductors through surface mounted or concealed medium duty GI conduits confirming to IS 1239 with earth wire. The wires shall occupy 60% of the conduit area.
(c) 650 V / 440 V grade stranded copper conductor, PVC insulated, colour coded, wires laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous area, outdoor areas like road lighting, cable wiring shall be adopted.
(d) Minimum size of wires in case of conduit wiring shall be 2.5 sq.mm. copper in case of lighting and 4 sq.mm. copper in case of receptacle wiring.
(e) Wires of different phases shall be run in separate conduits. However, wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles shall be carried out in separate conduits and on separate circuits.
(f) For outdoor lighting, the cable shall be buried at a minimum depth of 750 mm from ground level or run in cable trays. The buried cables shall have suitable bedding, protective covers and markers.
(g) Material used for saddles, clamps, JBs, etc. shall be galvanised. Switchgear room / control room shall have concealed wiring with 2.5 sq. mm. cable using GI conduits.

## 14.6 Conduits

(a) All conduits shall be of medium gauge Class B GI and with wall thickness conforming to IS:9537 in all respects. The conduits are to be free from burrs and internal roughness. No conduits less than 20 mm in dia. shall be used, unless specified.
(b) The Contractor using the particular brand of conduit shall furnish certified test certificate from National Test House or any other Government accredited laboratory with each quantity of

supply, along with supply of conduits to site. In some cases conduits, if required to be concealed, DJB / Consultant approval.

### 14.7 Specific Requirements

(a) Exhaust Fans

Exhaust fans for toilets, battery rooms, pumphouse, switchgear room etc shall be provided with their control devices (MCBs) & louvers.

(b) Ceiling Fans

Switchgear Room, Control Room, and offices shall be provided with ceiling fans The fans shall be provided with local speed controllers and switches adjacent to each individual unit.

(c) Air Conditioning

As a minimum, the control room shall be air conditioned. The Contractor shall also provide additional air conditioning units to meet the requirements. AC unit shall be provided in Control room and Office.

The air conditioning shall be designed to maintain a dry bulb temperature of 22 $^{0}$C and relative humidity of 50% under the outside mean monthly maximum shade temperature and humidity.

### 14.8 Lighting Circuit Design

(a) In an area, the lighting fixtures shall be arranged in different phase / LPs such that even in case one lighting panel is faulty complete lighting is not affected. In all locations the lighting shall be arranged from two phases.
(b) The circuit loading on each circuit shall be restricted to 80% of the MCB rating.
(c) The voltage drop from LDB and any fixture shall not exceed 3%.

### 14.9 Tests

(a) Acceptance tests and routine tests for the lighting fixtures and accessories, LDBs shall be carried out as per relevant standards and report to be submit to DJB for review.
(b) Test to be carried out for LDB shall be as follows :

- IR test before and after HT test.
- HV test by HV megger.
- Checking for functions of components for each module.
- Checking for interchangeability of similar components.
- Testing and calibration of all indicating meters.

## SUB-SECTION 15. BATTERY AND BATTERY CHARGER

### 15.1 General

One sets of 24V DC system in accordance with this specification herewith which shall comprise of the following:

- Battery chargers (Float and Boost)
- DCDB
- Ni-Cd maintenance free batteries complete with racks and mounting accessories.
- 24V DC system.

### 15.2 Standards

(a) The equipment covered by this specification shall unless otherwise stated, be designed, manufactured and tested in accordance with lasts revision of relevant Indian Standards (IS) some of which are listed below.

| | |
|---|---|
| IS- 4064 | Air break switches and isolators. |
| IS- 2208 | HRC cartridge fuse links up to 650 V |
| IS- 2147 | Degree of protection provided by enclosure. |
| IS- 2705 | Current Transformer. |
| IS- 3156 | Voltage Transformer. |
| IS- 722 | A.C. Electrical Meters. |
| IS- 3231 | Electrical Relays. |
| IS- 2959 | Contactors. |
| IS- 6875 | Control Switches and Push Button Stations. |
| IS- 8623 | Factory built assemblies. |
| IS- 694 | PVC insulated Cables. |
| IS- 1248 | Electrical indicating instruments. |
| IS- 4047 | Heavy Duty Air Break Switches. |
| IS- 1651 | Battery |
| IS- 1248 | DC Electric Meters |

### 15.3 Design and Sizing

#### 15.3.1 Ni-Cd Maintenance Free Battery

(a) 24V DC Battery shall be rated to cater to the following loads with minimum duration as indicated. The design of the DC system shall be such that the variation in the DC system voltage is limited to +10% to -15% of the nominal voltage of 24V. Number of cells, ampere hour to be realised as per the requirement.

i. Momentary load (Loads consuming DC power for 1 minute or less)
   - Tripping load of breakers.
   - Closing load of breakers.

ii. Emergency load (For a duration of more than 1 min but less than 2 hours)
   - Annunciation.

iii. Continuous Load (For duration of 5 Hours)
   - Indicating lamps on switchgear and control panels
   - Numerical & Auxiliary relays

(b) The battery shall be sized in accordance with the latest version of IEEE 1115 considering temperature correction factor, contingency, ageing factor (min. 25%), K-factor and design margin (min of 10%). The ageing factor for Plant type Batteries shall be one (1).

(c) The following minimum design requirement shall be met: -

| S. No. | Design Parameter | Ni- Cd. |
|---|---|---|
| 1 | Nominal Voltage | 1.2 V |
| 2 | End Cell Voltage | 1.14 V |
| 3 | Discharge capacity | 5 hour |
| 4 | Ageing Factor | 1.25 |
| 5 | Design Margin | 10% |
| 6 | Float Charging voltage | 1.4 to 1.42 |

(d) All other factors shall be as per relevant standard and all standards shall be of latest revision.

### 15.3.2 Battery Charger

(a) Each Float cum Boost charger (FCBC) shall be calculated from the following, whichever is higher.

- Float Charger: Continuous load on the DC bus with 10 % margin + Trickle charging current.
- The Boost charger unit shall be rated such that the battery can be charged from fully discharged condition within 5 hours.
- The 24V DCDB will be provided with two incomers and a bus coupler.

(b) Under normal conditions, Bus coupler will be kept open with each Float cum Boost charger will feed 50% of the total load and trickle charging current of the respective battery.

(c) In case of total AC supply failure in the plant or power supply failure to the charger, the respective battery will meet the corresponding loads. In case one of the chargers require repair/maintenance, then all the DC loads are transferred to the healthy battery charger by isolating the corresponding incomer to the DCDB and closing the bus coupler.

(d) During this period, if there is an AC supply failure, the battery which is connected to the healthy charger will feed 100% loads.

(e) After restoration of AC supply, the fully/partly discharged battery will be recharged one at a time using the corresponding boost charger. During this time, the charger will be disconnected from the loads, by opening the DCDB incomer and 100% of the loads will be fed from the other charger.

## 15.4 Specific Requirement

### 15.4.1 Battery System

(a) Battery shall be Ni-CD maintenance free type. The battery shall be closed top or sealed in type. Open type cells are not acceptable.

(b) All the accessories required for testing and maintenance shall be supplied with the batteries along with electrolyte for first filling. These shall also include + 3 volts DC voltmeter with suitable leads for measuring cell voltage.

(c) The batteries shall be located on FRP stand.

### 15.4.2 24 V Battery Charger

(a) The float cum boost charger offered shall be static type with silicon controlled rectifiers and diodes, complete with resistor/capacitor network for surge protection, connected in three phase full wave bridge circuit.

(b) Battery Charger shall be provided with IP-42 protection and colour shall be RAL-7032 Siemens Grey. Component Mounting plate shall be Glossy White.

(c) Charger shall have provision for manual control if the auto mode fails. Load limiting features shall be provided. The charger shall be designed for adequate short time over load to take care of the starting of the largest DC motor/testing of lamps, etc. with other DC loads connected to bus.

(d) The chargers shall be provided with automatic voltage regulation in float mode and automatic constant current regulation in boost mode.

(e) The charger shall have following Voltage Regulation:

- Load Variation : 10-100 %
- Line Variation : + 10%
- Frequency Variation : + 5 %
- Temperature Variation : 0$^{o}$C to 50$^{o}$C

(f) The charger shall have following instruments:

- DC voltmeter and ammeter of size 96 x 96 mm of suitable range for float cum boost chargers. Necessary shunts for local and remote metering shall be provided.
- Moving coil centre zero ammeter, with shunt, size 96 x 96 mm to read discharge / charge current of the battery.
- AC input volt meter with selector switch for AC supply monitoring.
- Suitable provision shall be made on charger for reading the battery & battery charger voltage.

(g) Fault indicating lamps shall be provided on the charger cubicle and following initiating contacts shall be provided for remote alarm for each of the float cum boost chargers. The alarms shall be provided on the CRT in the common control room.

- Main AC failure
- AC input fuse blown
- DC output fuse blown
- U/V and current limit protection
- Over voltage protection
- Overcurrent protection
- Filter condenser fuse blown
- Rectifier fuse blown
- In addition to the above, any additional indication/alarms considered necessary during the detailed engineering shall also be provided.

(h) Battery Charger shall be provided with indications ( 5 mm LED), Protections, Control and Switches and following Special Features:

- Auto Phase Reversal Operation
- Soft start on DC Side
- Class F insulation with class F temperature rise.
- Charger current limiting
- Battery Current limiting
- Remote Shut Down
- Anti Condensation Heater with Thermostat
- Automatic Float to Boost Changeover based on current or Voltage.

## 15.5 Tests

### 15.5.1 For Batteries

(a) All routine and acceptance tests shall be conducted as per the relevant standards.
- Physical Examination
- Dimension, Mass and Layout
- Marking
- Polarity and Absence of Short Circuit
- Air Pressure Test.
- Ampere Hour Capacity.
- Insulation Resistance.

(b) Type test certificates for tests conducted on identical design and capacity of the battery shall be submitted for review. If type tests have not been done or the certificates are found to be not in order by purchaser then these type tests shall be conducted on one set of battery to be supplied for this project.

(c) Capacity test and test for voltage during discharge shall be carried out at site on completion of installation and commissioning and immediately prior to putting the battery in service.

### 15.5.2 Tests for Battery Chargers

The following routine tests shall be conducted at Vendor's works:

- Visual checks for dimensions and general arrangement.
- Wiring checks
- Functional checks
- Voltage regulation for rated input supply for loads from 0-100%.
- Load test to show the charger can deliver the rated duty without the current limiter device operating.
- Ripple measurement by oscilloscope at different loads.
- Demonstration of guaranteed efficiency and power factor
- Insulation test (with 500 V megger).
- High voltage test, excluding electronic controller, at 2 kV AC for one min.
- Heat run test shall be conducted as a type test at the factory for 24 V charger.
- Test certificates shall be submitted for bought out items.

## 15.6 DC Switchboard

(a) The switchboards shall be provided with suitably rated incomers, required quantity and type of outgoing feeders for the auxiliaries, control supplies to various panels/systems in accordance with the number of 24V DC supplies for each load and auxiliary separate feeders shall be provided.

(b) 1 No. Alarm module for common alarm of outgoing feeder fault.

### 15.6.1 Specific Requirement

(a) Incommer of DCDB shall be provided with Ammeter, Voltmeter, Indicating lamps.

(b) The constructional features of all DC switchboards shall comply with the requirements of 415V AC switchgears.

(c) Positive and negative bus bars in the DC switchgear shall be completely segregated from each other by sheet steel partitions.

(d) Alarm module for outgoing feeder faults shall be provided with switch fuse, alarm accept, reset PBs, 'supply ON' lamp, 'fault detected' lamp, hooter, necessary auxiliary contactors, control circuit for detecting, annunciating, accepting, resetting the fault in bus section. Contacts from this module for common feeder fault and its own module supply failure shall be provided and used for annunciation in control desk.

(e) Following indications/alarms shall be available in the control room PLC / SCADA System

- Incomer : ON & OFF
- Incomer current
- Alarm module supply failed
- Outgoing feeder fault
- Incomer alarm supply fail

# Technical Specifications

# C5. Instrumentation Works

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# SUB-SECTION 1. INSTRUMENTATION — GENERAL

## 1.1 Scope

This part covers the general requirements for the design, supply, installation, inspection and testing of the instrumentation works and associated plant and materials.

## 1.2 Reference standards

All the Works under the Contract shall be carried out in accordance with the relevant quality standards, test procedures or codes of practice, collectively referred to as Reference Standards. Except where otherwise specified, all Plants, Equipment, Materials and Workmanship shall comply with the requirements of the relevant Indian Standards (hereinafter referred to as IS) issued by the Bureau of Indian Standards. If no standard is specified, the relevant Indian Standard or, in the absence of such standard, international standard shall apply. All Standards used shall be the current (latest updated) version.

Keeping in view of International Competitive Bidding (ICB) Contract and the JICA's Guidelines to use the recognized International Standards, extensive reference of British Standards (BS) is provided in the specifications for the easy and proper understanding of the Bidder on the nature and quality of the work. However, any material, methodology or workmanship prescribed herein in accordance with any International or other country's Standards shall be substituted by the equivalent Indian Standards, if available, under the approval of the Engineer.

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

| | |
|---|---|
| IEC 60381-1:1982 | Analogue signals for process control systems. Specification for direct current signals. |
| IEC 60947-4-1:2000 | Specification for low-voltage switchgear and control-gear. Contactors and motor-starters. Electromechanical contactors and motor-starters. |
| IEC 60947-4-2:1999 | Specification for low-voltage switchgear and control-gear. Contactors and motor-starters. A.C. semiconductor motor controllers and starters. |
| IEC 60947-4-3:1999 | Specification for low-voltage switchgear and control-gear. Contactors and motor-starters. Contactors and motor-starters. AC semiconductor controllers and contactors for non-motor loads. |
| IEC 60770-1:1999 | Transmitters for use in industrial-process control systems. Methods for performance evaluation. |
| BS ISO 1217:1996 | Displacement compressors. Acceptance tests. |
| ISO 2112:1990 | Specification for aminoplastic moulding materials. |
| ISO 6817:1997 | Measurement of conductive liquid flow in closed conduits. Method using electromagnetic flowmeters. |

| | |
|---|---|
| BS EN 837-1:1998 | Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing. |
| BS EN 1057:1996 | Copper and copper alloys. Seamless, round copper tubes for water and gas in sanitary and heating applications. |
| BS EN 1092-1:2002 | Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges. |
| BS EN 60529:1992 | Specification for degrees of protection provided by enclosures (IP code). |
| BS EN 60534-1:1993 | Industrial-process control valves. Industrial-process control valves. Control valve terminology and general considerations. |
| BS EN 60546-1:1993 | Controllers with analogue signals for use in industrial-process control systems. Methods for evaluating performance. |
| BS EN 60654:1998 | Operating conditions for industrial-process measurement and control equipment. All relevant parts. |
| BS EN 60751:1996 | Industrial platinum resistance thermometer sensors. |
| BS EN 61000-6:2001 | Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments. |
| BS 89:1990 | Direct acting indicating analogue electrical measuring instruments and their accessories. All parts. |
| BS 1042-1.4:1992 | Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2. |
| BS 1041-2.1:1985 | Code for temperature measurement. Expansion thermometers. Guide to selection and use of liquid-in-glass thermometers. |
| BS 1041-2.2:1989 | Code for temperature measurement. Expansion thermometers. Guide to selection and use of dial-type expansion thermometers. |
| BS 1041-3:1989 | Temperature measurement. Guide to selection and use of industrial resistance thermometers. |
| BS 1553-1:1977 | Specification for graphical symbols for general engineering. Piping systems and plant. |
| BS 1646-1:1979 | Symbolic representation for process measurement control functions and instrumentation. Basic requirements. |
| BS 1646-2:1983 | Symbolic representation for process measurement control functions and instrumentation. Specification for additional basic requirements. |
| BS 1646-3:1984 | Symbolic representation for process measurement control functions and instrumentation. Specification for detailed symbols for instrument interconnection diagrams. |
| BS 1646-4:1984 | Symbolic representation for process measurement control functions and instrumentation. Specification for basic symbols for process computer, interface and shared display/control functions. |
| BS 4675-2:1978 | Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity. |
| BS 4999-142:1987 | General requirements for rotating electrical machines. Specification for mechanical performance: vibration. |
| BS 5728-3:1997 | Measurement of flow of cold potable water in closed conduits. Methods for determining principal characteristics of single |

| | |
|---|---|
| | mechanical water meters (including test equipment). |
| BS 6004:2000 | Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring. |
| BS 6739:1986 | Code of practice for instrumentation in process control systems: installation design and practice. |
| BS 7671:2001 | Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition. |

Instrument Society of America Standards and Recommended Practices:

| | |
|---|---|
| S 5.1 | Instrumentation symbols and identification |
| S 5.4 | Instrument loop diagrams |
| RP 18.1 | Specifications and guides for the use of general purpose annunciators |
| S 26 | Dynamic response testing of process control instrumentation |
| RP 31.1 | Specification, installation and calibration of turbine flowmeters |
| S 37.1 | Electrical transducer nomenclature and terminology |
| S 37.3 | Specifications and tests for strain gauge pressure transducers |
| S 50.1 | Compatibility of analog signals for electronic industrial process instruments |
| S 51.1 | Process instrumentation terminology |
| RP 60.08 | Electrical Guide for Control Centres |

## 1.3 General Requirements of Instrumentation

This is an indicative list. Being a DBO contract, the contractor shall provide for all the item/services required for safe & reliable operation as per the Process Design requirements. (Please refer Drg.Nos. P225-225-S-SD-001,002A,002B & 003 (Rev-3)

### 1.3.1 Receive and Store information from

**A. Electrical System: -**

Input voltage, Amperage of 11/3.3 kV and 415 V systems, and input voltage, Amperage to individual motors and auxiliary transformers

a. Power consumption (kWH), and power factor of 11/3.3 kV and 415 V system, auxiliary transformers
b. Status of all breakers
c. Status of all LT motors (on/off)
d. Winding temperatures and bearing temperature of motor (if available)
e. Transformer winding temperature, oil gauge pressure

**B. Mechanical Equipment: -**

a. Status of all pumps, dewatering pumps.
b. Status (on/off) of all valves, on individual pumps (delivery & suction), manifold pipe etc.

c. Temperature of pump thrust / shaft bearing

**C. Instrumentation Equipment:-**

a. Flow data (instantaneous flow rates and total flow) from the pump houses & DMA (through flow meter installed), common discharge header of the BPS and at DMAs.
b. Level of water in the underground reservoirs (UGRs), dewatering sumps.
c. Pressures at delivery of each main pump & manifold, distribution mains, pipelines in the DMAs.
d. On line Residual Chlorine and Turbidity monitoring at BPS common outlets and at lowest pressure points of each DMA..

### 1.3.2 Alarm Situations

The alarm schedule is indicative of what is required. The contractor shall provide for the annunciation of all alarms necessary in order to achieve control and monitoring requirements.

**A. Pumping Stations: -**

i. 415V power failure
ii. Motor tripped on overload
iii. High temperature of windings/bearings (if available)
iv. Sudden Pressure rise and drop in the Pipe-Lines

**B. UGRs and BPS**

i. Pumps fail to start/stop
ii. Level of water in UGRs abnormally high or low

**C.** Fire and Intruder Alarm system along with CCTV monitoring

## 1.4 Statement of compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement.

All standards which the Contractor intends to use but which are not referenced herein shall be submitted to the Engineer for consent before any design against that standard proceeds.

Installation works shall comply with all relevant local Indian Regulations including the Code of Practice for Electrical Wiring Installations – IS 732.

## 1.5 Submissions by Contractor

### 1.5.1 General

The Contractor shall make submissions to the Engineer of all design drawings and schedules relating to instrumentation and control equipment and systems provided under this Contract. These submissions shall include, where relevant, the following:

### 1.5.2 Functional design specification

The Contractor shall submit a complete functional design specification (FDS) for approval by the Engineer. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, set-point and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program in each programmable item. The format of the program details may be chosen by the Contract, however it is suggested that this format be chosen to satisfy the requirements of the software design documentation, if applicable, as described elsewhere.

The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which take place during system start-up and shut-down.

The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

The Contractor shall submit and obtain approval of the FDS from the Engineer before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

### 1.5.3 Drawings and schedules

(a) Process and instrumentation diagram which shall comply with BS 1646 (all parts) and BS 1553-1:1977.
(b) General arrangement drawings of field-mounted instruments showing installation details.
(c) General arrangement drawings of instrument and control panels, fully-dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
(d) Layout drawings of panel fascias showing instruments, controls and details of all labels.
(e) Layout drawings of panel interior showing equipment, terminal blocks and cable ways.
(f) Annunciator arrangement and engraving details.
(g) Internal circuit and wiring diagrams for instrument and control panels.
(h) Schematic control diagrams.
(j) Instrument loop diagrams.

(k) Instrument wiring and piping diagrams.
(l) Interconnection wiring diagrams.
(m) Cable block diagrams, drawings and schedules.
(n) Instrument system and panel power distribution diagrams.
(p) Programmable-device functional design specifications which shall include hardware details, logic flow charts, ladder diagrams and program listings.
(q) Schedules of inputs to and outputs from programmable controllers and telemetry outstations.
(r) Labelling schedules.
(s) Comprehensive testing schedules for all off-site, on-site, pre-commissioning and commissioning tests and take-over tests.
(t) Any drawing/documents not covered above, but required for executing this contract

All other drawings necessary for the provision of ducts, openings, trenches, fixing holes for panels and the like and for the complete understanding of the operation, maintenance and extension of the system including any required for the Purchaser to dismantle, repair, maintain, modify or extend the Plant.

### 1.5.4 Data and calculations

(a) Manufacturers' catalogues and data sheets.
(b) Calculations to support control system design.
(c) Specification for protective coatings and painting.

### 1.5.5 Certificates

(a) Manufacturers' works tests.
(b) Pre-installation checks.
(c) Pressure-testing schedules.
(d) Instrument loop test check sheets.
(e) Installed instrument performance tests.
(f) System tests.

### 1.5.6 Operation and maintenance instructions

Composite manual describing the functional and operation of each piece of equipment.

Composite manual for testing and servicing every system and individual item.

## 1.6 Basic features

Each instrumentation system shall be designed, manufactured and installed to achieve the following basic requirements:

- to maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance;
- User friendly system to the staff who will:
  (a) use the systems;
  (b) service the systems.

- to measure, indicate, process, store and control the relevant parameters, as specified;
- to give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of 'operations and maintenance' personnel and plant and to collect, display and store the data, as required;
- to derive, present and utilise, as required, such additional data as required to facilitate:
  (a) the most efficient operation of the plant;
  (b) the routine maintenance of the plant.

## 1.7 Design requirements for instrumentation systems

The instrumentation, control and automation installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.

The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of 'Requirements for Electrical Installations' BS 7671:2001, and with the relevant Indian standards of the area in which the plant is to be installed. All electrical consumable items shall be readily available within India.

All installations, shall also comply in conjunction with associated mechanical and electrical plant installations with the UK's Health and Safety at Work Act 1974 and the Electricity at Work Regulation 1989, which specify standards of safety for industrial plant installations, and with the relevant standards of the Country in which the plant is to be installed.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.

The instrumentation, control and monitoring system equipment and materials shall have an operational life of not less than 10 years, unless otherwise consented by the Engineer.

## SUB-SECTION 2. INSTRUMENTATION EQUIPMENT

### 2.1 Components, equipment and system design

All equipment shall be designed for rapid fault-diagnosis and replacement of major sub-assemblies and components, which shall be mounted on printed-circuit boards or plug-in type bases with high-grade, non-ageing plugs and sockets with gold-plated contacts. Components on printed circuit boards shall be tropicalized and varnished. All transformers shall be double-wound with an earthed screen between primary and secondary windings. All transformers shall be vacuum-impregnated and all except power transformers shall be epoxy-resin encapsulated. Routine maintenance and repair shall, as far as possible, require neither highly-skilled personnel nor soldering and wire-wrapping techniques.

Integrated circuits shall be used and, except in protection and shut-down circuits, solid-state devices shall be used in preference to moving-armature relays and electro-mechanical timers. Relays shall be of the plug-in type and shall have polycarbonate covers. When used in tropical locations, the relays shall be hermetically sealed.

Electronic units shall be fully solid state and the selection and installation of components shall give the maximum life possible. Wire-wound resistors shall be on ceramic formers and embedded in fire-proof and damp-proof material.

Plant state indication systems shall be designed so that a failure of any component or circuit or power supply associated with the indication system cannot lead to the masking or inhibition of the indication of a potentially dangerous state.

Plant protection and control systems shall be designed so that their outputs are de-energised or neutralised whenever a failure occurs of any component or circuit or power supply associated with that protection or control circuit.

No single equipment fault shall prevent the correct operation of any protection or shut-down circuit whenever necessitated by a plant fault condition or control action.

Under emergency, failure or shut-down circumstances, each regulating device shall move to the appropriate safe condition or stay-put in accordance with rlevant part of the Specification.

### 2.2 Instruments and ancillaries — general

All instruments, gauges and control equipment which perform similar duties shall be of uniform type and make throughout the Works in order to facilitate maintenance and the stocking of spare parts.

All equipment shall be fully tropicalized and suitable for the worst environmental operating conditions. Panel-mounted instruments shall have damp-proof and dust-proof cases. Instruments mounted outside instrument panels shall have weatherproof and dust-proof cases. Instrument cases shall be of corrosion-resistant material or finish. Instrument screws (unless forming part of a magnetic circuit) shall be of brass or bronze. Access to terminal compartments of instruments mounted outside panels or other enclosures shall not expose any

working part. Moving parts & contacts shall be adequately protected from the ingress of dust.

Unless otherwise specified, instruments shall be finished in the manufacturer's standard colour. Instrument dials shall be of such material that no peeling or discolouration will take place with age under tropical conditions.

Plant-mounted indicators and gauges shall be sized to give full legibility when viewed from a position with convenient and easy access or from the point at which any operation requiring observation of the gauge is performed. The minimum diameter for any gauge shall be 100 mm except where forming part of standard instruments and accessories such as air-sets.

Dials and bezels shall be of bronze and internal components shall be of stainless steel, bronze or other corrosion-resistant material.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with IEC 60381-1:1982 or equivalent and shall use a signal of 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of IEC 60770-1:1999 or equivalent.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Equipment provided with anti-condensation heaters shall be capable of operating without damage if the heaters are left on continuously. Unless provided with unalterable factory configured ranges, measuring instruments shall have zero and span adjustment.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

The installation arrangements for meters measuring residual chlorine residual shall include a sample bench and other facilities for operating portable test meters.

Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter, tundish and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points.

Sample transport times shall be minimised by provision of a by-pass and drain with control and isolating valves and a local flowmeter to enable the correct sample flow to be adjusted.

## SUB-SECTION 3. FLOW-MEASURING EQUIPMENT

### 3.1 Electromagnetic Flow Meter

### 3.1.1 General Specification

Full bore bi-directional electromagnetic flow meters shall be designed, manufactured and calibrated as per ISO/IEC 17025 standard. Meters shall also have actual Flow rate & Totalized value for effective water management purposes with GPRS remote wireless transmission comprising of flanged meter tube with 10 Kg/sq.cm. working pressure rating. Sealed coil housing and microprocessor based signal converter, The meter shall be manufactured to highest standard available for mag-meters. The meter shall be equipped with minimum six-digit digital totalizers, reading in units of kilolitres and shall be accurate within 0.5% of true flow. The accuracy should be inclusive of linearity, hysteresis, repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 4 m/sec and be constructed as follows:

**A Meter Tube/Sensor -** An electromagnetic flow sensor/Meter Tube, suitable for installation in buried water main. The sensor shall be connected to the mains by means of PN 10 flanged connection. Meter Tube shall have waterproof construction and shall be suitable for installation in a flooded chamber and for being directly buried. The sensors shall be as per DVGW / ISO standard lengths (ISO 13359), so that interchangeability can be carried out for the applicable flow meter sizes. The sensor shall also have empty pipe detection facility for detecting partial flow condition & efficient operation purposes. Removal of flow sensors shall be possible when pipe lines are pressurised and should be leak proof at 1.5 times the working pressure at that location or 10 Kg/sq.cm whichever is higher and shall withstand maximum working temperature of about 50°C. The sensors shall be rated IP68.

**B Coil Housing -** The sensor coil housing shall be fabricated from anti-corrosion powder coated cast aluminum / SS-316 material with NEMA 4X / IP67/68 rating capable for submerged or buried operation shall be fabricated from The sensor coil housing shall be fabricated from anti-corrosion powder coated cast aluminum / SS-316 material with NEMA 4X / IP67/68 rating, capable of submerged or buried operation stainless steel for corrosion resistance and welded to the tube providing a completely sealed environment for all coils, electrode connections and wiring harness capable of submerged or buried operation.

**C. Flow Transmitter/Signal Converter-** Flow Transmitter shall be rated IP67 and shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the Meter Tube. The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and revere directions.

- The converter shall provide an isolated 4-20 mA DC HART output proportional to flow rate, into minimum 500-ohm load The current output shall be galvanically isolated. The Converter shall be fitted with switched mode power supply capability

0-250V or 24 DC and 45-65Hz to cope with power transients without damage. The Totalizer value shall be protected by EEPROM during power outage, and utilizes an overflow counter.

Frequency output of a maximum of 0-10 KHZ and a scaled pulse output. The microprocessor based signal converter shall have a backlit display that must continuously display 'Rate of Flow' 'Total Volume, Velocity & Conductivity.

The flow range shall be adjustable. The flow meters shall be suitable for measuring flow at velocities of water from 0.3 to 4 m/sec.

Contractor shall construct a suitable concrete chamber for enclosing flow meter, to be mounted on the underground pipelines. A concrete cabin shall be constructed above the chamber for housing the flow transmitter. A concrete cabin shall be constructed for housing the flow transducer

- The converter shall be compatible with Microsoft Windows and other software programs with suitable communication capabilities. The converter shall have the feature to remotely mount up to 50 m from the sensor, It shall be possible to separate the sensor and transmitters up to 300 meters without the need for signal boosters or amplifiers. However, the exact distance shall be found at a convenient location as close as possible to the Flow meter tube,
- The transmitter shall be having facility of indicating electrical conductivity measurement.

The signal converter housing should be die-cast aluminium with glass window. The converter cum transmitter should be fully programmable from the front facia. The programming should be user friendly, self-prompting menu driven.

The water meter shall be powered by batteries, if 230 V AC supply is not available, and batteries shall be integral to the electronic display unit and shall be capable of providing uninterrupted power supply at specified voltage for not less than 3 years duration without battery replacement. The contractor shall replace at no cost, any batteries that fail or require routine replacement throughout the contract period.

On a minimum water meter shall provide with the following facilities at the electronic display unit –

- Integral real time clock for date & time recording of flow data.
- Integral data logger for storing the data for a minimum period of 31 days.
- Serial or suitable communication port to enable data to be passed from the display unit, to display flow and pressure details.
- A second serial or suitable communication port for temporary connection to a laptop computer.
- Input/output block for connecting GPRS transmitter for transfer of all display/error codes and status functions from the electronic display unit to Zonal(Central) SCADAas well as to DJB Central monitoring system(CWMC), to be executed by the Pkg-1 contractor.

PSION and Laptop leads and appropriate software licenses shall be provided, to facilitate configuration of the water meters and for down loading the integral data logger for data

analysis.

### 3.1.2 General Specification

a. Full bore electromagnetic flow meter shall consist of Meter Tube (flow sensor), grounding rings/electrode, flow transmitter, flow indicator & integrator and any other item required to complete the system. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided as specified/required by the flow meter manufacturer and in line with the applicable standards. Contractor shall finalize the exact location of flow meter in consultation with Engineer.

b. Flow measurement shall not be affected by physical properties of water viz. temperature, pressure etc., within given limits. Contractor shall provide compensating electronic circuit, if required.

c. A lockable encloser shall be provided for the flow transmitter cum computing unit.

d. Flow meters shall be suitable for the water turbidity level at site, during various seasons. Flow tube shall be rugged in construction and shall be suitable for continuous operation. Flow tube shall have waterproof construction and shall be suitable for installation on underground/above ground pipe lines.

e. The flow computer and transmitter shall be a single unit suitable for field mounting. It shall accept inputs from flow tube, process the signals and shall provide an output proportional to the flow rate. The output shall be 4-20mA.

f. Magnetic flow meters shall be supplied with built in software feature to analyze and continuously monitor the health of the sensor, display errors in text format. Transmitter should be capable of performing the verification program on demand or on request without taking meter off the line or without any additional external hardware/accessories.

g. The transmitter shall be capable of being fully programmable. It shall have a set-up menu, so that all relevant parameters may be user-set from the self-prompting driven menu.

| **A General:** | | |
|---|---|---|
| 1 | Application | Potable water with silt particles |
| 2 | Overall Measuring accuracy of flow measurement loop | ± 0.5 % of measured value for velocity range 0.5 to 4 m/s |
| 3 | Operating Pressure & Temperature | Max 10Bar & 50°C |
| 3 | Measurement | Rate of Flow, Totalized Flow & Electrical Conductivity |
| | B Meter Tube / Flow | |

| | | |
|---|---|---|
| | Sensor | |
| (i) | Full Scale Velocity | 0.4 to 10 m/s, vendor to provide the detailed *sizing calculations based on the process details.* |
| (ii)(a) | Type | Pulsed DC excitation |
| (ii)(b) | Power Supply | 230VAC,50Hz or 24VDC |
| (iii) | Size of flow tube | To suit mains flow parameters. Pipe reducers to be provided, as necessary. |
| (iv) | Process connection | Flanges of Carbon Steel of rating PN-10 up to size 1200mm, PN-6 above1200 mm to 2000 mm |
| (v) | Weather Protection Class | IP 68 as per IS 13947 |
| (vi) | Material of Construction | |
| | Electrodes | SS-316 |
| | Coil Housing | Powder-coated die-cast aluminum Anti corrosive grade / SS-316 material with NEMA 4X / IP68 protection class, with 50/20 meter cable for remote mount transmitter connection. |
| | Flanges | Carbon Steel PN 10, PN 20 as per EN 1092-1 depending on site conditions. |
| | Meter Tube Grounding | SS-304 grounding rings or In-built Grounding Electrode of SS316L |
| (vii) | Flow tube Lining | Polyurethane or Hard Rubber with WRS or NSF approved certificate must. |
| (viii) | Accessories | Mating flanges, gaskets and fixtures etc as per site installation requirements |
| (ix) | Fluid conductivity | > 20 μ Siemens/cm |
| (x) | Marking | Direction of flow with arrow, size, Sr. no, make |
| | | |
| **B** | **FLOW TRANSMITTER** | |
| (i) | Type | Microprocessor based, Modular Design with facility to configure the ranges |
| (ii) | Display | • Min. 2 line back lit LCD for indication of actual flow rate, forward, reverse, sum totalizer,velocity & conductivity. Display with 8 digits for main information index, menu and status symbols for dedicated information.<br>• Key for toggling through the information and reset customer totalizer and call-up function<br>• Selectable default information and accessible menus:<br>➢ Operator<br>➢ Meter<br>➢ Service<br>➢ Data logger |
| (iii) | Programming | • Through Key /keypad on front facia |

| | | |
|---|---|---|
| (iv) | Input | Flow tube/Sensor |
| (v) | Outputs | 1-One 4-20 mA HART DC (isolated) Proportional to flow rate.<br>2- One scaleable pulse output<br>3-One Status output |
| (vi) | Power Supply | 11 to 40 V DC / 0-250VAC 45 to 60Hz with SMPS |
| (vii) | Zero and Span Adjustment | Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters |
| (viii) | Weather Protection Class | IP 65 as per IS 13947, |
| | Ambient temperature | $-2^0$ C to $+60^0$ C |
| | Enclosure | Die Cast Aluminum with polyurethane finish with glass window |
| | Interface | Needed For Data Transmission |
| (ix) | Power failure mode | Provision of RAM/EEPROM to store parameter entered and measured flow data during power failure |
| | | • All data stored shall be stored in an EEPROM Totalizers shall be backed up every 10 min, statistic every hour and power consumption and temperature measurement every 4 hour Minimum 31 days of data shall be stored in EEPROM.<br>• Password protection of all parameters and hardware protection of calibration and revenue parameters. |
| (x) | Facility for on line diagnosis | Following diagnostic required -<br>• Continuous self-test shall include coil current to drive the magnetic field signal input circuit<br>• Data calculation, handling and storing features -<br>➢ Alarm statistics and logging for fault analysis.<br>➢ Electrode impedance to check actual media contact.<br>➢ Flow simulation to check pulse and communication signal chain for correct scaling.<br>➢ Number of sensor measurement (excitations)<br>➢ Transmitter temperature (battery capacity calculation)<br>➢ Low impedance alarm for change in media.<br>➢ Flow alarm when defined high flow exceeds<br>➢ Verification mode for fast measure performance check<br>➢ Statistic flow and consumption data. |

The Meter Tube shall be suitably lined to withstand abrasion of the fluid. The lining shall be suitable for use in contact with potable water with silt particles (UKWFBS listed)

The Meter Tube/Flow Sensor shall be supplied complete with a factory-fitted umbilical cable for communication with the electronic display unit. The cable length shall be determined by the contractor for each meter location but shall not be less than 50 / 20 meters long as per site requirements for BPS & DMAs, so that it can be cut on site, to suit the selected location for electronic display unit. The construction of signal connectors and cable shall protect the water meter from electromagnetic interference and shall be suitable for buried use and outdoor installation. The cable shall be protected by a suitable robust polyethylene sleeve to prevent accidental damage.

The contractor shall provide all sundry items such as grounding electrodes or grounding rings, gaskets, fixtures etc, as necessary for installation and satisfactory operation of the sensor.

### 3.1.3 The Electronic Display Unit

The unit shall have backlit LCD displays to show the following parameters as selected by the operator

- Cumulative forward flow
- Cumulative reverse flow
- Instantaneous flow rate
- Instantaneous velocity
- Minimum night flow
- Peak day flow
- Pressure
- Date and time.

The user shall be able to configure the electronic display unit to display:

- Cumulative flow in m3
- Flow rate in m3/h or I/s
- Velocity in m/s
- Pressure in m or kg/cm2

There shall also be status indicators for each of the following conditions:

- Battery low
- Fault
- Empty Pipe

Calibration / Volumetric Testing (ISO-8316): All flow meters shall be wet calibrated using volumetric method as the flow meters are volumetric device. Each meter shall be calibrated with 3 point calibration to verify performance in accordance with the specification & submit report for the same. The complete meter assembly and signal converter must be wet accuracy tested and calibrated as a unit near minimum, intermediate, and maximum specified flow ranges of the meter (full range of flow). The overall uncertainty of the calibration rig should be at least three times better than the uncertainty of the full bore electromagnetic flow meter as per ISO 9104. The competent Government authority must certify the test facility in accordance with ISO/IEC 17025:2005. All the meters shall be calibrated for a minimum of 3 point.

The supplier shall have full ISO 9000 series accreditation and fully traceable calibration methods. The magnetic flow meter should perform within the required accuracy of measured value without being affected by change in pressure due to demand fluctuation. Only, one manufacture shall make all meter sizes and styles required for this contract. Manufacturing facility for the flow meters should have EHS certification for Environmental Management System ISO 14001 and Occupational Health and Safety Management System OHSMS 18000.

Electromagnetic Flow meter manufacturer must have manufacturing setup of flow meters and should be manufacturing Electromagnetic Flow meters in for last Fifteen Years. Manufacturer should have in-house calibration facility in accordance with ISO/IEC 17025: 2005 dully accredited by NABL.

Supplier must have test facilities, spare parts, and personnel to maintain, instruct, train or whatever is necessary to assure that meters shall be maintained throughout the guarantee/maintenance contract period.

The Bidder should submit data sheet of Electromagnetic Bulk flow meter to be supplied along with the proposals. After award of contract, the contractor shall submit the work plan, quality plan and different check lists to the Engineer concern for approval and FAT at their works.

### 3.1.4 Water Meter Operation & Performance

The accuracy, linearity and repeatability of each water meter shall be in accordance with the latest version of ISO 4064 class C or better, and shall be maintained for an ambient and liquid temperature range of 0°C to 50°C

### 3.1.5 Miscellaneous

Wherever a water meter is to be installed in a water main with cathodic protection, insulating flanges shall be provided on both sides of the sensor and insulated copper satraps shall be installed to provide electrical continuity between the pipes on each side of the sensor.

The electronic display unit shall be installed on a removable blackboard in a vandal-resistant weatherproof IP65, floor/wall or post mounting cabinet enclosure with 5 cable glands. The enclosure shall be constructed from galvanized steel/ CRCS which is at least 1.5 mm thick. The enclosure shall have a hinged access door, which shall have a facility for padlocking in the closed position. Batteries shall be easily accessible for periodic changing. For floor mounted enclose, the enclosure shall be mounted on a concrete plinth, the surface of which shall be at least 150mm above the surrounding finished ground level. A cable duct shall pass through the plinth to enable the cable from the flow sensor to enter the enclosure. A label showing details of the employer's name and the water meter's unique reference number shall be fixed to the external face of the access door. Contractors or equipment manufacturer's details shall be fixed to the external face of the access door.

The enclosure shall be well ventilated, dust-proof and vermin-proof, and be suitable for robust use in a tropical climate. It shall also be suitable for:

- The housing of the integral data loggers and the temporary housing of a battery powered data logger which could periodically be used in conjunction with the water meter.
- The permanent hosing of any lightning protection system.
- The permanent housing of GPRS transmitter and battery pack, and any other items necessary to facilitate communication with the central SCADA system.

Except where the cable is underneath the concrete plinth, there shall be a minimum of 500mm cover for the cable. The cable shall be surrounded by sand bedding at least 75 mm thick and interlocking cable protection tiles shall be installed above the cable. An 'electric cable' warning tape shall be installed above the tiles. Wherever practicable, the cable shall be installed at least 600mm away from any other cables.

Details of the sensor, including its diameter and the size of main together with a unique reference number, shall be permanently indicated on the outside of the cabinet enclosure housing the electronic display unit.

## 3.2 Consumer Water Meters- Domestic meter for Potable Water

### 3.2.1 General

This specification shall be for the supply and installation of 15, 20, 25, 40 and 50 mm volumetric cold water meters suitable for installation on potable water supplies.

The meters shall confirm to the latest version of ISO 4064. The size of meter shall mean the clear internal diameter of inlet to and outlet from the meter. The overall length of meter between connector faces shall be in accordance with those lengths as stated in ISO 4064/1 or BS 5738/1, Part 1.

The meter type must have had life cycle testing undertaken as part of meter pattern approval. Typically, this would have been achieved by means of an accelerated wear test as described in ISO 4064 part 3 or EC Directive 75/33.

Meters shall perform in accordance with ISO 4064 in terms of error and head loss for the stipulated meter class. Copies of relevant production test certificates are to be provided by the meter manufacturer.

Meters shall be capable of withstanding a maximum working pressure of 10 kg/cm$^2$, a test pressure of 15 kg/cm$^2$, and a maximum working temperature of 50°C.

All meters to be offered under this specification shall be multi jet dry magnetic type. Meters that have external calibrating devices are not acceptable. The water meters shall be suitable for installation in horizontal planes without loss of accuracy.

All parts of the meters shall be finished to ensure interchangeability, which is to be

guaranteed. The meters shall be guaranteed against defects in materials and workmanship from the date of installation on the service connection until completion of project including O&M period. Parts to replace those in which a defect may develop within such period shall be supplied and fitted without charge. Meters shall be designed for easy disassembly and re-assembly without the use of special tools or equipment and shall be easy to maintain and repair.

The meter body shall be manufactured from a non-magnetic alloy. It shall be constructed in two halves with threaded joint and watertight seal between the two. Meters are to be robust, resistant to vandalism, and suitable for permanent submergence in water to IP 68.

The meter shall be supplied complete with a set of non-magnetic alloy connections containing no less than comprising cap nuts, linings and fibre scaling washers.

Meters shall be protected against tampering in reading and shall be sealed with self-lockable seals of approved type and with unique serial numbers. Seal wires shall be copper wires. The seals and seal wires shall be supplied by the meter manufacturer.

Each water meter shall be marked on the casing with the following information:

(a) Direction of flow of water on both sides of the meter
(b) Class of meter (or on the counter register)
(c) Serial number
(d) Manufacturer's name
(e) Country of origin
(f) Year of manufacture
(g) Name of the client- DJB

The register (counter) shall be direct straight reading in cubic meters with minimum 5 digits and fractions of cubic meters can be in the form of wheels (99999). The number wheels should not be in contact with the water being measured.

The contractor shall bench test under the supervision of the Engineer, 1% of the new meters randomly selected from delivery batches to confirm satisfactory meter performance in conformity to the metrological class of the meter.

Consumer meters shall be installed in a low point created in the service pipe to ensure that the meter is always filled with water in order to lubricate the bearings and moving parts, as well as to prevent hardened accumulations of debris and the deposition of dissolved salts from water due to evaporation.

### 3.2.2 Technical Particulars

| No | Details | Parameter |
|---|---|---|
| 1 | Type | Inferential multi-jet |
| 2 | Sizes (mm) | 15, 20, 25, 40, 50 |
| 3 | Applicable standard | ISO 4064 |
| 4 | Metrological class | Class B minimum |

| No | Details | Parameter |
|---|---|---|
| 5 | Register reading | Cubic meters |
| 6 | End connections | Screwed |
| 7 | Process liquid | Cold potable water with suspended particles and chlorine content to local potable water quality standards |
| 8 | Maximum working pressure | 10 kg/cm$^2$ |
| 9 | Maximum working temperature | 50°C |
| 10 | Head loss at maximum flow | <1.0 bar |
| 11 | Materials of construction | Caps and lids shall be manufactured from unbreakable and non-corrosive material, corrosion wear resistant and non-toxic for internals |
| 12 | Register dial | Dry or dial with magnetic drive coupling |
| 13 | Acceptance and type tests | As per ISO 4064; number of sample meters to be selected for tests shall be as per ISO 4064 |

The contractor shall set up an NABL accredited meter test bench and calibration facility in Delhi to test samples of the new meters to be supplied, or utilize external accredited facilities for all new meters testing requirements. The NABL accreditation test certificate shall be submitted to the Engineer for review and approval.

## SUB-SECTION 4. LEVEL-MEASURING EQUIPMENT

### 4.1 General

a) The level transmitter shall be mounted in suitable weatherproof lockable pedestal enclosures near the level sensor.

b) Level monitoring devices (the level sensor equipment shall be secured to prevent interference by unauthorised personnel)

c) The necessary bracketry to secure the instruments to be mounted.

d) Ultrasonic type level measuring devices shall comprise of a transducer, a transmitter, remote level indicator and all other items required to complete the control system.

e) The level sensor and the field-mounted transmitter shall be separate and interconnected by integral cable of sufficient length.

f) The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected as per IP65. It shall have ambient temperature compensation and adjustable datum setting facilities.

g) The design and application of this 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.

h) 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 application where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

i) The transmitter will be provided an isolated 4-20mA 2 wire o/p.

j) To remove the effect of water turbulence in reservoirs averaging facility should be provided in the transmitter unit.

### 4.2 Ultrasonic type Level Measuring System

| **Ultrasonic Level transmitter** | |
|---|---|
| ***Transmitter*** | |
| Type | Ultrasonic |
| Principle | Pulse Time of flight |
| Output | Profibus PA (2 wire) /4-20 mAHART |
| Housing | Die Cast Aluminum with polyurethane finish with glass window |
| Electromagnetic compatibility | Interference emission to EN 61326; Equipment class B<br>Interference immunity to EN 61326; Appendix A (Industrial) |
| Ingress Protection | IP67 |
| Accuracy | +/- 2 mm or 4 mm depending on selection or 0.2% of set measuring distance |
| Area Classification | Non-Hazardous |

| **Ultrasonic Level transmitter** | |
|---|---|
| Temperature range | -40°C to +80°C |
| Display | 4 line LCD display.<br>Menu guided operation.<br>Display of Envelope curve. |
| Configuration | Using Keypad on display |
| ***Sensor*** | |
| Range | For Water, as per process requirements |
| Temperature range | -40°C to +80°C |
| Max Pressure | 3 bar abs |
| Materials | Sensor: PVDF Seal: EPDM |
| Process connection | Threaded or universal flange dependent on model selection |
| Degree of protection | IP68/ |

### 4.3 Capacitance Type Level Measuring System

(a) The capacitance type level measuring system shall consist of a sensing probe, a transmitter and a digital indicator.

(b) The level-measuring probe shall be installed on a standpipe on a tank and shall be connected to level transmitter which shall generate a DC analog signal for connecting it to the digital level indicator on the panel.

### 4.4 Level Switch (LS)

Level sensors of capacitance type, suspension mounted shall be provided for level measurement of water in tanks/ sump/ reservoir. Guide pipe shall be provided for probe support. Technical parameters shall be as follows: -

| Title | Description |
|---|---|
| Name of instrument | Level sensor |
| Location | Outdoor/indoor on tanks/ sump/ reservoir |
| Application | Measurement of water level |
| Mounting | Flange /socket mounting |
| Input | Level |
| Output | DPDT contact rated 5A at 230 V A.C. |
| Accuracy | 2.0% FSR |
| Required Range | As per process requirements |
| Power Supply | 230 V AC or suitable |
| Connection Details | 2x1.5 $mm^2$ CYWY cable |

## 4.5 Level Transmitter (LT)

Level transmitter shall be provided for continuous level measurement. Level transmitter shall be of capacitance type with 4-20 mA output. Canopy arrangement shall be provided for each LT.

| Title | Description |
|---|---|
| Name of Instrument | Level Transmitter |
| Location | Outdoor, Tank Mounted |
| Application | Transmission of water level |
| Mounting | Direct/Flange Mounted |
| Input | Water level |
| Output | 4-20 mA |
| Accuracy | 2.0% FSR |
| Required Range | To suit the requirement |
| Power Supply | 230 V A.C. or suitable |
| Connection Details | Single pair screened twisted core cable |
| Enclosure | Al Diecast, Weather Proof ,IP65 |

## 4.6 Level Indicators (LI)

Level indicators shall be preferably Bar-graph type..and digital, flush mounted, 7 segment LED indication type for other applications. Bar graph single/dual Indicator of 101 segment LED with, Hi & Lo alarms and numeric display 4 digit 0.3”. and shall be provided on the local control panel as per site requirement, for continuous level indication at sump/ tanks/ reservoir. Each level indicator shall have input of 4 - 20 mA from respective field mounted level transmitter.

| Title | Description |
|---|---|
| Location | Control panel |
| Mounting | Flush mounting |
| Application | Water level |
| Input | 4-20 mA |
| Output | Digital display |
| Power supply | 230 V A.C. or suitable |
| Display | 7 segment large size LED with 3 ½ digit display. |
| Accuracy | ±1 % |

| Title | Description |
|---|---|
| Name of Instrument | Bar-Graph Indicator |
| Location | Control panel |
| Mounting | Flush mounting |
| Application | Water level, Pressure, Flow |
| Input | 4-20 mA |
| Display | Single/Double, 101 segment LEDs 100 mm high display |
| Range | 0-100% or specified engineering units |
| Resolution | 1.0% |
| Zero & Span | Adjustable |
| Power supply | 230 V +10% 50Hz, A.C. |
| Numeric Display | 7 segment LED with 4 digit ,0.3” LED |
| Accuracy | +1 % of Full Scale |
| Alarm Contacts | Hi and Low adjustable |

## SUB-SECTION 5. PRESSURE-MEASURING EQUIPMENT

### 5.1 General

Pressure measuring system shall consist of pressure transducer, transmitter and digital/ bar-graph type pressure indicator and any other items required to complete the pressure measuring system.

The required Pressure tapings shall be provided in the pumping stations, in the pipelines, before and/or after the valves and electromagnetic flow meter, for pressure gauges, pressure switches and pressure transmitters as per approved drawings.

Pressure transmitter shall be rugged in construction and shall be suitable for continuous operation. Pressure transmitters shall be designed for operation over 130% of full range.

Pressure transmitters shall be suitable for field mounting. They shall provide 4-20 mA DC output proportional to pressure. Transmitter output shall be isolated and shall be suitable for transmitting over long distance. Pressure transmitters shall have high degree of weatherproof protection as specified in technical particular.

Pressure transmitters shall be capable of operating in the range of pumps discharge pressure and be of the diaphragm type. It shall be provided complete with impulse tubings, fittings, two valve manifold with drain cock/calibration valve. Local and remote display units shall be provided

### 5.2 Pressure Transmitters

| | | |
|---|---|---|
| Service | : | pressure measurement on discharge header of pumping station |
| Quantity & Range | : | As per process requirements |
| Accuracy of measuring loop | : | ± 0.5% of reading or better |
| Sensor Capacitive Celltype) 2 wire type | : | Diaphragm Sensor (Piezo Resistive/ |
| Wetted parts material | : | SS 316 |
| Range | : | adjustable over full span |
| Zero & span adjustment | : | required |
| Output signal | : | 4-20ma, dc HART |
| Enclosure protection | : | IP 68 of is IS 13947 (part-I) |
| Local Display | : | LCD Display |
| Dampening circuit | : | Required |

| | | |
|---|---|---|
| Remote display unit | : | digital panel meter with 3½ digit backlit LCD/LED, ± 0.25% accuracy, high and low alarm set point, input 4-20 ma d.c. or Bar graph single/dual Indicator 101 segment LED, Hi & Lo alarms, numeric display 4 digit 0.3" as per site requirements. |

## 5.3 Pressure Switch

Electro-mechanical pressure switch shall be provided to operate in the range of pumping station discharge pressure for the detection of a burst in the transmission main. Pressure switches shall also be provided on the surge vessels.

| | | |
|---|---|---|
| The pressure switch shall have a manually adjustable set point and differential switching level. The switch shall be mounted on the station discharge main downstream of the non-return valve. The switch shall be provided complete with an isolation valve, impulse tubing, fittings, field enclosures and surge damper device etc. Type | : | Non-Indicating |
| Sensing Element | : | Bourden/Bellows |
| Switch type | : | Microswitch |
| Set pressure | : | Adjustable |
| Accuracy | : | ± 1% of span |
| Switch Contacts | : | 2 NO + 2 NC |
| Switch Rating | : | 24 V D.C., 2A |
| Wetted parts material | : | SS 316 |
| Range | : | As per process requirements |

## 5.4 Pressure Gauges

Pressure gauges shall comply with IS 3624/ BS 1780. Snubbers shall be provided where the gauge is subjected to pressure pulsation and / or vibrations. The internal parts of pressure gauge shall be stainless steel.

Pressure gauges shall be provided on discharge of each pump and compound pressure gauges shall be provided on suction of each pump. Pressure gauge shall be bourdon type and calibrated for the required range. The gauge shall be supplied complete with impulse tubing, two valve manifold with drain cock/calibration valve, fittings etc. The pressure gauges shall have an accuracy of ± 1.5% full scale and weather protection class IP 68. All wetted parts material shall be SS 316.

The minimum diameter for round pressure gauges shall be 150/ 200 mm unless specified otherwise or where the gauge forms part of a standard item of equipment.

The zero and span of pressure gauge shall not change by more than ±0.1 % of the span per $^{0}$C changes in ambient temperature.

## 5.5 Pressure Monitoring in Pipelines and DMAs

During Construction required pressure tapings shall be made in the pipelines, before and/or after the valves installed for the DMAs and also at lowest pressure point within the DMAs as shown in the drawings. A pressure transducer shall be connected to the pressure tapping, with the connector and signal cable to IP 68 standard. The pressure signal cable shall either be integral with the meter signal cable or bundled with it and connected to the electronic display unit in the steel cabinet enclosure through a protective PE sleeve. Wherever the protective PE sleeve is above ground, it shall be further protected by mounting in the post.

Technical Particulars:

| | |
|---|---|
| Service | : Pipeline, adjacent to electro-magnetic flow meter |
| Quantity and ranges | : As per BOQ, drawings and process requirements |
| Accuracy of measuring loop | : ± 0.5% of reading or better |
| Sensor | : diaphragm Sensor (external) |
| Material | : SS 316 |
| Range | : adjustable over full span |
| Zero and span adjustment | : Required |
| Output signal | : 4-20mA, DC HART |
| Ingress protection of sensor | : IP 68 of IS 13947 (part 1) |
| Data Logger | : Required |
| Wireless Communication Module | : Required |

## SUB-SECTION 6. DAMPENING CIRCUIT: WATER QUALITY ANALYSIS SYSTEMS

### 6.1 General

Instrumentation for the measurement of electro-chemical or water-quality parameters shall be classified as analysis systems and shall be subject to the general requirements below.

Where more than one parameter is being measured and where practical, analysis systems shall be mounted and piped on a back plate which forms part of a rack on which shall also be mounted all accessories such as isolating and flow-control valves, flow and pressure indicators, tundishe and the like. All components, materials and fittings used in the construction of the rack shall be suited to the particular environment.

Each throttling valve shall be downstream of the sensor with which it is used.

Pipework materials and configuration shall be as specified under 'Plant instrument piping', and 'U' sections shall be incorporated to ensure that measuring cells remain full. The rack shall be assembled and tested in the factory. All pipework shall be neatly run and rigidly fastened to the rack with clips. Tundish shall be incorporated to collect used samples and surplus liquid shall be provided and connected at Site to appropriate approved disposal points. Facilities for taking hand samples and for the checking and servicing of each analyser shall be provided.

Any associated transmitter, signal amplifier, marshalling box, distribution board isolator and the like shall also be mounted on the rack.

Sample lines shall be as short as possible and the flow rate shall be such as to avoid undue sample transport delays. Sharp bends, changes in cross-section and other features which could lead to the accumulation of debris shall be avoided. Line routing shall avoid sources of light and heat which could encourage biological activity. Where appropriate, bypasses shall be provided around measuring cells to maintain an acceptable sample velocity.

Where possible, an analyser rack shall be installed in a building; if this is not possible, the rack shall be contained in a weather-proof and vandal-proof cubicle whose size or canopy area shall also afford protection against climatic conditions to personnel and test equipment during normal usage and servicing.

Each analyser shall have an integral local indicator or a separate one mounted adjacent to the analyser. Each analyser shall have an RS 232 port as well as terminals for its isolated 4mA to 20mA dc analogue signal.

### 6.2 Residual chlorine meters

Residual chlorine meters shall comprise of measuring cells, transmitters and indicator units. These shall be arranged for continuous monitoring of the residual in samples delivered to measuring cells from selected locations.

The residual measuring cells shall be either located in floor-standing plastic/composite

cabinets of modular construction or in wall mounted cabinets of the same construction. Each measuring unit shall include a bi-metallic cell generating a micro-ampere signal proportional to the residual chlorine in the sample passed through the cell. Where necessary, each unit shall incorporate the facility for addition of a buffer solution to minimise the effect of pH variations on cell output or to increase cell output at high pH. The sample flow-rate through the cell shall be adjustable by means of a spring and diaphragm regulator or similar device. The materials of construction and sealing shall be compatible with the sample fluid. Cells shall incorporate means of maintaining the electrodes free from fouling.

Each cell shall be capable of measuring both free available chlorine and total chlorine. Where required, a facility for addition of a buffer solution containing potassium iodide shall be installed.

Where reagents are used, they shall require replenishment not more frequently than once per 10 days. The reagent feed shall be stopped automatically in the event that sample flow is lost.

Unless otherwise specified, means shall be provided of detecting that sample flow is healthy and, where applicable, that a reagent supply is available. Volt-free contacts shall be provided for remote signalling of these conditions and/or alarm initiation.

The transmitter shall incorporate an integral indicator and produce a 4–20mA signal proportional to residual chlorine. The unit shall be housed in a surface mounting enclosure protected to IP 54. The fascia shall have indicator lights for high and low alarm conditions, alarm set-point adjustment, lamp-test facility and volt-free changeover contacts for re-transmission of high and low alarm conditions.

The overall accuracy of the residual chlorine meter shall be better than $\pm 0.04 \times M$ mg/l and the repeatability shall be better than $\pm 0.02 \times M$ mg/l where M is the maximum value of the selected meter range. Subject to replenishment of reagents, where applicable, the meter performance shall be maintained without manual intervention for a minimum period of 30 days.

## 6.3 Turbidity meters

Turbidity meters shall be continuous flow, continuous reading, on-line instruments using the nephelometric principle of measurement. They shall utilize a single silicon photodiode to detect the level of light scattered by particles at 90° to the incident light beam which in turn converts it to an electrical signal for display.

The turbidity meter shall be provided with an auto-ranging digit display with automatic decimal point positioning to eliminate range-setting and reading errors. Two fully-adjustable volt-free turbidity alarm contacts and instrument failure alarm contacts shall be provided.

A 4 to 20 mA dc output signal programmed to cover any part of the instrument range shall be provided.

Each instrument shall be provided with an integral bubble trap.

Means shall be provided for the checking and adjusting of the instrument calibration which does not require the use of standard solutions and reduces the maintenance of the measuring cell to a minimum.

Enclosures for the turbidimeter and control unit for indoor use shall provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids (NEMA–12) or an equivalent approved by the Engineer.

The overall accuracy shall be better than ±5% of reading or 0.25 NTU whichever is greater and the repeatability shall be better than ±2.5% of reading or ±0.1 NTU whichever is greater. The instrument performance shall be maintained without manual intervention for a minimum period of 30 days.

## SUB-SECTION 7. MEASURING EQUIPMENT

### 7.1 Temperature meters

Unless otherwise specified, platinum resistance elements shall be used for measuring spans of up to 200°C.

Each temperature sensor, unless otherwise specified, shall have a stainless steel thermo well, or pocket-and-extension assembly, non-corrosive metal sheath and waterproof terminal head. Sockets for steam, oil and pressurised-water lines shall be welded; sockets for other duties shall be screwed.

The sensor assembly shall be designed to permit removal of the temperature element without twisting the leads.

### 7.2 Platinum resistance thermometers

Platinum resistance thermometers shall comply with BS 1041 Parts 2 and 3 and BS EN 60751:1996. Sensors shall have a resistance of 100 ohms at 0°C and shall conform to the European standard curve (DIN 43720), where Alpha = 0.00385. Each element shall be artificially aged during manufacture. Terminal heads and amplifiers shall be designed for four-wire connections between head and amplifier.

Platinum resistance elements shall be spring-loaded and fully encapsulated in ceramic material and the elements and high-temperature-resistant lead wires shall be hermetically sealed. The associated resistance-to-current converters shall have zero and span adjustments and input-output circuit isolation.

Thermo-wells:

Suitable size and rating Thermo-wells shall be provided as required, for measuring the Pumps efficiency for all the Pumps.

### 7.3 Temperature switches/Thermostates

Temperature switches shall have contacts with differing ‘cut-in’ and ‘cut-out’ values. Their nominal operating points shall be fully adjustable over the whole range of the instrument and the set-value shall be clearly indicated by a dial and pointer.

### 7.4 Push-buttons and indicator lights

Push-buttons in control circuits shall have shrouds, guards or other suitable means for preventing inadvertent operation.

Status-indicator lights shall be of the high-intensity LED type. Indicator lights shall be of a design which allows easy LED replacement from the front. Indicator lights shall be easily visible above the ambient light level when viewed from within an included angle of 120 degrees. LEDs shall be chosen to ensure clear discrimination between the energised and

de-energised states and to ensure an average working life of not less than 3000 hours. A 'lamp-test' push-button shall be provided for each group of indicator lights.

The colours of push-buttons and indicator lights on instrument panels shall be as follows:

| Duty | Push-button | Signal lamp |
|---|---|---|
| Start or on (energise) | Green | — |
| Stop or off (de-energise) | Red | — |
| Open valve | Black* | — |
| Close valve | Black* | — |
| Accept | Black | — |
| Lamp test | Black | — |
| Reset | Black | — |
| Motor running (energised) | — | Red |
| Motor stopped (de-energised) | — | Green |
| Valve open | — | Red |
| Valve closed | — | Green |
| Urgent alarm | — | Red |
| Non-urgent alarm | — | Yellow |
| Plant healthy or ready for use | — | White |

* Panel-mounted push-buttons for valve operation shall be coloured black, unless otherwise agreed with the Engineer, with the duty clearly defined by legend on an associated label.

## 7.5 Analogue signal transmission

Unless otherwise specified, analogue signal-transmission systems shall be in accordance with BS EN 60546-1:1993 and shall use a signal of 4 to 20 mA dc. Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter. Transmitters shall be capable of meeting the performance requirements laid down in the appropriate part of IEC 60770-1:1999.

## 7.6 Programmable logic controllers

### 7.6.1 General

A programmable logic controller (PLC) shall be any digitally-operating electronic apparatus which uses a programmable memory for the internal storage of instructions for performing particular operations (eg logic, sequencing, timing, counting, analogue and arithmetic). This apparatus shall control, via digital and/or analogue input/output modules, various items of plant or processes and provide inputs to other controllers and to associated data acquisition systems. A PLC shall comprise a central processor, input/output interfaces, logic memory, data storage memory and a programming device and shall have the necessary input and output

facilities to provide correct interfacing with plant to achieve the specified system operation.

A PLC shall have immunity to mains-borne and radiated electrical interference. Input interfaces shall be optically isolated and digital integrated circuits shall use the latest hybrid semiconductor technology in keeping with industry standards.

The highest possible level of "user friendliness" shall make PLC programming, interrogation and operation simple and easy to understand.

A PLC shall have diagnostic routines to identify any component and circuit failure and to neutralise the effects of any such failure.

### 7.6.2 Memory

PLC program and data memory shall be provided with a minimum of six months integral battery back-up.

A minimum of 20% spare programme memory and 20% spare data register memory shall be available when final commissioning is complete. In addition, the memory shall be expandable, using expansion modules, to provide a further increase in capacity of at least 50% for future use.

### 7.6.3 Diagnostics

PLCs shall be provided with diagnostic capabilities to identify failures to the circuit board level. Diagnostic indication shall as a minimum, consist of notification of processor failure, input or output module failure, communications failure, and battery low. these conditions shall also be available as outputs from the outstation for panel indication. These diagnostics shall all be available as digital outputs for remote indication.

### 7.6.4 Communications

PLCs shall be capable of connection and incorporation into a network of devices for data communication. The communication protocol shall include a state-of-the-art error detection scheme to ensure error-free data transmission and reception. The communication protocol shall include repeated attempts at error-free transmission before a network device (node) is declared as "failed".

Where dual redundant communication facilities have been specified, interface facilities shall be provided in all PLCs for connection to the dual redundant communication system. The communication system shall automatically take action such that a single interface failure does not render the PLC unable to communicate.

Communication failure at a network node shall not effect communications at any other node.

Software development facilities shall be provided for defining, modifying and monitoring the communication network.

PLCs shall contain sufficient communication ports such that a portable programming device

may be connected and operated without disconnecting other wiring.

### 7.6.5 Input/output

PLCs shall be fitted with input and output circuits to interface with field devices for data acquisition and control. Input and output circuits shall be arranged on plug-in modules to facilitate replacement. Plug-in input and output modules shall be fitted with connects which allow replacement of the module without disconnection of field interface wiring. All field inputs, both analogue and digital, shall be optically isolated.

Inputs and outputs for any particular set of duty/standby equipment shall be arranged over multiple I/O cards wherever possible such that a failure of a single I/O card does not prevent the operation or monitoring by the PLC of more than one device of the set.

When commissioning is complete, PLCs shall have a minimum of 20% spare inputs and outputs of each type (ie digital inputs, digital outputs, analogue inputs and analogue outputs). Input and output capacity shall be expandable, using additional input and output modules, to give a minimum of a further 50% additional inputs and outputs of each type for future use.

The Contractor shall be responsible for considering each output load in detail to ensure that the loading capabilities of the PLC are adequate.

### 7.6.6 Operator interface

All programming of a PLC shall be possible via integral or portable plug-in programming devices which shall be supplied with each instrument. The programming device shall also provide local manual control as well as the facility to interrogate the PLC for more detailed diagnostics than those previously mentioned.

The programmer keyboard shall have keys for controlling and editing functions and for entering arithmetic, timer, counter, basic and special instructions and numerical values. Programming shall be simple to understand and carry out. A key switch or other approved security facility shall be provided to restrict access to the program to authorised persons.

Complete software of the latest version and revision shall be provided, fully loaded and operational, on the portable programming device.

### 7.6.7 Failure

Any control circuit output of a PLC shall be de-energised or neutralised whenever a failure of a circuit, component or power supply occurs in the input or output loop associated with the particular output. The equipment shall automatically detect failures of input circuits and output devices and take action to avoid any unsafe or operationally-undesirable condition.

## 7.7 Signal-conditioning devices

Signal-conditioning devices shall include isolators, amplifiers, current-to-pulse and pulse-to-current converters, arithmetic modules, trip amplifiers and similar units.

Each device shall be designed for mounting within an enclosure using a mounting plate, rack or rail. The operating power supply shall be a nominal 110V ac or 24V dc. An indication of 'power supply on' shall be provided at the front of each unit.

Input and output circuits shall have impedances to suit the signal sources and loads with which they operate. Each analogue input and output circuit shall have independent zero and span adjustments. Set-points on the instrument front shall be fully adjustable by means of a knob with an engraved lid. Input, output and power circuits shall be mutually isolated up to 1000V rms and from earth.

The states of relays used in conjunction with digital inputs or outputs shall be indicated at the front of the unit. Analogue inputs or outputs shall be indicated on the front.

Each device shall be immune to normal industrial interference and RF up to 400MHz.

## SUB-SECTION 8. MISCELLANEOUS EQUIPMENT

### 8.1 Portable Sound Level Meter

Portable sound level meters shall be provided for each pumping station. The sound level meter shall comply with BS5969, BS6998, ANSI S1.4 and S1.43 (Type 2)

| | | | |
|---|---|---|---|
| (a) | Type | : | Portable sound level meter |
| (b) | Range | : | 0-150 dB |
| (c) | Display | : | Back lit LCD to Display<br>• Signal level with a quasi analog bar<br>• Measuring range<br>• Menus for displaying and editing settings<br>• Stored measurement results<br>• Selected parameters with levels |
| (d) | Microphone | : | Pre-polarised free field ½" microphone |
| (e) | Power supply | : | Chargeable battery operated |
| (f) | Memory for previous records | : | Required |
| (g) | Internal Real time clock for marking measurements with date and time | : | Required |
| (h) | Data storage and processing | : | The instrument shall be capable of storing records of measurement results |
| (i) | Communication link and necessary software for down loading data to PC | : | Required |
| (j) | Accessories | : | Microphone, Shoulder bag, Protective cover, batteries, battery charger |

## 8.2 Portable Vibration Meter

Portable Vibration meter shall be provided for measurement of pump and motor vibrations for each pumping station.

| | | | |
|---|---|---|---|
| (a) | Type | : | Portable vibration meter |
| (b) | Range | : | 0-100 mm/sec, selectable for 0-1mm/sec and 0-10 mm/sec |
| (c) | Frequency range | : | 10Hz to 10 kHz |
| (d) | Display | : | LED/LCD type displaying instantaneous, true peak, with m/s and mm/s$^2$ scales |
| (e) | Sensor (Accelerometer) | : | Piezo electric type |
| (f) | Mounting Magnet | : | Required |
| (g) | PTFE Self adhesive tape | : | Required |
| (h) | Power supply | : | Chargeable battery operated |
| (i) | Memory for previous data storage and processing | : | The instrument shall be capable of storing records of measurement results |
| (j) | Communication link and necessary software for down loading data to PC | : | Required |

## 8.3 Portable temperature measuring System

A portable temperature measuring system at raw water and clear water pumping stations shall be provided for measuring temperature of pump and motor bearing.

| | | |
|---|---|---|
| 1 | Type | Fixed temperature measuring system |
| 2 | Range | 0-200 °C |
| 3 | Display | 3½ digit LED/ Backlit LCD |
| 4 | Sensor | Thermocouple / Pt 100 |
| 5 | Power supply | Chargeable battery operated |
| 6 | Memory for previous data storage and processing | The instrument shall be capable of storing records of measurement results |
| 7 | Accuracy | ± 0.5°C |

| | | |
|---|---|---|
| 8 | Accessories | Temperature sensor with various attachments for measuring bearing temperature, carrying bag, protective cover, batteries and battery charger. |

## 8.4 Lightning Protection Unit (L.P.U.)

Two numbers of lightning protection units shall be provided for each signal loop. The lightning protection unit shall be suitable for withstanding the surge arising out of high energy static discharge/ lightning strikes and prevent 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 weather proof casing and shall be suitable for field/back of panel mounting. LPU provided shall be suitable for connecting in 24 V / 48 V, 4-20 mA DC signal lines. There should be total isolation between input, output and ground terminals. The LPU shall have a minimum surge rating of 10 KA

## SUB-SECTION 9. INSTALLATION OF INSTRUMENTATION

### 9.1 Installation of instruments and sensing devices

Each instrument and sensing device shall be installed in accordance with the recommendations or instructions of the manufacturer for the particular application. Each mounting position shall be chosen to give correct operation of the equipment, faithful reproduction of the quantity to be measured, ease of operation, reading, maintenance and servicing, freedom from any condition which could have adverse effects and with particular regard to the safety of personnel and plant. Each item of plant shall be levelled and securely fixed to the surface, bracket or framework on which it is mounted.

Instruments to be installed in areas of high or low temperature or high humidity shall be provided with adequate protection from adverse effects.

### 9.2 Plant instrument piping

Instrument piping shall be in accordance with the manufacturer's recommendations for the specific applications. All connections from plant pipework and vessels to instruments shall be made with grade 316 seamless stainless steel 15mm outside diameter, minimum wall thickness 1.5mm.

Sample water pipework and fittings for water quality monitoring shall be sized and selected to suit service conditions generally in the range of 12mm to 25mm NB and shall be in uPVC or grade 316 stainless steel as applicable. Sample pipework and fittings for dissolved oxygen meters shall be in grade 316 stainless steel or titanium.

Piping shall be neatly run and shall be clipped to walls, ceilings or other building structures or shall be supported on galvanised mild steel tray. Piping routes shall be chosen to avoid obstructing traffic or personnel movement through the plant and to avoid interference with accessibility for the removal of plant. Piping shall be routed away from hot environments, places of potential fire risk or mechanical abuse. Piping routes shall also avoid areas where liquid spillage or vapour or gas leakage may occur. Piping and supports shall avoid vibrating structures or equipment. Piping shall slope continuously upwards or downwards with a minimum slope of 1 in 10 and in accordance with any other recommendation of the equipment manufacturer and sharp bends shall not be used. Drain and vent facilities shall be provided at the lowest and highest points respectively according to service.

Pipework to pressure gauges, transmitters and switches shall incorporate fluctuation dampers, instrument isolating valves and plant connections with either isolating valves or valve manifolds suitable for portable test gauges or manometers. Tapping points for instruments connected by impulse pipework shall have additional isolating cocks.

Pipework shall be arranged to minimise the transmission of vibration. Each instrument and accessory shall be supported independently of its pipework.

All pipework for fluids which may contain solid particles shall contain joints and bends of the

'cross' type for rodding-through and shall contain valves and connections for blowing down. The length of any line under vacuum shall be as short as possible. Gas-analyser sample-venting lines shall be sloped downwards away from the instrument or other precautions taken to prevent condensate flowing back to the cell.

Capillary tubing shall be clipped to mild steel, galvanised tray and shall not be pierced, stretched or twisted. The minimum bending radius shall be 100mm. Any excess length shall be neatly coiled at the measuring instrument and clipped in coils of not less than 200mm diameter.

Before connecting any instrument to its associated impulse or air supply pipework, all isolating valves shall be opened and the pipework shall be blown through to clear any matter. Each line shall be flow-tested for continuity, followed by a pressure test at 2 bars, or as otherwise specified using clean dry air. Instruments and other ancillary equipment shall be connected immediately after the successful completion of the pressure test, if possible, and all open tube ends shall be sealed against the ingress of moisture.

## 9.3 Instrument Power Supply Cables and Instrumentation Signal Cables

Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.

Cable joints in instrument signals and power supply cables shall not be permitted.

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

Cables shall be capable of operating satisfactorily under a power supply system voltage variation of ±15%, a frequency variation of ±5.0%

### 9.3.1 Instrumentation Cables

#### 9.3.1.1 Cables for Digital Signals and Power Supply to Instruments

1100 V grade multicore cables, multistrand high conductivity annealed 1.0 sq.mm stranded tinned copper conductor, extruded XLPE/ PVC insulated, with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium tape, inner sheathed with extruded XLPE/ PVC, armoured with galvanised steel wire overall sheathed with extruded PVC conforming to IS:1554 & IEC:189 Part II.

#### 9.3.1.2 Cables for Analog Signals and Signals from Temperature Sensors

1100 V annealed, tinned, high conductivity 1.0 sq.mm multi-stranded tinned copper conductor extruded XLPE / PVC insulated two/three cores twisted into pair/traid, laid up

collectively, individual pair/traid shielded and overall shielded with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded XLPE/ PVC, armoured with galvanised steel wire, overall sheathed with extruded PVC conforming to IS:1554 & IEC:189 Part II.

#### 9.3.1.3 Data cables

Connection cable for data-bus-components (e.g PROFIBUS) used for the transfer technique RS 485.
Suitable for transfer speed from 9.6 kBit/s up to 12 Mbit/s. The cable may be used for fixed installation outdoor and direct burial.

- solid bare copper conductor, ø 0,64 mm (AWG22)
- foamed PE insulation with coloured skin layer, core colours red and green
- 2 cores + 2 dummies stranded
- wrapping with plastic tape
- screen of AI/Pt-foil, longitudinally applied, aI-part outside, tinned copper braid
- PVC or HFFR-compound outer sheath
- type B-02YS(ST-C)YY: PVC inner sheath + outer sheath
- characteristic impedance 150 ± 15 Ω (3 - 20 MHz)
- insulation resistance ≥ 5 GΩ x km
- capacitance < 30 nF/km
- loop resistance < 110 Ω/km
- test voltage core/core 1500 V (50 Hz, 1 min.)
- core/screen 1500 V (50 Hz, 1 min.)

#### 9.3.1.4 Laying Of Cables

A distance of minimum 300mm shall be maintained between the cables carrying low voltage AC and DC signals and a distance of minimum 600mm shall be maintained between cables carrying HT and LT signals. In outdoor areas, the cables shall be directly buried. Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box. Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.

Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for Engineer's Representatives approval.

All cable routes shall be carefully measured and cables 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 1 meter shall be left near each field instrument before terminating the cable.

Cables shall be complete uncut lengths from one termination to the other.

All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedules. Non-corrosive identification tags shall be securely fastened to

the cables at both the ends.

Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.

## 9.4 Valve Actuators (Motorized)

The Valve Actuators shall meet the following SCADA functional requirements –

1. Shall be Open-Close (On-Off) or Regulating type as per the plant operation requirements.
2. Shall have a Hand-wheel for local manual operation in case of power failure
3. Shall be suitable for 3-Phase,415V 3-Phase or 230V 1-Phase power supply as per power availability at site.
4. Shall have adequate number of Limit & Torque Switches and Analogue Position Transmitters for position feedback to PLC/SCADA.
5. Shall have in-built starter/electronic valve positioner to receive and operate as remote commands from SCADA system
6. Shall have weather proof encloser protection
7. Electrically operated actuators for valves/gates shall be sized to guarantee valve closure at the maximum possible differential pressure across the valve. The safety margin of motor power available for unseating the valve shall be at least 50% in excess of maximum closing torque at the nominal supply voltage. The operating speed shall be as to give valve closing and opening at approximately 2 to 5 minute unless otherwise specified and shall be finalized during Detail Engineering.

## 9.5 Specification for electric actuators – Integral motor control

### 9.5.1 General

The actuators shall be suitable for use on a nominal 415 volt 3 phase/230V 1-Phase 50 Hz power supply and are to incorporate motor, integral reversing starter, local control facilities and terminals for remote control and indication connections, housed within a self-contained sealed enclosure.

In order to maintain the integrity of the enclosure, setting of the torque levels, position limits and configuration of the indication contacts etc shall be carried out without the removal of any actuator covers over an Infra-red interface.

The torque rating shall be 150% of the nominal torque required by valve.
Protection Rating : IP 68
Travel Time/Speed: As per process requirements
Gear Box : as per site conditions
Limit Switches: 2 nos 2 C/O for close conditions, 2 nos with 2 C/O for Open condition.
Torque & Limit switches with additional Auxiliary contact shall be provided as per requirements to meet the PLC monitoring.
Manual Override Handle with clutch assembly required

**9.5.2 Enclosure**

Actuators shall be 0-ring sealed, watertight to /IP68, NEMA 4, 6.

**9.5.3 <u>Motor</u>**

The motor shall be a low inertia high torque design, class F insulated with a class B temperature rise giving a time rating of 15 minutes at 40°C(104°F) or twice the valve stroking time, whichever is the longer.

The actuator motors should be provided with jammed valve protection, Single phasing and phase rotation correction. Motor burn-out protection shall be provided by direct sensing of motor temperature by a thermostat embedded in the motor winding. The trip shall be self-resetting and shall include a changeover volt-free contact for remote indication of motor tripped.

**9.5.4 Motor Controls**

The reversing contactor starter and local controls shall be integral with the valve actuator. The starter shall comprise mechanically and electrically interlocked reversing contactors of appropriate rating to the motor size, fed from a 450V/ 110 volt control transformer. The common connection of the contactor coils at the transformer shall be earthed so that the contactors drop out in the event of leakage to earth. The primary winding shall have taps for single and three phase supplies and shall be separated from the secondary by an earthed screen. Two primary and one secondary fuses shall be provided, of an easily replaceable cartridge type. Local controls shall comprise pushbuttons for open, close and stop, and a local/ remote selector switch padlockable in any of the four positions:

In any of the four positions: positlaceable cartridge type. Local controls shall comp

**9.5.5 Gearing**

(a) The actuator gear box shall be of the totally enclosed grease packed/oil filled type, suitable for operation at any angle and provided with the appropriate filling and drain plugs. The output shaft shall be hollow to accept a rising stem. Thrust bearings or the ball or roller type shall be provided in such a way that the gear case can be opened for inspection or disassembled without releasing the stem thrust or taking the valve out of service.

(b) Drive Bushing
The valve actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gear box input shaft. The drive bushing shall preferably be positioned to enable standard length valve stems to be used.

**9.5.6 <u>Hand operation</u>**

A handwheel shall be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel drive shall be mechanically independent of the motor drive, and any gearing shall be such as to permit emergency manual operation in a reasonable time.

### 9.5.7 Torque and Position Limit Switches

For remote valve position /actuator status indication electric actuators shall be provided with open and close torque and position limit switches with changeover volt-free contacts at each end of travel for remote indication and interlocking. Means shall be provided to prevent the open torque switch tripping while the initial high unseating torque requirement occurs. Provision shall be made in the design for two extra sets for limit switches to be available to order, comprising at least three switches per set, each set independently adjustable to any valve position. Provision or adequate number type and rating of contacts to suit the specified requirements shall be the responsibility of the Contractor. Contacts shall maintain and update position indication during hand wheel operation, when all external power to the actuator is isolated.

The contacts shall be rated at 5A, 250V AC, 30V DC.

For Regulating type Valves, shall have in-built electronic analogue valve positioner to give position feedback, receive the remote commands from PLC/SCADA system and operate the valve accordingly in Auto mode

### 9.5.8 Position Indication

A mechanical dial indicator shall be provided to indicate whether the valve is fully open, fully closed or in intermediate position. If required provision shall be made in the design for the addition of Position Out Put unit having multiturn 4-20mA.

### 9.5.9 Local controls

The actuator shall incorporate local controls for Open, Close and Stop and a Local/Stop/Remote mode selector switch

### 9.5.10 Monitoring facilities

Monitoring alarm should be generated to the control room in case of any one of the following:

- Loss of power supply
- Actuator control selected to local or stop
- Motor thermostat tripped
- Actuator internal fault

### 9.5.11 Wiring and terminals

Internal wiring shall be with at least 650V grade PVC insulated, stranded tinned copper, 1.5 sq.mm conductors for control circuits, each wire shall be clearly numbered identified at each end. The terminals shall be of the stud type, and the 3-phase power terminals compartment shall be designed so that the integral controls are not adversely affected by heavy rainfall while the terminal cover is off for wiring on exposed job sites. Cable entries shall be suitable for armoured power and control cables. A separate terminal box shall be provided for the

heater.

All actuators shall be provided with communication port & suitable for operation with 2 wire system from remote.

### 9.5.12 Enclosure

The actuator enclosure shall be at least fully weatherproof and hose-proof to NEMA 3 and 4 and shall be fitted with an anti- condensation heater.

### 9.5.13 Documentation

Each actuator shall be supplied complete with installation instruction and wiring diagram and sufficient spare cover screws and seals to make good site losses. A detailed write-up on the operation scheme of actuators shall also be submitted.

# Technical Specifications

# C6. SCADA & AUTOMATION - General

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## SUB-SECTION 1. SCADA AND AUTOMATION – GENERAL

### 1.1. Scope of Work

One of the objectives of the Delhi Water Supply Improvement Project (DWSIP) shall be equitable distribution of water. For this purpose, a Central Water Management Centre (CWMC) shall be established at the Chandrawal WTP site for the acquisition of the information from WTP SCADA and all the three Distribution SCADA zones, to monitor, supervise and control the whole water supply systems as and when required. The works of CWMC and WTP SCADA are placed under a separate package (Package 1) of the project.

The scope of work for West Zone (Package-2) Distribution SCADA and Automation under this contract is the complete system design, manufacturing/procurement, delivery& storage at site, installation and complete commissioning, comprising of all necessary auxiliaries, software programs, licences, documentation and O&M manual of the following:

- SCADA system (hardware and software) for all the works viz. Transmission Pipelines, Reservoirs, Pumping Stations, Distribution Pipelines and District Meter Areas (DMAs), under the Package-2.
- Monitoring and Control (Automation, Remote and Local Manual Control) of the UGRs, BPSs and DMAs under the Package-2.
- Application software integrated with Zonal LWMC SCADA for occasional control (as required), water demand forecast & planning, energy management, water loss and pressure management for leak/NRW reduction and equitable distribution of water

All SCADA, Automation and ancillary works shall be executed on **Design, Built and Operate (DBO) basis,** so as to meet all the SCADA and Automation requirements of the process, under the contract. The Contractor will ensure System Completeness and shall provide all the required items, at no extra cost, to meet Tender Specification/System Architecture/process automation requirement. The BOQ attached with the NIT for SCADA and Instrumentation in only indicative one and contractor has to furnish the final BOQ with Price Breakup based of final approved Design"

This West Zone SCADA along with other two zone's Distribution SCADAs and WTP SCADA shall be integrated with CWMC. Therefore, all these SCADA systems should be designed and interfaced in such a way that they can be configured easily and satisfactorily perform their respective required functions as envisaged.

### 1.2. Plant operation and control Philosophy for UGR, BPS and DMA under this package

#### 1.2.1. Introduction

The Purpose of the SCADA and Automation specifications is to portray the complete scheme of programmable Operation and Control of UGRs, Booster Pumping Stations (BPS) and DMAs of the referring Zone. A reliable and obstruction free dual data and voice communication system will be provided for continuous monitoring of the system at the referring Zonal SCADA, its associated Pumping Stations and at Central Water Monitoring Centre (CWMC) level.

### 1.2.2. Interlocks general Statements

The typical control algorithms associated with each mode of control are as given in the Particular Requirements. This control algorithm is indicative only. The contractor shall submit control algorithms and FDS of BPS as per main Equipment's approved functional requirements for the Engineer's approval.

## 1.3. Scope of SCADA Software and Application Software

The SCADA software shall have following features and shall be capable to perform the same, which is described in Sub-section 4.

**i.** Zonal SCADA (West) will continuously Monitor and Control all the referring Zone SCADA components namely the works of Transmission Pipelines, Reservoirs, Pumping Stations, Distribution Pipelines, District Meter Areas (DMAs), CCTV/Fire & Intruder Alarms monitoring, and water quality monitoring etc. of the referring Zone by graphical displays and to communicate two way with CWMC and related Pumping Stations.

**ii.** Alarm and signal management

**iii.** Database management and historical data management by graphical displays

**iv.** **Energy Management**: SCADA software shall support the following by sophisticated data-base management.

- monitoring, registering and appraising the performance of the booster pumps.
- regarding the power-time curve in order to optimize the automatic and not automatic switching of power, aiming and preventing power peaks, which could cause higher peak power costs and produces unnecessary losses.
- regarding the head-flow curve in order to optimize the pump characteristic by changing the impeller or by changing the voltage and/or frequency of the power supply or by exchanging the pump.
- monitoring, registering and appraising of the energy consumption or the thermal losses in order to recognizing bad or decreasing efficiency of booster pumps.
- SCADA software shall support this together with suitable physical sensors (pressure, flow and temperature) and shall calculate the pump efficiencies and the drift of efficiencies. This will enable the operating agency to prepare budget-targets and take reasonable energy saving measures w.r.t. investments.

**v.** Spare Parts Inventory Control

**vi.** To provide Computerized Maintenance Management System (CMMS) for the whole works.

**vii.** **Water Distribution and Pressure Management Software**

Water Distribution and Pressure Management Software shall have the following functions:

- Real Time Calculation: - The system shall run real-time calculation using pipe network data and measured data imported from the SCADA system with automatic processing.
- GIS Monitoring Screen with colour: - The values of calculation results registered in pipe network data shall be displayed on the GIS Map by colour coding distributions or numerical labelling.

- Editing Pipe Network Data: - The pipe network data of GIS shall be edited and set virtual measurement points. The pipe network data for calculations shall be generated with them.
- Pipe Network Calculation: - The pipe network calculation shall be executed based on past and current data. Users can execute the pipe network calculation specifying a date and time.

**viii. Water Leakage Management Software**

Water Leakage Management Software shall have the following functions:

- NRW Estimation: - NRW amount shall be estimated for each DMA with necessary data, such as inlet flowmeter measurement and metered consumption. The system should be easy-to-use for the NRW situation. The system shall gather the inlet flowmeter measurement and calculate for estimation of NRW amount online. The system shall manage the billing data for estimation of NRW amount. As an output, the system shall estimate NRW amount for each DMA with colour coding on the GIS.
- Water Leakage Estimation: - Amount of water leakage shall be estimated at each DMA. The function allows for the prediction of new water leakage information and shall be shown on GIS.
- Leakage Risk Evaluation of Pipeline: - Leakage risk of pipeline shall be evaluated. The evaluated leakage risk can be used as reference for maintenance of pipeline such as prioritization of leakage survey and planning of pipe replacement. It shall have to manage water leakage history database. It shall be done by using the pipe network asset information e.g. pipe type, installation year, land environment etc. The risk factor shall be displayed on the GIS adjusting the colour accordingly.

**ix. Water Supply Operation Software**

The SCADA shall provide water supply operation software for optimizing 24x7 water supplies. The software shall forecast daily water demand based on temperature, weather, day of the week and other peak factors. Water Supply Operation software shall have the following functions:

- Water Demand Forecasting: - Daily water demand shall be forecasted according to statistical analysis of temperature, weather, day of the week and other information which shall be entered by the operator. The parameters used for statistical analysis shall be automatically updated.
- Planning 24 hrs water supply operation: - 24 hours shall be planned in consideration of the overall water intake and supply balance. The supply plans shall be sent to the water facilities such as water intake plant, water treatment plant and reservoirs. It shall have the function of creating a database out of the cumulative operation performance. It shall allow automated search on the past operational performance on factors such as temperature, weather, day of the week which assists the operational planning and allow for manual changes in water supply plan. The system shall allow for 24 hour advance water supply plan at every hour to be sent to the intake pumps, WTP and reservoir via GSM/GPRS network limited to Chandrawal Water Supply Area.
- Monitoring the pressure in Transmission Mains and UGR water filling level control: The water level in the UGRs shall be controlled by the position of the inflow valve.

**x.** Booster Pumping Station automation to control Pumps operations

**xi.** DMAs automation to maintain the pressure at lowest Pressure Point and residual chlorine level of each DMA

## 1.4. Abbreviations

In alphabetic order:

| Abbreviation | Description |
|---|---|
| ADC | Automatic Device Configuration |
| ADR | Automatic Device Replacement |
| API | Application Programme Interface |
| BPS | Booster Pumping Station |
| BW | Backwash Water |
| CW | Clear Water |
| CWMC | Central Water Management Centre |
| CWR | Clear Water Reservoir |
| DBMS | Data Base Management System |
| DLP™ | Digital Light Processing |
| DMA | District Meter Area |
| DNP3 | Distributed Network Protocol |
| DOS | Disk Operating System |
| DPR | Detailed Project Report |
| DSL | Digital Subscriber Line |
| DWSIP | Delhi Water Supply Improvement Project |
| ERP | Enterprise Resource Planning |
| GIS | Geographic Information System |
| GPRS | General Packet Radio Service |
| GPS | Global Positioning System |
| GSM | Global System for Mobile Communication |
| HART | Highway Addressable Remote Transducer Protocol) |
| HDM | Historical Data Management |
| HMI | Human Machine Interface |
| HTML | Hyper Text Markup Language |
| I&C | Instrumentation and Control |
| ICA | Instrumentation, Control and Automation |
| IEC | International Electrotechnical Commission |
| LAN | Local Area Network |
| LCD | Liquid Crystal Display |
| LCP | Local Control Panel |
| LED | Light Emitting Diode |
| MCB | Miniature Circuit Breaker |
| MCC | Motor Control Centre |
| MCN | Multi Channel Network |
| HMI | /Human Machine Interface |

| | |
|---|---|
| MSDN | Micro Soft Developer Network |
| NPSH | Net Positive Suction Head |
| NRW | Non-Revenue Water |
| NTU | Nephelometric Turbidity Unit |
| O&M | Operation & Maintenance |
| ODBC | Open Data Base Connectivity |
| OLT | Optical Line Terminal |
| OPC | Open Platform Communication |
| P&ID | Process and Instrumentation Diagram |
| PC | Personal Computer |
| PLC | Programmable Logic Controller |
| PRV | Pressure Reducing Valve |
| PS | Pumping Station |
| PSTN | Public Switched Telephone Network |
| PV | Process Variable |
| RFID | Radio Frequency Identification system |
| RSSI | Received Signal Strength Indication |
| RTU | Remote Terminal/Transmission Unit |
| RW | Raw Water |
| SAP | System Application Products in data processing |
| SATA | Serial Advanced Technology Attachment |
| SCADA | Supervisory Control and Data Acquisition |
| SFC | Sequential Function Charts |
| SQL | Structured Query Language |
| UGR | Underground Reservoir |
| UPS | Uninterruptible Power Supply |
| VDU | Visual Display Unit |
| VPN | Virtual Private Network |
| VFD | Variable Frequency Drive |
| WBW | Waste Backwash Water |
| WCS | Web Coverage Service |
| WLAN | Wireless Local Area Network |
| WTP | Water Treatment Plant |
| XML | Extensible Markup Language |

## 1.5. Works Included in the Contract

The scope of works under the contract shall be on design, built and operate (DBO) basis including design, supply, installation, all cablings/terminations, testing, commissioning, O&M of existing system for 5 years during construction and 5 years O&M after construction of complete Instrumentation and SCADA systems under the contract, including application software and hardware to link Western zone SCADA with the CWMC SCADA, related UGR/BPS and DMAs. This also includes supply, installation and commissioning of all field mounted instruments including RTUs and PLCs.

The additional Application software to be supplied and integrated with Western Zone SCADA includes Water Distribution and Pressure Management Software, Water Leakage Management Software, Water Supply Operation Software and energy management.

The nature of works included in the Contract shall consist of:

- all design works (calculations, drawings, system proposals), complete documentation comprising application software description
- list of documents & drawings etc along with its submission schedule, required for smooth execution of the Project all documents, data-sheets and drawings shall be submitted to the Engineer (Consultant) for approval, before the installation of the referring equipment (minimum three copies)
- BOQ along with its manufacturing/procurements delivery schedule matching with Project commissioning schedule (for proper monitoring the execution schedule)
- Factory Acceptance Tests (FAT)
  - The schedule of FATs shall be submitted for approval and information. The Consultant and Client will then decide, which FAT will be witnessed by them. All dates of the FATs shall be scheduled and intimated minimum 4 weeks before in advance. Each delivery shall be announced to the Consultant and the Client by detailed bill of delivery. The Contractor shall give the Consultant and the Client the possibility to check each delivery
- monthly status of Balance Supply highlighting the delay if any in schedule of delivery
- complete installation,
- Site Acceptance Testing (SAT) and commissioning at site
- Supply of all software with their licences, dongles, interfaces and cables, which are needed for programming and operation
- programming of the PLCs, the RTUs, the HMIs and the instrumentation transmitters at the peripheral stations
  - Detailed schedule of installation and testing shall be submitted. The Contractor shall give the Consultant and the Client the possibility to check each installation and to witness each test
- programming/ customization of the PLCs, the PCs, the Servers and further to be programmed equipment at the SCADA centre
- preparation of the necessary contracts with the telecommunication service providers in liaison with DJB
- commissioning, test operation, training and education
  - The schedule of training and education comprising suggestions for locations shall be submitted for approval and information.
- O&M manual, O&M Spares& consumables

The Contractor shall consider and supply all items required for efficient, safe and durable working of the works as a whole, whether they are specified or not, at no extra cost.

The Contractor shall be solely responsible for system completeness on turn-key basis, and for the overall co-ordination of the Contract. No direct formal communication between his Sub-contractors and the Engineer or Client shall be allowed.

It shall be the Contractor's responsibility to submit all design calculations, programs, data,

drawings and equipment catalogues/data sheets to the Engineer for approval.

## 1.6. Reference Standards

All goods, materials and workmanship shall comply with the requirements of the latest issue (with up to date amendments) of the appropriate standard such as:

General:

| | |
|---|---|
| Bureau of Indian Standards | BIS |
| International Standards Organization | ISO |
| International Electro-technical Commission | IEC |
| American Society for Testing Materials | ASTM |
| Federal Communications Commission | FCC |
| International Telecommunication Union | ITU |
| American National Standards Institute | ANSI |
| Institute of Electrical and Electronic Engineers | IEEE |
| European Telecommunication Standards Institute | ETSI |

Especially:

| | |
|---|---|
| International Electro-technical Vocabulary | IEC 60050 |
| Identification of Conductors by Colours or alphanumeric | IEC 60446 |
| Functional Safety of electrical / electronic / programmable safety related systems | IEC 61508 |
| Industrial-process measurement and control – Evaluation of system properties for the purpose of system assessment | IEC 61069 |
| Tele-control equipment and systems | IEC 60870 |
| Low-Voltage Switchgear and Control gear Assemblies | IEC 60439 |
| Low Voltage Electrical Installations | IEC 60364 |
| Low Voltage Switchgear | IEC 60947 |
| Insulation Coordination within Low Voltage Systems | IEC 60664 |
| IP Code | IEC 60529 |
| Protection against lightning – Part 4: Electrical and electronic systems within structures | IEC 60870 |
| Analogue signals for process control systems | IEC 60381 |
| Controllers with analogue signals for use in industrial process control systems. | IEC 60546 |
| Graphical symbols for diagrams | IEC 60617 |
| Programmable Controllers | IEC 61131 |

## 1.7. SCADA System Overview

The proposed system shall provide (Drg. No.P-225-225-S-SD-001,02A,02B&003):

- A centralised router processing function, complete with standby facilities, workstations, advanced monitoring devices, data storage and redundant UPS.

- Distributed intelligence using microprocessor based Remote Terminal Units (RTU's) for monitoring and data logging. The RTUs are combined or linked to PLCs for local control.

The automation programmed in the PLC shall be stopped and started by zonal SCADA (Western), however, the central starting and stopping of single devices shall be provided, if the PLC programmed interlocks allow this. The SCADA (West) shall be capable to change or updates of the RTU and the PLC programs. However interruption of the automatic programs by stopping or local manual control is necessary for the downloading of program changes. Parameters (e.g. timers, pressure, flow and level limit values) of the automation shall be changed online in the automatic operation mode. The automation program shall be capable to avoid illogical or dangerous situations caused by those central commands. The data gathered from the RTUs shall be incorporated into the database and shall also be made available to further application programs

The system shall operate using 'management by exception' techniques. The PLC shall monitor and control the site and record operational data. Any alarm shall be sent to SCADA centre. When an alarm conditions arise, individual alarm presentation with alarm lists, mimic and tabular diagrams, and help pages shall be available to assist the operator. The signals arrived at SCADA centre shall be distinguished as events (change of status), alarms (information about abnormal situation), or tripping alarm (alarm about automatic reaction caused by abnormal situation).

The system shall have provisions for 30% space and 20% spare or minimum 10 nos of each type of I/O Cards for future extensions.

## 1.8. General requirements

### 1.8.1. Introduction

The Clauses in this Section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all monitoring, control and data management equipment (excluding switchgear and motor control centres) and shall be applicable to these works unless stated to the contrary in the application clauses.

Where components or equipment forming part of the monitoring, control and data management, installation are not defined by Clauses in this Section, then the requirements of Particular Specification shall apply.

### 1.8.2. Contractor's Responsibility

The Contractor shall be responsible for:

(i) all aspects of design, system completeness, application and, where applicable, subsequent operation of the equipment, monitoring facilities and control circuits in accordance with the requirements of this Specification,

(ii) liaison between Sub-contractors to ensure complete compatibility of all equipment at both component and system interface levels,

(iii) overall systems engineering and submission of Drawings & Documents in required number of copies for approval, to ensure that all equipment, components and systems together form a consistent, rational and fully integrated automation and SCADA installation,

(iv) ensuring that each system shall be handed over complete in all respect and in perfect working order,

(v) the supply and installation of all components including interposing relays (signal isolators), amplifiers, converters, filters, line/equipment protection devices, surge protection (overvoltage), voltage stabilisers/ UPS, inverters, power supplies, both electronic and electrical earthing arrangements and all similar items as shall be necessary to achieve the correct functions as specified and to provide a safe and reliable installation; whether or not such items are specifically called for in the Specification at no extra cost,

(vi) the supply and installation of all interlocks, alarms and other facilities as the Engineer shall consider necessary to ensure safe and efficient operation, whether or not such items are specifically called for in the Specification.

The approval by the Engineer of any drawing shall not absolve the Contractor from his complete design responsibility.

### 1.8.3. General Design Requirements

The equipment shall be guaranteed suitable for operation under the prevailing environmental conditions and shall be designed:

(i) such that routine and occasional maintenance throughout its life time shall be a practical minimum and compatible with the preservation of maximum reliability,

(ii) to withstand the electrical, mechanical, thermal and atmospheric stresses, it shall be subjected under operational conditions, without deterioration or failure, and

(iii) manufactured & installed to the highest available standards of manufacture, reliability, accuracy and repeatability.

Where more than one component or item of equipment is supplied to perform a particular function, all such items shall be identical and interchangeable.

The degree of protection for equipment enclosures shall be in accordance with IEC60529 equal or better:

(i) IP42 for indoor applications,
(ii) IP54 for outdoor applications or rooms mainly designed for pumps, water valves and pipes,
(iii) IP68 for transducers and other equipment mounted within valve or meter chambers or similar locations.
(iv) IP67 for equipment and locations like for IP68, if the contractor can guarantee by technical measures (emergency pump or valve with emergency power supply) that the submerse of the equipment under water surface will not be deeper than 1m and will not last longer than 30 minutes

All equipment cabinets shall have lockable doors.Ventilation openings or louvers shall have

effective dust filters. Any cooling fans shall have fan failure alarm contacts connected to input into the automation and/or SCADA system.

External equipment shall be protected from direct sunlight by a well-ventilated cabinet, canopy or other approved type of sunshade.

Equipment in air-conditioned locations shall be rated for continuous operation in ambient temperature up to 30°C. External equipment and internal equipment not in air-conditioned locations shall be rated for continuous operation over the ambient temperature range 0°C to 50°C. The above temperatures make no allowance for local temperature rises due to operation of the equipment itself or by adjacent equipment.

All equipment shall be protected against aggressive and/or corrosive environment.

All instruments shall be installed in the locations shown on the Contractor´s drawings and where connections shall be made into pipelines, each installation shall be complete with the necessary manifolds, isolating valves, drain valves cum drainage system, test points, sample cocks, etc., as appropriate. In all cases it shall be possible to isolate and remove the instrument, and fit check gauges, or take samples as appropriate.

All analogue transmitters, receivers and direct wire transmission systems shall have the signal level of 0-10 V or preferably 0/4-20 mA.

All panel indicator lamps shall be of the multiple LED type and shall have a lamp test facility.

### 1.8.4. Installation Drawings Approval

Where there is no detail in the Specification or associated drawings regarding the exact location or method of installation of measuring equipment, sensors, or other site mounted equipment, the Contractor shall submit details of his proposed installation to the Consultant for approval and obtain this approval before starting any installation work.

Cable Laying and Termination: The Contractor shall submit all relevant drawings like Cable Laying Schedule, Cable Termination Schedule, Cable Routing, LCP GA and Wiring drawings etc. for approval of the Engineer.

### 1.8.5. Testing and Commissioning

All equipment, including panels, consoles, pillars and all separate items shall subject to inspection and full functional test at the manufacturer's works (FAT). All equipment, sequences, programs and the like shall be proved and demonstrated to the Consultant as being in accordance with the application requirements.

Test Certificates, including characteristics covering the full operating range of measured variable against output signal, shall be provided for all instruments or sets of equipment measuring primary quantities.

Site Acceptance Test (SAT) shall include demonstration of the satisfactory operation of each system individually and the complete system as whole at site after installation, before the start of main plant commissioning.

As an integral part of the setting to work and commissioning procedures, the Contractor shall ensure and demonstrate to the Consultant's approval, that all items of equipment incorporating any form of variable setting (level electrodes, float switches, transmitters, trip amplifiers, meter relays, controllers, timer etc.) shall be adjusted to achieve optimum control of the process or plant operation.

Regarding all variable settings Plant-wise list shall be prepared by the Contractor and will be part of documentation (operation manual).

## SUB-SECTION 2. DOCUMENTATION

### 2.1 Submissions by the Contractor

The submissions by the Contractor, pertaining to the Supervisory Control & Data Acquisition (SCADA) shall be in accordance with the requirements detailed elsewhere and shall comprise the following as a minimum:-

(a) A functional design specification (FDS) for the SCADA, the PLC, HMI and RTU programming.
- The FDS shall include a detailed block diagram
- The FDS shall include operational details of automation, control and SCADA, which have an effect on plant operations, such as power failure response, communication failure response, and automatic shut-down, start-up of the pumping processes and start-up of these processes powered by alternative Power source.
- The FDS shall include a description of the data exchange between SCADA and the GIS database.
- The Contractor shall submit a preliminary FDS and obtain approval before the system architecture design is finalised or detailed design takes place. The Contractor shall formally notify the Engineer for approval of any amendments or additions to the approved FDS. The final FDS shall be submitted for approval before submission of the factory acceptance test definition documents.
- The Contractor shall take note of the importance of this obligation.

(b) Layout drawings for each piece of equipment fabricated or assembled by the Contractor, showing the position of each component with required clearances where applicable, and with overall dimensions.

(c) Circuit diagrams indicating each component of the system and all wiring and cabling thereto, ranges and nomenclature, referencing the P&I D where applicable, with inputs, outputs, cable wiring and terminal identifications.

(d) SCADA mimic displays in the form of hard copies of screenshots, which shall be clearly legible and notated to indicate dynamic data.

(e) Representative samples of the pull down menus and windows in the form of hard copies of screenshots, which shall be clearly legible and notated to indicate dynamic data.

(f) Representative samples of alarm and event lists in the form of hard copies of screenshots, which shall be clearly legible and notated to indicate dynamic data.

(g) Complete digital I/O lists giving type, tag name, short description, outstation, database reference, associated field device, status (event, alarm, tripping alarm) and the like.

(h) Complete list of measured (analogue) data comprising measuring range (sensor), transmitted (relevant) range, indicated range, fixed limits, variable limits (parameter), kind of layouts (figures, moving bars, moving lines etc.) at SCADA screen and at HMIs

(i) Parts lists of the delivered SCADA centre equipment comprising brand, explicit type

number or designation and main technical data

(j) Parts lists/ data sheets of the delivered control- and switchgear assemblies (for RTUs, PLCs, UPS, instrumentation transmitters, power distribution etc.) comprising brand, explicit type number or designation and main technical data

(k) Description of quality control methods and approvals comprising copies of the certificates.

(l) Detailed works and acceptance test procedures.

(m) Appendices, as necessary, to include manufacturer's literature for each item of equipment supplied.

(n) Cable list/schedule and Termination schedule of all connections (data and power) comprising cable type and size, terminals designations at both sides comprising the terminals for the cable screens, designation and location of the equipment or switchgear assembly at both sides.

(o) Room layout drawing showing location and size of the SCADA components for the SCADA centre as well for the RTU stations

(p) For control- and switchgear (PLC, RTU, UPS and instrumentation transmitters) and for the server rack: layout of the equipment installed inside the enclosure plus front door layout (if applicable) i.e. GA Drawings of all Panels and Cabinets

(q) Regarding drawings and documents submission - the comprehensive list of drawings along with its scheduled date shall be submitted to the Engineer. These times shall be given by working days after contract signature. The schedule shall comprise the software documentation (describe in later chapter) and all other required documents as well.

## 2.2 Format of submissions

The above documentation shall be on A4-size loose-leaf numbered sheets, bound in hard-cover ring or lever-arch type files, labelled on the cover and spine with the Employer's name, title of Scheme and/or Contract, Contractor's name, volume number and reference numbers.

All drawings shall be according to ISO-Norm 216 A3 format, minimum A4 and maximum A1. All sizes larger than A4 shall be size folded to A4 and shall be preferably bound in a separate volume.

All drawings shall comprise

- Employer's name and title of Contract;
- Contractor's name;
- Title of drawing, drawing number, and revision number;
- Date and originator;
- Signature of Contractor to the effect that the drawing has been checked by him before submission.

## 2.3 Software Documentation

The Contractor shall provide complete software documentation for each programmable device. This shall minimum include

(a) All the manufacturer's standard published reference materials and user's guides.

(b) Complete documentation for any packaged software incorporated into the system including software written by other manufacturers.

(c) A working copy and complete documentation for any program-development software used for this project. This software and documentation shall be of the same version and revision numbers used for development under this contract.

(d) A working copy and complete documentation for any database management, report generation, screen graphic builder or other similar software used for development under this contract. This software and documentation shall be of the same version and revision numbers used for development under this contract.

(e) Hard-copy documentation of all configuration data, all user-accessible source code including control program code, reports and database contents including listings. All program listings shall be clearly and completely commented so as to convey to the reader a full understanding of the function of the program. So-called 'self-documenting' code without additional, supplementary comments will not be acceptable.

(f) A Software System Specification document which describes all control programs furnished with the system. Design documentation shall include, as a minimum:

- a description of the software development environment, including development procedures, limitations, restrictions, configuration management, documentation standards and compatibility;
- an overall description of the software design, including application structure and subsystem divisions, control strategy, monitoring and display hierarchy, data acquisition and storage, notational and operational conventions and operator access restrictions;
- a description of each application sub-system;
- an English-language description of each control scheme;
- a flow chart or 'pseudo-code' description of each program module detailing the flow of control throughout the module;
- a list of files used by the system, including location and a brief description.

All packaged and system software licenses shall be registered by the Contractor in the name of the Employer. The licenses shall be prepared for a certain number of PCs and servers.

**The price for the licenses shall include update services for 15 years starting with commissioning of the whole SCADA plant (meaning the contractor has to add his software implementation time).**

## 2.4 Operation & Maintenance Manual

Operation and maintenance manuals detailing the following:

- As Commissioned versions of all the documentation/ drawings.
- general description and operating principles;
- technical description of the equipment - manufacturer's standard brochures only being acceptable if the particular item of equipment described is clearly designated, adequate information is supplied, and irrelevant information is deleted or otherwise delineated;
- complete operating instructions defining the sequence of operations
- procedures for dismantling, cleaning, servicing, replacing parts and reassembling, including recommended clearances and tolerances;
- details of all instrument and equipment settings as applicable to this contract;
- maintenance schedules;
- fault diagnosis procedures;
- dated and priced list of significant spare parts and special tools, including identification numbers and sources of supply;
- simplified arrangement drawings showing the components of the equipment.
- general description and operating principles;
- operating instructions for normal procedures in a step-by-step format including control operations, requirements for display or printing of data, performance monitoring, response to alarms or failures, changing of operational parameters, and manual data entry.
- Any other documents/details required but not covered above.

## SUB-SECTION 3. ZONAL SCADA AND CENTRAL CONTROL ROOM EQUIPMENT

### 3.1 General

The requirement is for a centralised SCADA router for Zonal SCADA centre of each Zone of Distribution system.

All equipment required to fulfil the requirements shall be industry standard proven computing equipment with a demonstrable long-term life cycle and support and meet the requirements as as per the system architecture drg. no P-225-225-S-SD-001 as a minimum. Any item required reliable, smooth and safe operation of the SCADA System, but not indicated in above drg. shall also be deemed included.

All equipment shall permit other manufacturer's equipment, e.g. RTUs, PLCs, to be added to the SCADA system. All equipment shall interface using open-system communications protocols.

### 3.2 System Availability

The strategic importance of the telemetry system requires a high level of system availability, i.e. not less than 99.9% availability for each calendar year. Therefore, the SCADA system shall therefore be provided with the following.

The system shall be provided with a master and standby router-server where the standby server shall be continually updated and automatically assume responsibility within 30 seconds following failure of the master Dispatcher.

Synchronisation of the databases following system recovery shall be automatic i.e. shall not require manual intervention.

- **Business Continuity Plan (BCP) and Disaster Recovery (DR) for the SCADA**

Recent Events have increased our Awareness of the Criticality and Vulnerability of our Utilities, therefore, to protect existing data from loss, continue to collect critical data and to return the SCADA system to normal operations ASAP, the following details are required to be submitted by the Bidders.

- Business Continuity Plan -

Bidder to submit a detailed document containing the recovery timeline methodology, test validated documentation, procedures, and instructions developed specifically for use in restoring organization operations in the event of a declared disaster.

The Business Continuity Plans also requires testing, skilled personnel, access to vital records, and alternate recovery resources including facilities *i.e. Business Continuity Plan* is working out how to stay in business in the event of disaster

- Disaster Recovery Plan (DRP)

Bidder to also submit a detailed document containing DR planning i.e. preparation for disaster and creating a plan for response to disaster.

DR enables us to prepare for, respond to and recover from a disruptive event

The BCP is the process of being prepared and getting your Utility back to the normal delivery of service, whereas the DR replaces the loss of Information Technology (IT) Hence Bidders have to submit the both i.e. BCP& DRP.

### 3.3 Router Server

The redundant router-server shall be of state of the art industrial quality and of proven high reliability, suitable for continuous operation.

The Server includes all main SCADA functions like data acquisition, data storage

Minimum requirements: CPU: Quad Core, 3.9 Ghz, Cache 10MB, RAM 16 GB, 4X1TB SATA (Serial Advanced Technology Attachment) Hard Disc.

### 3.4 Data storage

The SCADA centre shall have available redundant (hot stand-by) data storage capacity for all required data over a time sequence of **fifteen years**. The storage devices shall function on the technical basis of an autoloader system.

The capacity shall be easily extendable without service interruption and without system change.

### 3.5 Workstations

The SCADA centre control room is mainly equipped with minimum two workstations.

The required number of workstations is quoted in the Particular Requirements.
Each UGR/BPS will also have a PC based Work Station

Workstations are high quality standard PCs comprising of high quality LCD VDUs with minimum size of 32”. Specific SCADA software, which is specified elsewhere, shall be installed.

Minimum hardware requirements of the workstations:
CPU: quad core, 2.8 Ghz, cache 10MB, RAM 16 GB, 1TB SATA drive

### 3.6 Printer

For fast availability of information in a paper printed form, generally three types of printers shall be required:

A. Alarm/Event printer
   Four colour dot matrix printer with minimum 100 characters per second, upper and lower case ASCII character set with true descenders, a minimum of 132 characters per

line, and a self-test facility capable of printing automatically the entire character set.

B. A4 printer
A4 colour laser printer for reports and Excel schedules

C. A3 printer
A3 colour printer for screen shots, schemas, large schedules, etc.

### 3.7 Overview screens

A. LED VDU

High quality wall mounted LED screen with the minimum 75" ultra narrow and professional grade.

B. Video projector

High quality standard video projector ("beamer") system comprising reflective projection screen and additional cables and fixtures shall be provided.

Minimum technical data:
Display resolution: 1080 p
Light output: 4000 lm

### 3.8 Data Transfer from and to the SCADA centre

All necessary modems or data transfer interfaces shall be installed together with the router server in the technical room of the SCADA centre.

For greater reliability of communication system, dual communication links (i) by Broad Band with static IP and (ii) by VPN with static IP, of different service providers shall be provided between CWMC, Zonal SCADA Centre and Pumping Stations

Any of the following interfaces shall be provided to ensure the best communication link between the SCADAs / PLCs/Field Instruments:

A. Radio transmission
B. GSM based transmission
C. GPRS based transmission via VPN network
D. Fibre cable based DSL transmission by VPN network

### 3.9 Uninterruptible Power supply (UPS)

The SCADA system shall be provided with redundant UPS capable of supplying all the main computer equipment (central processing units, discs, communications processors, screens etc.) of the servers and work stations, the SCADA centre RTU/PLCs, modems and the alarm/event printer of required power rating for a period of not less than 60 minutes.

The contractor shall investigate as an option the connection or substitution of the UPS

batteries to the central batteries buffering the solar power plant.

Not connected to the UPS shall be the other printers, the extra-large screen and/or the beamer.
The UPS shall be provided to cater for a 50% increase in load without the need for additional hardware.

Redundant UPS system shall be installed in the technical room of the SCADA centre.

Note: Essential services, e.g. UPS, generator and security etc. shall be monitored by the SCADA centre PLC.

### 3.9.1 Specification:

(a) Zonal SCADA Room and BPS Control rooms shall be provided with Uninterruptible power supply system (UPS System) which shall cater to the instrumentation and control system loads and PLC system loads.
(b) The UPS shall be sized considering full load plus spare loops plus 25% margin. The output shall confirm to stringent requirements in respect of voltage & frequency regulation, harmonic content & transient recovery.
(c) The UPS shall be of "parallel redundant with static bypass to regulated supply" type with chargers and inverters and battery bank, bypass line transformer and voltage stabilizer, AC distribution board, other necessary protection devices and accessories. UPS shall derive power from LV switchgear. UPS Battery shall be of Ni-Cd maintenance free will 60 minutes back up.
(d) The system shall have a combination of two inverters (UPS modules) with on line double conversion VFI (Voltage & Frequency Independent).
(e) The UPS shall include AC distribution board with air break switch, fuses, current transformers, meters, alarm and indications. It shall incorporate complete circuit protection against all types of abnormal conditions, the system is likely to encounter while in service.
(f) Requirement of the 24V DC or any other voltage level system for PLC, High voltage Panel and other system if any shall be derived from the UPS supply. The UPS shall be sized for the same. A separate 24V DCDB shall be provided for distributing feeders to the 24V DC system.
(g) The UPS system offered shall be suitable for normal operation, emergency operation with required protections for Thyristor, Automatic synchronization etc. The UPS system shall be provided with necessary meters (accuracy class 1.0 or better), indications and alarms. Group alarms and analog parameters of each branch of parallel redundant UPS shall be made available on PLC. The UPS shall be suitable for PC connectivity and necessary hardware and software shall be included.
(h) The UPS system shall be based on latest generation technology having proven performance of satisfactory operation for similar applications.

### 3.9.2 System Requirements

(a) The UPS system shall be of the static type, composed of static inverters, static switches for added protection and transfer of loads with no break or with minimum interruption of the order of a fraction of a cycle during under voltage condition to the healthy inverter or

to standby regulated supply. The components of UPS shall isolate power line voltage transients, frequency variations and high/low voltage conditions from the critical load and act as a line filter and voltage regulator, apart from providing no-break power at constant frequency during normal power outage.

(b) Suitable isolation transformers shall be provided at the inputs to prevent switching transients entering the 415 V system from the UPS.

### 3.9.3 Mode of Operation

(a) The system shall have a combination of two inverters (UPS modules), operating in synchronism, each having isolating facility from the critical bus by a static switch.

(b) In addition to the two inverter systems, a back-up from a regulated AC supply through transformer and voltage stabilizer derived from a standby AC supply shall be provided. The system shall have a selector switch. In the `Normal' position, both the inverters share 50% load each, with output of both inverters being automatically synchronized with each other. If one inverter fails, the healthy inverter shall supply the full 100% load by the operation of the static switch. When any one of the UPS is under maintenance, the selector switch shall be suitably changed and the branch circuit supplying 100% load shall be synchronized with the frequency of the standby source.

(c) If the frequency of the standby source is beyond the preset limit, the inverter frequency control shall get disconnected from the standby synchronizing signal. The operating inverter shall continuously monitor the frequency of standby source and upon restoration of proper frequency of the standby source, the inverter shall use the frequency of the standby source as the synchronizing signal.

(d) When the selector switch is in bypass position the standby source shall cater 100% load, isolating both inverters from the critical load bus. The output of the UPS shall feed all the essential loads through the ACDB. The connection from the UPS to ACDB shall be through a switch and fast acting semiconductor fuses, trip fuses and micro switch with alarm contacts. The feeders shall be designed by the Contractor to suit the load requirements.

### 3.9.4 Inverter

(a) Inverter shall be of the CVT (Constant Voltage Transformer) or PWM (Pulse Width Modulation) type, adequately designed to meet the requirements as specified.

### 3.9.5 Static Transfer Switch

(a) Inverter output shall be connected to the AC bus through a static switch and fast acting fuses. The static switch comprises an interrupter and transfer switch, enabling loads to be connected to the standby regulated AC supply.

(b) Automatic initiation of the transfer from a faulty branch circuit to the standby regulated source shall be accomplished during following conditions:
- Loss of inverter square wave/inverter failure
- Loss of inverter AC output

### 3.9.6 Regulated Stand-by AC Supply

Regulated standby AC supply shall be derived from standby supply through a stepdown transformer of appropriate rating and a servo controlled voltage stabilizer with isolation transformer and power conditioning equipment viz., spike arrester, etc.

### 3.9.7 Protection

The UPS system components and assemblies shall be provided with the necessary protection associated with all components.

### 3.9.8 UPS Panel Construction Details

UPS shall be of unitized construction, free standing, floor mounted, indoor type, dust and vermin proof.

### 3.9.9 Forced Cooling

(a) Forced ventilation of panel, if provided, shall be supplemented by 100% redundant fans. In normal operation, normal fans will be in service and on failure reserve fans shall start automatically. The power supply for the fans shall be tapped from the inverter output. Alarms & contacts for fan failure shall be provided.
(b) The panel enclosure shall confirm to IP-32 degree of protection. The panels shall be provided with illumination lamps, door switches, space heaters and power sockets.

### 3.9.10 UPS Distribution Board

(a) Sheet steel enclosed AC distribution board shall be provided as part of the UPS package. The distribution board shall be floor mounted, fixed type with compartmentalized construction, having horizontal and vertical bus bars. All bus bars shall be PVC sleeved. It shall be possible to operate the switches without opening the doors. Switches shall be provided with door interlock. Vertical cable alley shall be provided for the termination of outgoing cables. Suitable supports shall be provided for supporting incoming and outgoing cables. The enclosure cold rolled steel thickness shall be 2.0 mm minimum for load bearing and 1.5 mm for other non-load bearing members and enclosure class protection shall be IP 54.
(b) Incoming to ACDB from static switch shall be MCCB or ACBs of draw out module.
(c) All outgoing feeders shall be MCCB, MCB, with suitable starters and LED indications. Cable entry shall be decided during detail engineering stage. The gland plate of the distribution board shall be non-magnetic type.
(d) UPS distribution board shall be provided with individual feeders for each load. 25% spare feeder of shall be provided.
(e) Interposing relays / transducers / potential free contacts required for PLC system shall be mounted on the UPS distribution board.
(f) AC source of supply to UPS shall be as follows:

- Inverter-1 from Bus 1 of LV switchegar
- Inverter-2 from Bus 2 of LV switchgear
- Bypass from either buses of the LV switchgear

### 3.9.11 Tests

(a) Type and routine test certificates for all components made use in the UPS system shall be furnished. Tests for components shall be as per relevant standards.
(b) System tests shall be performed on the completely assembled UPS system at vendor's works. System tests shall include frequency regulation, voltage regulation, current limiting feature and harmonic content tests in addition to the tests to prove the functional requirements such as transfer of static switch for conditions of loss of square wave, overload and under voltage conditions.
(c) Routine tests shall be conducted on the UPS system in addition to the system tests. Certificates of type tests shall be submitted for review.

## 3.10 Technical Infrastructure and Furniture of the SCADA centre

The SCADA centre shall be divided into the "control room" for the personnel and the technical SCADA interfaces like workstations, screens and printers and the "technical room" for the UPS, the servers, modems and other technical interfaces. The two rooms shall be equipped with independent air conditioning systems for the different requirements referring temperature, humidity and O2 / CO2 balance.

The technical and the furniture design shall meet the requirements of the actual version of ISO 11064 (Ergonomic Design of Control Centres) or its equivalent.

The Contractor shall design, purchase, install and commission the complete electrical installation of the SCADA centre (control room and technical room) comprising support constructions like cable channels, suspending ceiling and false floor.

The Contractor shall design, purchase and install the complete Furniture.

The scope of supply includes:

- Room lighting
- Emergency lighting
- Air conditioning
- Power sockets
- Power distribution and cabling (normal net and UPS)
- Data cable installation
- Radio antenna cabling and installation, if applicable.

## SUB-SECTION 4. SCADA SOFTWARE

### 4.1 General requirements

The Contractor shall provide all software and licences, fully configured to accomplish the requirements of the Specification, including any supporting or configuration software used to generate the system.

The Contractor shall provide all necessary licenses to use all items of software on all processors in the system for the projected life of the installed system. All licenses shall be in the name of the Employer.

All software shall be standard, fully-debugged programs currently in use by the system supplier on similar systems. All software shall be of the most recent version and revision available at the completion of the Contract unless otherwise agreed by the Engineer. All software shall be fully-maintained by the Contractor throughout the Contract and warranty periods.

The Contractor shall supply the DJB, with all software updating free of charge for 15 years.

Contractor supplied enhancements to the operating system shall be accepted only if the following conditions shall be satisfied and demonstrated to the Engineer:

- The warranty validity shall not be affected.
- Upgrades, fixes and future releases of the operating system shall be implemented without modification to the application software.

The system shall be provided with a pre-emptive multi-tasking operating executive, capable of simultaneously executing multiple background tasks.

The RTUs shall be cyber secured. Fire-wall shall be provided at all SCADA computers.

#### 4.1.1 Proven Reliability

The SCADA system must be reliable and suitable for the critical applications including the large scale water transmission and distribution applications. The SCADA software shall use the latest technology and have state-of-art design and must be completely field proven performance for at least 2 consecutive years. The vendor must clarify how long the product has been marketed in the market and must show at least three references similar to the DJB project. The references shall include as minimum the name, address, email ID and contact numbers of customer, the application, the commissioning date, the number of I/O and process variables.

#### 4.1.2 Long Term Support

The SCADA system shall have maximum uptime and shall be fully functional for monitoring and controlling the process. It is mandatory that the SCADA system is supportable for the period of 15 years and that it is capable to keep up with the constantly increasing demands for

information. Therefore, it must be an open system and shall ensure an easy migration to future technologies of the application software. Backwards compatibility of the SCADA database for new software versions along with the support for older versions shall be provided. The vendor must describe that the said compatibility has been provided for the offered SCADA software and must guarantee- the policy will be maintained in the future.

### 4.1.3 Scalable Architecture

The SCADA software must have a modular structure and a client/server architecture allowing distributed functionality. It shall provide the capability of front-end processing of the I/O data at remote locations but simultaneously it shall be highly scalable, supporting from small to unlimited number of data items. Thus, it shall be reasonable for the SCADA software to have proven implementation on small scale application of 50 I/O points and shall be scalable according to the process requirements. Also it is mandatory that the system can be configured and expanded on-line without stopping the system. Online editing or modification must be provided for graphics, item (tag) definitions, reports and I/O drivers.

### 4.1.4 Open Interfaces to Other Systems

It is important for customer to have maximum flexibility for the choice of SCADA platforms from view point of long-term maintenance and/or future modification/expansion of the system. The SCADA server software must be platform independent and can run on multiple platforms such as Unix, Windows and Linux.

The SCADA software must have an open interface to connect 3rd party products like management information systems, GIS or leak detection systems, etc. and must support OPC, ODBC and XML.

### 4.1.5 Engineering, Operation and Maintenance features

<u>Fast Integration</u>

The SCADA software shall have capability to import and download application specific configuration data, which is managed by off-line using commercial software such as MS-Excel, MS-Access or other readable text file, without using SCADA engineering environment. This allows the user to develop/keep the data apart from the SCADA environment and to make the version management on the data easy. Yet, it allows to download the configured data such as tag data, I/O drivers, history group, programming code, etc. on-line without stopping the system.

Preferably it shall have capability to upload RTU tag database and to create SCADA database automatically including the faceplate generation so that the user can improve efficiency of the engineering and can avoid discrepancy of the database between RTU and SCADA.

<u>Object Oriented Programming</u>

Object oriented technology shall be adopted in the engineering tool of the SCADA software for enabling the efficient engineering work. The function blocks can be defined in

hierarchical arrangement by combining the primitive (lower layer) functions and are assignable to the objects (e.g. pumps, valves, meters) as many as required. The changes or modifications made to the function blocks shall be reflected to all assigned objects in the system automatically.

Easy for Maintenance and Modification

The I/O tag name for the SCADA system shall be able to support up to the maximum length of 45 alpha numerical characters, and the I/O tag name shall consist of at least two or more parts. This is to minimize the engineering and for easy maintenance when there are a number of locations where same PLC/RTU configuration might is used. The initial part(s) of the tag name will be direct to each location, and the last part of the tag name of the PLC's can be the same.

The I/O tag of the SCADA system shall also support on-line signal disconnect between the external field signal and the SCADA database, and the SCADA database shall freeze or hold the last state of the field data during the signal disconnection. This shall allow the situations where complete control of input signals is required, without the process interfering with any modifications that are made.

The disconnection of signal between the external field and SCADA database shall also allow for the situation in which equipment has to be disconnected from the system for maintenance, and to prevent the data being updated.

Built-in Reporting Function

Reporting function of the SCADA system shall be an integral part of the SCADA software. The reports are user definable/configurable and can be created/printed on time base, on an event base and on manual base. The output can be on screen, to printers and/or to disk and can be also exported to email, Excel, etc. It shall also be possible to send the reports to other destinations such as remote offices via telephone lines. In case of a printer failure (e.g. out of service, out of paper), it shall be rerouted to another back up printer while the data is always backed up by the disk for a certain period.

Historical Data Record and Storage

The SCADA system shall able to support scan based and event based recording. The scan based recording shall allow the data of the field value as recorded by the SCADA system at regular frozen for an instant, and the values of the specified sources are collected. For event based only new value is only collected by the SCADA system when a change is detected in the value of a selected source (i.e. when an event has occurred).

The SCADA system besides having the flexibility to configure to store the historical data in scan or event based, it shall also have the capability to store the data base on the item based that allows the information related to the item is stored in an organized way, which is relatively simple for retrieving the historical data for a given item.

Besides supporting historical trending display the SCADA system shall also support a playback function that allow user to view historical data through operator displays. The same operator displays that are used to control the system can be used for playback. This gives the

appearance of viewing the system as it appeared sometime in the past, which allow engineer for finding problems that happen in the past. And the playback function shall be capable in showing at least the alarm and trend data.

Tuning Tools to Optimize Performance

The SCADA software shall have diagnostic tools for analysing problems/running conditions and for optimizing performance of the system. Thus it can tune up the SCADA system by balancing network traffic between the server and the workstations in a redundant network preventing queue overflows by adapting queue sizes.

## 4.2 System security

The system shall be protected from unauthorised changes to the operating system and application programs.

The system shall prevent unauthorised users from re-booting the system or aborting or suspending system-related programs.

The system shall provide three levels of operator access to the system as a minimum, with the first level permitting access to viewing selected plant conditions as described below and the highest level intended for the system manager.

A mechanism shall be provided which prevents users operating at a lower level from accessing functions assigned to a higher level.

The system shall provide a password-protected, user log-on facility for definition of the user access level. Passwords entered during the log-on process shall not be printed or displayed. The system shall log the current user off after a pre-definable extended period of no operator interaction with the system and produce a printed log-off message.

System-generated log messages relating to operator actions, such as alarm acknowledgements or set-point changes, shall include the identification of the current logged-on user.

The Contractor shall provide the following defined user access levels, unless otherwise instructed by the Engineer:

(a) Normal viewing only (default level):
The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

(b) Daily access:
The daily access level shall allow viewing (ie default level) and printing of trend displays.

(c) Operator level (remote control):
The operator level shall permit authorised users to access lower levels and to carry out the following actions:
- perform control actions;
- acknowledge alarms;

- enter or modify manually-entered data for inclusion into reports.

(d) Monthly and yearly data archiving:
The level shall permit authorised users to access lower levels and shall provide the facility to down load specific data to long term data storage for archive purposes.

(e) System builder level:
The system builder level shall permit authorised users to access lower levels and to carry out and use the following facilities:
- modify alarm and control set points, dead bands and time delays;
- enter or modify historical data;
- add, delete or modify individual I/O points or point attributes;
- add, delete or modify field device configurations;
- create, delete or modify control algorithms;
- create, delete or modify graphic displays;
- create, delete or modify system reports;
- configure trend displays;
- access the operating system;
- perform any other system maintenance function.

(f) System administrator:
The system administrator level shall allow full access to the system (ie all lower levels) including the facility to view and assign user log-on access levels.

## 4.3 Signal processing

The system shall continuously receive data from the field devices, unless otherwise specified, such that a 'significant' change in field conditions shall be detected, processed and displayed by the system in less than 500 milliseconds. A 'significant' change is defined to mean any change of state of a discrete point or any change of an analogue point outside a definable deadband.

The scan rate to individual site units shall be configurable between 2 seconds and one hour with a 1 second resolution for local and directly connected remote site units and 5 minutes to 24 hours with a 5 minute resolution for PSTN/radio/GSM/satellite connected site units.

A report by exception method for acquiring field data shall be acceptable. However, in this case, no change of an analogue variable outside a dead band, in percent of full span, shall go undetected by the system. A full scan of each field device shall take place at least every 30 minutes for site based communications and for PSTN/radio/GSM/GPRS/satellite connected sites.

An analogue or discrete input point shall be definable by the authorised operator from the master station as blocked, in which case the input value of the point shall not be scanned by the system. The operator shall be able to assign a fixed value to a blocked point. The O&M manual shall point out the risks associated with leaving points in the blocked condition. Defining a point as blocked shall be a system manager level function.

## 4.4 Alarm processing

The system shall process alarm conditions in the form of process abnormalities, field device failures, sequence faults, outstation system component malfunction and other configurable events. The system shall provide a standard alarm management function which shall conform to EEMUA 191. Alarm processing and display shall comply with the following as a minimum:-

(a) A minimum of two alarm priorities shall be provided to distinguish between critical and non-critical alarms with different colour display. The Contractor shall define critical or non-critical status to all alarm conditions in the system, unless otherwise defined in the Specification, and shall submit these definitions for approval by the Engineer.

(b) An alarm acknowledgement function shall be provided. Acknowledged alarms where field conditions revert to normal (see also (c) below) shall be clear. Unacknowledged alarms where field conditions revert to normal shall not clear until acknowledged. The clear alarm conditions shall generate a log entry.

(c) An hysteresis band shall be definable for analogue points such that a change of value from an alarm condition to the normal condition shall not clear the alarm until the value has crossed back over the limit value by at least the hysteresis bandwidth. A limit alarm shall not re-trigger unless the alarm shall be previously cleared.

(d) The system shall provide a convenient method for acknowledgement of alarms by the user. Systems requiring the user to type the point name of each point to be acknowledged shall not be acceptable. Each alarm acknowledgement shall be logged. The log entry shall include as a minimum the point identification, the time and date of acknowledgement, the operator identification and the type of alarm. If the Contractor provides a 'global' alarm-acknowledgement function as part of his standard package this function shall be assignable to any of the security access levels to prevent unauthorised usage.

(e) Each new alarm condition shall activate an audible alarm and generate an alarm log entry as specified in the clause entitled 'Alarm and event logging'. The audible alarm shall be able to be disabled through use of a keyboard function. This function shall be assignable to any of the security access levels to prevent unauthorised usage.

(f) Any alarm condition shall be designated as such on any dynamic display which depicts the process involved. Unacknowledged alarms shall be distinguishable from acknowledged alarms. Symbols for discrete alarm conditions shall change colour and/or the symbol itself shall change when an alarm condition is present.

(g) The system shall allow an authorised user to inhibit alarm processing for any desired analogue, discrete or calculated point. All other processing by the system of an alarm-inhibited point shall continue. The O&M manual shall point out the risks associated with leaving points in the alarm-inhibited condition. Defining a point as alarm-inhibited shall be a system manager level function.

(h) Limit alarms shall be definable for all analogue points for over range, extra high alarm, high alarm, low alarm, extra low alarm and under range. Over-range and under-range alarms shall be provided for all analogue points.

(j) A delay-before-alarm interval shall be definable for each analogue point such that an alarm condition shall not be registered until the current value remains outside alarm limits for a period of time exceeding the interval. Each discrete point designated as an alarm shall have a definable delay-before-alarm interval.

(k) A change of state of a discrete point shall be definable as either an alarm, a logged condition or information only. A change of state of a point designated as a logged condition shall generate a log entry but not an alarm event.

(l) Control alarms shall be generated whenever control actions are attempted by the system and no status shall be received by the system indicating that the requested action has taken place.

(m) The occurrence of an alarm shall be definable as an event which shall be used by the system to trigger subsequent definable actions.

(n) For analysing alarm reasons the occurrence and status of process alarm for each TAG shall be summarised in the specified period, and shall displays the alarm in the descending order of the frequency.

(o) Alarm Time-Series Graph Analysis

The function shall search message records with specified search information displays the search result, with the numbers of messages and operations, in graph view. The functions help extracting the following problems by analysing graphs:

- Excessive alarms, e.g., unnecessary alarms/unnecessary operator operations.
- Excessive operations, e.g., Insufficient appropriate guidance/Complex operation.
- Alarm generation caused by operation, e.g., unstable system/Complex operation.

## 4.5 Alarm and event logging

The system shall provide for the generation of a log of events detected by the system. Events to be logged shall minimally include all alarm and alarm-clear conditions; all alarm acknowledgements by the operator; all changes of state of discrete points which shall be designated as a logging condition; all user operations which cause a change in the data base including control actions.

Log entries associated with events detected by a field device shall include the date and time of occurrence as detected by the field device. Other types of log entry such as operator actions shall include the current date and time.

If the event is associated with a particular process variable, the log entry shall include:

- the point name and short description;
- the current state or value in engineering units;
- the current alarm status if appropriate; and
- a descriptive phrase of the event.

If the event is associated with a user operation, the entry shall include:

- the point name and short description;
- the operation;
- the operator identification;
- the previous state or value; and
- the new state or value.

An authorised user shall be able to inhibit logging through use of a user function. The alarm-logging-inhibited condition shall be defined as a non-critical alarm.

The system shall provide for display and/or printout of all logged events for the previous 1000 events. The user shall be able to page forwards and backwards through the event log display.

The user shall have the option of defining which items appear in the event display/printout with the following query conditions as a minimum:-

- Process area(s): define which process areas/sites shall be selected for inclusion.
- Point name(s): define which points shall be selected for inclusion.
- Date/time window: the earliest and latest date and time for which the events shall be included.
- Maximum: the maximum number of entries shall be included.

## 4.6 Central SCADA commands

An authorised user shall be able to control the operation of electrical controllable equipment by deactivating the automatic control but shall not be able to deactivate the interlocks provided in the PLC program. The complete deactivating of the PLC control shall only be possible by manual local control. The central SCADA control shall be able to start full automation programs or special automatic subprograms like e.g. “starting pump operation”.

For Example “starting pump operation” is a subprogram consisting of the following automatic actions:
check, if pump is not already running; check, if suction valve is open; check, if level in the reservoir is not LL; check, if discharge pipe is empty or full (two program branches); check, if discharge valve is closed; check, if pump motor is able to start (more than one checks referring to the electrical equipment) – (this list of checks may not be complete);

After pump starting: Check, if pressure increase; check, if pressure reaches operational point – opening of discharge valve; check, if flow exists.;

After valve is open: check, if flow and pressure are in the limits;

Then start of subprogram “pump operating”.

Control and alarm parameters, such as set-points, shall be modifiable at the central SCADA workstations by authorised user through use of commands at the VDU console.

## 4.7 Calculations capability

The system shall be provided with calculations capability which allows the user to define calculated points, either discrete or analogue, for use in control and reporting. Actual discrete and analogue points as well as calculated points shall be usable in calculations.

The user shall be able to define the calculation to be performed through an interactive screen-based method, with on-screen syntax error checking.

## 4.8 General SCADA software and database

The SCADA software shall be of a proven design and reliable, and conforming to industrial standards and shall:

- support multiple RTU brands and models and shall provide the required software features needed to easily adapt an RTU which shall not be supported as standard to the SCADA system. The list of the RTUs supported by the Contractor's software shall be included in the Bid. The Engineer may request the Contractor to prove it by testing which shall be arranged at Contractor's own responsibility and costs.
- have an expandable architecture and scalability to provide future capacity increases in the SCADA system as well as meeting the present needs of the Administration.
- provide multi-level security and password mechanisms to prevent use of the system by unauthorized persons. The access privilege of authorized users shall be defined separately and permission shall be provided to the users only to access to the areas concerning them.
- provide an on-line operating environment. Adding a new RTU to the SCADA system or changing the configuration of the existing RTUs shall not result in stopping or hindering the working order of the SCADA system.
- be object-oriented and shall open more than one window (typically 8, upto 10 windows) simultaneously to present high resolution, animated color graphics to the users.
- provide advanced alarm checking and reporting features.
- provide advanced archiving and reporting features to store data coming into the centre, and produce graphical displays and statistical reports from the data stored.
- have a capacity of minimum 100000 data points. **The Contractor shall specify the maximum number of data which shall be achieved by the system without any performance loss.** The Contractor shall conduct the tests to prove the maximum number of data points achieved. The Contractor shall also be responsible to create additional data points necessary for conducting such tests. The cost of the tests shall be borne by the Contractor.
- allow importing of any bitmap graphics for graphics configuration. Scanned pictures, for example from a city map, shall be able to be imported and configured as the background picture of the overview process diagram. Any AutoCAD graphics shall be able to be converted to process diagrams.
- be re-loaded and operated after the completion of all works and during the tests. The Contractor shall hand over to DİSKİ the SCADA basis and application software (as CDs or DVDs) necessary for re-loading the software to the system in the case of failures. The CDs or DVDs shall be provided after making the necessary tests.

The operating system of the routers and workstations shall be of an architecture that provides a multi-tasking operating environment and the SCADA software shall also be multi-tasking.

Therefore, multiple tasks such as receiving the measurement results from the RTUs, displaying these results on the computer screen, storing on a computer disk, sensing the alarm conditions that may occur based on the measurement results, and displaying them to the users, generating reports from the collected data, and printing them out, transferring issued commands to the RTUs, that the SCADA software is supposed to execute, shall be handled simultaneously without one task waiting for another.

To configure the SCADA software or to change the system configuration definitions shall be

either defined directly by using a keyboard or another interactive tool or mechanisms that allow importing of the configuration definitions from a text file created with a text editor.

The database configuration shall be provided by means of an interactive program that contains menus or similar approaches and shall be easy to use. The database configuration definition program, when required, shall be capable of extracting definitions related to the configuration from the information created in text format to use as the definitions for the configuration.

The definitions of the measurement values coming from the RTUs, the values calculated from computations, and the instructions and parameters to be transmitted to the RTUs within the database shall be made by means of database blocks. The database blocks are the structures where all the information to be contained in the SCADA system are stored.

The database blocks shall be scanned periodically in accordance with the application requirements. The new values related to the measurements shall be received from the RTUs, and transferred to their respective database blocks as a result of this scanning. Scanning of the database blocks shall be performed fast enough not to miss any of the events occur in the SCADA system.

The definitions made with the database blocks shall be referenced with the dynamic display elements located on the screen displays that shall be prepared to allow operators to control and monitor the SCADA system, and the displayed elements shall be updated with the new values of the related database blocks and displayed to the operators by the graphics viewer.

The database configuration definition program shall provide the database integrity by controlling the appropriateness of the names that shall be assigned to the blocks and the accuracy of the block structures during the definitions of the configuration.

All erroneous conditions that shall arise during the definition of configurations shall be detected and reported to the user, and an accurate database configuration shall be maintained. Furthermore, following the start of operation of the SCADA system, the erroneous conditions related to the database blocks that shall arise during the operation shall be detected and reported to the users as messages.

The SCADA software shall provide possibilities to configure the data pre-processing, for example, scaling, filtering, and interpolation.

The SCADA software shall provide possibilities to assign/change PV (process variable) values with initial value, default value or guiding value for data emulation, which is important, for example, for tests, in the case of faulty devices, or in the case of interrupted communication.

For each process variable it shall be able to configure the rules for pre-processing, processing, event generation, display, as well as operation by configuring the coding type, processing type, event type, display type, and the operating type.

It shall be able to modify the data processing, archiving, and reporting from the process diagrams by modifying inhibit bits associated to every process variable, for example inhibit bits for even log, even archive, trend archive, alarm log, processing, limit value monitoring, guiding value processing, default value processing, etc.

The SCADA software shall provide a possibility to test signals and measured values from the process. For this purpose a test flag shall be assigned to each process variable and shall be modified from the process diagram.

The SCADA software shall provide time stamp for process variables with an accuracy of 1ms.

Making additions to the configuration definitions, modifying existing configuration definitions, or deleting the configuration definitions of the SCADA system shall be possible without the need for modifying, re-compiling, or linking the source codes. These types of additions or modifications shall be done using an interactive program to make the definitions.

The following shall be possible online without interruption or hindering of usual operations:

- Adding an RTU to the SCADA system
- Deleting an RTU from the SCADA system
- Changing the configuration information related to an existing RTU definitions
- Modifying the definitions in the database containing information about the measurement and control points
- Creating the screen pictures which offer operators to monitor and control the SCADA system
- Similar configuration changes.

SCADA software shall be upgradeable to new versions with an automatic mechanism to be provided by the Contractor. The old version of the software shall be overwritten by the new version without resulting in a change in any of the definitions created in the previous version, nor disturbing the operational logic defined in the previous version.

All text being available on the screen shall be in English language.

The database shall be configured on-line when the SCADA system shall be in operation. The changes on the existing definitions or new definitions related to the database shall be made when the data collection and control functions shall be performed.

The SCADA software shall be operated using the database that shall be resident in the memory. A copy of the database shall be kept in the computer disk for initial loading, restart or backup purposes.

The SCADA software shall provide possibilities to assign/change PV (process variable) values with initial value, default value or guiding value for data emulation, which shall be important, for example, for tests, in the case of faulty devices, or in the case of interrupted communication.

For each process variable it shall be possible to configure the rules for pre-processing, processing, event generation, display, as well as operation by configuring the coding type, processing type, event type, display type, and the operating type.

It shall be possible to modify the data processing, archiving, and reporting from the process diagrams by modifying inhibit bits associated to every process variable, for example inhibit bits for even log, even archive, trend archive, alarm log, processing, limit value monitoring,

guiding value processing, default value processing, etc.

The contractor shall provide in the SCADA software possibility to test signals and measured values from the process. For this purpose a test flag shall be assigned to each process variable and can be modified from the process diagram.

The contractor shall provide in the SCADA software possibility to provide time stamps (year, month, day, hour, minute, second) for the change of each process variable.

The Contractor shall state how the databases for run-time data model, for message archives (event archive, alarm archive, system message archive), for engineering data, for graphs, and for value archives are accessed from a general programming language. An API-interface or standard SQL-interface is preferred.

A virus protection program shall be installed to protect the SCADA system against viruses. The program shall be licensed and given to the client.

## 4.9 Data Exchange

The control system shall provide a method of real-time data exchange with different application programs like

(a) GIS
(b) Relational database
(c) Third party PC spreadsheet packages
(d) Report generation and graphical simulation packages

## 4.10 Historical data management

An historical data management (HDM) system shall be provided for archive, storage and retrieval of operational data comprising field input data, manually-entered data and calculated points.

Archived historical data shall minimally include averages, minima and maxima for each analogue value compiled over hourly, daily and monthly time periods, with a minimum capacity of 1000 points. The HDM system shall be capable of selectively increasing the rate of data capture based on events, such as process variable status, discrete inputs, or operator command. Minimum and maximum data shall include the time and date of occurrence. Gaps in collected data caused by faulty instruments or control system equipment shall not be included in average, minimum and maximum compilations. Archived historical data shall also include flow totals, equipment run times and number of starts compiled over daily and monthly time periods.

The HDM system shall provide for a minimum of **sixty-five (65)** days of data to be on-line at all times. These data shall be kept current such that the most recent data obtained by the system are available. These data shall be written automatically to archive storage media at least once every 24 hours.

A data-retrieval facility shall be provided which permits the operator to retrieve selected data

for display or reporting. The stored data shall include a 'time stamp' to facilitate accurate retrieval.

A user interface to the HDM shall be provided which allows the definition of data to be stored, and entry or modification to either on-line or archived data. Access to the HDM user interface shall be security protected.

The historical data management shall comprise the playback function:

Plant status shall be replayed on graphic screen based on the historical data. The historical data shall be plotted on a timeline and the user can play, pause, rewind and fast-forward. When an accident occurs, the function shall be used for accident analysis and visualising other details. The various types of operation patterns shall be saved in the SCADA database. Data sampling cycle shall be 3 seconds, and data storage life shall be 3 hours.

Full details of the HDM scheme proposed by the Contractor shall be submitted to the Engineer for approval.

### 4.11 Report generation

The system shall be provided with a report generator utility which shall enable authorised users to create, delete or modify report definitions. The report definitions shall allow for retrieval of data from the on-line database and from historical data files and for formatting the data for output to the printer.

The format of each report shall be definable by the user to include the definition of static or background data, the placement of data base values, the number of significant digits of a value, the date and time of the report and calculated values.

Calculation capabilities of the report-printing facility shall include but not be limited to:

- arithmetic operations: add, subtract, multiply and divide;
- square root;
- absolute value;
- average, maximum and minimum values (from historical data) including time and date stamp;
- Boolean functions: AND, OR, NOT and exclusive OR;
- conditional function: IF ... THEN;
- date and time manipulation;
- tests for equivalence, less than, greater than, zero, alarm status, out of range.

The system shall also be provided with a report-scheduling facility for the calculation and printing of the report. Report printing shall be schedulable either on a definable periodic basis, at a specific definable time and date, or on demand via an operator command from the system console.

### 4.12 Graphic display generation

The system shall be provided with an interactive on-screen graphic generation utility which shall allow an authorised user to create new graphic displays and modify or delete existing displays at any workstation including those associated with the LCP/outstations. The

generation utility shall include an interactive linkage process allowing the user to link symbolic, numeric and bar graph representations and data entry locations to dynamic data base variables.

The graphic display system shall be capable of making full use of the VDU resolution in the composition and display of graphic information.

Graphic symbols shall be definable by the user for display of static and dynamic data. The user shall be able to assemble a library of symbols which shall be retrievable into any graphic display.

Text and symbols shall be able to be enlarged, shrunk, moved, mirrored or rotated with reference to a given display.

The system shall be able to represent dynamic analogue data on a graphic display as a variable-length, sizeable bar graph, as well as numeric text.

### 4.13 Displays - general

All displays, excepting those containing data derived from historical files, shall be completely displayed within 2seconds of the operator request. Dynamic data shall be continuously updated while being displayed.

All screen displays shall provide the following displays which shall be fixed in their locations to normal operations:

(a) alarm banner window at the bottom of the screen display showing the last three highest priority unaccepted alarms. Where the system allows the contents of the banner to be limited (eg by the user name or group) then the selection criteria applied shall be displayed with the banner;

(b) Main display area for user selected displays e.g. mimics, alarm lists, etc;

(c) System dialogue banner window at the bottom of the screen shall display relevant system information such as error message and user prompts;

(d) A day, date and time indicator shall be able to show local time.

An alarm banner area shall be included on all displays which provide information regarding the most recent alarm events. The system shall allow the operator to obtain details of the most recent alarm event from any operational screen display through direct operation using a maximum of two keystrokes or selections.

The system shall allow the operator to obtain a print of any display, including graphics through use of a standard system command. Screen displays shall appear identical in printed form. Dynamic data contained on a display shall not change during screen print such that a 'snapshot' of conditions is portrayed.

Each display shall include the time of day in hours, minutes and seconds and the date in day, month and year format.

A facility shall be provided which allows 'paging' to related displays through the use of 'page' forward or backward keys, or through the use of pick points.

### 4.14 Generic displays

The system shall produce various generic displays automatically. The minimum requirements for generic displays are outlined in the following paragraphs. In addition, an on-line interactive graphic display generator utility shall be furnished as described herein:

(a) Alarm summary:

Alarm summary displays shall be provided which shall be quickly called up by the operator through a maximum of two key strokes. Alarms of both analogue and discrete conditions shall be presented on the same screen in reverse chronological order. Unacknowledged alarms shall appear in flashing mode. The alarm summary screen shall update automatically to reflect any changes. As a minimum, the point name and short description, the current state or value in engineering units and the type of alarm shall be indicated for each alarm.

Alarm entries associated with events detected by a field device shall include the date and time of occurrence as detected by the field device. Other types of alarm entry shall include the current date and time.

(b) Dynamic graphic trend display:

Dynamic graphic trend displays shall be similar in appearance to chart recordings with the variable(s) plotted against a definable timescale. Points which shall be plotted shall include analogue, discrete and calculated points.

The displays shall be selectable for a single-point or a multiple-point presentation of a minimum of 4 points simultaneously, with colour coding and a legend. The points to be displayed shall be selectable by the operator. A minimum of 50 trend display definitions shall be maintained by the system and shall be automatically available upon system boot-up.

(c) Historical graphic trend display:

The historical graphic trend display shall conform to the specification of the dynamic trend display with the exception that data for trending shall be retrieved from historical files. The system shall extract data appropriately from either the on-line storage or from archive files. The system shall detect if the requested data is not present and prompt the user for the correct archive file.

Through use of a cursor, it shall be possible for the operator to select a point on the plot and obtain a numerical reading of the value and the time and date of that point.

(d) Alarm-inhibited summary:

This display shall list all points whose alarming shall be inhibited (see 'signal

processing').

(e) Blocked-point summary:

This display shall list all points which shall be blocked (see 'alarm processing')

## 4.15 Non-generic displays

The system shall be provided with the following displays, which shall be either generic or non-generic, i.e. configurable.

(a) System display:

The system display shall provide a list of all outstations with the current status of each, i.e. scan status, service status and communication status. This display shall update automatically whenever any related status condition changes.

(b) Process control display:

A screen display shall be provided to give a working understanding of each process control strategy in the system. These displays shall be configured for use by operations personnel. Modifications to the control parameters shall be able to be made through use of this display. Any modified parameters residing in an outstation shall be downloaded to the outstation by the system and an alarm shall be generated if this downloading fails to take place correctly. As a minimum, the following information shall be displayed as applicable for each process control strategy:

- equipment or process identification;
- current set-point value;
- control output;
- current controlled measured variable value;
- intermediate calculated values;
- associated points and parameters;
- alarm status (alarm/normal/inhibit);
- tuning parameters;
- control status (manual/off/auto);
- set-point, measured variable and output range;
- alarm limits;
- output limits.

All numeric values not having the same engineering unit as the variable itself shall be displayed along with the appropriate engineering unit designation. A control loop output which shall be reached the maximum or minimum output limit shall be indicated on the display.

Set-point, control parameter and alarm setting modification shall be prohibited by the system for unauthorised users.

(c) Sequential control displays:

A screen display shall be provided to give a working understanding of each sequential control strategy in the system, as described above for process control displays. The sequence state shall be readily ascertainable from the display. Fault conditions for each state shall be indicated when appropriate with textual detail such that a clear understanding of the nature of the fault is conveyed. Provisions for operator abort of the sequence shall be available from this display.

(d) Graphic mimic displays:

Graphic mimic displays shall be configured by the Contractor, similar to process and instrumentation diagrams, which depict the current status of equipment and process variables and which update dynamically whenever a change shall be detected by the system.

The system shall provide a menu of all mimic displays, which allows an operator to choose one for display.

The graphic mimic displays which shall be supplied with the system shall include but not be limited to the following:

- an overall plant summary diagram showing the basic process groups;
- a diagram of each process;
- a diagram of each grouping of major equipment, such as UGRs, Booster Pumps Motorized Valves and DMAs etc

The diagrams shall depict layers of progressive detail such that the lowest level contains each measured variable and equipment status associated with the process or equipment group and that no diagram contains more than the data that shall clearly and comfortably fit on a screen display. The Contractor shall submit reproductions or drawings of proposed mimic displays to the Engineer for approval before factory acceptance testing.

Any point shown in a display in an unacknowledged alarm state shall be shown in a contrasting colour or highlight and as flashing. A point in an acknowledged alarm state shall be shown in a highlighted or contrasting colour and steady state.

The mimic displays shall allow the operator to control any controllable equipment which shall be displayed. The Contractor shall provide sufficient graphic mimic displays for complete monitoring and supervisory control of the system by an operator.

The Contractor shall use consistent standards for all displays for the following details:

- symbols and symbol colours;
- process lines and colours;
- point/tag name representations;
- dynamic conditions of analogue and discrete variables.

The Contractor shall submit details of these standards for approval by the Engineer

prior to configuration.

(e) Manual entry point summary:

This display shall list all manual entry points defined in the system and the current value of each point. This display shall allow authorised users to enter data into the system. The display shall update dynamically to reflect any related changes.

### 4.16 Electronic mail facility

If specified, the system shall be provided with a fully functioning electronic mail package linked to operator log-in passwords at each workstation. The system shall include server and modem facilities for linking the electronic mail facilities with off-site locations such as the Employer's regional offices and headquarters. The electronic mail software package shall be from a major supplier of such software and approved by the Engineer. The Contractor shall include details of the system software, hardware and functionality in his tender.

### 4.17 User help facility

The system shall be provided with help messages and screens that shall be called by the operator with a single key press at any time regardless of the function being performed.

In particular the help facility shall be available for alarms. In this case, when an alarm shall be selected from an alarm list, the system shall automatically make available a pre-defined alarm help page which the operator shall display if required through a standard and simple action. For alarms associated with the control system itself rather than site operational alarms, these system help pages shall be configured by the Contractor.

In addition the system shall provide specific plant related help pages that shall be accessible through help buttons that shall be located on the plant/process mimics.

This shall take the form of the Works Operations Manual imported on to the WCS in HTML format.

This shall then be “bookmarked” using “HTML” functions and links shall be provided from both the process/plant mimics via help buttons, and also from appropriate alarms.

The Contractor shall install the system manuals onto the WCS. It shall be possible to view and print pages of the documentation "on demand".

## SUB-SECTION 5. REMOTE TERMINAL UNIT (RTU)STATIONS

The RTU stations are composed by the RTU itself and by modems, UPS and data loggers and for the different applications combined with PLCs, measuring transmitters, water quality analysers, valve actuators, etc.

The programs for the process automation shall be implemented in the local PLCs. Each local PLC and Data Logger shall be combined with local RTUs for the SCADA data acquisition.

However a RTU shall be installed without a PLC at the location without automation. At more complex stations one RTU could collect the data of more than one PLC or equipment.

At simple automation stations RTU, Data Loggers and PLC shall be combined in one device.

### 5.1 ICA Panels/Cubicles comprising RTU Stations

The RTU station equipment shall be assembled in appropriate enclosures meeting the environmental requirements described elsewhere.

The RTU station shall comprise:

- RTU
- PLC, if applicable
- Instrumentation transmitter, if applicable
- Data logger
- Data transmission modem
- Modem antenna, if applicable
- UPS comprising battery for RTU, instrumentation, data logger, modems, antenna
- Power distribution for the RTU station comprising sufficient MCNs for each circuit

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment. It shall be constructed, assembled and tested according to IEC 60363 and IEC 60439-1.

All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure and board shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

The degree of protection for these enclosures shall be in accordance with IEC 60529 equal or better:

- IP54 for indoor applications,
- IP65 for outdoor applications or rooms mainly designed for water pumps, valves and pipes,
- IP67 for transducers and other equipment mounted near water surfaces or within valve or meter chambers and similar locations, if the Contractor guarantee by technical measures (e.g. by emergency supply powered drainage pumps), that the equipment's emersion under water surface is less than 1m and for less than 30 minutes.

- IP68 for transducers and other equipment mounted near water surfaces or within valve or meter chambers and similar locations.

It shall be mounted minimum 30 cm above the Ground Level and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings, are located where exposure to direct sunlight, will give rise to high top-panel surface temperatures, such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles. Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, 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 for all installed apparatus. Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere.

Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded so as to prevent inadvertent contact.

### 5.1.1 Enclosure design and construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor-mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels.

The design and dimensions of control consoles and desks shall be determined according to their intended function but shall be in accordance with the requirements of the Specification drawings. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified or shown in the Specification drawings, the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level.

Front-of-panel instruments and controls shall be mounted so that the height of their centres above the floor shall be generally between 1800mm and 900mm for indicators, 1400mm and 900mm for recorders and process controllers, 2000mm and 750mm for alarm facias and signal lamps and 1500mm and 750mm for manual controls. Controls, switches and push-buttons

shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings.

The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

### 5.1.2 Enclosure type "major"

Panels shall be constructed generally as specified in the preceding clause and as shown in the Specification drawings. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance. Flanged edges shall be straight and smooth.

Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of centre of gravity and method of fabrication, with the following minimum thicknesses except where otherwise shown in the Specification drawings.

- instrument bearing surfaces, gland plates and pneumatic distribution plates: 2mm;
- internal mounting plates: 2 mm;
- doors, covers and filler panels: 2mm.

Neither design involving the use of externally-visible assembly or fixing bolts and screws nor any design resulting in dust or water-collecting crevices will be accepted.

Stiffeners and supporting frameworks shall be provided where necessary inside panels. Framework shall be hinged or fixed, suitable for the installation of instruments, components and internal equipment for which it is provided and located to give easy access to adjacent equipment.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1m in length shall be provided with double doors.

Unless otherwise shown in the Specification drawings, each panel shall be mounted on a self-draining base frame fabricated from 150/100 mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50mm returned edges along all four sides and shall be braced to the

main steelwork of the panel.

A chequer-plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable. Sufficient removable undrilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230mm above the panel floor or not less than 230mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface-mounted enclosure may form a part of the base or top.

Panels containing pneumatic or other instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination.

Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air-circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces.

If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections. All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection.

Provision shall be made for safe and easy handling during transit and installation. If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cut-outs with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided.

Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

### 5.1.3 Enclosure type "minor"

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be classed as minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause.

Panels shall be fabricated from sheet steel or other approved material less than 2mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface-mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed, issued to the Purchaser and subsequently replaced with bolts after installation.

Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

### 5.1.4 Enclosure type "composite"

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and, at the sole discretion of the Engineer, ICA equipment may be combined within a single enclosure subject to the following conditions:

- the observance of all other clauses herein relating to enclosures, mounting boards and minor panels;
- the written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component;
- the total segregation of ICA equipment and switchgear including the glanding and termination facilities;
- the absence of any voltage exceeding 250V ac or 50V dc from any compartment containing ICA equipment;
- the use of the full height of the panel (excluding the busbar chamber and cable space) for any ICA equipment compartment.

### 5.1.5 Glass reinforced plastic (GRP) enclosures

Any panel required to be installed outside buildings shall, unless otherwise approved by the Engineer, be manufactured from double-skin, resin-bonded fibreglass, with a totally-encapsulated infill of rigid weatherproof and 'boilproof' plywood to BS 1203:2001 between the two skins to provide a rigid and vandal-proof enclosure. The environmental rating shall be IP 55 or better.

For any application in a non-temperate climate or where so specified elsewhere, the roof section shall be sloping and have a totally-encapsulated infill of end-grain balsa instead of plywood.

Box-section steel shall be encapsulated into door edges and door frames. Door locks, handles and hinges shall be of a high tensile strength, non-corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel-reinforced surfaces.

Threaded studs shall be incorporated into the design of the panel for the mounting of sub-frames within the panel. Any panel drilled to provide fixings for internal equipment will not be accepted.

Each cubicle shall be provided with a floor or deck with a removable gland plate for cable entry.

The laminate material shall have flame-retardant characteristics in compliance with BS 476 Class 2, and shall retain 'stability, integrity and insulation' for 30 minutes.

Colour-impregnated gel coats backed by coloured resin shall be used to ensure maintenance-free and 'colour-fast' finishes. The external finish colour shall be advised by the Engineer and the internal finish colour shall be white.

The fronts of externally-visible instruments and windows shall be of glass. An air-gap of 100mm shall be provided between the top surface of the panel and its protective canopy.

All internal equipment shall be mounted on supports built into the fibreglass structure. Fixing bolts through the skin will not be accepted.

### 5.1.6 Protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition.

All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic-moulded insulating material of an approved make. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier. Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage.

Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not

alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type.

At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainder are unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level. Remote alarms shall be operated on failure of the electrical supply to a panel or to any internal sub-circuit.

Clearly identifiable, switched socket outlets of 15A minimum rating to comply with IS 4615, supplied at the main cabinet operating voltages shall be fitted within the panel at the rate of one for each operating voltage per metre of panel length; for a panel whose length is less than one metre, one switched socket outlet for each main operating voltage shall be provided.

Suitable socket outlets for portable tools and handlamps shall be provided as specified elsewhere.

### 5.1.7 Power supply and Isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring-loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the ‘off’ position. The ‘on’ and ‘off’ positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position.

Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be live when the power supply isolators are in the ‘off’ position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labelled with suitable warning notices.

Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the ‘free’ plug and a socket mounted adjacent to the device.

The power supply connector shall be a socket.

### 5.1.8 Terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analysers, resistance thermometers, re-transmitting slide-wires and thermocouples may be terminated at their appropriate instruments.

A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty.

Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal mouldings shall be in melamine to ISO 2112:1990, polyamide or equivalent. Terminal rails shall be hot-dip galvanised. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer. Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type which permit the connection of a testing ammeter or continuity meter without disconnecting any wiring. Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables, or one internal wire shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross-connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable. Identification ferrules as specified in the clause for 'Panel wiring identification and termination' shall be fitted on each core of all external cables and on each internal wire.

The size of the terminals shall be appropriate to the size and rating of the cable cores which will be connected to them but shall not be smaller than Klippon type unless otherwise agreed with the Engineer.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified or shown in the Specification drawings, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit.

Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. 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 the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalised where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimise the risk of accidental contact.

### 5.1.9 Panel internal wiring

Internal connections to the instruments shall be made by one of the following methods:

(a) the twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel;

(b) the conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm² minimum copper conductor with XLPE/HPDE or PVC-insulated cable of adequate grade and rating in accordance with BS 6004:2000. Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm² minimum copper conductor with 250V grade, XLPE/PVC-insulated cable of adequate grade and rating. Wiring sheath colours shall be black for ac circuits, and grey for dc circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, or between 240V and 110V dc, shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals.

All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded. Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

### 5.1.10 Cubicle wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic

insulating material with permanent black characters on a colour-coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally. They shall be interlocking type with each other.

The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling.

Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

### 5.1.11 Cubicle earthing

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals.

In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s).

Instrumentation and instrument cable screen earthing shall comply with BS 6739: 1986, Section 10, unless otherwise stated in this clause.

### 5.1.12 Cubicle lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent or LED lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three metres of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

Wherever required specially in DMA panels, CCTV cameras, to be switched on/off through the Door Switch, shall also be provided for intrusion monitoring CCTV signal shall be transmitted to Zonal SCADA(West)

### 5.1.13 Cubicle ventilation and internal heating

Each panel shall be provided with ventilation fans as required, to ensure that equipment temperature within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably-labelled enclosed adjustable thermostat mounted internally in an accessible position.

Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

Air outlets shall be equipped with shutters and grids preventing the insertion of small insects, spiders, etc.

Each panel, which is installed, not in heated and dry rooms, if required shall be provided with suitable resistance heaters controlled by adjustable hygrometers. The heaters shall be installed internally at the bottom and the hygrostats together with the above mentioned thermostats internally at the top of the cubicle.

### 5.1.14 Labelling

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as shown in the Specification drawings. Wording shall be clear, concise and unambiguous and shall be subject to review by the Engineer before manufacture. Each label shall be permanently secured to the surface near the item to which it refers. Externally-fitted labels shall be of Perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black. The rear surface of each Perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally-fitted labels, which shall be white with engraved black letters.

Labels conforming with the requirements of the preceding paragraphs or other approved means shall be provided:

- to describe or identify circuits or circuit components;
- to identify dc polarity;
- to warn or remind about dangerous or potentially-dangerous circumstances;
- wherever elsewhere specified.

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high. The minimum practicable number of different sizes shall be used.

Manufacturers' nameplates shall not be fitted on panel external surfaces.

Manufacturer's name and the main rated data (voltage, current, IP number, etc.) shall be labelled inside (e.g. inside front of the cubicles door).

Each equipment comprising terminal strip shall be labelled with its short name written in the circuit diagram.

### 5.1.15 Enclosure finishing

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates, corrosion or grease. If rust-proof or hot-dip galvanised steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid.All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved anti-rusting priming coat and the final coat shall be an opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch-priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish to be advised by the Engineer. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer. The overall dry film thickness (DFT) shall be between 85 and 120 microns.

Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanised or otherwise finished to an approved standard.

A 500ml tin of matching touch-up paint shall be provided and packed with each panel.

The colour of glass reinforced plastic panels shall be to the approval of the Engineer.

## 5.2 RTU and PLC Hardware

For all RTUs and PLCs the same brand and type shall be provided, if applicable.

### 5.2.1 General

Programmable logic control devices (RTUs or PLCs) shall be used to affect the monitoring and control of the plant or process.

They shall be capable of operating as either a standalone unit providing local operator interface information or form part of a supervised system complete with communications facilities.

The RTU or PLC shall be a modular unit capable of expansion up to 512 I/O.

The RTU or PLC shall operate from a nominal power source of 24V DC.

The programmable logic controller shall have adequate memory and I/O ports to receive all control and sequencing signals and drive all indicator lamps, relays or solenoids as shall be required to accurately control all the necessary functions of the control system.

The controller shall indicate the operating state of the outputs by means of light-emitting diodes (LEDs) and be equipped with sets of LEDs to indicate the controller status and to notify of any internal faults.

An integral means of turning all outputs off and ceasing the processor operation shall be fitted.

The PLC shall perform the majority of sequential functions and shall drive, either directly or by interposing relays, all the necessary outputs as detailed elsewhere.

All the modules including the CPU & I/O module should be hot swappable. Separate marshalling & separate termination for I/Os modules and field signals.PLC/RTU should have required memory to store data for minimum 2 weeks and data logged in PLC/RTU during communication interruption shall be automatic back-filled to main SCADA server when communication resumes

Where the output load exceeds the rated capacity of an output port of the controller, suitably rated, top hat rail according to EN 50022mounted interposing relays shall be installed in the cabinet to amplify output controls signals. The control voltage of the relays shall be 24V DC.

D.I.N. rail mounted terminals shall be fitted in the bottom of the cabinet to allow the termination of all control and sequencing cabling. The terminals shall accept up to $4mm^2$ stranded conductors.

All output ports from the controller shall be correctly fused in order to protect the controller (by means of fused terminals).

The PLC shall be capable of supporting the following component parts either inherently or via expansion when required and shall support all the required process I/O as detailed elsewhere:

a) Power supply

b) Central Processor Unit

c) Digital input

d) Digital output

e) Analogue input

f) Analogue output

g) Communications

h) High speed pulse counter

i) Data logger

j) All the data should be stored in a separate file system which can be independently accesses by the Remote Network without disturbing the PLC operation and thereby maximizing the CYBER SECURITY

The CPU should support SD CARD for storing of local data.
The system should support following features:

- All the Programs shall be possible for a ONLINE download
- Should have a the facility for the Force Simulation
- Facility of Forcing Input /Output variables when the physical devices are not functional
- Should have user access with pass word protection
- Should have the facility to program the PLC for all the different phases
  - Start up phase
  - Normal operation phase
  - Shut down phase
  - The PLC should have the facility of the Web Server
  - The PLC should support firmware upgrades through network
  - The PLC should have facility of storing intermediate variables
- Program protection feature, network filter setup, Operation log function, function removal feature should be available
- User authentication, user-based operation restriction, and CPU operation restriction should be available\
- The CPU should be fast enough and capable of multi tasking capabilities like running various tasks at different programmable cycle times.
- The CPU should have min 64 MB RAM to cater to current and future program additions.
- The PLC should support all the file operating functions so that CSV file log can be stored in the basic CPU memory for maintaining the log in case of network connection failure.
- The PLC make brand shall be reputable with manufacturer, with the PLCs being used in a variety of worldwide locations and varying climatic conditions, especially in a tropical climate.
- The PLC shall be designed to a modular concept, with separate modules for each function. The modules shall be rack/rail mounted and may be quickly exchanged for field repair. It shall not be necessary to remove field wiring in order to exchange a module. The PLC shall support a wide range of input /output signals including status inputs, pulse (accumulator) inputs, analogue inputs, analogue outputs, and control outputs. The PLC shall support any combination of the above I/O points.
- It shall be possible to add PLCs and software enhancements in the future, without taking the system out of service. The design and physical layout of the PLC equipment shall be on a modular basis, so that extra facilities, such as an increase in the number of status points or analogues, may be added with no, or the minimum of disturbance.
- The PLC shall be expandable by simply adding I/O modules to the system bus. Other than user-friendly configuration of the new modules, no additional PLC software or firmware shall be required.
- The operational status of the PLC shall be indicated on the front panel of the processor module by means of LED lamps. In addition, each I/O card shall have LED status indication.
- Redundant TCP/IP on Ethernet (IEEE 802-3, or IEC 60870-5-104) shall be provided for PLCs network interconnection, towards Master Station.
- SCADA System is to be capable for configuring and programming of PLCs remotely, from Control Station.
- Open PLC programming standard shall be supported for PLCs, according to IEC 61131-3.

PLC Power Supply Technical Specification

Supply Voltage: 24 V DC

PLC input power from 18 to 36 VDC for our PLC

Inrush current is less than 10 A

From supply voltage L+, max. 1050 mA; 150 to 1050 mA output current for expansion modules (DC 5 V) 1000 mA"

### 5.2.2 Digital Input Requirements

i) Two classes of input shall be acceptable:

   a) Nominal 24V DC input rating, opto-isolated, reverse polarity protected.

   b) Nominal 230V AC input rating, opto-isolated.

ii) Mixing of 230V and 24V input ports in any given single installation shall not be acceptable.

iii) Field contact inputs shall be debounced such that status changes shall not be recognised unless the contact condition shall be maintained for at least 25 milliseconds.

### 5.2.3 Digital Output Requirements

i) Digital output shall be of the volt-free contact type.

ii) Each output shall be electrically isolated from other outputs, the rest of the circuitry and earth. It shall have an insulation resistance to the rest of the circuitry and earth of greater than 2 megohms, when tested for 1 minute with 500V DC insulation tester.

iii) System functionality shall be maintained when each output terminal shall be earthed in turn.

### 5.2.4 Analogue Input Requirements

The preferred input signal shall be 4-20mA; continuous; linear supporting a fully floating max 250 ohm input impedance load. Analogue/Digital conversion shall have a minimum 8 bit resolution, linear to ±1%, accepting signals in the range 0-10mA and 0-20mA and voltages 1-5V, 0-1V and 0-100mV as required.

### 5.2.5 Analogue Output Requirements

i) Analogue output shall be 4 to 20mA DC electrical signal with a linearly increasing output for increasing measured value.

ii) When the load resistance across the output terminals shall be varied from 0 to 1000 ohms the output signal current shall not change by greater than 0.1% of span, over the full output range.

### 5.2.6 Communication Ports

The following communication resp. data transfer devices shall be provided:

Interfaces for PROFIBUS, MODBUS or equivalent as required referring the peripheral sensors and actuators.

Interfaces for the modems (DSL, optical fibres, GPRS or radio) connecting the RTU with SCADA.

### 5.2.7 Protocols

i) Provision of the communication required to satisfy this Specification shall include all necessary protocols for its successful operation.

ii) A serial RS 232 port shall be available to enable interfacing to local PC's for MMI purposes to allow local database and control sequence loading, interrogation or modification. The port shall cater for communication with a suitable encoding device.

### 5.2.8 High Speed Pulse Counter

This input module shall accept voltage level input signals of either 5, 12, or 24 volt and have counting speeds up to 50 kHz. Encoded count signals of either 16 or 32 bit, bidirectional, shall be selectable and a minimum of 2, source or sink, independently configurable outputs shall be provided.

### 5.2.9 RTU and PLC Programming and Test Software

The Contractor shall provide software that operates on a personal computer to allow the RTUs to be programmed, tested and the test results to be examined either locally (from the station where the RTU is installed) or remotely from the SCADA centre.

The software shall perform the following functions:

a) Creation of the RTU configuration definitions, application specific database definitions and the application program, and downloading to the RTU.
b) Local or remote monitoring and testing of the RTU application program to ensure correct operation of the program, or detection of the source of error if there shall be an error in the operating logic of the program, and removing the error condition.
c) Testing the RTU hardware locally and remotely and again monitoring the applied test results locally and remotely.
d) Monitoring the message flow traffic in the data communication network that shall handle communication of the RTUs among themselves and with the centre.
e) Monitoring, locally or remotely through the designated communication channel, the error log generated for hardware or software errors that occur in the RTU.

## 5.3 Remote Access and Programming

The Contractor shall have to establish a 9600 bps auto-answer external modem at the SCADA centre for remote programming and testing of the RTUs.
Using this modem to remotely access the SCADA centre and then to access the RTUs in the stations through the SCADA centre shall allow the operations mentioned under heading to be performed remotely. The modem shall also be used for remote maintenance purpose by the original supplier from his head office.

## 5.4 RTU and PLC Application Programs

The application programs to operate in the RTUs and PLCs to provide local control logic shall be developed by the Contractor according to the operating logic of the stations as specified elsewhere.

The Contractor shall submit the application programs developed and the operating logic of the PLCs in the stations for approval. The basic criteria to be considered during the development of the application program in the stations shall continue to operate even at times when the SCADA centre is off line.

## SUB-SECTION 6. COMMUNICATIONS

The system shall communicate with outstations via one or more networks. Communications along the outstation network shall incorporate state-of-the-art error-detection schemes to ensure error-free data transmission. The communications protocol shall include repeated attempts at error-free transmissions before a network node shall be declared as failed. The system shall automatically initiate a 'health check' periodically on a failed node which shall not be removed from the active node list in an effort to re-establish communications.

Communications network shall be by fibre optic, copper network or wireless via radio transmission, GSM/GPRS network or via VPN network.

Communication failure at any one network node shall not affect communications at any other node.

Failure of the central processor to communicate with an outstation shall generate a 'communication failure' alarm and an alarm log including the outstation name, date and time as a minimum. Repeated alarm events shall not be generated unless error-free communications shall be re-established and then fail again as described above. Communication system diagnostic software shall allow the interrogation of communication error statistics.

## SUB-SECTION 7. SYSTEM RESILIENCE AND REDUNDANCY

The system shall be designed and implemented such that the failure of a central processor or VDU console shall not inhibit continuous automatic control of the plant. In the event of such a failure, historical data shall be recoverable to a condition, where a worst-case maximum of 15 minutes of historical data shall be lost.

Failure of a single outstation or communications to that outstation shall not affect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the signals associated with the control or operation shall be hard-wired. If such a failure shall affect the control of other healthy outstations, the non-failed outstations shall revert to a fail-safe/stay-put mode as appropriate.

**Dual redundant communications circuit cards and cabling shall be provided** and implemented such that automatic switch-over to the back-up communications system shall take place upon failure of the duty communication system. An alarm shall be generated whenever a communications system failure occurs.

All important data shall be stored additionally to the SCADA centre data storage locally in battery buffered static memories. These local data loggers shall have the capacity to store the data of one week at the referring station.

### 7.1 Environmental Requirements

The equipment shall be required to operate in a variety of locations with a wide variety of environmental conditions. It shall do so independently of external sources of heating, ventilation and air conditioning. All equipment shall be suitable for continuous operation in the environmental conditions of Delhi given elsewhere within this specification.

(a) Storage

Equipment shall be suitably packaged to meet the requirements of the specification with a storage temperature range of -40°C to +85°C.

(b) Transportation

Equipment shall be transported to site and off-loaded in such a manner as to ensure no damage can be incurred and that it shall be ready for immediate installation.

(c) Normal Operation

All control system equipment, peripherals and outstations/PLCs shall be suitable for operating continuously without degradation of performance over the following temperature and humidity ranges:

- Ambient Temperature +0°C to +50°C
- Humidity 5% to 95% RH

## SUB-SECTION 8. TESTING AND INSTALLATION

Various tests outlined in this section shall supplement testing clauses given elsewhere in the Specification. Where any discrepancy or contradiction arises between these various sections of the Specification, the control system testing clauses shall take precedence and supersede those other testing clauses.

### 8.1 Factory Acceptance Test (FAT)

The Contractor shall conduct a full programme of tests of the control system at the Contractor's testing facility in the presence of the Engineer to verify that all features of the system shall be provided, shall be operating correctly and in full compliance with the Specification. Unless otherwise specified or agreed by the Engineer, the entire control system shall be assembled and tested together as an integrated system, including all master station equipment, all operator's consoles, all outstations and telemetry equipment including modems, all instrumentation panels and uninterruptible power supplies included in this Specification. The scheduled date for the factory acceptance test shall be as agreed by the Contractor and the Engineer at least four weeks before the test.

Before the scheduled factory acceptance test, not less than one month, the Contractor shall submit to the Engineer for approval two copies of a (i) Test Certificates (ii) comprehensive manual/ drawings detailing each test to be conducted. The manual shall include a results form on which the results of each test shall be entered, including spaces for numerical values where appropriate and witness signatures.

Not less than 7 days before the scheduled factory acceptance test, the Contractor shall have to give written notification to the Engineer that a complete dry-run of the factory acceptance test has been performed successfully and the system shall exhibit stable operation and shall be ready for the formal factory acceptance test.

The factory acceptance test shall be considered successfully completed only when the system shall be successfully passed all factory tests. The system shall not be delivered to Site until the successful completion of the factory acceptance test shall be certified by the Engineer or unless otherwise approved by the Engineer. Delay in the delivery of the system due to failure of the factory acceptance test shall not constitute an unavoidable delay. If the system fails the factory acceptance test, the test shall be extended or rescheduled at the discretion of the Engineer.

Before software testing begins, all hardware to be used in the testing of the system shall be passed on an agreed preliminary hardware performance test to ensure known hardware operability.

After successful completion of the factory acceptance test, no software changes shall be made to the system without written authorisation by the Engineer. Any changes to the system which shall affect the system software documentation, such as input scale modifications or changes to the control logic shall be entered into the system documentation before delivery of the system to Site.

## 8.2 Factory acceptance test documentation

As a minimum, the following information shall be included in the factory acceptance test manual for each test:

- test identification number;
- test name and description;
- list of all equipment to be tested including any special test equipment required;
- description of the test procedure broken down into logical steps;
- description of the expected system response verifying the completion of each logical step;
- space for recording the results of the test and the time and date of the test;
- space for signatures of the Contractor and the Engineer.

In addition, the Contractor shall provide a method for recording and tracing all problems, discrepancies, queries and suggestions regarding the system and software, and for formalised control of any modifications to the system.

## 8.3 Factory acceptance test procedures

The scope of the tests shall include the proving of every aspect of hardware and software operation and functions as detailed below.

### 8.3.1 Hardware tests

- Verify the correct inventory of hardware including cables and printed circuit boards;
- Demonstrate that all spare-memory, disk-capacity and system-expansion requirements shall be met;
- Demonstrate that all input and output expansion requirements shall be met, including wiring and signal isolation, and verify that power supplies shall be capable of supporting the increased load for this expansion;
- Demonstrate all hardware and software diagnostics;
- Verify all power supply voltages shall be within tolerance;
- Verify proper earth connections and isolation of instrumentation earth for all equipment;
- Demonstrate operation of test simulation and indication equipment and its suitability for adequate functional testing of all system functions.

### 8.3.2 Software tests

- Demonstrate the editing of all system parameters including set-points, timers, etc.,
- Demonstrate system configuration capabilities including the addition and deletion of input and output points, outstations, and all data base parameters;
- Demonstrate the addition, deletion and modification of mimic displays and report formats;
- Demonstrate modification of the communications network;
- Demonstrate the capabilities of the communications monitoring and diagnostic facilities.

### 8.3.3 Functional tests

The functional tests shall verify proper operation of every specified system function as an integrated system. These tests shall be conducted in conjunction with functional tests of instrumentation and control panels as specified elsewhere. All failures or discrepancies found shall be documented in the test manual.

Following a failure of any functional test, should software or hardware modifications be required it shall be the decision of the Engineer whether the factory acceptance test shall to continue, re-start or be aborted. If testing shall be allowed to continue, any changes required shall be described in a system-modification document, signed by both Contractor and Engineer and be incorporated into the final factory acceptance test documentation. The failed test shall be re-conducted and the Engineer shall require the re-test of functions which shall be affected by the modification.

The functional tests shall include, as a minimum, the following:

- Verification of proper scanning and data acquisition from all outstations using the actual communications hardware shall be used on-site where possible;
- Demonstration that the system meets the requirements of the Specification for response time and speed of screen update;
- Verification of the accuracy of all analogue input points in the system. The procedure shall include applying the appropriate signal to each analogue input at a minimum of three points within the range of the input, checking for expected numerical results, and verifying appropriate update of related mimic displays. Proper sensing and action by the system to high and low out-of-range inputs shall also be verified;
- Verification of the proper logic sense, pulse accumulation and rate computation where appropriate, of all digital inputs and verifying appropriate update of related mimic displays;
- Verification of all control and sequencing operations and proper operation of all digital and analogue outputs. The procedure shall include simulation of all related process variables for both normal and abnormal conditions, including instrument and component failure, and demonstration of fail-safe response of the system. System outputs shall be indicated with appropriate lamps and indicators;
- Simulation of outstation communications errors and failures and demonstration of error detection and handling, failure detection and handling, and appropriate changes to control actions as designed and specified;
- Verification of fault detection and diagnostics by inducing a sufficient variety of fault conditions in the system to ensure that detection processes and fail-safe operation shall be adequately tested;
- Demonstration of proper operation of all mimic displays, help pages, reports, operator procedures and historical data accumulation;
- Demonstration of proper operation of all outstations following a simulated master station central processor failure;
- Demonstration of proper operation of all equipment during both system-wide or isolated power failure, and following power restoration. The procedure shall include the demonstration of battery backup of both master station and outstation for the full length of time specified, and proper operation of power fail, low voltage warning and all associated alarms;
- Where redundant systems shall be specified, demonstration of switch-over to back-up

systems, including automatic switch-over where specified;
- Verification of the accuracy of all calculated variables and parameters;
- Demonstration of the proper operation of all approved changes to the specified system.

### 8.3.4 Reliability test

After successful completion of the functional tests a 48-hour continuous run of the system shall be performed. The test shall be passed if no system function is lost or no hardware or software failure occurs. Hardware failure shall be defined for this test as the loss of a major component such as the computer, an outstation, a VDU or a peripheral device. Non-repetitive mechanical failures of loggers, push-buttons, etc shall be excluded.

During this test, the system shall be exercised with simulated inputs and conditions in a manner which approximates the on-site operational environment. Unstructured testing by the Engineer shall be included during this test. Upon any system failure during this period, it shall be the decision of the Engineer whether the reliability test is to continue or be aborted. If testing shall be allowed to continue any changes to the system required shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final factory acceptance test documentation.

## 8.4 Installation

The system shall be delivered to the Site after the factory acceptance test shall be successfully completed and its completion shall be approved by the Engineer. Before any item of equipment shall be delivered to the Site, the Contractor shall satisfy himself that the mounting place and environment shall be ready for that item and that there shall beno conditions present in any way causing damage to the equipment. If such conditions exist, but it shall be advantageous to deliver the item to Site, the Contractor shall, after approval of the Engineer, provide a store which gives a standard of environmental protection equal to or better than that intended when the Plant shall be operational and keep the equipment in the store until installation can proceed.

Throughout the period from delivery to Site until the issue of the Taking-over Certificate, the Contractor shall ensure that each item of equipment shall be safeguarded against any potentially detrimental condition. In particular, equipment doors, covers and the like shall be closed except when work shall be in progress.

As soon as possible after delivery to Site, the Contractor shall inspect each item of equipment for damage and shall report accordingly to the Engineer and carry out any required remedial work to the approval of the Engineer.

The Contractor shall ensure that installation and commissioning of control system equipment shall be co-ordinated with work in the same area by other trades.

The location at which each item of equipment shall be installed as shown in approved drawings or as otherwise agreed with the Engineer. Each mounting position shall be chosen to give correct operation of the equipment, ease of operation, reading, maintenance and servicing, freedom from any adverse effects and with particular regard to the safety of personnel and plant.

## 8.5 Pre-commissioning tests

The Contractor shall perform pre-commissioning, or preliminary, testing of the control system in accordance with that specified for instrumentation. The purpose of pre-commissioning tests shall confirm readiness of the system for commissioning.

The scope of pre-commissioning tests shall be generally as specified for factory acceptance tests but real field inputs and final control elements shall be used wherever practical to provide inputs to the system and to confirm proper outputs. For impractical situations, simulation signals shall be injected as near as possible to their ultimate sources so as to include in the tests as much of the cabling system as possible.

Each process system shall be set to work under manual control and the system tested to confirm proper operation.

After proper operation of manual control mode shall be verified, tests of automatic controls of each process system shall be conducted wherever practical.

## 8.6 Commissioning tests

The Contractor shall submit all relevant draft operating manuals for the control system to the Engineer for approval prior to commissioning tests. Any faults or failures of the system detected during the previous tests shall be noted and corrected to the satisfaction of the Engineer before commissioning is allowed to commence.

The control system shall be commissioned in accordance with procedures described elsewhere in this Specification, and subject to routine tests as required by the Engineer.

## 8.7 Availability test/Site Acceptance Test (SAT)

As part of commissioning, the control system shall be tested for availability for a continuous period of 14 days. During this period, the system shall perform the normal functions according to the procedures described in the Contractor's documentation.

The system shall pass the availability test if all major components shall be free from fault or failure and exhibit full error-free functionality for 98% of the total duration of the test, unless otherwise agreed by the Engineer. Major components include all master station equipment, outstations, communications facilities and instrument panel components, excluding push-buttons, switches and lamps and any equipment not supplied by the Contractor.

During the availability test, no modifications to the system shall be made by the Contractor without the written approval of the Engineer. Erroneous functioning shall require software modifications or re-configuration to correct, other than set-point or parameter changes, shall constitute a failure of the availability test. Any changes to the system required and approved shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final test documentation. The test shall be restarted after corrections have been completed.

During the availability test, a minimum of one power failure for each outstation and for the master station shall be simulated. Improper operation during power down or power recovery

shall constitute a failure of 1% of the test duration.

During the availability test, a minimum of one failure for each component with redundant back-up unit shall be simulated. Improper switch-over to the back-up unit shall constitute a failure of 1% of the test duration.

If a situation shall arise during the availability test which renders the system unavailable but which, in the opinion of the Engineer, not accurately reflect the true system availability, the unavailable period shall be ignored and the test extended for an identical time period.

After the availability test period shall be completed, if the test objectives not meet the test shall be extended until the required system availability shall be achieved over a consecutive 14-day period. If the test shall be extended in this manner for over 8 weeks, the Engineer, at his discretion, may discontinue the test and the issues shall be resolved in accordance with contractual terms.

In order to establish that all failures shall be satisfactorily repaired, no repeat failure shall have occurred within 72 hours of the failure. The test shall be extended if necessary to satisfy this requirement.

# Technical Specifications

# C7. SCADA & AUTOMATION - Particular

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## SUB-SECTION 1. GENERAL REQUIREMENTS

### 1.1 Intentions and Preconditions

The new SCADA and Automation system shall be implemented in favour for more available and more economic water supply.

DJB intends to explore possibilities for more economic operation. This is:

- Automatic operation for relieving personnel from routine operation for more monitoring and maintenance activity.
- Faster and better detection of leakages/line-ruptures and better valuation of non-revenue water
- Better energy management by optimising pump operations
- more appropriate corrective actions to any alarm originated at the pumping stations or reservoirs
- possibility of more efficient, impartial and economic water distribution by centralized control

The new sophisticated SCADA and Automation systems shall assure all these aims.

### 1.2 Control Philosophy

**Emergency control** is the manual or automatic stopping of operation, which functions directly on the motor starter's hardware (not via PLC) and therefore overrides all other kind of control. The activation of the emergency control shall be signalled by referring auxiliary contacts via PLC and RTU. It shall be finally acknowledged locally near the location of the reason for the emergency stopping.

Emergency controls are

- Tripping of circuit breakers or protection relays (direct electrical)
- Emergency pushbutton (local manual)
- Dry-run protection for pumps (hard wired automatic) by low level (or low pressure) switch, and by high pressure switch
- Bearing/ Winding temperature very high (if available)

The wiring from the emergency contacts to the motor starter shall be "fail safe" and the emergency contact must be connected directly to the power contactor or to the tripping coil of the circuit breaker.

The position of all emergency control switches shall be transmitted for information via PLC to SCADA

**Emergency control by SCADA**

For prevention of dangerous situations, which possibly could not be stopped locally, central emergency control shall be possible for certain drives.

These are:

- Emergency stop of a pumping station
- Emergency Closing of a DMA valve

The Emergency stop of a pump station will be activated by two soft buttons (two buttons for avoiding accidental activating) on the SCADA screen, which can only be operated by persons with the referring authorisation. The command will be sent via the SCADA data transmission system. The referring output at the RTU shall be directly hardwired to the tripping contact of the main circuit breaker, meaning this "Stop" will switch off the whole station in the same way like a power blackout.

The Emergency stop from the SCADA for a single pump is not sensible.

The Emergency Closing of a DMA valve will be activated by special soft button on the SCADA screen, which can only be used by persons with the referring authorisation. The command will be sent via the SCADA data transmission system. The referring output at the RTU shall be directly hardwired to the close contactor, meaning the closing is unconditioned (means, it is also possible in the manual local mode). For those valves which are provided for Emergency Closing special UPS for the Valve shall be considered.

**Manual local control**

The status of the direct manual controlled (no electrical drive) valves shall be signalled via PLC/RTU to SCADA by limit switches (open or close).

For all electrically controlled drives (pump motors, etc.) the control shall be selected by local Manual-0-Remote or Manual – Remote switches. For each drive the signals of the selector switch positions

- Manual or 0 (zero)
- Remote

Shall be sent to SCADA.

The manual local control is located at Local Control Panels (LCPs), which must be in sight distance of the referring equipment, and/or at the front panel of local switch- and controlgears (e.g. the MCCs). The manual local control is provided for the possibility of maintenance and repair. The usual operation should be automatic (selector switch in position "remote"). Assuring safe operation for the personnel the manual local operation overrides all other control except the emergency control. If two levels of local manual control are installed, the manual control, which is nearer to the equipment overrides the other manual control.

The manual local control shall also be possible in the case of outage of the PLC.

If it is necessary for client's reason an additional permission for local control at SCADA shall be implemented as soft switch at the SCADA workstations. However the independency of local control means that the mentioned permission must be fail safe: in case of outage of the PLC or the SCADA data transmission the "no permission" is automatically off.

**Automatic control**

The automatic control (automation) is the closed loop control operated by the implemented programs in the PLCs and finally controlled

- by the measuring devices (instrumentation/transmitters)

or

- by programmed time schedules or other logical links

The PLCs will be equipped with special interfaces for connection to modem or connected via RTU forthe data exchange with the SCADA centre.

**Adjustable Set Points**

As the water demand in DMAs varies during 24 hour cycle of a day, it is proposed to monitor the Flow rate at the common Header and it will be controlled by varying the motor speed via VFD Panels based on the Adjustable Set Points/Value programmed in the respective PLC. The water demand will be divided in four real time based zones namely -

- Low Flow between 23.00.PM to 5.00AM
- Peak Flow between 5.00AM to 10.00AM
- Average Flow between 10.00 AM to 5.00 PM
- Peak Flow between 5.00 PM to 11.00 PM.

The Water demand i.e. Set Value to the Automatic Controller, will be different at different Booster pumping station (BPS) depending up on the Area and Population of that Zone, the real time based Set Values will be programmed in the respective PLC accordingly. Each BPS will have a dedicated PLC for controlling the Flow rate as per above Peak, Average Low water demands.
When the system is in auto mode, this real time based variable Set Value will be compared with the Measured Value i.e. the actual flow in the common header is measured by a Magnetic flow meter. These Set and Measured Values will be compared in the PLC and any difference (Error) will be neutralized by varying the Pump speed through VFD. The PLC will give such corrective commands to VFD (a) to increase the speed if Demand(Set Value) is more, or (b) to decrease the pump speed if the actual flow rate(Measured Value) is more.
When the system is in Manual mode this Set Value can be varied manually by the Operator to control the flow rate.

**Supervisory control (Control by SCADA)**

The supervisory manual control at SCADA is to be understood as (quote IEC) “the purposeful action on” the water distribution system, aiming to avoid lack of water for consumers by leading the water flow superordinate to the local automation. The local automation is acting dependent on the flows, pressures and reservoir water levels which are physically linked to the referring pumping station. The automation system do not concern the whole distribution system. Therefore, the supervisory control must influence the automation, however without touching any safety aspect of the pumping procedure and without disturbing the smooth automatic control, as far as possible.

This is possible by the following measures:

1. By activating the referring (key protected) soft switches by authorised persons at Zonal (West) SCADA the signals Stop or Start Pumping is sent to the referring station RTU. The referring outputs of the RTU are linked to special inputs at the PLC, which initiate the programmed start or stop sequence of the pumping station. Supervisory starting or stopping of single pumps are not possible. If the starting or stopping sequence is finalised in a certain time (program parameter) the pumping station status "Automation Mode" is sent to SCADA. If the starting is not complete in pre-settime an alarm signal is sent to SCADA. Then no further actions at the pumping station via SCADA are possible.

- Automatic speed controlled pumps through VFDs of respective pumping stations are for regulated water pressure optimisation~~,~~ meaning the speed of the pumps is regulated to hold the pressure at the same value for all flows in order to save power consumption. This is only possible inside certain limits for the flow depending on the system data. However this set-point of pressure, which is a PLC program parameter, can be changed (also in limits dependent on system data). For speed controlled pumping stations with more than one pump, the switching over point from one to two and from two to three pumps shall depend on the actual flow. These special flow values, which caused the starting or stopping of pumps, are PLC program parameters too.

  So, the second possibility of influencing the flow of water in an automated system is to change those parameters from remote like change the pressure parameter to save the power consumption.

  If the new pressure set point sent from SCADA is out of the programmed limits, message like "out of limits" shall be sent to SCADA and no change of parameter will be accomplished.

2. The automatic operation of the pumping stations are not only influenced by the flow and pressure on the discharge side, but also by the reservoir water level of the suction side.

   The automation has to be programmed, that, if the pressure on the suction side is low (fixed programmed parameter e.g. NPSH), the pumping will stop. This measure shall be implemented additionally (not in exchange) to the dry-run protection!
   Because of this fact, SCADA can influence the pumping without interference into the automation of the pumping station by:

   a. changing the parameter "Low Level" in limits dependent on system data
   b. closing/opening the inflow valve of the referring reservoir (time delayed control of pumping).

   It has to be considered, that the controlling of the inflow of the reservoirs will influence the pressure in the whole distribution system.

3. This aim of SCADA controlled water distribution could be reached too, with the help of the direct influence of consumer groups summarized in DMAs.

The authorised SCADA operator has the possibility to close and open the DMA valves provided, that it is not switched in the local mode and the public power supply is available locally.

The local RTU has to send all necessary data about flow, pressure, status of the DMA valve and the power supply to SCADA comprising acknowledge and accomplishing of the actions by SCADA.

All these measures will influence the "flow of water" in the whole distribution area (respectively the zone).

These supervisory controls are reasoned by decisions for actions, which can only be done responsibly by knowing the distribution system's multi depending functionality and knowing the multi depending impacts on any central SCADA action.

The SCADA data-base and its referring software can help to find the right decisions.

However, these data base has to be filled first by data of the control operations and the instrumentation over a possibly large period of time and by GIS data.

**Supervisory automation**

All control actions explained under "Supervisory Control" can be theoretically automated. However, the criteria for the automation program can only be found by long term experience (e.g. two years) with the whole water system supported by GIS and the iterative creating and developing of hydraulic models.

However, without that support, the simplest kind of automatic is a time schedule control. The more sophisticated supervisory automation programs are specified elsewhere.

**Local SCADA**

For UGR stations a local SCADA is required.

The SCADA system, which shall consist of a workstation linked to the referring zone SCADA centre however the control shall be limited to the UGR/BPS area and its linked DMAs.

The possibility of monitoring and manual control are the same like that of the central SCADA, however only over this limited area. Local SCADA needs not to be used for strategic decisions like pressure and power management and therefore needs not be equipped with those special software packages.

The Local SCADA is Manual Control, however not the, before described Local Manual Control. It cannot override all other controls. However, the Local SCADA can influence the automation, same like the central or zone SCADA.

Avoiding control conflicts, the control authority must be clarified, either generally or before each action separately.

Special signals will be sent between central or zone SCADA and local SCADA questioning

for allowance and giving allowance for control. However in doubts and failure of the data transmission Local SCADA shall control.
The Local SCADA is physically linked by data bus to the RTU and/or to the PLC to receive all necessary data.

## 1.3 Design Documentation Requirements

The Contractor shall prepare and submit for approval complete design documents for SCADA and Automation. These are mainly as follows:

To be submitted three weeks after assignment:

- Project schedule comprising the affirmation or correction of the dates in the Tender documents. The schedule has to be updated possibly each week respectively minimum each four weeks with proper reasoning for any failure/delay
- Updated description of the complete scope of supply
- Updated list of the equipment and software with the names of brands and manufacturers and states of origin
- Updated Functional Design Specification of SCADA and Automation

To be submitted within six weeks after assignment

- Layout drawings of the equipment with integration into the civil/architectural drawings
- Data sheets of all equipment

To be submitted ten weeks after assignment

- Shop drawings (single line diagram, circuit diagrams, lay-out drawings, parts lists, main assembly data) of the RTU respectively ICA cubicles

To be submitted sixteen weeks after assignment

- Final versions of the above mentioned “list of equipment and software” and “Functional Design Specification”
- Documentation of the PLC automation programs (verbal program description, program description according to IEC 61131, list of PVs.
  PV (process variables) are all changeable program parameter plus all analogue and binary in- and outputs (I/Os).
- Documentation of the RTU application programs (verbal program description, program description according to IEC 61131, list of PVs comprising changeable parameters and I/Os)
- Documentation of the local SCADA programs(verbal program description comprising description of each window and each pull-down menu)
- Documentation of the SCADA program (verbal program description comprising description of each window and each pull-down menu, explanation of each status change, list of possible signal comprising its status: event, alarm, tripping alarm,etc.)

This listing may not be complete. The contractor shall submit any other documents/drawings etc.as required for the execution of the project.

## SUB-SECTION 2. ZONAL DISTRIBUTION SCADA (WEST) HARDWARE

### 2.1 SCADA Control Centre

Separate Zonal SCADA centres for each of the three zones (Package 2, 3 & 4) shall be established. Each of these SCADA centres will be connected by own separate servers and communication modems to the UGRs, BPS and DMAs of the referring zone.

These Zonal SCADA centres are also connected to SCADA of the CWMC via wireless two way data & voice communication links.

For this scope of contract, the zonal SCADA centre is proposed to be established in Than Singh UGR Premises. This Zonal Centre will collect all the distribution data from all DMAs under this package. The data collected will be processed and transmitted to CWMC for monitoring.

#### 2.1.1 SCADA Control Room Design

Referring the SCADA control room special requirements, regarding air-conditioning, lightning and ergonomic principles shall be considered. Most of it is regulated in ISO 11064-3.

The Contractor shall provide a special neighbouring “technical” room for separating the servers, routers, modems etc. from the workplaces. The UPS and the grid power distributions by MCBs shall be installed there too.

For each of the three zones the Contractor shall provide 4 workplaces (2 SCADA workstations, each with two screens, one programmer workplace with laptop and one for the security personnel with CCTV screens) plus a table or board for the printers and other general equipment and suitable cupboard. For visitors about 6 chairs with table shall be provided.

The architectural design or detailed layout shall be coordinated with the CWMC SCADA layout and is described in the referring specification.

For all SCADA rooms false floors shall be provided, if required.

#### 2.1.2 SCADA Control Centre Equipment

The contractor shall provide according to the General Specification for SCADA and Automation the following equipment for each zone:

##### 2.1.2.1 In the technical room

Modular built rack for electronic equipment, comprising

- Redundant SCADA server
- DSL router
- GPRS router
- Redundant data storage “autoloader”

- Internal SCADA Control Centre Ethernet LAN and/or WLAN (TCP/IP)
- UPS supplied distribution switchgear with MCBs and the referring cabling (cables, channels, conduits)
- The UPS shall be capable to supply the whole SCADA centre for one hour. The full reloading time after 80% discharge shall not exceed two hours.
- The cabling shall be installed under a false floor.
- The technical room shall be redundant air-conditioned to ensure the temperature maximum 30°C.
- Common grid supplied distribution switchgear with MCBs and the referring cabling (cables, channels, conduits)

#### 2.1.2.2 In the Zonal Control room

- Two SCADA workstations, each with two 32" (minimum) screens
- One Laptop workstation for software services
- Alarm printer (Dot-matrix printer): SCADA controlled printer, printing selected alarms without ejecting the printed paper)
- A4 laser printer with Scanner
- A3 colour laser printer with Scanner
- Referring cabling (cables, channels, conduits)
- An overview large display equipment- 67" ultra-narrow and professional grade wall mounted LED Large Video Screen (LVS) display.
  The minimum requirement for LVS shall be as follows.
  - It shall be capable of 24X7 continuous operation under normal ambient lighting in the control room
  - The LVS and its accessories shall be designed such a way that the brightness in the centre of the screen and the edges of the screen to be uniform and there is no perceivable difference in the quality of the picture in the centre and at the edges of the screen
  - The display shall be ultra-narrow and professional grade LED
  - The display shall be full HD definition of 1920 x 1080 to display HD contents with a stronger sense of reality
  - The LVS shall have eco-friendly features, decreasing energy consumption, lowering expenses over the life cycle of the display and contributing to the environmental awareness
  - It shall have high reliability and user friendly control features
- Acoustical alarm device
- Remote SCADA workstations in special offices

#### 2.1.2.3 Technical Security Centre

The Contractor shall provide the technical security centre for the UGRs/BPS, which shall be installed in the Zonal SCADA centre or alternatively in a separate room. The security centre consists of

- The central screens of the CCTV system
- Intrusion detection and alarming centre
- Fire detection centre
- Flooding alarm tableau (if it is not incorporated in the SCADA system)

#### 2.1.2.4 General technical facilities

The contractor shall design and install the complete technical infrastructure of the SCADA centre as described in the General Specification of the SCADA works.

#### 2.1.2.5 Furniture in the Control Room

- 3 desks, minimum 120x60cm with set of two drawers for the workplaces and a compartment for the desktop computer, prepared for hidden cabling of the computer, screens, etc.
- 3 ergonomic workplace chairs
- 6 chairs, stackable, for visitors and as reserve
- 2 tables, minimum 120x60cm for printers and reserve
- 1 cupboard, about 180x80x30, with shelves for standard sized folders, one compartment shall be lockable
- 1 metallic screened and dustproof storage cupboard for movable data storage devices
- 1 “Pin wall” for fixing A0 drawings

## SUB-SECTION 3. DATA TRANSMISSION AND RTU STATIONS HARDWARE

### 3.1 Data transmission

Generally four types of data transmission systems are available for SCADA system

#### 3.1.1 GSM

This system uses the existing wireless networks of mobile phone providers for sending data packages by demand.
Referring SCADA these data are
From site to SCADA

- alarms or other non-regular unusual change of the physical status on site.
- in certain sequence packages of data, which are locally registered (stored)

From SCADA to site

- control signals (ON, OFF, OPEN, CLOSE)
- change of control parameters (limits like “low level”, “high flow” etc.)

#### 3.1.2 Wireless Broadband by GPRS

The wireless access to internet as a VPN (Virtual Private Network) for transmitting continuous data in both directions without time delay (or tolerated minimum delay) as defined in the SCADA General Technical Specifications.

The quality referring interruptions depends on the quality of the provided network at the specific location.

The wireless internet access shall be the main media for the SCADA data transmission.

#### 3.1.3 DSL Broadband (cable)

Cable aided connection for internet access as VPN for transmitting continuous data in both directions without time delay (respectively tolerated minimum delay) as defined in the SCADA General Technical Specifications.

The quality referring speed and interruptions depends on the quality and traffic density of the provided network at the specific location especially. The speed problems could be minor, if the cable material and technique is fibre and not copper.

Cable aided internet access shall be the main redundant possibility for SCADA data transmission. Both options should be possible at each RTU station.

#### 3.1.4 Radio

Radio communication bases on a physical “private” network working inside certain private frequency band.

Radio shall be only the redundant system at location, where one or both of the before mentioned techniques are not possible or of very bad quality.

### 3.1.5 Selection of redundant systems

The Contractor shall establish GPRS aided internet connection plus modems for fast fibre connection with internet. If fibre connection is not available, the Contractor shall introduce two different wireless internet providers.

## 3.2 Remote Terminal Units (RTU)

The RTUs are the interfaces between the physical process and zonal/West SCADA.

The components of the RTU stations shall be installed inside the ICA cabinet combined with the transmitter or transducer of the instrumentation.

At pumping stations the components of the RTU stations shall be installed in the control adjacent to (or combined with) the SPS cubicles.

For “small” automation tasks the RTU shall be combined with the PLC to RTU/PLC device.

The ICA cabinet (and PLC cubicle) equipment comprises:

- Power incoming circuit breaker and (if applicable) energy meter comprising fuses and ( if necessary) current transformer
- Power distribution by MCBs
- UPS power supply (Batteries, battery charger, if necessary rectifier) and its distribution (if necessary DC and AC) by MCBs
- Transducer, transmitter of the instrumentation, signal isolators/multipliers if not locally at the sensors
- RTU, PLC
- Data logger for the storage of all from the RTU acquired data of one month minimum
- Modems, router for the SCADA data transmission
- If sensible and required Local SCADA (workstation at the UGRs and/or BBS)
- As a back up Local Control Panel (LCP) with pushbuttons and LED signal luminaires/ Bar Graph Indicators shall be provided

### 3.2.1 RTU Station / ICA Cabinets

The cabinets are either

- Indoor wall mounted control-gears

or

- Compartments incorporated in the referring MCC

or

- Outdoor controlgears mounted at robust and weather-proof framework( rooms for

SCADA systems shall be provided at all places except in DMAs)

The RTU cabinets shall be built with reference to IEC 60364 and IEC 60439-1.

The degree of protection for these enclosures shall be in accordance with IEC 60529 equal or better:

- IP54 for indoor applications,
- IP65 for outdoor applications or rooms mainly designed for water pumps, valves and pipes,
- IP67 for transducers and other equipment mounted near water surfaces or within valve or meter chambers and similar locations, if the Contractor guarantee by technical measures (e.g. by emergency supply powered drainage pumps), that the equipment's emersion under water surface is less than 1m and for less than 30 minutes.
- IP68 for transducers and other equipment mounted near water surfaces or within valve or meter chambers and similar locations.

Outdoor cabinets shall be protected against direct sun radiationby a canopy.

Outdoor cabinets shall be protected against rain by suitable roof, especially at the side of the LCP and/or HMI, where cabinet's door can be opened.

### 3.2.2 Data acquisition general requirements

In principle all data, which could be transferred in binary data format or 4 – 20mA analogue data format, shall be input into the RTU for the transfer to SCADA centre. It is the task of the SCADA software to decide, whether and in which way these information will be used.

Some measured data shall additionally transfer to another RTU for the reason of automatic control, if the closed loop sensors and drives are at different locations.

The automation PLC is linked to the RTU by data bus transferring all data of the automation to the RTU and receiving commands from SCADA via RTU.

However important data shall be INPUT into the PLC and the RTU. Then the same single data, which is input at the RTU and the PLC will be checked for identical value and by that the functionality of RTU and PLC is checked.

The RTU and ICA cabinets shall be located adjacent to the process equipment at suitable locations avoiding long signal cable ways.

### 3.2.3 Data acquisition at switchgears and other power distribution components

Each switchgear (MCC and distribution) shall be related to a certain RTU stations for transferring the following data via RTU to SCADA:

- Position of all incoming switches (circuit breakers)
- Fault message of all incoming switches (circuit breakers)

- Position of the coupling switches
- Position and fault message of the outgoing switches (circuit breakers)
- Peak power (kW), actual power (kW) and actual reactive power (kVAr)
- Accumulated power and accumulated reactive power (kWh and kVArh)
- Delta Voltage of all three phases for all incoming feeders
- Signalisation of Presence of voltage "before" each incoming feeder
- Signalisation Presence of voltage at each "bus-bar"
- Emergency Off signal of the switchgear (complete power switch off)

If applicable most of the signals can be transferred from the referring PLC to the RTU.

### 3.2.4 Data acquisition via PLC

The local automation (mainly at pumping stations) is descript elsewhere. The referring PLC shall be of the same brand as the RTU and shall communicate by suitable interface dependent on the chosen brand of PLC and RTU brand. All data acquired by the PLC for automation shall be transmitted to the RTU for sending to the data logger and to central SCADA.

### 3.2.5 Data acquisition from the process instrumentation

The data of the following instrumentation shall be submitted to SCADA by the means, described in the chapter before.

#### 3.2.5.1 Water level measuring in the reservoirs

The water level in each reservoir chamber will be measured by ultrasonic sensor.

The 4-20mA signal is wired to the PLC/RTU of the reservoir or pumping station. The level signal will be used for automatic valve control, for indication of HH, H, L and LL, for registration into the data logger and for transmission to SCADA.

The HH signal, generated by separate level switch, shall be wired to the stations PLC to close the inflow valve and for "logic control" of the ultrasonic level sensor, for release "overflow" alarm and sent to the RTU for the data logger and transmission to SCADA.

The LL signal, generated by separate level switch is wired "fail safe" for emergency stop of the regarding pump station, the switch position signal (auxiliary switch of the LL switch)is wired to the stations PLC for alarm at the local control centre, for "logic control" of the ultrasonic level sensor and to the RTU for the data logger and transmission to SCADA.

#### 3.2.5.2 Water pressure and flow measuring at the pumping stations

The discharge pipe of each pump will be equipped with pressure gauge and pressure transmitter. The pressure gauge is necessary for manual starting of the referring pump and the transmitter signal will be input into the pumping station's PLC and is necessary for the automatic starting and pump efficiency monitoring.

Additionally the pressure and flow of the common outflow at the pumping station will be measured for the pumping station's operation control, for the data logger, transmission to SCADA and for Booster Pump Efficiency monitoring and downstream line rupture.

#### 3.2.5.3 Water pressure and flow measuring at the reservoir inflow

For the SCADA tasks of Pressure & Power Management and NRW detection, the water flow and the pressure at the inflow of the UGR shall be measured, registered in the local data logger and sent to SCADA. The fault messages of the instrumentation shall be acquired too.

Additionally the logic of the values pressure, flow and valves opening status shall be checked against the rated data of the valve by the programme of the local PLC.

Illogic status will be sent as alarm to SCADA and local control centre.

#### 3.2.5.4 Water pressure and flow measuring at the DMA valves

For the SCADA tasks of Pressure and Power Management and NRW detection, the flow and the pressure at the DMA valves shall be measured, registered in the local data logger and sent to SCADA. The fault messages of the instrumentation shall be acquired too.

Two pressure measurements shall be provided, at the inlet and outlet of the valve.

Additionally the logic of the values pressure, flow and valves opening status shall be checked against the rated data of the valve by the programme of the local PLC/RTU.

Illogic status will be sent as alarm to SCADA and local control centre.

#### 3.2.5.5 Remote single flow measuring

At DMAs outflow pipes, flow meters are provided for monitoring and registering by SCADA.

These remote flow-meter chambers will be equipped with RTU stations for registering and submitting to SCADA flow data, and fault alarms.

#### 3.2.5.6 Remote single pressure measuring

At some "strategic" locations inside DMAs additional pressure measuring shall be provided. "Strategic" locations are those where the pressure could be critical low.

These pressure measuring locations will be equipped with its own RTU station or pressure transmitters with built-in wireless outputs for registering and submitting to SCADA pressure data and fault alarms.

#### 3.2.5.7 Residual chlorine measuring

Residual chlorine measuring shall be provided at designed locations. These locations are according to the INST. AND SCADA TYPICAL DRAWINGS at out-flow of each BPS r and each DMA lowest pressure point . Further locations could be according to detailed process layout design at the lowest pressure points in the DMAs.

These stations will be equipped with RTU for registering and submitting to the local control centres and to SCADA the minimum chorine alarm and fault alarms. The chlorine value should only be sent to the local BPS control centres.

The RTUs for the before mentioned stations “single flow”, “single pressure” and “residual chlorine” could be combined in common stations, if possible concerning the process monitoring design.

#### 3.2.5.8 Turbidity measuring

Turbidity measuring shall be provided at designed locations. These locations are according to the INST. AND SCADA TYPICAL DRAWINGS at the out-flow of each BPS .

These stations will be equipped with RTU for registering and submitting to SCADA the high turbidity alarm and fault alarms. The turbidity value should only be sent to the local control centres.

The RTUs for the before mentioned stations “single flow”, “single pressure” and “residual chlorine” could be combined in common stations, if possible concerning the process monitoring design.

### 3.2.6 Data acquisition from auxiliary and safety equipment

#### 3.2.6.1 Vacuum pumps

Omnibus fault message of each pump shall be registered at the data logger and sent to SCADA.

#### 3.2.6.2 Flooding sensors and drainage pumps

The triggering of the flooding sensor and omnibus fault message of drainage pump station (comprising flooding sensor) shall be registered at the data logger and sent to SCADA.

#### 3.2.6.3 Ventilators and air conditioners

The pumping room ventilators shall be automatically controlled by thermostats installed at a sufficient location in the pumping room.

The thermostat switches shall be wired directly to the starters (contactors) of the ventilators (not via PLC). Additionally each ventilator shall be controlled by a LCP (local control panel) with Manuel-Auto selection switch.

One alarm signal for each room(too high temperature or tripping of thermostat MCB) shall be registered at the data logger and sent to SCADA.

#### 3.2.6.4 Intrusion detection and fire alarm

Intrusion protection and fire alarm shall be ~~is~~ provided in UGR/BPS area. Omnibus signals of these plants shall be registered at the data logger and sent to SCADA.
Independent from SCADA, the JICA security centres or organisations like police or fire fighters shall be the addresses by those plants.

### 3.2.7 Control at the pumping stations

The normal operation of pumping station shall be pressure (and partly flow) controlled automation.

However also the starting and stopping of a pumping station and each individual pump shall follow an automated sequence:
If water consumption is almost zero the automated stopping sequence will be initiated and if flow starts again (respectively the pressure drops) the pump starting will be initiated automatically.

However, this above described automation of the pumping station could be initiated manually by LCP pushbuttons and/or by HMI and by SCADA command.

Normal automation control is pressure control. The pressure is measured in the common discharge pipe of the pumping station. The set point for control (parameter) is a pressure value, which is calculated and set after considering the pumps characteristics, the client's pressure demand and the hydraulic model of the network downstream the pumping stations. For economic reasons and by the knowledge of more detailed data of the hydraulic model this parameter "set-point-pressure" (changeable parameter)could be changed by SCADA in limits fixed by the pump station characteristics (fixed parameter).

As alternative, if automated speed control does not function, the pumps shall be started and stopped according to a daily time cycle program based on Peak/Average/Lean demand period.

If a pumping station consists of more than one active pump the automation shall manage the starting and stopping of the further pumps depending on the measured flow and pressure and on the set control parameters, which should be changeable in limits. These limits
- Maximum flow
- Minimum flow
- Maximum pressure
- Minimum pressure

are given by the pumps and pipes data.

The Contractor shall submit the referring pump diagrams for approval.

Additionally the automation shall manage the starting of stand-by pump in case of pump failure and manage duty rotation.

Beside automation and remote control, each individual pump ~~should~~could also be started and stopped manually at the local control panel and at the pumping station LCPafter switching the SCADA system from remote to local.

However the manual local control shall be restricted as follows:

- Local manual pumping control shall be possible only for the complete pumping station (comprising main pumps, suction and discharge valves, vacuum pumps) and not for one individual pump

or

- Switching off of one single pump (possibly by slowing down the speed)
  Automation program would consider this as the black-out of one pump and would start eventually the redundant pump. Therefore manual restart shall not be possible. (In automation mode the starting of a pump is only provided by process criteria (e.g. change of flow).

or

- Emergency stop of the whole pumping station. Could be done locally or by SCADA.

Emergency stop shall function immediately, therefore the higher risk of water hammer should be considered. Restart after an emergency stop shallonly be possible locally after acknowledge of the emergency stop.

The auxiliary devices vacuum pumps, drainage pumps, ventilation etc. shall not be controlled by SCADA (however monitored).

### 3.2.8 Local Manual Control of Pumping Station

The local manual Control in a pumping Station should consist of the following components:

a.) Emergency Stop pushbutton with auxiliary contact NO for input in the PLC. The main contact NC must be directly wired (fail safe) to the main contactor, starter or frequency converter of the referring pump.

b.) Manual control at the switchgears (MCC) for switching on and off (possibly by lockable isolator switch or circuit breaker) and for changing the frequency (or speed) of the referring pump.
Because these switching is unconditional, this should only be done by experienced person in charge.

c.) Local control boxes, just adjacent to the equipment with remote-0-run control switch for vacuum pumps, drainage pumps and compressors.

d.) Local control wall mounted boxes with auto-0-run for single or groups of ventilators.
e.) Local Control Panel

At the pumping station's LCP all main pumps, the vacuum pumps and all valves shall be controlled manually.

The LCP ~~is~~ shall be capable of functioning without the PLC. Therefore all necessary signals for control and local monitoring must be duplicated by interposing relays respectively DC amplifier. These relays and amplifier shall be integrated in the LCP or installed in a cubicle adjacent to it.

Before manufacturing, the Contractor shall submit a listing comprising all necessary signals for approval.

Minimum the following control switches, pushbuttons and signal luminaires shall be provided at the pumping stations control panel:

Whole Station:
pushbutton Emergency OFF, pushbuttons START AUTOMATIC, STOP AUTOMATIC, LAMP TEST, analogue signal: PRESSURE, FLOW

Vacuum pump:
pushbuttons ON, OFF, signals LOCAL, ON, OFF, FAULT

Reservoir and suction valve:
pushbuttons: OPEN, STOP, CLOSE, signals: res. EMPTY, valve RUNNING OPEN, OPEN, RUNNING CLOSE, CLOSE, FAULT, analogue signal (bar graph): LEVEL

Main pump:
Pushbuttons: START, STOP, signals: RUNNING, OFF, FAULT, analogue signal: POWER [kW], SPEED [1/min],

Because this manual control is unconditional, the operator at the LCP shall have a clear sight of the pumping station comprising the pressure gauges.

f.) Local SCADA

The local SCADA system shall consist principally, of the same features than the Zone SCADA. However the control facilities are limited to the UGR supplied area.

Especially the parameter of the automation can be changed at the local SCADA.

### 3.2.9 Combined PLC/RTUs for reservoir inflow valves

The reservoir inflow valves shall be SCADA controlled and automatic controlled by the water level in the reservoirs. Each chamber(meaning each reservoir of the UGR plant) shall be controlled separately.

#### 3.2.9.1 Inflow valves

Modulating inflow valves

The valve will be automatically move in such opening status, which causes almost constant level in the reservoir. The value of this required level is a programmed parameter, which can be changed in sensible limits by SCADA.

The automatic movement of the valves shall be not continuous. It shall be opened (closed) about a certain angle (programmed parameter), when the level reached a certain point under (above) the required level. The difference between these switching points and the required level (half hysteresis) is the third programmed parameter. Optional sophisticated programs could calculate the hysteresis depending of the speed of water level change.

ON/OFF inflow valves

Also the ON/OFF inflow valve will be controlled by the water level. H level means close the valve and L level means open the valve. The parameter H level and L level are depending individually on the geometry of the reservoir. However only the parameter HH (overflow) and LL (dry) will be fixed parameter. At SCADA or at local HMI the difference between H to HH and L to LL (parameter switching hysteresis) can be changed for pressure and power management.

Valid for both, modulating and ON/OFF valves: Manual or automatic SCADA commands the opening and closing of the valves by the requirements of pressure and power management of the central distribution control of the zone and the CWMC. The local automation software shall check the local restrictions of these commands and will send referring messages to the centres:

- If the water is on a high level (above H), the valve should not be opened more. Message: high water level.
- If the valve is out of order, the valve cannot be moved. Message: Valve Fault
- If the valve control is in local mode, the valve cannot be moved. Message: Local mode
- If level measurement is out of order, the valve could be moved. Message: Level measuring fault

### 3.2.10 Combined PLC/RTUs at DMA valves

DMA inflow valves are modulating valves. Their purpose is:
- to insulate the DMA from one of its supply (DMAs could have more than one inflow valves) as ON/OFF valves.
- to regulate the pressure in the DMA as modulating valves.

Both actions are understand as central operations, meaning the valves will be operated at the referring UGR control centre, at the zone distribution SCADA and at CWMC.

The central control is initialised by the measured values of the pressure before and behind the valve, the measured flow into the DMA, the flow out of the DMA (seldom) and the pressure at "far" locations i.e. (meaning the lowest pressure point of that DMA.

The local automation software shall check the local restrictions of these commands and will send referring messages to the centres:

### 3.3 Security Systems

The security systems, especially the CCTV system, shall use their independent transmission systems according to the security standards.

However additionally some signals shall be input in the SCADA RTU to give information on the SCADA screens.

#### 3.3.1 CCTV system

CCTV or IP-cameras shall be installed for the surveillance of the pump house, reservoirs and other selected equipment. The data shall be transferred by systems which are separate from SCADA.

#### 3.3.2 Intrusion Detection

Intrusion detection system comprising motion sensors and door contacts shall be installed additionally to the IP camera system. The Contractor shall submit design concept considering motion sensors at sufficient locations supervising every possible entrance of every building.
The intrusion detection centre shall be integrated in the SCADA control room. Direct alarming of police station or other external security guards shall be possible.

#### 3.3.3 Fire Detection

The Contractor shall submit design concept considering the different types of fire or smoke detection (e.g. optical smoke detectors, air ionisation detectors, flame light detectors etc.). The fire detection shall be installed in all office and social rooms, in the SCADA and control rooms, in all rooms with electronic or electrical equipment and motors. The detectors shall give independent acoustical alarm and the signal shall be sent to the fire detection centre, which shall be installed in the local control room. The alarms shall be transmitted to SCADA centre via RTU. Direct alarming of next fire fighting station, police or other external security guards shall be possible too.

#### 3.3.4 Flooding Detection

The contractor shall design, install and commissioning water or fluid detection sensors, which shall be installed in the pumping stations, the valve and water meter chambersand other rooms, where accidental flooding might be possible.
The referring signals shall be connected to the next RTU and a corresponding alarm and red light shall be provided at the SCADA screens.

## SUB-SECTION 4. SOFTWARE

### 4.1 Distribution SCADA and Automation Software

The SCADA software for the distribution zones shall possibly be the same brand name than that for the CWMC.

The SCADA software packages shall be state of the art software as described in the Tender Document "General Specification, SCADA Works".

Referring the General Technical Specification the special software packages "Energy Management", "Water Distribution and Pressure Management", "Water Leakage Management", "Water Supply Operation", UGR & BPS Automation and DMA Automation shall be implemented as well in the CWMC SCADA and in the Distribution SCADA.

The SCADA software packages shall be developed by proved company with long time experienced of providing SCADA system in water distribution systems as per the specified qualification criteria.

The Contractor shall be able to provide qualified and experienced application programmer for the whole project duration.

The Contractor shall document the programs in such quality, that the programs are understandable for process engineers and operators.

### 4.2 Automation

It is recommended that the automation shall be programmed by the same software brand than the SCADA software.

The automation hardware, the PLCs, and the automation software shall be of the same manufacturer than the SCADA software and the RTUs.

The PLCs are directly connected to the RTUs or at smaller stations combined with them.

PLCs and RTU are modular composed: power unit, CPU, interfaces, I/O units, etc.

Supply voltage shall be 24V DC for direct connection to the UPS batteries.

The automation program shall be written and documented according to IEC 61131.

The automation applications are described under the following items referring the special RTU and ICA stations.

## 4.3 SCADA Graphic Mimic Displays

The mimics are the SCADA tools for monitoring and control. They have to be controlled for this project individually.

The other SCADA tools
- Water Demand and Forecasting.
- Water Distribution and Pressure Management
- Water Leakage Management
- Energy Management

are described in the General Technical Specification

### 4.3.1 Complete Zone overview

The Contractor shall create two zone overview mimics, one geographical and one logic. Basis shall be the attached AutoCad drawings respectively by GIS generated and imported drawings. The overview mimics shall show the geographical places respectively water pipe links between all UGRs and Pumping station including the main pumps at the WTP.

The BPS symbols shall be lightened
- green as “in operation mode”, which means for the pumping stations the automation mode and does not mean necessarily, that all pumps are available for operation;
- yellow as “in maintenance mode”, which could mean in local mode only, and does not mean necessarily, that the pumps cannot be operated
- red as “out of order”, means that any operation is not possible

The UGR symbols shall be lightened
- green as “in operation mode”, which means that all instrumentation and valves are faultless
- yellow as “measurement fault”, which means, that some of the instrumentation is faulty or that inflow valve cannot be moved remotely.
- red as “in maintenance”, means that the reservoir cannot be used.

Additional information of the overview mimic could be the colour of the pipes:
Blue with measured flow and grey without measured flow.

By clicking on the UGR or BPS symbol the referring mimic will open.

### 4.3.2 Mimics of drives

#### 4.3.2.1 Valves

The valve status shall be shown in the mimics as follows:
- blue valve symbol, if open
- blinking blue valve, if moving in open direction

- grey valve symbol, if close
- blinking grey valve, if moving in close direction
- blinking red valve, if position transmitter is out of order

If it is a modulating valve
- the % value shall be given in figures at the valve

The valve actuator status, symbolized by an M in a circle, shall be shown as follows:
- green, if controlled by PLC automation
- grey, if controlled manual locally or at the local control centre
- blinking red, if actuator is out of order

Blinking red signals will turn into continuous red signal after acknowledge.

By clicking on the valve and actuator symbol, a pop up menu will open showing all available data of the equipment:
- the status (open or close or out of order)
- the kind of control (local manual control or local control centre control or automation or SCADA control)
- TAG number
- brand and fabrication number of valve and actuator
- type and size of valve
- type of actuator
- date of commissioning
- number of openings and closings
- maximum opening time
- maximum closing time
- last maintenance date
- recommended maintenance sequence (time period and/or number of openings/closings)
- if applicable: indicator, indicating the open position in % (figures)
- fault indication by red signal and short fault description
- only for special authorised (key protected) SCADA user: fault acknowledge push-button

If it is a SCADA controlled valve, the control pop-up menu will open additionally, however it is only active, if the SCADA user has the referring (key protected) authorisation. The control pop-up menu shows:
- the SCADA requiring control push-button
- push-button “open”, with blinking signal, when the actuator is operating
- push-button “close”, with blinking signal, when the actuator is operating
- push-button “stop”
- if applicable, indication of the active remote control level: “local control centre” or “SCADA”
- request push-button for central SCADA control (if local control centre is active)
- reset of SCADA control push-button (if SCADA control is active)
- link buttons to this valve referring pressure and flow measurement

#### 4.3.2.2 Main pumps

The pump status shall be shown in the mimics as follows:
- blue pump symbol, if pumping
- grey pump symbol, if not pumping
- blinking red pump, if pump is out of order

If it is a speed regulated pump
- the % value shall be given in figures at the pump

The pump motor status, symbolized by an M in a circle, shall be shown as follows:
- green, if controlled by PLC automation
- grey, if controlled manual locally or at the local control centre
- blinking red, if pump motor is out of order
- blinking red signal for "Emergency Stop"

Blinking red signals will turn into continuous red signal after acknowledge.

By clicking on the pump symbol, a pop up menu will open showing all available data of the equipment:
- the status, which are already shown by the symbol (operating, out of order, kind of control)
- TAG number
- brand and fabrication number of pump and motor
- type and rated data of the pump (head, flow, efficiency)
- type and rated data of the motor (power, voltage, current, power factor, efficiency)
- date of commissioning
- operation hours
- next recommended maintenance date
- if speed regulated pumps: indicator, indicating the speed (or electrical frequency) in % (figures)
- indicating of fault by red signal and a short fault description
- only for special authorised (key protected) SCADA user: fault acknowledge push-button
- additionally for speed regulated pumps:
- brand and fabrication number of the frequency converter
- type and rated data of the frequency converter (power, voltage, efficiency)
- date of commissioning
- actual frequency
- adjusted minimum frequency
- adjusted maximum frequency
- adjusted maximum current
- indicating of fault by red signal and a short fault description
- link button to the pump referring pressure measurement

Control at SCADA for a single pump shall not be possible.

#### 4.3.2.3 Auxiliary drives

Auxiliary drives are the motors for the vacuum pumps, drainage pumps, room ventilators and, if applicable, compressors.

Their status shall be shown in the mimics as follows:
- red symbol, if out of order
- green symbol, if not out of order
- red signal “high room temperature”
- red signal “room flooded”
- blinking red signal “Emergency Stop”, if applicable

By clicking on the symbol, a pop up menu will open showing the following data of the equipment:
- TAG number
- brand and fabrication number
- type and rated data of the device (power, voltage, current, power factor, efficiency)
- date of commissioning
- operation hours
- next recommended maintenance date

Control at SCADA for the auxiliaries shall not be provided.

### 4.3.3 Plant Typical Mimics

#### 4.3.3.1 Reservoir

Reservoirs shall be showed as section views from the side with markings given the overflow level HH, the empty level LL and the distance between HH and LL by a scale of water volume % (HH = 100%, LL = 0%).

The actual water level shall be shown as a movable line indicated by the water volume percentages.

The volume percentages have to be calculated by the geometry of the reservoir for the referring level.

The reservoir symbol shall be designed with its TAG number (the name of the reservoir shall be written as headline of the plant mimic), its volume in m3, the maximum height of the water (difference between HH and LL).

By clicking on the reservoir symbol a pop-up menu will open, showing the already mentioned main data of the reservoir and
- the geographical data (position and geographical height)
- TAG number
- Date of construction and subsequent refurbishment
- Brand and type of the level measuring equipment

- Rated data of the level measuring equipment (range, accuracy)
- date of commissioning
- last maintenance date
- recommended maintenance sequence
- adjusted switching points (L and H)
- Brand and type and of the level switches
- adjusted switching points (LL and HH)
- only for special authorised (key protected) SCADA user: push-buttons for
    - lifting the H point (limit HH)
    - lowering the H point (limit L plus minimum hysteresis)
    - lifting the L point (limit H minus minimum hysteresis)
    - lowering the L point (limit LL plus safety distance)

The mimics of the inflow and outflow valves are explained before already.

If required and applicable the reservoir will be equipped with a chlorination station. This shall be monitored by separate local control centre and monitored by SCADA. Remote control shall not be provided. Safety systems avoiding chlorine gas accidents or overdosing shall be part of the local system.

The chlorination station shall be shown by a referring symbol and pop-up menu:
- TAG number
- Brand and type of chlorination plant, the residual chlorine measuring andthe chlorine gas alarm system
- Rated data of the chlorination plant (e.g. storage capacity, rated chlorine dosing)
- date of commissioning
- last maintenance date
- recommended maintenance sequence
- actual chlorine dosing
- residual chlorine
- red signal “Chlorination Fault”
- red signal “Gas Alarm”

If required and applicable the reservoir will be equipped with a water quality analysis station. This shall be monitored by separate local control centre and monitored by SCADA. Remote control shall not be provided.

The water analysis station shall be shown by a referring symbol and pop-up menu:
- TAG number
- Brand and type of the water analysis station
- Rated data of the analysis station (kind and accuracy of analysis)
- Tolerated limits
- date of commissioning
- last maintenance date
- recommended maintenance sequence
- actual measured values
- red signal “Water analysis out of order”

#### 4.3.3.2 Booster Pumping Station (BPS)

The pumping station mimic shall be similar to the layout in the P&I diagrams meaning as ground plan and not as section like the reservoirs. To avoid misinterpretation in the mimic the connecting pipe shall be connected at the bottom of the reservoir.

The pumps, valves and the other equipment (vacuum pumps, drainage pumps, ventilators, etc.) shall be shown as described before. The pipes shall be marked with an arrow for the water flow direction. Those pipes where water flow is recognised by flow meter and open valves, shall be blue, the others grey.

#### 4.3.3.3 Pressure and flow measuring

Each pressure and flow transmitter shall be shown as a referring symbol.

By clicking on the pressure transmitter symbol a pop-up menu will open, showing
- TAG number
- Brand and type
- Rated data (range, accuracy)
- date of commissioning
- last maintenance date
- recommended maintenance sequence
- pressure value
- adjusted switching points, if applicable
- red signals with fault designation

By clicking on the flow transmitter symbol a pop-up menu will open, showing
- TAG number
- Brand and type
- Rated data (range, accuracy)
- last maintenance date
- recommended maintenance sequence
- flow value
- total flow
- start date and time for flow totalizer
- adjusted switching points, if applicable
- red signals with fault designation

#### 4.3.3.4 Complete UGR and BPS plant

The complete plants mimics shall be individually composed by the before described typical mimics plus the following active links:
- All inflow pipes shall be linked by mouse click to the referring supplying plants
- All outflow pipes shall be linked by mouse click either to other UGR plants or to the DMAs

Each DMA shall be designated and shown as a symbol (similar to a valve symbol), which shall turn from green to red, if any fault is reported by its RTU.

If complete plant with all these links, is too large for one screen, so it shall be divided into two or more. The links between these parts shall be active on the screen as well.

Additionally a geographical overview screen of the UGR supply area shall alsobe available. It shall be according to the zone overview screen plus DMA symbols, which shall be shown as described before.

### 4.3.3.5 DMA

The DMA mimic shall be a simplified geographical mimic, in which the following symbols are shown

- SCADA controlled ON/OFF valves
- SCADA controlled modulating valves
- Pressure measuring
- Flow measuring
- Water Quality Analysers status

and main pipes, which shall be blue or grey as described before. Referring arrow for flow direction shall be provided too.

The symbols are detailed described before.

Supervisory Control & Data Acquisition (SCADA) and Water Quality Monitoring (WQM) at DMAs

1. DMAs Average/Lowest Point Pressure Control

To achieve the goal of 24x7 water supplies equitably to all the DMAs it is proposed to monitor the Average Pressure and Lowest Pressure Point wireless Pr. Transmitter may be provided to control the Lowest Point pressure by modulating the Control Valve of each DMA. For this, each DMA shall have a underground Valve chamber and a Flow meter chamber, and a Local Control Panel (LCP) above the ground in each DMA at suitable location.

As these LCPs are to be installed in the road side open areas, as such safety measures are required like providing fencing, locating it to a safer place like public garden etc.

Also at some DMAs it will not be feasible to install the LCPs or the Lowest Pressure Transmitters due to non-availability of space, due to small Road width of 6 feet or so, with cluster of houses on both side of the road without any foot-path.

It will also be required to check and ensure that communication signal strength is good at all LCP Locations.

240V 1-phase AC supply connection shall be required at each LCP from near-by source like

electric pole for operation of the Control Valve and Flow Meter etc.

However, for pressure measurements at Average & Lowest Pr. Points we propose to go for suitable tapping with Pr Gauge adopter and a isolating valve.

As the transmission distance of wireless transmitters is limited to 200 meters between LCP and these points, we may have to go for signal boosters if this distance is more.

2. Computerized Maintenance Management System (CMMS) –

A CMMS software package maintains a computer database of information about an organization's maintenance operations. A CMMS software package to maintain a computer database of information about an organization's maintenance operations, i.e. CMMIS – computerized maintenance management information system. This information is intended to help maintenance workers do their jobs more effectively (for example, determining which machines require maintenance and which storerooms contain the spare parts they need) and to help management make informed decisions (for example, calculating the cost of machine breakdown repair versus preventive maintenance for each machine, possibly leading to better allocation of resources). CMMS data may also be used to verify regulatory compliance. CMMS packages also to produce status reports and documents giving details or summaries of maintenance activities

# D. O&M Services

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## SUB-SECTION 1. WORK REQUIREMENTS FOR OPERATION AND MAINTENANCE

### 1.1 Definitions

In Connection with the O&M works, the following words and expressions shall, unless it conflicts with the context or meaning thereof, have the meaning hereinafter as described to them:

(a) Transmission Mains

The water mains carrying clear water from the water treatment plant up to the UGRs. No service connections shall be taken from this pipe line.

(b) Secondary Mains

Trunk water mains from the UGRs to the inlet of the DMAs. No service connections shall be taken from this pipe line.

(c) Distribution network

The entire water distribution network inside the DMA except the Secondary Mains passing through the DMA and Service connections. All service connections shall be made from this water network.

Distribution Network consists of two kinds of pipelines described in earlier sections; Distribution Mains and Distribution Pipes. Distribution Pipes are also called Feeder mains from which Service Connections are given.

(d) Service connection

The water pipe connection from the saddle on the tertiary network (Distribution pipes or Feeder Mains) up to the customer water meter.

(e) Customer service

All the works related to the Customers from receiving the application for new water service connection to the design, supply, installation, reinstatement, supply & installation of the water meter, management of the billing system, reading the water meter, billing and reducing the illegal water connections and Customer care.

(f) Customer

The customer(s) shall mean the registered domestic or non-domestic consumer(s) within the service area receiving service from DJB's water network in the project area.

(g) Active customer
Active customer is the registered customer/ subscriber which is not disconnected or cancelled.

The terms 'customer', 'consumer', and 'subscriber' have the same meaning and may be used interchangeably.

(h) Operator

The Contractor of the main contract will be called as the Operator for O&M Contract/services. So, during the O&M Contract period, the Contractor will mean the Operator. The Contractor and Operator words may be used interchangeably and wouldn't vitiate the meaning.

(i) Water losses

The losses of water from the Transmission and Distribution System (including Reservoirs) added together shall give the Water losses value under the contract. Water losses from the Transmission and Distribution system shall be calculated as per the formula given in other section of this document. The Water Loss considered under this Contract is different from the Non-revenue Water (NRW) in that 'Unbilled authorized consumption' is a part of NRW but not that of Water Loss.

(j) Customer complaint response time

The time measured from formal receipt of complaint by the Operator until the formal completion of work under the complaint.

(k) Repair or maintenance response time

The time measured from formal receipt of information about a complaint until formal completion of work under the complaint.

(l) Old Assets/ Existing Assets

The Assets existing at the time of handing over the Project Site / Project Facilities to the Operator for execution of works and O&M of the system. The Operator shall make a comprehensive Asset Register in the Preparatory Period along with DJB personnel. The Asset Register shall clearly mark the Assets handed over to the Operator.

(m) New Assets

The Assets created during the Construction / O&M period of this Contract.

## 1.2 Objectives of Operation and Maintenance

The objective of this O&M contract is to ensure an efficient operation and maintenance of Water Supply and Distribution System by providing safe and clean drinking water distributed equitably in the project area at a specified quantity, quality and pressure on a continuous & sustainable basis in economic cost as possible. The Operator shall be entrusted with the work for Transmission mains, UGR's, Booster pump stations, Machinery & equipment, Distribution system, and Customer services (excluding revenue collection) for the provision of continued and satisfactory service to the user of the water supply system by effective control, deployment of technical & experience personnel and maintenance of worn or damaged items for continuous serviceability. The responsibility of Operator shall also include Water Loss

reduction. The DJB shall hand over all O&M technical functions as well as customer interfacing activities (except revenue collection) to the Contractor from the Construction phase (after preparatory period) up to the end of post-construction O&M period.

## 1.3 Operation and Maintenance Contract Period

The O&M contract period shall be for Nine (9) years and 6 months starting from the six months after the award of work. The initial 6-months period will be considered as Preparatory Period during which DJB will continue to be responsible for the O&M works. During preparatory period, the contractor shall assess the condition of the existing system, prepare the inventory of assets and undertake all necessary physical and documentation works for taking over of the entire system from DJB for subsequent O&M activities including customer services.

The O&M Contract is divided into two parts; O&M during the construction phase and O&M during post-construction phase as in Table below.

| S.N. | Phase | Period | O&M Works | Remarks |
|---|---|---|---|---|
| 1 | O&M during Construction Phase | 4 years and 6 Months | O&M of all existing system and new assets created and commissioned during the construction phase | The performance and payment conditions are different for each phase. |
| 2 | O&M during Post-Construction Phase | 5 years | O&M of entire system (New and Old) | |

The conditions of contract, particularly on performance and payments, shall differ for each phase as described in these documents.

During construction phase, works are expected to be completed and commissioned on cluster-wise basis gradually. The O&M conditions for the existing as well as new assets in this period shall be subjected to the O&M during Construction Phase.

The Conditions related to O&M during post-construction phase would be applicable from the 6th year onwards with a six-month's grace period initially.

## 1.4 Modality of O&M Contract and Payment

The Contract and Payment terms and conditions for the O&M works shall be of two types as follows.

(1) O&M during Construction Phase (i.e. from the end of preparatory period till the end of overall construction phase of 5 years):
- In this period, the payment shall be made on Fixed fee rate basis. The Operator will be paid on monthly basis but after deducting of withholding sum (e.g.

control of water loss is not achieved to the desired level during construction) and penalties, if any applicable.

No O&M Cost will be paid beyond 4.5 years in the Construction Phase if the delay is attributable to the contractor.

(2) O&M during Post-Construction Phase (i.e. from the beginning of 6th year till the end of 10th year of the Contract):

- In this period, the O&M sum will be split and calculated in two parts; fixed payment and performance-based payments. Performance-based payment shall be calculated based on the performance assessed on the specified KPIs and their calculation method in the contract.
- However, there will be six (6) months grace period initially (initial 6 months of the Post-construction O&M period). During this period neither any penalty shall be levied for failure to meet the defined benchmark of any KPI nor any incentive shall be paid for exceeding the defined benchmark of Water Loss. In this period, the Operator would be expected to do any and all kinds of works required for achieving the KPIs targets but at no additional cost to the Employer.
- The payment shall be made on billing cycle basis (normally bimonthly) so as to assess the KPIs and corresponding payment amounts.
- The annual O&M amount quoted by the Operator shall be split equally into the billing cycle basis.
- Any penalties, recoveries or withholding sums leviable due to non-compliances on the contractual conditions or performances shall also be deducted from the running bills.

| S.N. | O&M Phase | Contractor's quoted amount in the Contract (Price Schedules) | Billing Frequency (Running Bills) | Applicability of Penalties, Recoveries, Incentives and Withholding sums as per contract conditions |
|---|---|---|---|---|
| 1 | O&M During Construction Phase | Annual Basis | Monthly.<br>Annual figure to be split into monthly on equal basis. | Applicable on each Running Bill for adjustment. |
| 2 | O&M During Post-Construction Phase | Annual Basis | As per Customer's Billing cycle (normally Bi-monthly).<br>Annual figure to be split into Bi-monthly on equal basis. | Applicable on each Running Bill for adjustment after six (6) month's grace period. |

During the entire O&M period, electricity charges for net consumption (total consumption less the solar power generated) supplied through Power Company grid shall be borne by the Employer to the extent of maximum guaranteed net energy consumption quoted by the Operator. If actual net energy consumption exceeds the maximum guaranteed value, the charges for the excess net energy consumption shall be borne by the Operator including any other levies/penalties such as on required minimum power factor.

## 1.5 Asset Ownership

The ownership of the entire assets including the customer water meter remains with DJB. The isolating valve installed at the outlet of the customer water meter will be the boundary between the public network and the customer property.

The Customer shall not be allowed to replace, repair and change any part of the water network which is owned by DJB including the water meter.

## 1.6 Scope of Works- O&M of Water Supply System including SCADA and other Instrumentation- Overall

The main objective of the project is to achieve the equitable distribution and continuous water supply in the West zone by the use of stable operation of the water transmission mains, UGRs, BPS, the distribution network, customer service works and water loss reduction works in the West zone in addition to attainment of 24×7 water supply in required quality and quantity at adequate pressure.

The Operator shall operate and maintain the water transmission mains, the underground reservoirs, the booster pumping stations, the water distribution network, customer service works and all allied works under the Contract in West zone.

The Operator shall operate and maintain (old & new assets) water supply system including SCADA and other instrumentation equipment installed/retained under the contract during the construction period. The O&M works shall be carried out as specified in this contract and as per CPHEEO's manual "Operation and Maintenance of Water Supply Systems", CPWD specifications, other international codes or international best practices under the approval of the Engineer. The O&M (old and new assets) activities shall include but not be limited to:

- Transmission system from the Chandrawal water treatment plant to various UGRs and appurtenances.
- Underground reservoirs (UGRs).
- Booster pumping stations (BPSs).
- Water distribution system.
- All the Buildings, Civil Structures, SCADA & CCTVs Systems.
- Preventive and breakdown maintenance of District Meters, data loggers, water quality testing units and other fixtures for smooth functioning to make sure that the flow and other data are recorded/transmitted for the purposes intended under the contract. The Operator shall make sure that the power supply to the district meters are working properly with preventive maintenance.
- Update the GIS maps prepared during the construction period for any addition and deletion in the system for transmission and distribution mains and their appurtenances and use them for O&M works. The maps shall show the pipe diameters, material, year of laying, routes, location of valves, flow meters and pressure gauges etc.
- Operation of transmission, UGRs and BPSs for continuous supply of water to the distribution system including proper operation of valves, level gauges, flow meters and

all other appurtenances either by manual or by SCADA systems as required to maintain 24X7 supply with adequate pressure.

- Preventive and routine maintenance of the pipelines and appurtenances (all kinds of Valves such as gate, butterfly, Air, Washout etc) and repair/replacement in case of bursts or leaks. Maintenance and rehabilitation of chambers and their covers.
- Preventive and routine maintenance of all the bulk water meters and their instrumentations. Measurement of inflows and outflows at all the identified strategic locations to calculate the net flow and water loss level for the contract.
- Preventive and breakdown maintenance of SCADA system with all instrumentation equipment including PLC and RTUs.
- Regular leak detection surveys shall be undertaken to locate the leaks and arrest of the same. Thrust should be given to the mains which are frequently leaking. Arresting of the identified leaks shall be carried out irrespective of the water loss level in the system.
- Sufficient stock of spare parts (special for pipes, leak repair clamps, spare parts for instrumentation equipment etc.) for all assets shall be maintained for regular maintenance of the system including replacement of damaged ones.
- Records should be maintained for operations and maintenance of transmission system, UGRs, BPSs, distribution system, etc.
- The repair/replacement/laying works for the transmission/distribution system shall include excavation, supply, installation, testing, commissioning, disinfection and reinstatement to complete in addition to any other works or resources required to complete the works.
- Identification and reporting of illegal connections to DJB for action (legalization/disconnection) as per DJB bye-laws.
- Monitoring of achieved water loss level (target level), calculation of the water loss level and reduction of the same if it exceeds the target level as required in the contract
- Service connections and customer water meters. Providing of new service connection as well as replacement of old connections as necessary with fixing of water meters.
- Ensuring stable operation of the water system to attain water quality and quantity with adequate pressure for equitable and continuous water supply.
- Reading of water meters and issuing water bills.
- Flushing & cleaning of pipes and other assets as and when required.
- General cleanliness in and around of all the assets under the contract including maintenance of road, lights and horticulture works in all the premises shall be maintained.
- Appropriate safety measures to prevent access of unauthorized persons to the premises of any assets under the contract shall be taken.
- Painting of all the assets under the contract shall be carried out at least once in every three years.
- Maintenance of roads, pathways, buildings, street lights, horticulture, storm water drains, water supply and wastewater pipelines within the premises of UGRs, BPSs, office buildings etc.
- Maintenance of solar power generating systems, electric supply lines and other utilities within the UGRs, BPSs, office buildings etc.
- Ventilation and lighting systems shall be maintained at all the buildings/assets.
- Fire-fighting system shall be provided at all the premises of the assets under the contract.

- Standby power units shall be provided at all the premises of the assets as per the contract.
- Office and administration areas, including room for lockers, dress change and utilities for sanitary and hygienic needs of the working staff.
- All necessary works required for achieving Key Performance Indicators (KPIs) and Power consumption guarantee as envisaged under the contract
- Attending customer complaints, water leakage complaints and other related improvement works.
- All the costs related to the supply, installation and works shall be borne by the Operator.
- Preparation/review of the O&M manual and standard procedures for all the components of work under the contract. The procedures shall also include the operations of the system in the expected abnormal conditions.

Within the Operator's quoted cost, the Operator is to ensure that the KPIs and Power consumption guarantees are maintained during the operation and maintenance period. Each is explained in further detail in a separate section.

At the end of the 9th year of the Contract, an assessment on the condition of the water system facilities under the O&M contract will be done by the Employer and based on that assessment the Operator shall, at no extra cost to the Employer, repair and recondition all the mechanical and electrical equipment in the concluding year of the O&M contract to a good operational condition with regular preventive and recommended maintenance as per manufacturer's instructions.

### 1.6.1 O&M of Transmission mains

The Operator shall operate and maintain the old & new transmission mains and their appurtenances. The O&M activity of the transmission mains shall include but not be limited to:

- Regular leak detection surveys shall be undertaken particularly for bursting pipes and leaky joints. Arresting of the identified leaks shall be carried out irrespective of the water loss level.
- Sufficient stock of spare pipes, leak repair clamps, appurtenances and specials shall be maintained for replacement of damaged pipes and arrest of leaks.
- Measurement of water loss level as required by the Contract.
- No service connections will be given from the Transmission Mains.

### 1.6.2 O&M of Underground Reservoirs

The Operator shall be responsible for the operation and maintenance of the old & new UGRs. The O&M activities for the UGRs shall include but not be limited to:

- Measurement of inflows and outflows.
- Inspection and repair of the structural leakages if any. Water tightness should be tested annually.
- Maintenance of reservoir opening covers and ladders, air vents, valves, pipes, appurtenances, boundary walls etc. The manhole opening, ventilating shafts and overflow pipes shall be properly closed and protected.

- Cleaning and flushing of the reservoirs shall be undertaken at least once a year. During the cleaning process, there should be facility to bye-pass the supply to distribution system.

### 1.6.3 O&M of Booster Pumping Stations

The Operator shall be responsible for the operation and maintenance of the BPSs. The O&M of the BPSs shall include but not limited to the O&M of:

- Preventive and breakdown maintenance of pumping units, motors and all appurtenances including electrical equipment, panels and starters.
- Improvement of the power factor to not less than 98%.
- Standby power units.

### 1.6.4 O&M of Distribution Systems

Distribution Systems include all the pipelines and assets from the outlet of the UGRs till the Service Connections. The Operator will be responsible for the O&M of the entire Distribution System (old & new). The O&M activities shall include but not be limited to:

- Ensuring stable water supply with required quality and quantity for equitable and continuous water supply with adequate pressure in the contract area.
- Carrying out water loss calculations for all DMAs, Clusters and contract.
- Inspection, maintenance & replacement of the customer water meters.
- New service connections approved by DJB shall be given from distribution mains intended for providing service connections with water meter.
- Ensure 0.2mg/l of residual chlorine in the distribution system.

### 1.6.5 O&M of Solar Energy System

The Operator will be responsible for the O&M of the Solar Energy System. The Operator shall install an energy meter to measure the power production from this system.

### 1.6.6 O&M of Local Water Management System (Distribution SCADA system)

The Operator shall operate and maintain the Local Water Management Centre (LWMC), SCADA for West Zone, in synchronization with the CWMC. The Operator shall be responsible for all complaints concerning his work in his zone. The Operator shall reduce the complaint response time to the acceptable levels as per KPIs otherwise he will be subjected to the penalties as per the conditions.

### 1.6.7 Water Loss Reduction

The Operator shall be responsible for reducing the Water Loss level as per target levels specified in the section (NRW reduction and KPIs) during the construction period and maintain it during the Post-construction O&M period. The operator shall also be required to undertake construction works / O&M works during construction period in a manner to meet

the intermediate targets of Water Loss during construction period. During the Post-construction O&M period, contractor should adopt pro-active measures to control the water loss level below the target level and if the water loss level increases beyond the target level, Contract shall adopt best practices of water industry to bring it back to the target level. As part of pro-active measures, contractor should have sufficient leak detection teams for carrying out active leak detection during the Post-construction O&M period to maintain the target level. The leak detection team shall carry out routine as well as planned leak detection activities using the best method and equipment suited for the West zone water supply network.

Also the Contractor should test about 5% of consumer water meters for accuracy. If the tested meters fails accuracy level, the failed meters should be replaced with new meters in consultation with DJB.

Contractor to maintain sufficient stock for leak arrest such as repair clamps, specials, pipes, consumer meters etc. required for maintenance of water loss level at target level.

## 1.7 Operation of DMA, Water Distribution and Billing System

### 1.7.1 Water Facilities

The Operator shall deploy trained staff for the operation of the water facilities, solar energy equipment and SCADA system. In case of any damage to the facilities equipment due to negligence of the Operator or due to faulty operation, it shall be the sole responsibility of the Operator to replace/repair the equipment as per standards of the equipment at free of cost. In case of any fault in operation, maintenance and performance of the facilities, Operator or the Operator's staff at duty will immediately report to the Employer/Engineer about it.

The Operator shall run the facilities at the proper voltage. Operator shall record all power failures and voltage levels in daily log sheet. Operator will bring into the notice of power supply agency as well as CWMC and Employer/Engineer about all power failures and related breakdowns. Operator will also get the electricity restored immediately.

Any dispute with the workmen shall be Operator's responsibility as per Labor Laws/Government Rules and Regulations. In no way the Employer/Engineer shall be responsible for the disputes between them. The Operator shall follow the rules and regulations as per Factory Act as applicable. The Operator shall arrange all necessary required tools, tackles and instruments in advance for proper operation and maintenance of the entire facilities.

The Operator shall operate and maintain all electrical, control, instrumentation, SCADA, mechanical equipment and water lines and other allied works under this scope as per the instructions of the respective equipment manufacturer.

### 1.7.2 DMA Structure

The DMAs are designed by the Employer such that:

- DMAs boundaries were established during the construction period by conducting PZTs, therefore, DMAs have clear cut hydraulically discrete boundaries.
- All the DMAs have known inlets and out lets with clear cut boundaries.

- Pressure monitoring points (average zonal point and critical point) have been identified, established and mapped in each DMA.

If there is a need to adjust the DMA boundaries then the Operator shall do after taking the approval from the Employer/Engineer. The boundary adjustment shall be reported and adjusted on the GIS based maps.

### 1.7.3 DMA Isolation

All the DMAs were established by conducting PZTs during the construction period, therefore, all the DMA boundaries are water tight and hydraulically discrete.

However, the Operator shall inspect and assure that:

- The consumption from the water distribution network in the DMA is only by customers from the same DMA. Cross connections with other DMAs are not allowed.
- All the customers inside the DMA boundary shall get their water from their DMA water distribution network.
- The Operator shall inspect the service connections of all premises on the DMA boundary to cancel any cross connection between DMAs.

### 1.7.4 DMA Water Meters

The Operator shall do and ensure the following:

- The water supply to the DMA network shall be measured by bulk water meter installed for this purpose.
- All the water consumption from the DMA water distribution network shall be metered.
- The Operator shall have the stock of sufficient customer's water meters as per technical specifications and bill of quantity for replacement as and when required during the O&M.
- The Operator shall replace the defective and not working meters noticed during the O&M period.
- The operator to test the consumer meters installed by him and existing for accuracy on routine basis to ascertain the accuracy. However, during the test, if the tested meters (installed by the operator) fails the accuracy test shall be replaced with new meter at no cost to the employer.

The Operator shall install, seal and report to the customer service billing system the initial reading of the meter, the serial number of the meter, type, size, date of installation, customer name and the customer identification number (KNO).

### 1.7.5 DMA Process Monitoring parameters

The water supply to the DMA shall be monitored to have the working pressure in the DMA water distribution network within the designed range as under:

- Pressure monitoring will be at the inlet of the DMA.
- Pressure monitoring/control at Lowest pressure point (Critical point) or Average pressure point as per site suitability of space. This pressure has to be kept not less than the prescribed value

- SCADA system shall be used to monitor pressure at the DMA critical points.
- On line Residual Chlorine monitoring will be done at the farthest point in the DMA.

### 1.7.6 Illegal water use

Illegal water use from the public water distribution system represents a considerable portion of the apparent water losses. The Operator will be fully authorized for inspection, identification and reporting to DJB for further action i.e. either disconnection or regularize the connection. The Operator shall prepare the procedures necessary to reduce the illegal water consumption and to discuss these procedures with the Employer and take his approval before implementation. The DJB water bylaw and regulations and instructions contained in it shall be the reference for the preparation of the procedures. Please refer to: Delhi Water & Sewer (Tariff and Metering) Regulations, 2012and revised up to date.

### 1.7.7 Water Quality

The Operator has to test the water quality from designated locations in the water distribution network on periodical basis and from the customers water tap when required as per the standard practice (as per CPHEEO manual or IS 10500) and report the results to the Employer. There should be no substantial deterioration on the water quality from the level supplied from the WTP except on residual chlorine which should also comply to the minimum level of 0.2 mg/l.

The Operator shall supply all the necessary equipment to monitor and test the drinking water quality. The Operator can use his own Lab or accredited Lab from the private sector. In both cases, the lab shall be available all the time including holidays. DJB/Engineer shall have the access to monitor the water quality all over the water system.

The Operator shall be responsible for taking samples and analyze for the different types of parameters. The number of samples for all types of tests and parameters shall be as detailed elsewhere in this report.

The Employer/Engineer can instruct for other locations or increase the number and type of samples if it considers so necessary in view of potential contamination and the operator has to oblige the same without any additional cost to the Employer.

## 1.8 Customer Service

The Operator will be responsible for customer service works which will include but not limited to:

- O&M of the customer’s water meters
- O&M of the service connections
- Reading of the customer water meters
- Billing of water consumption as per water meter reading
- Handling the customer’s complaint or objections for the water meter reading and billing
- Handling the customer’s complaint for low pressure or shortage of water
- Handling the customer’s complaint for water quality
- Train DJB staff for customer care.

For applicable DJB instructions and regulations, Delhi Water & Sewer (Tariff and Metering) Regulations, 2012(amended up-to-date) may be referred to.

### 1.8.1 Type of Water Service Connections

(1) Domestic service connection:

The connection serving the people for the need of only domestic purposes like drinking, cooking, bathing, washing cleaning & flushing of toilets, and individual air conditioning; is termed as domestic connection,

(2) Institutional service connection:

The connection serving the institutes like schools, colleges, Govt. & semi Govt. offices, Govt. Hospitals, charitable trusts, and institutions not run for profit; is termed as institutional connection.

(3) Commercial service connections

The connection serving any institute or organization like Hostels, Shops, Theatres, Laundries, Community halls, private hospitals, Hotels etc. which are being run for profit; is termed as commercial connection.

(4) Industrial service connection

The connection serving industries like oil mills, paper mills, ice factories, service stations, workshops, foundries packaging industries or any other industry which consumes water for producing the final product directly or for the purpose of serving domestic needs of the people working or staying in the premises of industries; is termed as industrial connection.

For exact and further details, the Operator shall refer to Delhi Water & Sewer (Tariff and Metering) Regulations, 2012 amended up-to-date and understand accordingly.

### 1.8.2 Providing Service Connection

Permanent subscription: Any person or consumer intending to have a new connection of water supply or transfer of existing connection or alternation in the existing connection shall apply by making an application to the Employer directly.

Temporary subscription: an application for supply of water for construction activities shall be considered by DJB depending on the availability of water and it has to be converted to permanent connection after paying the required fees. Otherwise it has to be disconnected.

Cancelling the service connection or transferring from one name to another shall be dealt by DJB as per laws & regulations.

The Operator shall follow all laws and regulations concerning customer services. If any changes are needed, it has to be approved by the Employer.

DJB will collect the service collection fees, cost, deposits etc. directly.

For any new connection request during post-construction O&M period, the Operator shall study and design the requested service connection. The design shall include the length, size and route of the service connection. The design shall be on GIS based maps.

The Operator shall supply, install and reinstate the service connection with the water meter, seal the meter and report to the Computerized Billing System so as to be included in the reading and billing sequence. The operator shall also update the GIS map with the service connection on the water system drawings.

### 1.8.3 Meter Reading and Billing System

#### 1.8.3.1 Computerized Billing System

The Employer shall provide the Operator access to the computerized billing software (for his service area) without charges. The Operator shall not be allowed to create a separate database for the customers within the Service Area for the purpose of billing. The Operator will be required to feed in, the customer meter data and generate bills on behalf of the Employer. In case the Operator requires any additional reports that are not available through the software, the Employer shall make the same available to the Operator if it is requested.

#### 1.8.3.2 Reading and Billing Procedure

The Operator shall read the customers water meters and issue the bills as per the Employer's water by-law, regulations and instructions.

- After finishing the preparatory period, the Operator shall be responsible for the reading, and billing operations as per the prevailing water tariff notification.
- The reading, billing operations shall be done bi-monthly.
- The bill form will continue to be by the name of the Employer and the Operator will work on behalf of the Employer. If the Operator decided to modify the water bill form then he has to take the approval of the Employer.
- The Operator will bear the cost of printing of the water bill forms. The Employer shall support the Operator by an official letter that he is authorized to do that.
- The Employer shall issue the necessary official letters to the official departments that Operator is authorized to work on behalf of the Employer and to cooperate and facilitate his work.
- DJB will collect all the water charges, security deposits, new connection fees or cost and any other fees.
- If the water tariff is revised; increased or adjusted, the Employer will be responsible for developing the Computerized Billing System to suit the new water tariff.
- The Operator shall carry out the reading and billing operations only in his contract service area.

Delhi Jal Board is also introducing another new age solution for all smart consumers. Consumer can now download the DJB Mobile Application on their smart phone to view and pay Water Bills with any time anywhere convenience. This application virtually brings the DJB office right before consumers. The Operator shall make use of this App too.

#### 1.8.3.3 Doorstep reading and billing

To improve the quality of service, the Operator shall carry out the following:

- The Operator shall prepare the GIS based routes for the reading of the water meters and billing.
- The Operator shall use the Handheld Units or units with Barcode for Door Step Billing (reading, issuing and distributing the bills in one stage) and download the data on daily basis.
- The Operator shall find a way to interface the location of the Customers on the GIS with the KNO of the RMS. This will enable the Operator to map the reading and billing routes properly.

### 1.8.4 Customer Service Procedures

The Operator shall use the existing procedures. If the Operator wants to develop these procedures, he has to prepare and discuss with the Employer to take his approval before applying it. The procedures shall cover the following activities:

- New water service connection application and approval process to be handled directly by DJB.
- Reading and billing procedures.
- Handling the customer's objections for the charged water quantities.
- Testing of the DJB customer water meter & replacement.
- Handling water meter vandalism cases.
- Handling illegal water consumption cases.
- Replacement of private meter.

### 1.8.5 Disconnection of the Service Connection

The Operator shall work with the compliance to the Employer's water by-law, regulations and instructions. The Operator may face the following undesirable situations among others, which has to be handled properly.

- The customer installing a pump directly on the service connection.
- The customer damaging the sealing wire before and after the water meter.
- The customer damaging the factory seal of the water meter.
- The customer damaging the meter.
- The customer is not putting the water meter in a box to protect it from adverse environmental conditions.
- The customer is consuming water by an illegal connection.
- Wasting the water.

The Operator will be authorized to apply the Water Bylaw and DJB regulations for the inspection , disconnection and reconnection of the water service with due approval from DJB.

## 1.9 BPS/UGRs for operation during Construction Phase

| S.N. | Name | S.N. | Name |
|---|---|---|---|
| 1 | Gali No. 8 Baljeet Nagar | 26 | Pandu Nagar |
| 2 | Gali No. 6 Prem Nagar | 27 | Naraina |
| 3 | 35 Block West Patel Nagar | 28 | Naraina Village (online BPS ) |
| 4 | Shiv Charan Ranjeet Nagar | 29 | Shadi Pur |
| 5 | C1 Block Ranjeet Nagar (No existence) | 30 | Rock garden |
| 6 | Khanna Market | 31 | Janta Park |
| 7 | C Block Ranjeet Nagar | 32 | Shivangi Kunj 320 Flats |
| 8 | O Block West Patel Nagar | 33 | Pragati Appt. 356 Flats |
| 9 | 28 Block West Patel Nagar | 34 | Kharra Market |
| 10 | Old Farid Puri | 35 | Patel Nagar Online BPS |
| 11 | New Farid Puri | 36 | Sarai Basti BPS |
| 12 | D Block Karam Pura | 37 | Shahzada Bagh BPS |
| 13 | Nehru Nagar (online BPS ) | 38 | Inder Lok BPS |
| 14 | Durga Park (online BPS) | 39 | Gulabi Bagh BPS/Shastri Nagar |
| 15 | Dusghara Village (online BPS) | 40 | Vivekanandpuri BPS |
| 16 | Dusghara Village | 41 | Daria Nala BPS |
| 17 | Jullahana Mahola, Naraina Village | 42 | Than Singh Nagar BPS |
| 18 | I Block Naraina Vihar | 43 | Bapa Nagar BPS |
| 19 | H- Block Naraina Vihar | 44 | Sarai Rehilla BPS |
| 20 | Inder Puri | 45 | Zakhira |
| 21 | Toda Pur | | |
| 22 | Rajender Park, Old Rajender Nagar (not in use) | | |
| 23 | Rajender Nagar | | |
| 24 | Near Dispansary, Naraina Village | | |
| 25 | (online BPS ) | | |

Note: During the period of construction phase of 5 years, some of the existing UGR/BPSs would be abandoned and some newly constructed/rehabilitated UGR/BPSs would be put in operation, especially from the beginning of 4th year onwards as per the planned cluster-wise completion schedules.

## 1.10 BPS/UGRs for operation during Post-Construction O&M Period

| S.N. | Name | UGR status | BPS status |
|---|---|---|---|
| 1 | Shastri Nagar | Existing Rehabilitated | Existing Rehabilitated |
| 2 | Zakhira | New Built | New Built |
| 3 | Janta park | Existing Rehabilitated | Existing Rehabilitated |

| | | | |
|---|---|---|---|
| 4 | Shadipur & Rock Garden | Existing Rehabilitated and New Built | Existing Rehabilitated and New Built |
| 5 | New Rajendra Nagar | New Built | New Built |
| 6 | Naraina | New Built | New Built |
| 7 | Than Singh Nagar | Existing Rehabilitated | Existing Rehabilitated |

Note: Solar Power generation and utilization is also in this scope.

## 1.11 Preventive Maintenance of Equipment and Plants

Preventive maintenance (PM) is defined as those maintenance procedures that are implemented repetitively at regular interval. Preventive maintenance aims to keep the breakdown to minimum for critical equipment and plants. However certain breakdown may occur in spite of proper maintenances. Therefore, the Operator shall take the breakdown maintenance on top priority to keep the disruption to the systems at a minimum level.

The works carried out for routine and preventive maintenance shall consist, but not be limited to, the following.

- Greasing, oil changing, provide fuel, distilled water, recharging gas;
- Cleaning from dust, mud and sediments, testing, calibrating, checking of tightness of all connections, general cleaning for the body, charging, cleaning filters;
- Check gauges, adjust gland - packing and repair or replace if required;
- Replace worn-out drain lines, fittings replace fuses, bulbs and similar, if required;
- Inspecting all fans, compressors, motors wiring, switches,
- Check for correct operation;
- Any other related works in accordance with manufacturer specifications and instructions.

### 1.11.1 Routine/Preventive maintenance for Pumpsets and Motors

(a) Daily Maintenance
- Clean the pump, motor and other accessories.
- Check coupling bushes/rubber spider.
- Check stuffing box, gland etc.
- Servicing as per Manufacturer’s/supplier's instructions

(b) Monthly Maintenance
- Check free movement of the gland of the stuffing box; check gland packing and replace if necessary.
- Clean and apply oil to the gland bolts.
- Inspect the mechanical seal for wear and replacement if necessary.
- Check condition of bearing and replace if necessary.

(c) Quarterly maintenance
- Check alignment of the pump and the drive. The pump and motor shall be decoupled while correcting alignment, and both pump and motor shafts shall be pushed to either side to eliminate effect of end play in bearings.
- Clean oil lubricated bearings and replenish with fresh oil. If bearings are grease lubricated, the condition of the grease should be checked and replaced/replenished to the correct quantity. An anti-friction bearing should have its housing so packed with grease that the void space in the bearing housing should be between one third

to half. A fully packed housing will overheat the bearing and will result in reduction of life of the bearing.

- Tighten the foundation bolts and holding down bolts of pump and motor mounting on base plate or frame.
- Check vibration level with instruments if available; otherwise by observation.
- Clean flow indicator, other instruments and appurtenances in the pump house.

(d) Annual Inspection and Maintenance

Pumps:

- Clean and flush bearings with kerosene and examine for flaws developed, if any, e.g. corrosion, wear and scratches. Check end play. Immediately after cleaning, the bearings should be coated with oil or grease to prevent ingress of dirt or moisture.
- Clean bearing housing and examine for flaws, e.g. wear, grooving etc. Change oilor grease in bearing housing.
- Examine shaft sleeves for wear or scour and necessary rectification. If shaft sleeves are not used, shaft at gland packings should be examined for wear.
- Check stuffing box, glands, lantern ring, mechanical seal and rectify if necessary.
- Check clearances in wearing ring. Clearances at the wearing rings should be within the limits recommended by the manufacturer.
- Check impeller hubs and vane tips for any pitting or erosion.
- Check interior of volute, casing and diffuser for pitting, erosion, and rough surface
- All vital instruments i.e. pressure, vacuum, ammeter, voltmeter, watt meters, frequency meter, tachometer, flow meter, testing equipments etc. shall be calibrated.
- Conduct performance test of the pump for discharge, head and efficiency.
- Measures for preventing ingress of flood water shall be examined. Ingress of flood water in sump, reservoir etc shall be strictly prevented.
- Check vibration level

Motors:

- Clean external surface of motor.
- Examine earth connections and motor leads.
- Check temperature of motor and check whether overheated. Temperature observation should be taken with RTD or thermometer.
- In case of oil ring lubricated bearing. Examine bearings to check whether oil rings are working.
- Note bearing temperature.
- Add oil if necessary.
- Check for any abnormal bearing noise.
- Blow dust from the motor.
- Check functioning and connections of anti-condensation heater (space heater).
- Check insulation resistance by meggering.
- Clean winding of motor, bake and varnish if necessary.
- Check condition of stator, stamping, insulation, terminal box, fan etc.
- Check insulation resistance to earth and between phases of motors windings, control gear and wiring.

### 1.11.2 Routine/Preventive Maintenance for Valves

(i) Sluice valve and Knife gate valve

- Check gland packing of the valve at least once in a month. It shall be ensured that packings inside the stuffing box are in good trim and impregnated with grease. It may be necessary to change the packing as often as necessary to ensure that the leakage is within limit.
- Grease should be applied to reduction gears and grease lubricated thrust bearing once in three months.
- Check tight closure of the valve once in 3 months.
- A valve normally kept open or closed should be operated once every three months to full travel of valve and any jamming developed due to long disuse shall be freed.
- Inspect the valve thoroughly for flaws in guide channel, guide lugs, spindle, spindle nut, stuffing box etc. at least once in a year.
- It should never be operated with oversize hand wheel or cap or spanner.

(ii) Reflux (non-return) valve

- Check proper operation of hinged door and tight closure under no-flow condition once in 3 months.
- The valve shall be thoroughly inspected annually. Particular attention should be paid to hinges and pins and soundness of hinged door.
- Condition of dampening arrangement should be thoroughly examined once in year and necessary maintenance and rectification as per manufactures' instructions shall be carried out.
- In case of dampening arrangement, check for oil leakage and replace oil once in a year.

(iii) Butterfly valve

- Check seal ring and tight shut-off once in 3 months.
- Lubricate gearing arrangement and bearing once in 3 months.
- Inspect the valve thoroughly including complete operations once in a year.
- Change oil or grease in gearing arrangement once in a year.
- Operate bypass valve wherever provided once in 3 months.
- Flange adapter/dismantling joint provided with valve shall be loosened and retightened once in 6 months to avoid sticking.

(iv) Valve Actuators

- Declutch and operate manual hand wheel.
- Check oil level and top up if required.
- Re-grease the grease lubricated bearing & gear trains and change oil or grease in gear box and thrust bearing as required.
- Check insulation resistance of the motor.
- Check for undue noise and vibration and take necessary rectification measures.
- Tighten limit switch cams and check for setting and readjust if necessary.
- Examine all components and wiring thoroughly and rectify as necessary.
- Check condition of gears & replace gears if teeth are worn out.

### 1.11.3 Panels, Starters, Breakers, Contactors and Protection relays

(a) Daily Maintenance

- Clean the external surface.
- Check for any spark or leakage current.
- Check for overheating.
- Check spring charging mechanism and manual cranking arrangement for operation.
- Clean all exposed insulators.
- Check trip circuit and alarm circuit.
- Check opening & closing timing of breaker

(b) Monthly Maintenance

- Blow the dust and clean internal components in the panel, breaker and starter.
- Check and tighten all connections of cable, wires, jumpers and bus-bars. All carbon deposits shall be cleaned.
- Check relay setting.
- Check spring charging mechanism and manual cranking arrangement for operation.
- Clean all exposed insulators.
- Check trip circuit and alarm circuit.
- Check opening & closing timing of breaker

(c) Quarterly Maintenance

- Check all connections as per circuit diagram.
- Check fixed and moving contacts and clean with smooth polish paper, if necessary.
- Check insulation resistance.
- Check condition of insulators and Busbars.
- Check control circuits including connections in marshalling boxes of breakers and transformer.

(d) Yearly/Two yearly Maintenance

- Check and carry out servicing of all components, thoroughly clean and reassemble.
- Calibrate voltmeter, ammeter, frequency meter etc.
- Testing of protection relay with D.C. injection shall be carried out once in a year.
- Servicing of MV breaker and contactor shall be carried out once in 2-3 years.
- Check male & female contacts for any pitting and measure contact resistance

### 1.11.4 Transformer and Substation

(a) Daily Maintenance

- Check winding temperature and oil temperature in transformer and record
- Check leakages through CT/PT unit, transformer tank and MV/LT bushings.

(b) Monthly Maintenance

- Check relay contacts, cable termination, connections in marshaling box etc.
- Check operation of switches and fuse assembly.
- Pour 3-4 buckets (6 to 8 buckets in summer) of water in earth pit. The frequency of watering shall be increased to once in a week in summer season. The water for earthing shall preferably contain small amount of salt in solution.
- Inspect MV/LT bushing for cracks and dirt.

(c) Quarterly Maintenance

- Check insulation resistance of all equipments in sub-station, continuity of earthings and
- Earth leads.
- Check operation of tap changing switch.

(d) Yearly/Two yearly Maintenance

- Check insulation resistance of transformer.
- Check contact faces of switch
- Measure resistance of earth pit. Resistance shall not exceed 1 ohm.
- Check bus bar connections, clean contact faces, change rusted nut bolts.
- Calibrate the protection relay for functioning. Check relay setting and correct if necessary.
- Ensure that sub-station area is not water-logged.
- Check drainage arrangement to prevent water logging in substation area and cable trenches.
- Painting of transformer tank and steel structure of sub-station equipments shall becarried out after every two years.
- The core of transformer and winding shall be checked after 5 years for transformer

### 1.11.5 Lifting Equipment

The maintenance schedule shall be applicable for lifting equipments, i.e. chain pulley block, monorail (travelling trolley and chain pulley block), manually operated overhead crane and electrically operated travelling crane shall be as follows.

(a) Quarterly Maintenance

- Check oil level in gear box and top up if required.
- Check for undue noise and vibration.
- Lubricate bearings and gear trains as applicable.
- Check insulation resistance of motors.
- Clean limit switches.
- Clean all electrical contacts.

(b) Yearly/Two yearly Maintenance

- Change oil in gear box.
- Conduct load test of crane for rated load or at least for maximum load required to be handled. All fast moving components which are likely to wear should be thoroughly inspected once in a year and if necessary shall be replaced.

## 1.12 Minimum Staff to be deployed for O&M for Civil Works Division

The Operator shall deploy a minimum of following number of personnel with their required qualifications for O&M during construction phase & during post construction phase

**Minimum Staff deployment as per required qualifications for O&M (Civil Division)**

| S. No. | Designation of personnel | Qty- Numbers |
|---|---|---|

| | | **During Construction Phase** | **During Post Construction Phase** |
|---|---|---|---|
| 1 | Asstt. Manager (Trans & Distribution network) Civil/Electrical/Mechanical Engineer, 8 years experience in water sector and at least 3 years in similar works. | 1 | 1 |
| 2 | Accountant | 2 | 2 |
| 3 | Attendant (Call Center) | 7 | 7 |
| 4 | Supervisor (Technical) Civil Engineer, 3 years experience in similar works. | 4 | 4 |
| 5 | Supervisors (Billing) | 8 | 10 |
| 6 | Electrician | - | - |
| 7 | Fitters ITI certificate in Fitter trade with 3years experience in similar works. | 4 | 6 |
| 8 | Asstt. Fitters ITI certificate in Fitter trade with 1 year experience in similar works. | 7 | - |
| 9 | Welders/Machine operator ITI certificate in mechanical / electrical with 5 years experience in similar work | 2 | 2 |
| 10 | Bill Clerk | 4 | 4 |
| 11 | Meter Readers | 25 | 30 |
| 12 | Bill Distributor | 15 | 20 |
| 13 | Drivers Heavy Vehicle With valid Driving License with 3year experience | 2 | 2 |
| 14 | Drivers Light Vehicle With valid Driving License with 1 year experience | 4 | 4 |
| 15 | Skilled Labour, Helpers 8th pass | - | - |
| 16 | Labour/ Helper | 22 | 20 |
| | **Total Amount/Year** | **107** | **112** |

### 1.13 Minimum Staff to be deployed for O&M for E & M Works Division

The Operator shall deploy a minimum of following number of personnel with their required qualifications for O&M during construction phase & during post construction phase

**Minimum Staff deployment as per required qualifications for O&M (E&M**

**Division**

| S. No. | Designation of personnel | Qty-Numbers | |
|---|---|---|---|
| | | During Construction Phase | During Post Construction Phase |
| 1 | Supervisor/Asstt. Manager (UGR's& BPS) Electrical/Mechanical/Instrumentation Engineer, 8 years experience in water sector and at least 3 years in similar works. | 1 | 1 |
| 2 | Foreman /Supervisor Electrical Engineer/Ist. class competency certificate with 5 years experience | 1 | 1 |
| 3 | Electrician ITI certificate in Electrical trade with 3 years experience | 5 | 3 |
| 4 | Operators ITI certificate in Electrical trade with 3 years experience in similar works | 151 | 25 |
| 5 | SCADA Supervisor for Zonal SCADA Diploma Instrumentation with 3 years experience | - | 4 |
| 6 | Computer Operator | - | 1 |
| 7 | Fitters for BPS and UGR's ITI certificate in Fitter trade with 3years experience in similar works. | 5 | 3 |
| 8 | Chemist University Degree in Chemistry, 8 years experience in water sector and at least 3 years in similar works. | 1 | 1 |
| 9 | Asstt. Chemist University Degree in Chemistry, 3 years experience in water sector and at least 1 year in similar works. | 1 | 1 |
| 10 | Helpers for Fitters | 5 | 3 |
| 11 | Electrical Helpers | - | 3 |
| 12 | Cleaner | 4 | 3 |
| 13 | Watchman | 3 | 9 |
| 14 | Helper / Beldar | 151 | 25 |
| 15 | Horticulture Staff | 4 | 3 |
| | **Total Amount/Year** | **332** | **86** |

## 1.14 Safety and Security

The Operator shall take all safety precautions under various acts and rules under the Central and State Governments. The Operator shall be responsible for safety of staff and the consequences thereof. The Operator shall deploy round the clock security personnel at the facilities entrance and in the compound for the safety of the facilities and premises directly from the end of the preparatory period up to the end of the O&M Contract period. The Operator shall be completely responsible for the safety of the facilities, equipment and personnel.

The care of the whole of the permanent/temporary works shall remain with the Operator who 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 to any cause whatever, whether such damage or defects were occasioned by the negligence of the Operator or not or completion whereof or whether payment may wholly or partially have been made or the works approved as supposed to have been properly done and no certificate of approval of any works by any officers or members of the Engineer shall affect or prejudice the right of the Employer/Engineer against the Operator or be considered or held as at all conclusive as to the sufficiency of any work materials.

Adequate safety precautions against fire, flooding, lightening, electrical shocks, accident due to moving /non- moving heavy /light equipment shall be strictly observed by the Operator at the Operator's own cost. Suitable safety measures like safety shoes, gloves, safety belts, ladders, safety lamps, gas masks, Oxygen apparatus, insulated tools, Fire suites, alarm etc. shall be provided by the Operator. Necessary medical first aid kit shall be made available all time at each pump house.

In presence of observance of above safety precautions, the Operator shall be responsible for any unforeseen loss of the equipment or persons dealing with it. Special care shall be taken by the Operator while carrying out the work in chlorine gas areas. Any incidence of loss of human life or accident will be totally Operator's responsibility.

The Operator 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 safety regulations and manufacturer's special instruction for safety /gas handling. The staff shall use: gas masks, oxygen breathing apparatus, safety shoes, safety belts, safety lamps and hand gloves during execution of the work as required per the task.

During night hours, the main gate shall be locked. However, shift duty staff shall be alerted and they shall open the gate during surprise checking by Employer/Engineer's staff or any other Government authorities or the Operator's nominee without any wait after checking their proof of identification. Smoking, consumption of alcohol and other illegal substances are strictly prohibited within the facilities sites.

The staff engaged shall wear common uniform with name plate indicating name and designation during duty hours.

The health & safety measures shall be strictly applied for the O&M works directly from the end of the preparatory period to all over the duration of the O&M works period.

## 1.15 Reporting

### 1.15.1 Monthly Reports

The Operator shall prepare daily and monthly reports about the work performance in the UGRs, BPSs, SCADA, Solar Energy Equipment, water transmission & distribution network and submit to the Employer/Engineer and assist the department in preparing the necessary documents for their purposes and records as performance given from time to time. The reports shall contain the following:

- Maintenance report about the work carried out in the reporting period;
- A report on major failures, if any, their causes and remedial actions taken;
- Power, consumables and chemicals, oil and lubricants consumed in the reporting period;
- An inventory of the chemicals and spare parts available at the end of the reporting period;
- Time sheet for the O&M staff deployed by the Operator during the reporting period;
- Major repair works, if any;
- Reports generated by the Computerized maintenance management system (CMMS) or equivalent
- Report and analysis done by Various Application Softwares on water distribution, energy efficiency etc.
- Operator is required to maintain separate register/computerized records at all sites of the following information:
    - Power consumption;
    - Working hours register;
    - Staff attendance register;
    - Power failure records;
    - Solar energy system.

### 1.15.2 Bi-monthly reports

The Operator shall report on Bi-monthly basis about all the customer service activities to show the progress achieved.

**a- New connections**

| # | New service connections | Unit | Running Cycle | Previous Cycle |
|---|---|---|---|---|
| 1 | No. of applications received after sanctioned by DJB | No. | | |
| 2 | No. of service connection completed | No. | | |

**b- Customer water meter remarks**

| # | Reading information | Unit | Running Cycle | Previous Cycle |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | Damaged Meter | No. | | |
| 2 | Illegal Use / Connections (all types of illegal consumption) | No. | | |
| 3 | Using water for construction works | No. | | |
| 4 | Meter inside a box | No. | | |
| 5 | Meter in inaccessible location | No. | | |
| 6 | House is closed and can't read the meter | No. | | |
| 7 | No permission to enter | No. | | |
| 8 | Supply water to neighbours | No. | | |
| 9 | Meter with vertical installation | No. | | |

**c- Reading water meters**

| # | Reading process | Unit | Running Cycle | Previous Cycle |
|---|---|---|---|---|
| 1 | No. of active customers | No. | | |
| 2 | No. of field readings | No. | | |
| 3 | % of field readings | % | | |

**d- Billing**

| # | Billing & distribution of the bills | Unit | Running Cycle | Previous Cycle |
|---|---|---|---|---|
| 1 | No. of active customers | No. | | |
| 2 | No. of total bills printed | No. | | |
| 3 | No. of bills distributed | No. | | |
| 4 | No. of bills not distributed | No. | | |
| 5 | Total billing | INR | | |

**e- Types of service connection**

| # | Type of service connection | Unit | Running Cycle | Previous Cycle |
|---|---|---|---|---|
| 1 | Domestic | No. | | |
| 2 | Institutional | No. | | |
| 3 | Commercial | No. | | |
| 4 | Industrial | No. | | |

### 1.15.3 Annual Report

The Operator shall submit Annual Reports to the Employer/Engineer representative before the last day of the first month following the year to which the report relates. Details of formats shall be approved by the Employer/Engineer.

(a) Summaries of quantities and characteristics of supplied and distributed water for each DMA during the reporting year.

(b) Summaries of operation of various electro-mechanical equipment at BPS, UGR, SCADA and instrumentation centres and energy consumption including power factors and their compliances.
(c) Summary data on solar power generations.
(d) Overall performance of the water facilities with highlights on non-compliance with Operational Performance and Environmental Performance Requirements.
(e) Summary of expiry dates for licenses, permits, insurance and certificate for the operation.
(f) Summary of major equipment breakdown, leakages, repair, overhaul, renewal, replacement, modification, Performance Tests, Condition Surveys carried out.
(g) Summary of incidents related to safety and health, environmental issues, security and complaints.
(h) Scheduled maintenance, overhaul, renewal, replacement, modification of the BPSs major equipment, Performance Tests and Condition Surveys in the forthcoming 12 months.
(i) List of changes ordered by the Employer/Engineer, with details and status.
(j) Public complaints and their compliance.
(k) Annual report shall include the annual figures of the bimonthly reports.

### 1.15.4 Formats

The Operator shall prepare all the O&M records and formats and submit to the Employer/Engineer for approval. All the O&M records shall be submitted in soft editable forms.

## 1.16 Spare parts

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the original equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

## 1.17 Tools and Equipment

The Operator shall provide all the necessary tools and equipment for the O&M of the Booster pumping stations, UGRs, Solar energy system, primary, secondary and tertiary water networks including service connections in addition to the LWMC.

## 1.18 Ancillary Works

The Operator shall ensure gardens and plantation in the facilities areas green, neat and tidy with removal of shrubs, weeds, grass and unwanted vegetation and make pruning, trimming and cutting of old big trees from the facilities area after approval from Engineer/Employer.

The Operator shall ensure to reinstate the roads and lighting fixtures and lighting circuits in booster pumping stations and UGR areas and the customer service offices to its original state. The Operator shall ensure to make good and in working condition for lighting fixtures and lighting circuits in the water facilities in booster pumping stations, UGRs and customer services offices.

The Operator shall carry out ordinary repairs to buildings. The repairs may include but not limited to the following items:

- Easing of doors and windows, monsoon repairs to roofs, attention to drains, rain water spouts, attention to all kinds of protection.
- External white or color wash, external or internal painting, internal distempering, renewal of approach roads within the compound of the water facilities.
- Any faults in the electric installation, leakages, earthing, exposed wire ends and any hazards on this account to the users of the buildings, should be taken care of suitably. Wiring, which is damaged /faulty, should be replaced.
- Damaged sanitary lines should be replaced and choked lines cleared.
- Proper drainage of the area around the building should be ensured to avoid stagnation of rainwater, in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains should be ensured. Any choked drains should be cleared properly.
- Leaking roofs should be attended immediately with suitable repairs/ treatment, as the case may be. The rain waterspouts should also be cleared of blockages, etc. The roof should be swept clean of leaves, debris, etc., if any.
- The plaster on outer walls of the building, which is exposed to weather, should be repaired to prevent dampness inside. Where plinth protection has been provided, it should be checked and the damaged portions, if any, should be repaired.
- Damaged flooring should be repaired/ replaced as per requirement, in order to prevent dampness inside the rooms, etc.
- Pump House ventilation system to be checked for effective heat dissipation from the Pump Motors and Electrical Equipment.
- UGRs construction shall be inspected for any defects.

### 1.19 Telecommunication system

- Make a good telecommunication system to ensure reliable and easy communication to and from booster pumping stations, UGRs, water network maintenance offices, customer service offices, the Local Water Management Centre and CWMC.
- Replacement of batteries, faulty sets and all other non-functional equipment of the exchange to ensure trouble free communication if required.

### 1.20 Technical Audit

The Engineer/agency authorized by Employer/Engineer has the right to conduct a technical audit by internal/External Agency for the work performance at the Booster Pumping Stations, UGRs, Solar Energy equipment and carry out any analysis or inspection it deems necessary. The Operator shall at the Operator's own cost and expense provide all assistance that the Employer/Engineer requires to complete these audits and inspections. Such audits may cover all or any of the obligators, including without limitations. The finding shall be binding to the

Operator:

- Verifications of the system / capacity for normal wear and tear during the O&M period.
- Verifications of the performance standards and useful life of the individual assets of the water facilities for normal wear and tear during the O&M period.

**1.21 Employer's Audit**

An Employer's audit of the water facilities operation shall be carried out on a monthly basis (upon the request of the Employer/Engineer), jointly by the Operator and the Employer's representative and shall include, without limitation, inspection and audit of the following:

- Distributed water quantities and characteristics
- General facilities and equipment condition
- Spare parts condition
- Storage of consumables
- Condition of security and safety installation
- Cleanliness, horticulture development and housekeeping
- Condition of chlorination system
- Lighting
- Noise
- Safety and health record
- Manning levels
- Operation record and data including LWMC and CMMS database
- Level water network maintenance
- Water meter reading &billing
- Customer complaint response time
- Customer care
- Customer satisfaction survey
- DMAs district meters for their functioning and transmission of data as per contract requirement
- Data loggers fixed in the contract area for their functioning and transmission as per contract requirement.

(a) The observation and finding of the Employer's Audit, among the observation and findings identified from the routine inspection carried out by the Employer's representative shall be used to determine compliance or non-compliance with the O&M Contract requirements. In such case, the Employer/Engineer will notify the Operator as soon as is practicable, specifying his observation of non-compliance in accordance with the Condition of Contract.

(b) On the basis of the Employer's Audit, the Operator shall be required to remedy any part of the operation that is not in accordance with the requirement of the contract.

(c) Nothing in relation to the Employer's Audit shall relieve the Operator of his obligation, liabilities and responsibilities and shall not constitute any admission on the part of the Employer/Engineer that any such obligation, liabilities and responsibilities have been complied with.

(d) The Employer's Representative will advise the Operator of the date and time of the Employers Audit. The Operator's Operation Manager and Safety Manager shall be present during the Employer's Audit.

## 1.22 Field Visits

The Employer/Engineer shall arrange with the Operator a site visit to the Booster pumping stations, UGRs, Solar energy equipment, Network maintenance offices and Customer Service Offices on periodical basis to check the conditions of the installations in the facilities. The site visits will be scheduled by the Employer/Engineer in coordination with the Operator and it can be periodical and as per need. A report shall be drawn up to record the opinions of both parties. The Employer/Engineer reserves the right to call the equipment manufacturers or specialized technicians for these visits. All expenses are to be borne by the Operator for this purpose.

## 1.23 O&M Manual

The Operator shall provide five copies of the draft O&M Manual to the Employer/Engineer at the time of the commissioning of the facilities. The Operator shall provide another ten copies of the final O&M after getting the approval of the draft copy.

The O&M manual shall include detailed operation and maintenance instructions, procedures and policies required to achieve the equitable and continuous water distribution in the related service area, by stable operation at the water facilities and attainment of water quality and water quantity for 24×7 water supply.

The Operator shall provide a complete O&M manual for the booster pumping stations, underground reservoirs, solar energy equipment, all pipeline networks in addition to the service connections to achieve full compliance with the operational guarantees.

The O&M Manual shall also include the instructions required to provide the necessary maintenance and repair for the booster pumping stations, UGRs, Solar energy system, pipeline networks in addition to the service connections to achieve full compliance with the maintenance specifications.

Without limiting the generality of the foregoing, the O&M Manual shall include descriptions, standard operation and maintenance procedures and shall comply with the requirements set forth in the provisions of the bid documents.

The Operator shall revise the draft O&M Manual to reflect any updates, changes or revisions, it deems appropriate, inter alia based on his experience and necessary to reflect any modifications or adjustments to the facilities. Without limiting the above, the Operator shall, on every three years, review, revise, update and modify the draft O&M Manual fully as may be necessary or appropriate. Any revision to the draft O&M Manual shall be subjected to the review and approval of the Employer/Engineer. The Employer/Engineer shall have the right to require revisions to the O&M Manual as it may deem appropriate. The Operator shall prepare and submit to the Employer/Engineer, 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, revision and modifications. The Operator shall prepare the O&M Manual, as approved by the

Employer/Engineer, prior to the date of taking over operation and maintenance of the related water facilities.

During the term of the Operator's agreement, the Operator shall promptly notify the Employer/Engineer of any revisions, additions or modifications which the Operator, in the Operator's professional opinion, believes should be made to the O&M Manual, whether as a result of additional experience in operating and maintaining the water facilities. Such notification shall set forth the reason for the proposed revision. Any proposed revision shall be subjected to the approval of the Employer/Engineer. In addition, during the term of the Operator's Agreement, Employer/Engineer 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 O&M standards.

The Operator shall make a review of the maintenance experience at the end of the O&M period, including enumerating all major events and lessons learned and changes suggested in the original O&M manual.

## 1.24 Pre-handover Procedures

- The Operator shall take all reasonable steps and co-operate fully with the Employer/Engineer and any follow-on Operator so as to prevent and mitigate any inconvenience or risk to health and safety of the Employer and the public and also that the continuation of the operation is achieved with minimum disruption.

- The Operator shall use reasonable endeavours to assist the Employer in the preparation for, and conduct of a fair and competitive bidding process for any follow–on contract. In particular, the Operator shall make available to the Employer any information, and assist in the verification of any information as the Employer reasonably requires in connection with the bidding process.

- All the information provided by the Operator to the Employer shall be true and correct in all material respects and will not be misleading, by omission or otherwise.

- The Operator shall make available at least 18 months prior to the expiry of the O&M Contract Period, full details of the operation and maintenance documentation and records of the water facilities for the entire O&M Contract Period to date so that these can be made available for inspection by Operator for any follow-on contract.

- The report of the End-of-Contract Condition Survey and records of the subsequent maintenance and replacement works (if any) will be made available by the Operator for inspection by potential bidder for any follow-on contract.

- Prepare all the documents necessary for handing over the Customer Service works mainly the backups of the RMS (billing system) and the Customers database.

## 1.25 Handing Over of works after completion of O&M Contract Period

### 1.25.1 General

This section applies to procedure(s) on how to hand over the contracted works, before the expiry date of the Operation and Maintenance Contract period by the Operator.

The Operator, at the time of bidding, will be responsible to ensure the completeness and adequacy of his Bid Price to fulfil the entire responsibilities as described herein. His bid price shall include all costs for handing-over.

The procedure for Handing over shall be verified through the final examination by the Employer/Engineer. A Final Contract Completion Certificate shall be issued by the Employer/Engineer after the successful final examination and submission of the completion documents before the contract deadline.

All equipment, tools and office equipment, which the Operator was using during the O&M Contract period except provisioned to be retained by the Operator, shall be handed over to the Employer at no additional cost. The ownership of the tools and equipment brought in by the Operator for water leak detection and investigation shall remain with the Operator.

Handing over the Customer Service works mainly the backups of the RMS (billing system) and the Customers database shall also be done properly and smoothly.

### 1.25.2 Duties and Responsibilities

- The Operator shall provide all necessary labor, materials, instruments, meters, fuel required for joint inspections and tests. All costs for the examination and test /training and preparation of any document of the activities shall be the Operator's responsibility.
- Receiving inspection
  All of equipment and construction material arrived at site to be handed over shall be inspected by the Employer/Engineer to verify whether damaged or not. Rejected items shall be replaced by the Operator at his own cost.

  The typical examination shall consist of as follows:
  - Appearance test /Visual examination.
  - Performance examination.
- Database inspection
  The Operator shall facilitate the inspection of the Billing System, GIS, CMMS and LWMS data bases for handing over.
- Conduct training prior to Contract Completion
  The Operator shall provide the training to Employer's staff members before acceptance inspection and before completion of the 9th year operation & maintenance as per direction of the Employer/Engineer.
- Conduct Joint Inspection Prior to Contract Completion:
  To verify the performance of the booster pumping stations, UGRs, Solar Energy System and water network system before completion of the 9th year operation & maintenance, a joint inspection shall be carried out using the up-dated Operation and Maintenance Manual & GIS based maps provided by the Operator.
- Conduct joint inspection for the Billing System (RMS) and the Customers database.
- Submission of the report of completion documents:
  The Operator shall submit the completion document after passing the final examination before the deadline on the contract time.

The typical report will consist of relevant documents, requested for issue of the Completion certificate of the O&M Contract period.

### 1.25.3 Check list

(a) General

The Operator shall hand over all the components of works in good working condition for the following, but not limited to:

- All mechanical equipment, electrical facility including instrumentation & control equipment, Solar System and SCADA, as well as civil and building works at the Booster pumping stations, UGRs in neat and clean condition.
- Updated GIS based maps for the primary, secondary and tertiary water networks including the service connections and location of water meters.
- All electrical equipment.
- All consumables required for functioning of facilities with inventory of material.
- Equipment suppliers, as necessary for PLC and SCADA system or the authorized system integrator as executed for this project.
- Lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures.
- All equipment, tools and office equipment, which the Operator was using during the O&M Contract period, except provisioned to be retained by the Operator, shall be handed over to the Employer free of charge.
- All flow meters and data loggers.
- All chlorination units installed for water quality tests.
- Records for:
  - Repair history of all mechanical, electrical, instrumentation & control equipment in the Booster pumping stations, UGRs and Solar energy system and communication instruments;
  - Logbooks through PLC system;
  - Daily log of operations of all the important equipment with time tag;
  - Hourly readings of the main parameters in the facilities;
  - Daily list of alarms with time tag;
  - Daily log at specified intervals of various electrical parameters.
  - Logbook format and the data to be included in the logbook;
  - Last periodic maintenance done for all equipment/buildings of the system;
  - Required spares, general and special tools and test equipment,
  - Clearance records from all concerned authorities including related utilities concerning roads and streets reinstatement.
  - Repair history for flow meters and data loggers
  - Repair history for chlorination units installed for water quality tests.

However, before the end of the Contract, the Operator shall assist the Employer/Engineer in preparing a list of spares required for O&M of the facilities for two years after the expiry of the O&M Contract period.

- Repair of the roads, buildings and facilities areas utilities.
- Drinking water supply facilities.

- Record of stores for the electrical, mechanical, solar system, instrumentation and control equipment as well as that for consumables. The records will include but shall not be limited to:
  - Materials received and issued for works;
  - Proper arrangement of material in stores to ensure its safety and easy availability;
  - Maintaining store areas in a neat and tidy condition;
  - Keeping records and accounting for the incoming materials,
  - Keeping records and accounting for the consumed materials.

- Structures/buildings of Booster pumping stations, UGRs and others in the Contract must ensure adequate cleanliness, ventilation, illumination and structural safety.
- Updated operation and maintenance manual as defined in specifications for O&M works.
- 4 sets of Hard copies and 2 sets of Soft copies of all "As Built-in and Commissioned Final Drawings" for the BPSs, UGRs and Solar energy system.
- Updated GIS based maps for the primary, secondary and tertiary water networks including the service connections and location of water meters.
- All Customer Service Records shall be handed over to the Employer as soft and hard copy.

(b) O&M Manual

Handing over document/manuals shall include sets of softcopies and hardcopies. The hard copies shall be spiral bound clearly indicating the version/revision submitted. All the contents shall be indexed. The contents of handing over document/manual shall be clearly legible and shall include original manufacturer's literature on a minimum, and incorporate any changes as per site conditions.

The comprehensive operation and maintenance manuals shall be submitted at the end of the operation and maintenance period and the number of the copies as specified in the technical specifications.

(c) Drawings

The Operator shall revise all as-built drawings, based on all modifications during O&M Period. All layout drawings of pumps and all other mechanical equipment and piping, all electrical drawings like Single Line Diagrams, Schematic Diagrams, Control Circuits Equipment Layout, Cable Layout & Cable Schedules, Earthing Layouts and all other drawings like P&ID, System configuration diagram (PLC & SCADA architecture), Instrument installation drawings, Instrument cable schematics, and cable layouts should be maintained and should be handed over in six Sets.

Updated GIS based water network maps to cover the primary, secondary, tertiary, service connections, customer meter locations, and any water network replacement.

(d) Completion certificates

- The Operator shall prepare a check list of items to be examined at the end of the O&M Contract period and submit to the Employer/Engineer for approval.

- The Operator before completion of O&M period will request the Employer/Engineer for a joint inspection of the water facilities and keep all the requirements/documents as specified in this contract are also ready for handing over.
- Based on the above request, a Joint Inspection with Employer/Engineer shall be arranged by the Operator to assess the condition of civil structures, Flow meters (bulk), data loggers, electrical, mechanical, solar system, and instrumentation equipment and First Joint Inspection Report, for various required remedial actions, repair actions, replacement actions, etc. shall be prepared.
- The Operator shall attend all points of Joint Inspection Report, by carrying out all such remedial/repair/replacement actions at his own cost, and after attending, will confirm the same to the Employer/Engineer.
- On receipt of the confirmation from the Operator, the Second Joint Inspection shall be arranged by the Operator, for certification of completeness of remedial work, as well as to confirm the condition of all civil works to its original appearance.
- The Operator shall submit the entire required documents to the Employer/Engineer for review and comments. The Operator shall resubmit the document incorporating the comments of the Employer/Engineer, if any.
- The Employer/Engineer shall issue the Completion Certificate to the O&M Operator within 30 days of acceptance of Second Joint Inspection Report, subject to the above documents and obligation are met by the Operator before 30 days prior to hand over of the facilities.

## SUB-SECTION 2. KEY PERFORMANCE INDICATOR FOR DISTRIBUTION SYSTEM O&M

### 2.1 Key Performance Indicators and Payment Conditions

The performance indicator given in this section shall be used to measure the performance of the operator during the post-construction operation and maintenance period. The performance indicators shall be measured for every billing cycle starting from the first billing cycle after the completion of construction period (5 years). However, a six (6) months grace period shall be given during which no penalty (reduction in performance payment) shall be levied.

The Water Loss indicator shall be measured starting from the last billing cycle of 2nd construction year itself on cluster wide basis. This will set a baseline water loss level of existing system based on which the contractor would draw its plan to reduce the water loss annually such that it would achieve the target of 15% at the end of construction phase.

#### 2.1.1 Key Performance Indicators

The Key Performance Indicator under this Contract shall be as follows

1. Extent of Water Loss
2. Continuity of water supply (24/7)
3. Efficiency in redressal of customer complaints
4. Quality of supplied water
5. Meter reading, billing & distribution efficiency
6. Response time for providing new water supply connections
7. Functioning of consumer water meters installed
8. Efficiency in power consumption

#### 2.1.2 Payment Conditions for O&M

Payment for O&M cost during the construction period shall be Fixed payment only based on the work done or quoted cost as applicable with deployment of requisite staff as per the contract document.

Payment Conditions during post-construction O&M period shall be split into fixed payment and performance based payment as per following ratio.

| Category | Payment as % of O&M cost | Remarks |
|---|---|---|
| Fixed Payment | **60%** | The deduction will be applicable for non-deployment of requisite staff as per tender document |
| Performance Based Payment | **40%** | as per calculation against the KPIs |

However, there will be a six (6) month's grace period during which no reduction in the Performance Payment will be done even if the KPIs fall short of target, and the

contractor/operator is required to do all sorts of work required for achieving the KPIs, wherever it is falling short, at no additional cost to the Employer.

### 2.1.3 Target for KPIs and Payment Breakdown

The Target of KPIs and their weightage of performance-based payment under this contract shall be as follows.

| S.N. | KPI | Target | Max. Payment as % of agreed O&M Cost | Remarks |
|---|---|---|---|---|
| 1 | Extent of Water Loss Total Water Loss (Transmission + Distribution Loss) | 15% | 15% | Incentive shall be given in case of exceeding the target and penalty for falling short of target.<br><br>Deduction of certain percentages (given below under separate section) from "max. payment as % agreed O&M cost" for falling short of target below 15% to 25% and penalty for performance below 25%. This penalty is applied by deducting the corresponding % (from graph) from the fixed payment of O&M cost |
| 2 | Continuity of Water Supply (24 Hrs) | 100% | 5% | Deduction of certain percentages (given below under separate section) from "max. payment as % agreed O&M cost" for falling short of target upto 80% and penalty for performance below 80%. This penalty is applied by deducting the indicated % from the fixed payment of O&M cost |
| 3 | Efficiency in redressal of Customer Complaint: | 90% | 5% | Deduction of certain percentages (given below under separate section) from "max. payment as % agreed O&M cost" for falling short of target upto 75% and penalty for performance below 75%. This penalty is applied by deducting the indicated % from the fixed payment of O&M cost. |
| 4 | Quality of Water supplied | 100% | 5% | Target is 100% but no reduction in payment until 99%. |

| | | | | |
|---|---|---|---|---|
| | | | | Deduction of certain percentages (given below under separate section) from "max. payment as % agreed O&M cost" for fall short of target upto 94% and penalty for performance below 94%. This penalty is applied by deducting the indicated % from the fixed payment of O&M cost. |
| 5 | Meter Reading, billing and distribution efficiency | 100% | 5% | Deduction of certain percentages (given below under separate section) from "max. payment as % agreed O&M cost" for fall short of target upto 90% and penalty for performance below 90%. This penalty is applied by deducting the indicated % from the fixed payment of O&M cost. |
| 6 | Response Time for new Water Supply Connections | 100% | 3% | Deduction of certain percentages (given below under separate section) from "max. payment as % agreed O&M cost" for fall short of target upto 85% and penalty for performance below 85%. This penalty is applied by deducting the indicated % from the fixed payment of O&M cost. |
| 7 | Extent of Functional Water Meters | 100% | 2% | Target is 100% but no reduction in payment until 98%.<br><br>Deduction of certain percentages (given below under separate section) from "max. payment as % agreed O&M cost" for fall short of target upto 94% and penalty for performance below 94%. This penalty is applied by deducting the indicated % from the fixed payment of O&M cost. |
| **Total** | | | **40%** | |
| 8 | Efficiency in power consumption | Power Factor of 0.98 or more | As covered separately under the provision in 'Power Guarantee' | |

## 2.2 Reduction of Water Loss to Target Level and Control

The main objective of the project is to bring down the water loss to the target level of 15% (transmission and distribution together) by carrying out the water system improvement as per the Contract requirement. The Water Loss shall be calculated from the end of 2nd construction year but the provision of incentive or penalty shall be applicable from the latter half of the first year of the post construction O&M Period.

- Water Loss shall be used as a KPI instead of NRW
- Water Loss shall be calculated for every billing cycle (presently it is bi-monthly) starting from the end of 2nd construction year.
- Water loss shall be calculated separately for transmission and distribution system:
  - Transmission system: from WTP outlet to UGR inlets.
  - Distribution system: from UGR inlets to customer meters
- Distribution Water Loss shall be calculated cluster wise and added together for the contract area. The clusters are made as follows.
  - Cluster 1: Sashtri Nagar UGR command areas.
  - Cluster 2: Zakhira, Janta Park and Shadipur UGR command areas.
  - Cluster 3: Rock Garden, New Rajinder Nagar and Naraina UGR command areas.
- The target total Water Loss (Transmission Loss + Distribution Loss) shall be 15% or less.
- Transmission Water Loss shall be calculated considering the difference between water measured at the outlet of WTP and inlet of all related UGRs.
- Payments for Water Loss performance shall be calculated for every billing cycle starting 2nd half of post-construction O&M period.
- For any intermediate Water Loss values (%), standard interpolation methods shall be used to determine the percentage of O&M payment.
- For Water Loss value higher than 25%, deductions shall be made from the fixed portion of O&M payment or any other payment due to the contractor (operator).
- If the water loss is more than 30%, then the Operator performance will be concluded as non-satisfactory.

**<u>Water Loss in transmission system:</u>**

Transmission Water Loss (%) =((Y-Z)/Y) ×100%

Where:
Y = Water measure at output of the WTP during the period (typically 1 billing period)
Z = Water measure at inlets to the reservoirs during the period (typically 1 billing period)

**<u>Water Loss in Distribution System:</u>**

Distribution Water Loss shall be defined as:

$$\text{Water Loss (\%)} = \frac{X - (A + B + C + D)}{X} \times 100\ \%,$$

Where:
X = Water input to all UGRs under the contract area during the period (typically 1 billing

period).
A = Water billed during the period
B = Water legally supplied but not billed (including slum and stand post consumption) during the period
C = Operational use (scouring, jetting, dust suppression, etc.) during the period
D = Tankers metered and billed/unbilled during the period

**Contract wide Water Loss:**

For this, the transmission as well as distribution losses shall be added to obtain the total loss for the Contract area. For distribution losses, the formula given for distribution system shall be used but the water into the system shall be the total cumulative inflow measured at the inlets of reservoirs in the Contract area for the billing cycle. Similarly, other components like billed consumption, legally supplied but not billed etc shall be total cumulative of all the DMAs for the billing cycle.

The rate of payment for Water Loss performance is as shown in the following Figure and Table. The same rate of 20.0% incentive shall apply for WL levels of 10% or lower. Similarly, the same rate of -10.0% (i.e. penalty) shall apply for WL levels of 30% or higher.

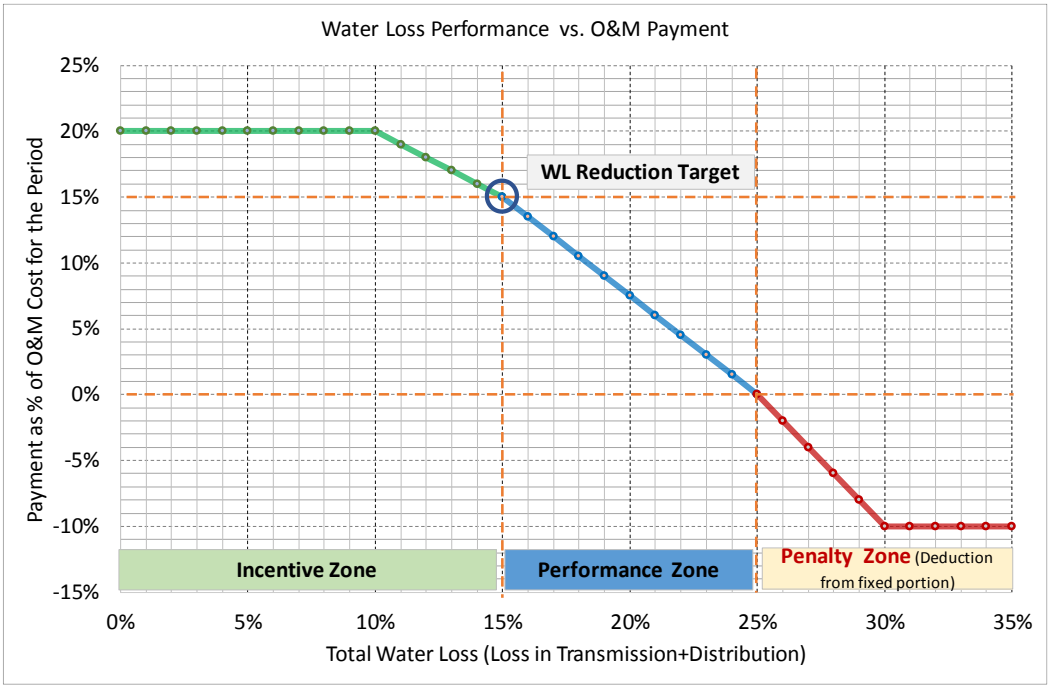



Figure: Total Water Loss vs. Performance payment as % of O&M cost

Table: Total Water Loss vs. Performance Payment as % of O&M cost

| Water Loss rate | 10% or less | 11% | 12% | 13% | 14% | 15% | 16% | 17% | 18% | 19% | 20% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Performance Payment (as % of O&M Cost of the billing cycle) | 20.0 % | 19.0 % | 18.0 % | 17.0 % | 16.0 % | 15% | 13.5 % | 12.0 % | 10.5 % | 9.0% | 7.5% |
| Water Loss rate | 21% | 22% | 23% | 24% | 25% | 26% | 27% | 28% | 29% | 30% or more | |
| Performance Payment (as % of O&M Cost of the billing cycle) | 6.0% | 4.5% | 3.0% | 1.5% | 0% | -2%* | -4% | -6% | -8% | -10% | |

## 2.3 Continuity of Water Supply (24×7)

The water supply shall be 24 hours daily with adequate pressure. The minimum pressure in the system shall be 17m except the DMAs supplied by gravity wherein it may sometimes go to 12m. The water head at the critical pressure point (CPP) in each DMA shall be more than minimum required pressures of 17m (except the DMAs supplied by gravity wherein it should be 12m) at 90% of the time on daily basis. The pressure at the CPP shall be monitored (using SCADA) through Data logger which has transmitter capable of transmitting the data to central SCADA system. The calculation shall be done on daily basis for each DMA and the DMAs which are meeting the 90% criteria will be considered as DMAs complying with the requirement on daily basis. Bench mark shall be calculated as given below:

(1) Continuity of supply is measured as the average number of hours of pressurised water supply per day.
(2) The measurement shall be taken hourly by online instruments indicating date and time.
(3) Number of hours in a DMA when water pressure is equal to or more than the required pressure at critical point – (a).
(It is required that 90% of the time the pressure to be more than required pressures in each DMA on daily basis; this calculation will be done for each DMA on daily basis and the).

DMA passes (complies) if $100 \times a/24 \geq 90$ i.e., if 90% or more of the time the pressure in the critical point of the DMA is equal to or more than the required pressure.

| | | |
|---|---|---|
| Continuity of Water Supply Performance**(B)** | = | 100 × C**omplying DMA-Days** during the billing cycle [#] |
| | | **Total DMA-Days** in the billing cycle[$] |

Note:

[#]: Number of DMAs complying the pressure criteria on daily basis should be added together for the entire billing cycle to obtain the total number of complying DMAs for that billing cycle.

[$]: Number of DMAs in the whole contract (or cluster) area multiplied by number of days in the billing cycle.

The O&M payment for this performance shall be as given in the following Table.

| **Continuity of water supply performance (B)** | **Payment payable to the Operator (As percentage of total agreed O&M payment)** |
|---|---|
| 100% | 5% |
| From less than 100 to 96% | 4% |
| From less than 96 to 92% | 3% |
| From less than 92 to 88% | 2% |
| From less than 88 to 84% | 1% |
| From less than 84 to 80% | Nil |
| Less than 80%, penalty will be deducted from the other due payments | |
| From less than 80 to 76% | -1% |
| From less than 76 to 72% | -2% |
| From less than 72 to 68% | -3% |
| From less than 68 to 64% | -4% |
| Below 64% | -5% |

## 2.4 Efficiency in redressal of Customer Complaints

The efficiency in attending the Customer Complaints other than revenue collection shall be considered for performance evaluation of this KPI. It is required that at **90% of the time**, customer complaints be addressed within 24 hours of the complaint. Bench mark shall be calculated as given below:

(1) The total number of customer complaints received during the billing cycle - (a). Includes all customer complaints except related to revenue collection.
(2) The total number of customer complaints redressed within 24 hours – (b).
(3) Performance **(C)** = 100 x b / a

Benefit on delayed redressal of complaint (if any) will not be passed on to the contractor.

The payment of O&M shall be as in the table given below:

| **'Customer Complaint Redressal Efficiency' Performance (C)** | **Payment payable to the Operator (As percentage of total agreed O&M payment for the billing period)** |
|---|---|
| 90% or above | 5% |
| From Less than 90 to 87% | 4% |
| From Less than 87 to 84% | 3% |
| From Less than 84 to 81% | 2% |
| From Less than 81 to 78% | 1% |
| From Less than 78 to 75% | Nil |
| Less than 75%, penalty will be deducted from the other due payments | |
| From less than 75 to 72% | -1% |
| From less than 72 to 69% | -2% |
| From less than 69 to 66% | -3% |
| From less than 66 to 63% | -4% |
| Below 63% | -5% |

## 2.5 Quality of Water Supplied

The water supply to DMAs should meet the potable water quality standards as per the contract requirement. Residual chlorine shall be measured by online equipment to be installed at pre-identified point. Rate of its sampling shall be one (1) sample per DMA per day. In case of contamination complaints, additional samples shall be collected manually and tested for related parameters. Samples shall also be taken manually in case of failure of online equipment. In addition to above, bi-monthly 1 sample from each DMA from the above pre-identified point shall be taken manually and tested for the parameters specified for test in finished water of Chandrawal WTP.

The samples shall be considered passed or failed as described below.

| S. N. | Water quality at DMA sampling point | Pass / Fail |
|---|---|---|
| 1 | All water quality parameters should meet the same standard specified for WTP outlet water (i.e. no substantial deterioration in water quality) except for the residual chlorine | Pass |
| 2 | If any water quality parameter which meets the requirement at WTP outlet but doesn't meet in the distribution system | Fail |
| 3 | Residual chlorine level less than 0.2 mg/lwhen the residual chlorine at the outlet of WTP is 1.5 mg/lor more) | Fail |

The KPI shall be calculated as given below:

(1) Total number of water samples tested per billing cycle - (a).
(2) Number of samples that meet the specified potable water standards in the billing cycle – (b).
(3) Performance **(D)** = 100 x b / a.

The performance in terms of quality of water supplied expected is 100%. The payment of O&M cost against the performance of this performance indicator shall be as given in the below table:

| **'Quality of Water Supplied' Performance (D)** | **Payment payable to the Operator (As percentage of total agreed O&M payment for the billing period)** |
|---|---|
| From 100% to 99% | 5% |
| From less than 99 to 98% | 4% |
| From less than 98 to 97% | 3% |
| From less than 97 to 96% | 2% |
| From less than 96 to 95% | 1% |
| From less than 95 to 94% | Nil |
| Less than 94%, penalty will be deducted from the due payments | |
| From less than 94 to 93% | -1% |
| From less than 93 to 92% | -2% |
| From less than 92 to 91% | -3% |
| From less than 91 to 90% | -4% |
| Below 90% | -5% |

## 2.6 Meter Reading, Billing and distribution efficiency

The Contractor shall be responsible for reading the customers water meters, billing the water consumption and distribution of water bills to all the consumers. Performance shall be calculated as given below:

(1) Total number of households which have service connections for billing – (a).
(2) Total number of households for which meter readings taken and bill issued – (b).
(3) Performance **(E)** = 100 x b / a

The expected performance in terms of water meter reading, production and distribution of bills is 100%. Payment of O&M cost against this PI shall be as given in the below table:

| **'Meter Reading, Billing and Distribution Efficiency' Performance (E)** | **Payment payable to the Operator (As percentage of total agreed O&M payment for the billing period)** |
|---|---|
| 100% | 5% |
| From less than 100 to 98% | 4% |
| From less than 98 to 96% | 3% |
| From less than 96 to 94% | 2% |

| | |
|---|---|
| From less than 94 to 92% | 1% |
| From less than 92 to 90% | Nil |
| Less than 90%, penalty will be deducted from the other due payments | |
| From less than 90 to 88% | -1% |
| From less than 88 to 86% | -2% |
| From less than 86 to 84% | -3% |
| From less than 84 to 82% | -4% |
| Below 82% | -5% |

## 2.7 Response time for New Water Supply Connections

The new water supply connections approved by DJB shall be provided on priority. The performance shall be evaluated based on response time in providing the new service connection with water meter. Bench mark shall be calculated based on the time taken for providing new service connection and installation of water meter after sanction by DJB and as explained below.

(1) Total number of households in the contract area seeking for new service connection during a particular billing cycle and sanctioned by DJB – (a)
(2) Number of service connections provided and installation of water meter completed within15 days after sanction by DJB in that billing cycle – (b).
(3) Performance**(F)** = 100 x b / a

The expected performance in terms of providing new service connection with water meter is 100%. Payment of O&M cost against this performance shall be as given in the table below.

| **'Response Time for New Water Supply Connections' Performance (F)** | **Payment payable to the Operator (As percentage of total agreed O&M payment for the billing period)** |
|---|---|
| 100% | 3% |
| From Less than 100 to 95% | 2% |
| From Less than 95 to 90% | 1% |
| From Less than 90 to 85% | Nil |
| Less than 85%, penalty will be deducted from the other due payments | |
| From less than 85 to 80% | -1% |
| From less than 80 to 75% | -2% |
| Below 75% | -3% |

## 2.8 Functioning of Water Meters

All the consumer meters installed by the operator should function as per the manufacturer standards and contract requirement. Performance shall be calculated as given below:

(1) Total number of Water Meters installed in the entire command area by the operator – (a).
(2) Total number of functional (working) water meters from among installed by the operator in the entire command area– (b).
(3) Performance **(G)** = 100 x b / a

The expected performance in terms of functioning of water meters installed by the operator is 100%. Payment of O&M cost against this performance shall be as given in the table below.

| **'Functioning of Water Meters' Performance (G)** | **Payment payable to the Operator (As percentage of total agreed O&M payment for the billing period)** |
|---|---|
| From 100 to 98% | 2% |
| From Less than 98 to 96% | 1% |
| From Less than 96 to 94% | Nil |
| Less than 94%, penalty will be deducted from the other due payments | |
| From less than 94 to 92% | -1% |
| Below 92% | -2% |

## 2.9 Penalty for delay in arresting/repairing of Leaks

The penalty shall be applied for the leaks which are not attended for period of more than 2 days as given below:

- Penalty for one pending HSC leak beyond 2 day is Rs.500/per day for one week (7 days). Beyond 7days, the penalty rate will be doubled.
- Penalty for one pending other leak (mains, appurtenance etc) beyond 2 day is Rs.1000/per day for one week (7 days). Beyond 7days, the penalty rate will be doubled.
- Response time will be counted after official record of the complaint.
- However, the identification of underground leaks by the operator, the response time shall start after the confirmation of the leaks.

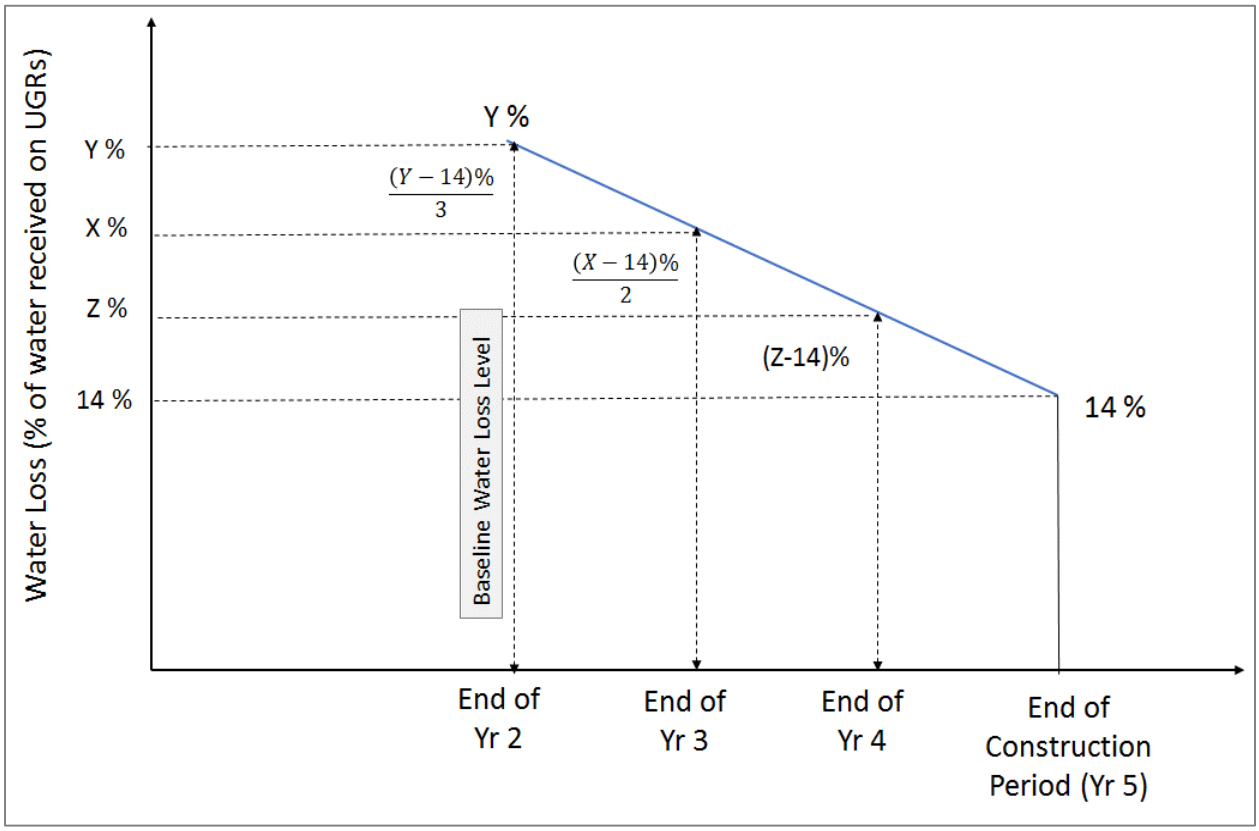
This penalty sum shall be deducted from the contractor's running bills.

## 2.10 Incentives for finding Illegal Connections

The contractor shall be provided an incentive of INR5,000 for each case of illegal connection discovered by it and confirmed by DJB.

## 2.11 Water Loss reduction in Construction Phase

- The Contractor should calculate the water loss level at the last billing cycle of 2nd year, which will be considered as Baseline water loss level. Water loss calculation during the construction period from the last billing cycle of 2nd year shall be calculated by considering the total water into the cluster minus billed & other consumption in the cluster as per the formulae given elsewhere in the Contract document. If there are no flow meters at strategic points to measure the inflow into the cluster, the operator shall carry out temporary flow measurement for a week continuously where ever required. Using this flow data, the operator shall extrapolate the flow for the entire billing period to calculate the water into system which will be used for water loss level calculations.
- Target water loss level at the end of 5th year (construction phase) shall be 14%.
- Target water loss level (distribution water loss) at the end of 3rd, 4th and 5th year shall be achieved as per the method and formula shown in the figure below.
- If the operator fails to achieve the stipulated progress in any year, a caution deposit of 10% of the running bills in the following year shall be deducted and kept on hold until the operator achieve the stipulated progress. As and when the operator achieves the target, the deposit money shall be released without any interest.
- This will be done on Cluster-wise level.
- In case the operator can't achieve the target till end of 6th year, this deposit money will be adjusted against the performance penalty.



## 2.12 Monitoring and Control of Water Loss levels during O&M Period

The monitoring and control of water loss will start after 60 months (5 years) from the date of commencement of contract. It is the responsibility of the contractor to plan the activities to reduce the water loss level within the contract area in the 5 years Construction Period. During the post-construction O&M period the operator shall maintain total water loss level to 15% or lower.

The performance of the operator for water loss levels will be evaluated at every billing cycle from the beginning of the post construction O&M period but the performance based payment on KPIs/SLBs shall apply after six months of post-construction O&M period. It is presumed that all capital works required would have been executed during construction period. The physical works after the construction period can be summarized as follows:

- Repair of leaks in the pipes
- Repair of leaking valves / replacement if required
- Consumer meter testing installed by Operator for accuracy
- Installation of consumer meters for new connections / replacement of not working (not installed by operator). Meters installed by operator but not working will be replaced by operator at his cost.
- Leak detection and repair to control the water loss level below the target level of 15%.

Repair of Leaks in the Pipes & Valves during O&M Period:

- Contractor to attend to all leaks (report and identified) in the project area. Repair of leaks that have been developed because of no fault of the contractor will be reimbursed accordingly. Repair cost of leaks on pipes earlier laid by the contractor will not be reimbursed.
- Repairs to a pipe burst not previously replaced by the operator to be undertaken by the Operator. The payment shall be done as per the BoQ to the operator. However, the pipeline laid by the operator and fails due to burst, will be replace at no cost to the DJB.

## 2.13 Electrical Energy (Power)Consumption Guarantee

The operator shall provide a Guarantee on power consumption, annual energy consumption, in the prescribed format as enclosed/ specified in the Price Schedules. The operator is also required to maintain a power factor of 0.98 or more.

In case of more power consumption than the guaranteed figure or non-compliance on power factor, the penalty shall be imposed as follows.

| Performance Parameter | Rate or amount of Penalty |
|---|---|
| For more electrical power requirement than that of committed in the Contract (attached with the Price Schedules) calculated on annual basis | The rate of NDPL or any other parallel body as charged in bills during the applicable period $\times$(Actual power consumption – Guaranteed Power value) |
| If the Power factor is less than 0.98 | As levied by the power regulatory authority |

Note:

(1) Rate of electric charges per unit shall be worked out on the basis of demand charges, commercial power charges, equipment charges, misuse charges, if any, meter rent, electrical tax and any other charges levied by Power distribution agency.

(2) After award of the contract and approval of detailed design, the contractor shall provide the break-up of total power consumption on fixed and variable power components with calculation details. In case of reduced or increased supply of treated water from the WTP or any shut downs undertaken in the contract beyond the fault of the contractor, the power guarantees figure shall be adjusted (upward or downward) as applicable.

**Incentive for savings in guaranteed power:**

| Particular | Rate or Amount of Incentive |
|---|---|
| In case of savings in the electrical energy charges from the guarantee figure | The savings shall be shared between the operator and DJB on 50:50 proportion. |

## 2.14 Penalties for non-deployment of specified minimum staff for O&M works

Default in compliances on staff attendance falling short of minimum requirement specified shall be as per table below.

| # | Description | Deficiency | Penalty/day |
|---|---|---|---|
| 1 | Manager | Not present on duty | Rs. 15,000 |
| 2 | Asstt. Manager / SCADA cum Inst. Engineer | Not present on duty | Rs. 10,000 |
| 3 | Water Supply Engineer (International). | Not present on duty | Rs., 20,000 |
| 4 | Foreman / Revenue Officer | Not present on duty | Rs. 5000 |
| 5 | Accountant/ Jr. Accountants/ Safety Officer | Not present on duty | Rs. 5000 |
| 6 | Supervisor / Chemist/Bacteriologist/ Asstt. Chemists | Not present on duty | Rs. 5000 |
| 7 | Mechanic/ Drivers | Not present on duty | Rs 3000 |
| 8 | Bill Clerk/ Cashier/ Meter Readers/ Bill Distributor/ Operators / Fitters/ Welder / Electrician / Attendant/ Asstt. Fitters | Not present on duty | Rs. 3000 |
| 9 | Helpers/ Watchman/ Cleaner/ Horticulture Staff | Not present on duty | Rs. 2000 |

## 2.15 Penalties for default in safety and other compliances

Default in compliances on safety, routine/preventive maintenance works and other works shall be as per table below.

| # | **Description** | **Deficiency** | **Penalty in Rs.** |
|---|---|---|---|
| 1 | Cleaning of Site | Not attended up to 1 day | 1000/- |
| 2 | Non-compliance with safety measure (e.g. not wearing Safety shoes, helmets, etc.) and first aid facilities | Any time on duty | 1000/- |
| 3 | Non-observance of preventive maintenance schedule | Any time on duty | 5000/- |
| 4 | Delay in getting the equipment repaired with specific period | To be specified by the considering type of equipment | 5000/- |