### 8.3. For Concrete Design: Limit State Of Serviceability

<table>
<thead>
<tr>
<th>LOAD CONDITION</th>
<th>LOAD COMBINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERECTION</td>
<td>1.5 * (DL + EL) ± 1.5 * WL</td>
</tr>
<tr>
<td></td>
<td>0.9 * (DL + EL) ± 1.5 * SL</td>
</tr>
<tr>
<td>TESTING</td>
<td>1.5 * (DL + EL) ± 1.5 * WL</td>
</tr>
</tbody>
</table>

### 8.4. For Structural Steel Design: Limit State Of Strength

<table>
<thead>
<tr>
<th>LOAD CONDITION</th>
<th>LOAD COMBINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERVICEABILITY</td>
<td>1.0 * (DL + LL)</td>
</tr>
<tr>
<td></td>
<td>1.0 * (DL ± WL)</td>
</tr>
<tr>
<td></td>
<td>1.0 * (DL ± SL)</td>
</tr>
<tr>
<td></td>
<td>1.0 * (DL + LL + EL)</td>
</tr>
<tr>
<td></td>
<td>1.0 * (DL + EL ± 0.8 * (LL ± WL))</td>
</tr>
<tr>
<td></td>
<td>1.0 * (DL + EL ± 0.8 * (LL ± SL))</td>
</tr>
<tr>
<td>OPERATING</td>
<td>1.5 * (DL + LL + ELo)</td>
</tr>
<tr>
<td></td>
<td>1.5 * (DL + ELo ± WL)</td>
</tr>
<tr>
<td></td>
<td>1.2 * (DL + LL + ELo) ± 0.6 * WL</td>
</tr>
<tr>
<td></td>
<td>0.9 * (DL + ELo) ± 1.5 * WL</td>
</tr>
<tr>
<td></td>
<td>1.5 * (DL + ELo ± SL)</td>
</tr>
<tr>
<td></td>
<td>1.2 * (DL + LL + ELo) ± 0.6 * SL</td>
</tr>
</tbody>
</table>
### LOAD CONDITION | LOAD COMBINATION
--- | ---
ERECION | 0.9 * (DL + ELC) ± 1.5 * SL
 | 1.5 * (DL + ELC ± WL)
 | 1.5 * (DL + ELs)
 | 1.2 * (DL + LL)
 | 0.9 * DL + 1.2 * LL
TESTING | 1.5 * (DL + ELt ± WL)
 | 1.5 * (DL + ELt)

#### 8.5 For Structural Steel Design: Limit State Of Serviceability

| LOAD CONDITION | LOAD COMBINATION |
--- | ---
SERVICEABILITY | 1.6 * (DL + LL + ELD)
 | 1.5 * (DL + WL)
 | 1.0 * (DL + SL)
 | 1.0 * (DL + ELD) + 0.8 * (LL ± WL)
 | 1.0 * (DL + ELD) + 0.8 * (LL ± SL)

Following points shall be noted while doing the load combinations:

- For structures which are supporting more than one equipment, only one equipment shall be hydro tested at a time
- If wind load is the main load acting on the structure, no increase in the permissible stress is allowed
- Earthquake is not likely to occur simultaneously with maximum wind

#### 9. SERVICEABILITY

#### 9.1 DISPLACEMENTS

The limiting permissible deflections for structural steel members shall be as specified in Table 6 from IS: 800.

The limiting permissible vertical deflection for RCC members shall be as per IS: 456.

The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times storey height. For RCC structures, under transient wind load the lateral away at the top shall not exceed 0.002 times the height of the building.
10. COMPUTER PROGRAMS

Following computer program is used for analysis and design.

STAAD.Pro V8i: All analysis and design work related with RCC or structural steel shall be carried out using STAAD Pro V8i.

Limit State Method of design as per IS: 456 shall be followed in the design of concrete structures unless otherwise specified elsewhere in this document for special structures.

Limit State Method of design as per IS: 800 shall be followed in the design of new steel structures unless otherwise specified elsewhere in this document for special structures.

11. DESIGN PHILOSOPHY

11.1 STRUCTURAL DESIGN OF RC ELEMENTS (CONCRETE MIX)

a) Type Of Cement:

Cement used in all types of concrete work (RCC, PCC & Plum Concrete) shall be factory blended Portland Pozzolana Cement (fly-ash based), conforming to IS: 1489 (Part-1).

b) Reinforced Cement Concrete (RCC):

Reinforced concrete conforming to IS: 456 shall be used with 40mm downgraded crushed stone aggregate for foundation and for other structural elements with 20mm downgraded crushed stone aggregate unless noted otherwise. Considering Moderate exposure condition the minimum grade of reinforced cement concrete to be used for different structures and foundations shall be M25. RCC to be used for grade slab inside enclosed buildings shall be of grade M20.

Minimum cement content 320 kg/m³ and maximum water cement ratio 0.45 shall be as specified in Table-5 of IS: 456.

Reinforced Cement Concrete (RCC) for Liquid Retaining Structures:

Unless otherwise specified minimum grade of RCC to be used for Liquid Retaining Structures and its foundations shall be M30 conforming to IS: 456 shall be used using 20mm and down size graded crushed stone aggregate.

c) Plain Cement Concrete (PCC):

Unless otherwise specified 100mm thick PCC of mix 1:4:8 (by weight, using 20mm and down size grade crushed stone aggregate) shall be provided under all RCC foundations. The PCC concrete shall extend 100mm beyond the foundation.

Minimum cement content and maximum water cement ratio shall be as specified in Table-5 of IS: 456.
d) **Plum Concrete:**

Unless otherwise specified Plum concrete of grade 1:3:6 (using 40mm and down size grade crushed stone aggregate) shall be used as filler material wherever loose sub grade exists by removing the loose soil/fill.

e) **Grouting:** Concrete grade for grouting shall be of M20.

f) **Aggregates:**

Aggregates shall confirm to IS: 383 - "Specification for coarse and fine aggregates from natural sources for concrete".

11.2 **Reinforcement Bars**

High Yield Strength Deformed (HYSD) Thermo Mechanically Treated (TMT) steel bars of minimum grade Fe 500D, confirming to IS: 1786 shall be used.

Mild Steel round bars shall not be used as reinforcement.

11.3 **Grouting & Minimum Grout Thickness**

The minimum thickness of grout shall be 25 mm and not more than 50mm.

All anchor bolt sleeves/ pockets and spaces under column bases, shoe plates etc. shall be grouted with free flow, non-shrink (premix type) grout having 28-days minimum cube crushing strength of 40N/mm². Ordinary cement sand (1:2) grout shall only be used under the base plates of crossover, short pipe supports (not exceeding 1.5 m height) and small operating platforms (not exceed in 2.0m in height) not supporting any equipment. Neat cement shall not be used for grouting under any condition.

Epoxy grout shall be used for setting rotating equipments such as generators, reduction gas compressor & gas turbine. Manufacturer’s recommended epoxy grout and guidance for minimum thickness shall be used.

11.4 **Minimum Cover To Main Reinforcement**

Minimum cover to main reinforcement shall be as per Table No.16 of IS: 456.

11.5 **Minimum Cover To The Foundation Bolts**

Minimum distance from the centre line of foundation/anchor bolt to edge of the pedestal shall be the maximum of the following:

a) Clear distance from the edge of the base plate/base frame to the outer edge of the pedestal shall be minimum 50mm.

b) Clear distance from the face of pocket to the outer edge of the pedestal shall be 75mm.
11.6 Minimum Thickness Of Structural Concrete Elements

The following minimum thickness shall be followed:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>RCC Works</th>
<th>Minimum Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Footings (All types including raft foundations without beams). (Note: Tapered footings shall not have thickness less than 1.50mm at the edges. Minimum average thickness shall not be less than 300mm)</td>
<td>350 mm</td>
</tr>
<tr>
<td>b)</td>
<td>Slab thickness in raft foundations with beam &amp; slab construction.</td>
<td>350 mm</td>
</tr>
<tr>
<td>c)</td>
<td>Floor / Roof Slab, Walkway, Canopy Slab</td>
<td>125 mm</td>
</tr>
<tr>
<td>d)</td>
<td>Walkway (1.3.8)</td>
<td>125 mm</td>
</tr>
<tr>
<td>e)</td>
<td>Cable/Pipe Trench/Laundry Walls &amp; Base Slab</td>
<td>125 mm</td>
</tr>
<tr>
<td>f)</td>
<td>Parapet</td>
<td>100 mm</td>
</tr>
<tr>
<td>g)</td>
<td>Precast Trench Cover / Floor Slab</td>
<td>75 mm</td>
</tr>
<tr>
<td>h)</td>
<td>Liquid Retaining / Leak Proof Structure Walls &amp; Base Slab.</td>
<td>150 mm</td>
</tr>
<tr>
<td>i)</td>
<td>Underground pit / Reservoir (below ground water table) Walls &amp; Base Slab.</td>
<td>250 mm</td>
</tr>
<tr>
<td>j)</td>
<td>Underground pit (above ground water table) Walls &amp; Base Slab.</td>
<td>200 mm</td>
</tr>
</tbody>
</table>

Reinforced concrete elements designed to resist earthquake forces and detailed as per IS: 13920 shall satisfy the following requirements:

Beams:
- a) Width of member shall not be less than 200mm.
- b) Width to depth ratio of the member shall be preferably more than 0.3.
- c) Depth of the member shall not be more than 1/4 of the clear span.

Columns:
- a) Minimum dimension of member shall not be less than 300mm.
- b) Ratio of the shortest cross sectional dimension to the perpendicular dimension shall not be less than 0.4.
11.7 Foundations

The sizes of the foundations will be based on the Allowable bearing pressure obtained as per soil investigation report.

12. STRUCTURAL STEEL DESIGN

12.1 General

The design of all structural steel work such as roof trusses, steel sheds, pipe racks, pipe bridges, tank supporting platforms, stairs, ladders, walkways, crane girders, steel enclosures etc. will be carried out in accordance with IS: 800-2007.

Design, fabrication and erection of the above work shall be carried out in accordance with the following IS Codes as applicable to the specific structures, viz.: IS: 800; IS: 814, IS: 875; IS: 1893, etc. Basic consideration of structural framework shall primarily be stability, ease of fabrication / erection and overall economy satisfying relevant Indian Standard Codes of Practice.

Simple and fully rigid design as per IS: 800 shall be used. Where fully rigid joints are adopted they shall generally be confined to the major axis of the column member.

Structural stacks continuously exposed to temperatures above 200 deg.C shall be designed for reduced stress as per Table 4 of IS: 6533 (Part-2). The expected temperature of steel components shall not be allowed to exceed 400°C.

Crane gantry girders shall generally be of welded construction and of single span length. Chequered plate shall be used for gantry girder walkway flooring.

12.2 Steel Grade

Structural rolled steel sections shall be of E250 grade, quality A/B/R, semi-killed/rolled and conforming to IS: 2062. Where, V-Notch energy > 27 J unless noted.

Structural steel plates shall be of E250, quality A/B/R, killed, tested for impact resistance and conforming to IS:2062 unless noted. Plates beyond 12mm and up to 40mm thickness shall be controlled rolling. Plates beyond 40mm thickness shall be normalizing rolling and shall be ultrasonically tested as per ASTM-A578 level B-52.

All Holding down Bolts (Anchor Bolts) shall be out of Mild steel of property class 4.6 conforming to IS: 5624-1993.

- Nuts shall conform to IS: 1363.
- Threading shall be coarse conforming to IS: 1367 and IS: 4218.
- Sleeve shall be M.S. Tubes (Medium) as per IS: 1239.
- Washers shall conform to IS: 2016.
- Stiffeners shall conform to IS: 2062 Grade-A or Grade-B.
12.3 Miscellaneous Steel Materials

Miscellaneous steel materials shall conform to the following IS codes:

- Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (Grade I) (For mild steel bars of anchor bolts, rungs, metal inserts, grating etc.) IS: 432
- Hexagonal head bolts, screws & nuts of product Grade C IS: 1363
- Plain washers IS: 2016
- Steel chequered plates IS: 3502
- Hexagonal bolts and nuts (M42 to M150) IS: 3138

12.4 Anchor bolts

Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant IS codes as mentioned above.

12.5 Limiting Permissible Stresses

Permissible stresses in structural members shall be as specified in:
- IS:800 Hot rolled sections
- IS:801 Cold formed light gauge sections
- IS:806 Tubular structures

Permissible stresses in Bolts shall be as specified in:
- IS:800 Hot rolled sections.
- IS:801 Cold formed light gauge sections.

Permissible stresses in Welds shall be as specified in:
- IS:801 Cold formed light gauge sections.
- IS:816 Metal Arc Welding

12.6 Limiting Deflection

The limiting permissible vertical and horizontal deflection for structural steel members shall be as specified in Table-6, IS: 800.

12.7 Environmental Exposure Condition & Painting

Environmental exposure condition for all structures shall be considered as Moderate as per clause 15.2.2.1, Table-28 of IS 800: 2007. Environmental classification shall be considered as Normal inland, mild as per Table-28 (a) of IS: 800.

Painting / Surface protection shall be as per clause 15.2.4, Table-29, of IS: 800-2007. Coating System - 4 shall be considered for structural steel works for normal inland, mild
environmental classification. Life of coating system – 4 is considered to be about 20 years as per Table-29 (a) of IS: 800-2007.

12.8 Design Criteria

Basic consideration of structural framework shall primarily be stability satisfying relevant Indian Standard Codes of Practice and specifications given herein.

12.8.1 Steel Staircase, Ladders, Handrails and Gratings

a) Steel staircases for main approaches to operating platforms shall have channels provided as stringers with minimum clear width of 750mm and slope not exceeding 45°. The vertical height between successive landings shall not be less than 2.6m nor exceed 4.0 meters. Treads shall be minimum 300mm wide made of grating (with suitable nosing) spaced equally so as to restrict the riser to maximum 200mm. Staircase head room height shall be minimum 2.2m.

b) All handrails, staircase steps and platform gratings shall be hot dip galvanized as per specs/IS Codes.

c) Ladders shall be provided with safety cages when the top of the ladder is more than 3.0 m above the landing level. Safety cages shall start 2.1 metres above the lower landing level. Ladders shall be of 450mm clear width with 20mm diameter MS rungs spaced at 300mm (maximum). Ladders shall preferably be vertical. In no case shall the angle with the vertical exceed five degrees.

d) Handrails, 1000mm high, shall be provided to all walkways, platforms, and staircases.

(e) Toe plate (100mmx5mm) shall be provided for all hand railing (except for staircases).

Spacing of uprights shall be 1500mm (maximum).

f) Types of Hand Railing shall be provided as under:

\[ x \] For walkways, platforms (except platform supported on vessels), and staircases:

- Top rail, mid rail and upright shall be 32 (M) NB Class B MS pipes

\[ x \] For platforms supported on vessels top rail shall be 40(M) NB Class B MS pipes but mid rail (flat 50x6) and upright (Angle 50x5x6) shall be of structural steel

f) MS Gratings shall be Electro-forged hot dip galvanized and minimum 25 mm deep. The maximum size of voids in the grating shall be limited to 30mm x 100mm. The minimum weld length shall be as per IS: 816. Deflection shall not be more than 6mm or span/200, whichever is lesser.

g) Galvanization shall be done in accordance with IS: 2629 and tested as per IS: 2633 and IS: 6745. Quantity of zinc coating shall be minimum 610 g/m² of surface area.

12.8.2 Connections

a) Welded connections shall be adopted in general, except for isolated cases where bolted connections are specifically allowed with prior permission from Owner/Owner’s representative. All permanent and erection connections shall have at least two 20mm diameter and 16mm diameter bolts respectively, unless restricted by the member size.
b) All connections shall be designed for full moment carrying capacity of the connecting members together with 60% full shear carrying capacity for rolled steel sections or for the actual design forces, whichever is more. For members with built-up sections from rolled steel and plates, 80% of full shear carrying capacity shall be used for end connections.

c) Connection shall be designed as per Section 10 of IS: 800.

d) The joint shall be able to sustain a minimum pullout load of 1.5 times the allowable shear capacity of the secondary member.

e) All fabricated structures shall be given one shop coat of primer compatible with the final painting. The final painting of steel surfaces shall be done as per specifications included elsewhere in this bid package.

f) Any connection bolt main framing members (e.g. Moment Connections) shall be high strength friction grip bolt conforming to IS:3757 property Class 8.8.

g) Connection bolts for minor connection such as hand railing connection / ladder and fixing of floor grating and grating tread, etc. shall be ordinary strength bolt conforming to IS:1367 property Class 4.6.

h) The ends of all tubes members shall be sealed by using 6 mm thick plates welded all round.

i) Minimum two nuts shall be used for all anchor bolts.

13 DESIGN REQUIREMENT FOR SPECIFIC APPLICATIONS

13.1 Machine Foundation

a) Design of machine foundation shall be as per IS:2974 and IS:456.

b) The soil stress below foundation under dead loads shall not exceed 80% of the allowable soil bearing capacity of static loading.

c) The eccentricity of load and foundation area shall be less than 5% for block foundation and 3% of frame foundation.

d) Foundation shall be so designed that natural frequency of the foundation system shall not resonate with the following:

i) Operating speed of the motor.

ii) Operating speed of machine.

iii) 2 x operating speed of the machine.

iv) Critical speed of machine (for centrifugal machine).

e) Natural frequency of foundation shall preferably be ±20% away from the above mentioned frequencies. However, amplitudes of vibration of the foundation block shall be checked to be within permissible limits.
f) The foundation and its superstructure shall be separate from adjacent foundation and platforms.

g) The ratio of weight of pump foundation to the weight of vibrating machine shall be greater than 3.

h) The amplitude of foundation shall not exceed 200 micron as per IS: 2974 or as indicated by vendor, whichever is less. Vertical sliding and rocking amplitude shall be calculated independently. Sliding and rocking modes are coupled to calculate critical horizontal amplitude.

13.2 Cable and Pipe Trench

a) All the cable trenches as per electrical requirements in the unit area / control building shall be RCC in 6mm chequered plate covering. The support for the chequered plate shall be at closer intervals.

b) The sides of trench shall be designed to resist earth pressure and the following loads:
   i) Cable load of 155 kg/m length of cable support + 75 kg on one tire at the end.
   ii) Earth pressure + uniform surcharge pressure of 2 T/m² (for outside the building).
   iii) Earth pressure + uniform surcharge pressure of 500 kg/m² (for inside the building).

c) Cable trench cover shall be designed for self-weight of top slab + UDL of 500 kg/m² and 200 kg at center of span on each panel.

d) Cable trench crossing the road shall be designed for Class A loading of IRC / relevant IS code. Alternatively, adequate number of hume pipe / HDPE pipe shall be provided and checked for class A loading of IRC.

e) Trenches shall be drained out. The trench bed shall have a slope if 1 in 1000 along the run and 1 in 250 perpendicular to the run. Necessary sumps shall be constructed and sump pumps if necessary shall be provided. Cable trenches shall not be used as storm water drains.

f) If trenches are outside the covered area, then top of trenches shall be kept at least 150mm above the high point of finish ground level or finish floor level. The top of the trench shall be such that the surface rainwater does not enter the trench.

g) All metal parts inside the trench shall be connected to the earthing system.

h) Trench shall be filled with fine sand if required.

13.3 Pipe rack

For designing the pipe rack superstructure and foundation the following loads shall be considered.

a) Vertical loading
The vertical loading shall be as per the inputs provided by the piping, electrical & instrumentation discipline. In calculating the actual weight of pipe, the class of pipe, material content and insulation, if any, shall be taken into consideration. Insulation density shall be taken as per the inputs from piping discipline. In case of gas/steam carrying pipes, the material content shall be taken as 1/3rd volume of pipe filled with water.

The total actual weight thus calculated shall then be divided by the actual extent of the span covered by the pipes to get the uniform distributed load per unit length of the span. To obtain the design uniformly distributed load over the entire span, the above load shall be assumed to be spread over the entire span. However, minimum loading for any pipe rack shall not be less than 1.25 kN/m². In case, the calculated loading is higher than 1.25 kN/m², this shall be rounded off to the nearest multiple of 0.25 (i.e. 1.50, 1.75, 2.0 kN/m²).

In absence of data, pipe operating loads (other than gas & steam pipes) up to 300mm diameter shall be considered as 0.9 kN/m² (empty weight) & 1.2 kN/m² as water filled weight. Loading for pipes of higher diameter shall be individual point loads as per piping inputs.

b) Friction Force (Longitudinal and Transverse)

Where the pipes are of similar diameter and service condition, the friction force at each tier on every portal, both in longitudinal and transverse directions shall be 15% of the design vertical loading of the pipes for four or more pipes supported on a tier.

For a single pipe or up to three pipes at a tier on piperack, tee supports, trestles, the frictional force shall be taken as 30% and 10% of the design vertical force acting simultaneously in transverse and longitudinal directions respectively or 10% and 30% of design vertical force acting simultaneously on the transverse and longitudinal directions respectively.

Longitudinal friction force shall be considered as uniformly distributed over the entire span of the beam at each tier and transverse friction force shall be considered as a concentrated load at each tier level.

c) Anchor And Guide Force (Thermal Load)

The Anchor or Guide Forces in longitudinal and transverse directions shall be as per piping inputs.

Steel beams subjected to above-mentioned horizontal anchor forces shall be designed for torsion arising from the anchor forces.

d) Cable Tray/Ducts and Walkway Loads

The estimated actual load from electrical trays and instrumentation ducts shall be considered at the specified locations, together with walkways, if provided.

e) Loads on Intermediate Secondary Beams

Intermediate Secondary at each piping tier level shall be designed for 25% of the load on the main portal beams, in case detailed piping loads are not available. A reduction of
10% in the loading on the main portal beams is permissible in case secondary beams are loaded as aforementioned.

f) **Loads On Intermediate Secondary Beams (Longitudinal Beams)**

Longitudinal beams at each tier level shall be strong enough to sustain 25% of the loads on the transverse beams. This load shall be assumed to act as two equal point loads acting at 1/3rd span locations. These loads shall be considered in addition to the axial forces that can be transferred to the longitudinal tie beams. Friction & anchor forces, if any as provided by the piping discipline shall also be taken into account in the design.

**Wind Loads**

To calculate wind load on the pipes in the transverse direction of pipe rack, a projected height equal to (diameter of largest pipe including insulation (m) +10% of width of pipe rack (m)) shall be considered. This projected height multiplied by the spacing of the portals shall be considered the effective area for calculating the wind load on each portal. The wind load in transverse direction shall be considered as point loads acting at

The ends of the transverse beams.

Wind load on structural members shall be calculated in addition to the wind loads on the pipes as mentioned in the above point.

Force coefficient, "Cf" for wind load on pipes shall be considered as 0.7

Wind load on cable trays in transverse direction shall be calculated considering a projected height of (Height of tray (m) + 10% of the width of the pipe rack (m)). The force coefficient, "Cf", for the cable trays shall be considered as 2.0

13.4 **SPECIAL CONSIDERATION**

Grade slab in the main plant building shall be designed to withstand the worst load arising due to fork lift or any other moving vehicle so as to ensure durability.

13.5 **CURRENT DEVELOPMENT IN TECHNOLOGY AND PRACTICES**

All current developments in construction practice are covered in technical specification.

13.6 **INNOVATIVE IDEAS**

The main plant ISBL structure is being relocated from the Malaysia to Dighi site. The plant layout will be developed considering there will not be any major changes and the material available/ brought will be consumed as is. All required space optimization and utilization for ISBL and OSBL areas will be taken up for same.

13.7 **MISCELLANEOUS WORKS**

13.7.1 **Roads**

- All the roads shall be of RCC with pavement quality concrete of M40 minimum grade
All roads shall be provided with a cross slope of 2.5% from the crown towards the edges.

The radius of curves for the roads junctions and bends shall be 1.5 times the width of road unless mentioned otherwise.

### 13.7.2 Storm Water Drainage

- Drains with sufficient width and depth shall be provided to route the storm water from new proposed plant area to main existing plot drains.
- Drainage network shall be planned on either side of the roads to discharge the storm water from the roads as well as the roof structures.
- Manning’s Formula is used to calculate the velocity & discharge in the drains with Manning’s roughness co-efficient as n= 0.015
  \[ v = \frac{1}{n} \times \frac{A}{S} \times \frac{2}{n} \times \frac{V}{x} \] in m/s
  \[ Q = V \times A \text{ in m}^3/\text{s} \]
- Drains shall be of Brickwork or RCC construction based on the width and depth of storm water drain required.
CHAPTER 8

STATUTORY AUTHORITIES
### CODES AND STANDARDS

Following codes and standards are used:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Particulars</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Fire protection facilities</td>
<td>OISD 144, 2nd edition, October 2005</td>
</tr>
<tr>
<td>4.</td>
<td>Bullet</td>
<td>BS PD 5000: 2009</td>
</tr>
<tr>
<td>5.</td>
<td>Pumps</td>
<td>API 610, 11th edition, September 2010</td>
</tr>
<tr>
<td>7.</td>
<td>Electrical</td>
<td>IS 5571 / IS 5572 / Indian Electricity Rules / OISD 113, 110, GDN 180, RP 149</td>
</tr>
</tbody>
</table>

### STATUTORY AUTHORITIES

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Item requiring statutory approval</th>
<th>Approving Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Additional Electric Power</td>
<td>Chief Engineer, Maharashtra Electricity Board</td>
</tr>
<tr>
<td>2.</td>
<td>Environment Clearance</td>
<td>Ministry of Environment &amp; Forest</td>
</tr>
<tr>
<td>3.</td>
<td>Permission for Intake of River Water</td>
<td>Chairman &amp; MD, Maharashtra Urban Water Supply &amp; Drainage Board</td>
</tr>
<tr>
<td>4.</td>
<td>NOC from Pollution Control Board</td>
<td>Environmental Officer, Maharashtra State Pollution Control Board</td>
</tr>
<tr>
<td>5.</td>
<td>Permission for Steam Boiler</td>
<td>Chief Inspector of Factories &amp; Boilers</td>
</tr>
<tr>
<td>6.</td>
<td>Operation</td>
<td>Chief Electrical Inspector</td>
</tr>
<tr>
<td>7.</td>
<td>Approval of Fuel Lift Storage Facility</td>
<td>Chief Controller of Explosives</td>
</tr>
<tr>
<td>Sl No.</td>
<td>Item requiring statutory approval</td>
<td>Approving Authority</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------------------------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Permission for Construction of Factory Buildings</td>
<td>Maharashtra Industrial Area Development Board</td>
</tr>
<tr>
<td>9</td>
<td>NOC from Fire Department</td>
<td>Regional Fire Officer</td>
</tr>
</tbody>
</table>
14.2 Determining the demand for air
The required volume of air is to be determined in order to design the ventilation system is composed of the following individual requirements.

14.3 Combustion air requirement
If the combustion air is drawn from inside the engine room, it must be included in the layout of the ventilation air system for the engine room. The combustion air temperature is one of the factors which influence the location-dependent output achievable by the engine.

15.0 Cooling air requirement for the engine and components
The radiation heat from the engine, the generator and/or other components in the engine room which radiate heat, such as e.g. auxiliaries, including pumps, separators, heat exchangers, boilers, etc must be discharged via the engine room ventilation system. Components such as e.g. compressors which operate only intermittently are likely to be neglected in most cases when determining the demand for cooling air.

15.1 Air ducts
Depending on the design of the system or the location of the engine room inside a larger building, e.g. in the basement in the case of emergency power systems, the air to ventilate the engine room may have to be brought in over longer distances. For this purpose, air ducts are to be employed. The pressure losses in these ducts must be considered when designing the fans. To avoid condensation, outside air ducts should be insulated.

15.2 Engine cooling systems
The coolants employed have water as a cooling medium and from an engine perspective must be closed systems. The genset engines shall have either single-circuit or dual-circuit

15.3 Single-circuit cooling
The coolant of gas engines with a single-circuit passes through the lubricating oil cooler, the mixture coolers and the engine, i.e. the total heat is discharged in one single circuit.
15.4 Dual-circuit cooling
Along with an engine water cooling circuit, engines with a dual-circuit also have a low-temperature mixture/charge air cooling circuit. As the temperature level in the mixture cooling circuit is comparatively low, the heat from those circuits should be normally discharged to the environment via fan coolers or cooling towers with a separate circuit.

15.5 Gas engines
All gas engines should be equipped with a two-stage mixture cooler on the engine. The high temperature stage is integrated into the engine cooling circuit and the heat from low temperature stage is discharged in the external mixture cooling circuit. Depending on the layout of the system as a whole, it can be installed on the water side in the engine circuit, in the low temperature mixture circuit or in the heating water circuit.

16.0 Fuel system
16.1 Gaseous fuels
The engines operated by combustible gas work as 4-stroke engines following the Otto cycle. The gas-air mixture is fed to the combustion chamber; combustion is then initiated by external ignition via a spark plug. The fuel gases mainly used are natural gas. The principal constituents of these gases are hydrocarbons (methane, ethane, butane and propane) as well as nitrogen and carbon dioxide. The minimum combustion gas characteristics must be maintained according to the data given in the Technical Circular for fuel gas.

16.2 Methane number
An important characteristic determining the use of a gas in a gas engine is its knock resistance, i.e. the gas mixture must not self-ignite before ignition, nor must any self-ignition effect cause it to explode suddenly after ignition. Its methane number gives the knock resistance of a gas. This indicates when a combustion gas in a test engine shows the same knock characteristics as a comparable mixture of methane and hydrogen. To ensure knock-resistant operation with different gases to be used, the methane number must comply with the data sheets. If a gas analysis is available, the respective methane number can be evaluated during detailed engineering.

16.3 Gas control line
Generally, gas engines may only be operated with gas control lines approved by genset manufacturer. Before the gas and air are mixed in the venturi mixer, the pressure of gas must be reduced to atmospheric pressure. This is performed by the membrane zero
pressure regulator in the gas control line. The zero pressure regulators have no auxiliary energy supply. At the inlet to the gas control line is a manually operated ball valve. This is followed by a gas filter as protection against major impurities. The filter insert comprises a filter mat; filtration rate is approx. 85 % for particles >5 μm. Then come two shut-off valves, which are implemented as solenoid valves or pneumatically operated valves depending on the nominal width. When using combustion gases which may contain oxygen, e.g. landfill gas and sewage gas, a deflagration device with temperature monitor is fitted after the shut-off valves. Finally, there is the zero pressure regulator. A minimum pressure sensor is always installed in advance of the solenoid valves. Dependent on the safety requirements for the system, the gas control lines may be equipped with leakage sensors, intermediate vent valves or maximum pressure monitors. Zero-pressure gas control lines are operated at an pre-pressure of up to 200 mbar. In the case of higher prepressures, either a special design of gas control line or a pre-pressure control line will be required.

Flowmeters shall be installed in the main incoming Natural Gas Line and shall also be installed in the branch lines for each genset.

16.4 Blow-off and breather lines for gas control lines

Lines to atmosphere have to be laid without restriction in the diameter (observe pressure loss) as indicated by the manufacturer of the gas pressure regulator and safety device. Shut-off valves are not allowed in breather lines. Blow-off and relief lines must not be connected to breather lines into a collection line. Only lines to atmosphere are exempted where breather and safety blow-off devices are already connected inside the units.

16.5 Throttle valve

The power output or the speed of the engine is regulated via the throttle valve by means of controlling the amount of the compressed mixture to the engine.

17.0 Lubricating oil system

The lubricating oil systems of the engines are implemented as wet sump lubricating systems.
All engine series have integral lubricating oil pumps; the oil is filtered and cooled by either engine-mounted or separate filters and oil coolers. The external oil-coolers and assembly parts have to be designed for a minimum design pressure.

18.0 Combustion air system

The normal composition of combustion air is considered to be dry air with a certain amount of steam. The steam content in the air is defined by the relative humidity at a defined air pressure and air temperature. Basically the combustion air must be free of components forming acids or bases; e.g. sulfur dioxide (SO₂) forms sulfuric acid when combined with water (H₂O).
WASTE HEAT RECOVERY BOILER ( WHRB)

1. Heat Energy of the 17MW Gas turbine exhaust shall be considered for the WHRB.


3. Parameters of WHRB are as mentioned below:

   3.1 Inlet Gas Temperature : 500°C
   3.2 Inlet Gas Source : Gas turbines exhaust
   3.3 Outlet Gas Temperature : 170°C
   3.4 Outlet Superheated Steam parameter : 10bar(g) @ 250°C
   3.5 Outlet Superheated Steam Flow : 12000 kg/hr (F & A 100°C)

4. Regulations followed:
   - Indian Boilers Regulations (IBR) -1950 with latest amendments
   - Central Pollution Control Board (CPCB) norms
   - BS845-1 Methods for assessing thermal performance of boilers.
   - IS 6533: Code of practice for design and construction of steel chimneys

5. WHRB as per IBR with below components has been considered:
   - Water tube Bank
   - Steam Drum
   - 4 stage Heat recovery units: Superheater, Evaporator, Economizers and Preheater
   - Feed water tank cum Deaerator
   - Working +1Standby Feed water pumps
   - Instrumentation
      - Feed water Control station
      - Pressure Safety valves
      - Field instruments
      - Safety interlocks, Monitoring and Control System
      - Cabling and Panels
      - Interfacing to Plant DCS
   - Electricals: Motors, Cabling, Earthing and Panels
   - Chemical Dosing system
   - Blowdown System
   - Piping with valves, specialties and supports
   - Inlet-outlet gas ducting
x Steel exhaust stack with aviation lighting, lightning arrester and Emission control, sampling provisions as per CPCB norms
x WHRB Casing
x Insulation
x Painting
x Support structures: Piping, Equipment, Cable trays
x Foundation bolts, Platforms and Access stairways

1.3.8 Performance after Commissioning
x Testing shall be executed by the Contractor as per BS 845-1 Indirect method after one month of trouble free operation.

x Guarantee shall be provided by Contractor for a minimum period of 18 months from the date of handing over after commissioning of all equipment and materials under the contract.
GAS FIRED BOILER


1.5 Parameters of Boiler are as mentioned below:

- Fuel: Natural Gas @2bar(g)
- Fuel Net Calorific Value: 8500 kCal/sqm Outlet
- Steam parameter: 10bar(g) @185°C Outlet
- Steam Flow: 10000 kg/hr (F & A 100°C) Flue
- Gas Temperature : 170°C
- Regulations followed:
  ¾ Indian Boilers Regulations (IBR)–1950 with latest amendments
  ¾ Central Pollution Control Board (CPCB) norms
  ¾ BS845-1 Methods for assessing thermal performance of boilers
  ¾ IS 6533: Code of practice for design and construction of steel chimneys

1.6 boiler as per IBR with below components has been considered:

- Horizontal Wetback 3-Pass package Boiler
- Mono-Block Automatic Burner for Natural Gas firing
- Force Draft Blower with inlet damper control
- Heat recovery units: Economizers and Air-Preheater
- Feed water tank cum Deaerator
- 1 Working + 1 Standby Feed water pumps
- Instrumentation
  ¾ Gas Pressure Reducing Station: 2bar(g) to 100mbar(g)
  ¾ Feed water Control station
  ¾ Pressure Safety valves
  ¾ Field Instruments
  ¾ Safety interlocks, Monitoring and Burner Management with 3-Element drum level control
  ¾ Steam to Fuel Ratio Monitoring system
  ¾ Cabling and Panels
  ¾ Interfacing to Plant DCS

- Electricals: Motors, Cabling, Earthing and Panels
Chemical Dosing system
Bloodstain System
Piping with valves, specialties and supports
Inlet-outlet gas ducting
Steel exhaust stack with aviation lighting, lightning arrester and Emission control, sampling provisions as per CPCB norms
Insulation
Painting
Support structures: Piping, Equipment, Cable trays
Foundation bolts, Platforms and Access stairways

1.7 Performance after Commissioning
Testing shall be executed by the Contractor as per BS 845-1 Indirect method after one month of trouble free operation.
Guarantee shall be provided by Contractor for a minimum period of 18 months from the date of handing over after commissioning of all equipment and materials under the contract.
COOLING WATER SYSTEM

1.0 DESCRIPTION

1.1 Open loop induced draft cooling tower of capacity 4000 m³/hr (500 m³/hr x 8 Nos) shall be installed for the process and utility requirement with supply and return temperature of 35°C & 85°C.

1.2 Cooling towers shall be out of FRP construction with hot dip galvanized structural members.

1.3 Cold water basin shall be of RCC type. Cooling tower basin capacity shall be cooling water pumped in five to six minutes by circulation pump.

1.4 The Return line pressure at the inlet of the cooling tower shall be 7 MLC.

1.5 Considering cycle of concentration (COC) of 5, blow down losses is 82 m³/hr. The maximum footprint for the cooling tower per cell shall be 8M x 8M.

1.7 EQUIPMENT LIST

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DESCRIPTION</th>
<th>CAPACITY</th>
<th>QUANTITY</th>
<th>POWER CONSUMPTION (KW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>COOLING TOWER</td>
<td>500 m³/hr</td>
<td>8</td>
<td>S 1 9</td>
</tr>
<tr>
<td>2</td>
<td>COOLING WATER CIRCULATION PUMPS</td>
<td>500 m³/hr</td>
<td>8</td>
<td>S 1 9</td>
</tr>
<tr>
<td>3</td>
<td>BLOW DOWN PUMPS</td>
<td>100 m³/hr</td>
<td>1</td>
<td>S 0 1</td>
</tr>
</tbody>
</table>
1. **OBJECTIVE**

   The scheme is proposed to generate Demineralised water of capacity 200 m³/hr required for Power plant. The proposed scheme is broadly as per following treatment steps.

   a) Pretreatment system for DM plant  
   b) Reverse Osmosis System  
   c) Degasser Tower Mixed  
   d) Bed (MB) Unit DM  
   e) Water Storage Tank  
   f) Chemical Handling System  
   g) Effluent collection System  

   Note: Above mentioned pretreatment system will not be applicable in availability of Potable water generated through SWRO system.

2. **DESIGN OBJECTIVES**

   The DM Plant shall be designed:

   a) To meet the performances in terms of desired production and treated water quality.  
   b) Lower operating cost and power consumption.  
   c) Minimize wastages.  
   d) To ensure reliability of overall treatment process.  
   e) Safe working conditions and ease of operation and maintenance for the operating personnel.

3. **DESCRIPTION:**

3.1 **PRETREATMENT SYSTEM**

   The entire plant shall be completely automatic.

   Pretreatment system for DM plant shall be consists of,

   - Dual Media Filter (DMF)  
   - Activated Carbon Filter  
   - Ultrafiltration system (UF)

3.1.1 **DUAL MEDIA FILTER (DMF)**

   Raw water will be passed through the Dual media Filter by means of filter feed pumps to remove suspended solids from the same. These Filters will be vertical cylindrical vessels with dished ends.

   The Operation of the DMF will be consists of two steps viz. Normal operation and backwash operation. On completion of normal operation time or high differential pressure across the filter bed, which occurs first and operator will initiate the backwash operation. Backwash will be done with filtered water.
Blower for Air Scouring of DMF will be provided. Air scouring is carried out before the backwash of DMF to loosen the filter media bed. This ensures the effective removal of trapped solids/impurities in the filter media during backwash.

3.1.2 ACTIVATED CARBON FILTER (ACF)
Filtered water is passed through the Activated Carbon Filter. One tapping from the outlet header of DMF will be connected to the overhead backwash tank. The Activated carbon filter frees the water from the traces of chlorine, traces of oil and grease as well as organic matter. Activated carbon works on the principle of adsorption. The impurities get adsorbed on the porous carbon. Backwash will be done with filtered water at once in a day. The filtered water is then passed to Ultra filtration system through basket strainer to trap any media carried by the water.

3.1.3 ULTRAFILTRATION SYSTEM (UF)
Water normally contains matter which is a subject of concern and needs to be treated through Ultra filtration especially with RO in the post Treatment. The Ultrafiltration membrane process is used to separate the concentrate macromolecules and colloids from water based on molecular weight of the impurities. The UF system will ensure removal of larger organic, bacteria, pyrogens, colloidal silica and iron, Total Organic Carbon (TOC) and emulsified oil.

Ultra filtration system is designed in such a way that the membranes can be back-flushed using UF permeate water with the help of UF Back flush pumps and fast flushed by the UF feed Pumps.

Backflushing and Fast flushing is necessary to clean the membrane surface of scale, which may build up. To clean the membrane, the permeate is forced back through the fiber under pressure in Back flushing mode and in Fast flushing mode water is made to pass through the hollow fiber in the normal Service direction.

Necessary valves and instrumentation will be provided to carry out this operation automatically.

Water from the outlet of the Ultra filtration system is stored in UF Permeate Water Storage tank (UPWST) for further treatment by reverse osmosis.

3.2 REVERSE OSMOSIS SYSTEM
Ultra filtered water from UPWST will be passed through Cartridge filter by means of RO Feed pumps for further filtration, prior to RO modules.

Antiscalant is added prior to the Micron filter to increase the solubility threshold limitation of sparingly soluble salts such as CaCO3, BaSO4 and CaF. Acid dosing adjusts the pH value of the filter water to prevent saturation of various organic salts. The pH analyzer controls acid dosing.
Sodium Meta-Bisulphite is dosed in the filtered water to neutralize any traces of residual chlorine present in the filtered water and to ensure complete dechlorination. The Sodium Meta-Bisulphite dosing is linked with an ORP analyser, which would give an alarm to increase the dosage manually.

An auto-dump valve is provided to drain the feed water if ORP & PH values exceed the set limits. The Dechlorinated water will then pass through cartridge filter. The Micron cartridge filter is provided which will remove fine suspended solids which if not trapped may clog the RO membrane. This would also eliminate problems in the high-pressure pumps due to presence of particulate matter.

Differential pressure transmitter is provided to measure differential pressure across the cartridge filters. When the pressure difference across the cartridge filter goes beyond set point, an alarm will be visible on the system controls to indicate replacement of filter is required. Periodically, the operator will stop the system and replace the cartridges using isolation valves at the inlet and outlet of the cartridge filter. The chemically conditioned & filtered water from the micron cartridge filter is then fed into RO unit via RO high-pressure booster pumps. RO High Pressure Pump shall be Vertical Multistage Centrifugal pump. The pressure transmitter are provided at RO high pressure feed pump suction & delivery, which provides protection for dry running of pump, and also protect the membranes from high-pressure exposure.

A flow transmitter provided on the RO skid on product line shall controls the flow to the membrane by giving feed back to the RO high-pressure pump. The conductivity transmitter is provided on the RO permeate line, which monitors the product water quality. Manual sampling valves are provided in the permeate line of each RO pressure tube.

The permeate water from RO system shall be passed through Degasser tower to reduce dissolved CO2 content in the water.

The R.O. unit will be provided with a Cleaning in place (CIP) system for occasional flushing of the membranes. Flushing of the membranes is required when significant drop in performance of the RO Plant is noticed.

3.3 DEGASSER TOWER
The Permeate Water shall be fed to degasser tower by means of Degasser feed pumps. Dissolved CO2 gas, which leads to high conductivity, in permeate water which cannot be rejected in the RO membranes are scrubbed off in DG Tower by means of DG centrifugal Blower. Conductivity is further reduced in the DG tower & pH is increased due to removal of CO2. Degassed water is then stored in DG water storage tank.

3.4 MIXED BED EXCHANGERS
Degassed RO permeate then feed to the MB containing mixture of strong acid cation exchange resin and strong base anion exchange resin. Cations and anions will be exchanged in mixed bed unit.
to insure the desired treated water quality at the outlet. The demineralized water will be then stored in the DM water storage tank.

The regeneration of the exchanger will be performed with Hydrochloric acid & Caustic soda solution. Regeneration will be done with Ejector. Chemical dilution will be performed with demineralized water. Regeneration sequence will be completed automatically. The water coming from the MB unit will be sent to the Dematerialized water storage tank.

Conductivity transmitter, silica analyser is provided at the outlet of each MB unit, which monitors the product water quality.

The effluents from the MB unit will be conveyed by gravity through channel to Neutralization pit. Neutralization pit will be in your scope. We will take tapping from Acid & Alkali storage tank for effluent neutralisation. Neutralised effluent will transfer to Effluent treatment plant.

3.5 DM WATER STORAGE TANK
The tank will be of outdoor installation, provided with Manhole, level indicator, level switch for high & low level, Vent with CO2 breather. The external surface shall be painted with two coats of high build epoxy zinc phosphate primer. The internal shell lining shall be of rubber lining.

3.6 BACKWASH COLLECTION SUMP
The sump consists of two compartments of RCC construction. The backwash on Dual Media, Activated carbon filter, Reject of UF Modules & backflush of the UF is collected.

3.7 CHEMICAL HANDLING SYSTEM
3.7.1 ACID UNLOADING PUMPS
Acid unloading pumps sized for filling the storage tank in one hour shall be provided. The pumps shall be designed for handling 30% hydrochloric acid. The pumps shall be horizontal, centrifugal type, directly driven by a suitable motor and mounted on a common base plate. Suction shall be connected with flexible hose and delivery to the acid storage tank with MS/pipe.

3.7.2 BULK ACID STORAGE TANK (BST)
The tank capacity shall be sufficient to hold acid of 15 days. The tank shall be of mild steel construction, lined inside with rubber. The material of the tanks shall be IS: 2062 Gr.B. Necessary connections will be provided to facilitate unloading into or transfer from the tanks. Tanks shall be complete with all connections such as drain, vent and other connections with isolation valves as necessary. The tanks will be located outdoor at an elevation and shall be filled by acid unloading pumps to be supplied under this specification. Transfer of acid from these tanks to the acid measuring tanks shall be done by gravity.

Suitable level gauges shall be provided for indicating acid level in the tank. Fume absorber shall be provided to each acid storage tank. The vent connection of the acid storage tank shall be piped to
the fume absorber. The storage tank shall be horizontal cylindrical type and provided with saddle support, manholes, ladders, platforms etc.

3.7.3 ACID MEASURING TANK

Acid measuring tank for regeneration of MB cation resins and one to meet the requirements for the neutralization of excess alkali present in regeneration waste from the DM plant in the N. pit.

The tank shall have level indicators for measurement of acid volume. The tank material shall be mild steel to IS: 2062 Gr. A. The tanks shall be complete with drains valves and vent connections.

Fume absorber with suitable size shall be provided to each acid measuring tank. The vent connection of acid measuring tank shall be piped to the fume absorber.

From the measuring tanks, acid shall be injected to the cation MB units by means of water ejectors. Pressurized water for ejector shall be taken from the MB water storage tank. The ejectors including the nozzles shall be specially designed for acid service and for the specified dilution ratio of acid to water.

3.7.4 CAUSTIC UNLOADING PUMPS

Caustic unloading pumps each sized for filling the storage tank in one hour shall be provided. The pumps shall be designed for handling 48% Caustic Lye. The pumps shall be horizontal, centrifugal type, directly driven by a suitable motor and mounted on a common base plate. Suction shall be connected with flexible hose and delivery to the acid storage tank with MSRL pipe.

3.7.5 BULK CAUSTIC STORAGE TANK (BSCT)

Caustic tank shall be of mild steel construction, lined inside with rubber. The material of the tanks shall be IS: 2062 Gr.B. Necessary connections will be provided to facilitate unloading into or transfer from the tanks. Tanks shall be complete with all connections such as drain, vent and other connections with isolation valves as necessary. The tanks will be located outdoor at an elevation and shall be filled by caustic unloading pumps to be supplied under this specification. Transfer of caustic from these tanks to the acid measuring tanks shall be done by gravity.

Suitable level gauges shall be provided for indicating caustic level in the tank. The storage tank shall be horizontal cylindrical type and provided with saddle support, manholes, ladders, platforms etc.

Activated carbon filter will be provided in alkali feed line to the alkali tank to remove free chlorine & impurity present in the alkali.

3.7.6 CAUSTIC MEASURING TANK

Caustic measuring tank for regeneration of MB cation resins and one to meet the requirements for the neutralization of excess acid present in regeneration waste from the DM plant in the N. pit.

The tanks shall have level indicators for measurement of alkali volume. The tank material shall be mild steel to IS: 2062 Gr.A. The tanks shall be complete with drains valves and vent connections.

Motorized agitator shall be provided for each tank.
From the measuring tank, alkali shall be injected to anion exchanger by means of water jet ejectors. Pressurized water for ejectors shall be taken from MB water storage tank. The ejectors including nozzles shall be suitably designed for alkali service and for the specified dilution ratio of alkali to water.

3.8 EFFLUENT COLLECTION SYSTEM

All the drains, flush of the dosing tanks, reject of the UF, RO system, alkali & acid effluent from the DM plant shall be neutralized in Neutralization pit before sending to effluent treatment plant. The effluent neutralizing system consists of one number acid & one number alkali tank. The effluent neutralization pit shall be of RCC construction with acid proof tiles lining.

Horizontal Centrifugal pumps for each compartment of N.Pit shall be supplied for re-circulation and disposal of effluents. The effluent should be slightly alkaline. The pump shall be suitable for operation under the suction lift & shall be with the drive, foot valve at the suction & with necessary priming arrangement.
NITROGEN GENERATION PLANT SYSTEM

1. OBJECTIVE
PSA - Nitrogen gas generation plant system is proposed to generate Nitrogen gas of capacity 15 Nm³/hr.

a) Air Compressor
b) Molecular Sieves Unit
c) Nitrogen Surge Vessel
d) Oxygen Analyser
e) Nitrogen Storage Tank

2. DESIGN OBJECTIVES
The PSA-Nitrogen Gas Generation Plant shall be for pipe line purging & blanketing.

3. DESCRIPTION:

3.1 Air Compressor
An air compressor shall be suitable for air handling capacity which will compress air upto 12 bar pressure and equipped with air cooled cooler, multistage oil filters (to make air oil free) after air receiver and other accessories required for trouble free operation.

3.2 Molecular Sieves Unit
Air from air receiver will be fed to twin tower molecular sieves unit where oxygen is absorbed and nitrogen of 99.5% purity comes out as product gas at 10.5 bar pressure.
Molecular Sieves unit shall have 2- vessels filled with activated alumina at bottom and carbon molecular sieves above alumina. This unit shall be operate at 12 bar pressure and produce nitrogen at 10 bar pressure continuously. Unit shall contain automatic switchover valves operated by pneumatic solenoid valves.

3.3 Nitrogen Surge Vessel
Nitrogen (≥ 99.5% purity) produced from molecular sieves unit at 10 bar shall be fed to the surge vessel at same pressure. Suitable size capacity vessel shall supplied along with all accessories, which can withstand in this pressure.

3.4 Oxygen Analyser
An on-line oxygen analyser shall be envisaged to show nitrogen purity. It will have electro-chemical sensor. This analyzer will have the facility of adjustable set point for alarm & nitrogen generator trip in case of low nitrogen purity.
3.5 Nitrogen Storage Tank

Nitrogen shall be stored in high volume tanks at 10 bar pressure. When tank will get full pressure, pressure switch would automatically trip nitrogen generator and air compressor but when pressure will come down in tank then gas generator would restart automatically at 5 bar pressure so that plenty of nitrogen shall be available from the storage tank. This complete system which will include vertical high pressure storage tank of required volume with safety valves, automatic pressure switch & other accessories.

3.6 Automatic Vent valve

Automatic valve shall be provided for venting nitrogen in case of lower purity or any other problem in gas generator / PSA unit.
COMPRESSED AIR SYSTEM

1.0 DESCRIPTION

1.1 2 No’s (1 Working + 1 Standby) of Oil lubricated centrifugal compressors of capacity 1500 cub. m/hr each shall be installed for the process and utility requirement.

1.2 Based on the pressure required at the battery limit, compressed air pressure at the discharge of the compressor is 9 kg/cm² (g). (Considering pressure drop in dryer and pipeline)

1.3 Considering the requirement, (Dew Point at line pressure shall be 15 deg C below the ambient temperature) 2 No’s (1 Working + 1 Standby) of Heatless Desiccant Dryer of capacity 1500 cub m/hr shall be installed.

1.4 Two numbers of suitable filters (1 Pre-Filter & 1 Post-Filter) shall be installed upstream and downstream of the air dryer to achieve the desired quality of air.

1.5 VFD shall be used for capacity control. This will contribute to the power saving, as its delivery can be varied based on the variation in the requirement.

1.6 Receiver capacities have been estimated considering 10 seconds storage of air (assuming 10 seconds time for auto start of standby compressor). The air receiver is placed after the air dryers. 2 Nos of 15 m³ air receivers shall be installed.

1.7 Compressed air quality shall be

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Class</th>
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<tbody>
<tr>
<td>Maximum Oil Concentration</td>
<td>Class-3 (≤1 ppm)</td>
</tr>
<tr>
<td>Maximum Particle Size</td>
<td>Class-1</td>
</tr>
<tr>
<td>Maximum Solid Concentration</td>
<td>Class-1</td>
</tr>
<tr>
<td>Pressure Dew Point</td>
<td>Class-3 (-20°C)</td>
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</table>

1.8 EQUIPMENT LIST

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Item</th>
<th>Quantity (Nos.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Air Compressor = 1500 cub m/hr</td>
<td>2 (1W+1S)</td>
</tr>
</tbody>
</table>
1. OBJECTIVE
The scheme is proposed to treat PVC plant Effluent (As per zero liquid discharge concept) of capacity 750 m³/day. The proposed scheme is broadly as per following treatment steps.
   a) Primary Treatment System
   b) Secondary Treatment System
   c) Tertiary Treatment System
   d) Sludge Handling System
   e) Multi Effect Evaporator

2. DESIGN OBJECTIVES
   The ETP Plant shall be designed:
   a) To meet Zero Liquid Discharge
   b) To meet the performances in terms of desired production and treated water quality.
   c) Lower operating cost and power consumption.
   d) To ensure reliability of overall treatment process.
   e) Safe working conditions and ease of operation and maintenance for the operating personnel.

3. DESCRIPTION:
   The Effluent generated (Total capacity: 750 m³/day) from entire factory shall be collected effluent collection tank of ETP. Description of the ETP system as given below. The plant shall be completely automatic.

3.1 EFFLUENT COLLECTION PIT:
   The effluent generated from various locations in factory shall be collected in effluent collection tank. This tank shall be provided with effluent transfer pump to transport effluent from effluent collection tank to Primary treatment unit of ETP.

3.2 PRIMARY TREATMENT SYSTEM:
   Effluent from the effluent collection tank shall be received into the primary treatment unit of ETP. Primary treatment system consists of Primary settling unit with Coagulant and Floculent dosing system for removal suspended solids. It will also reduce some amount of BOD/ COD value associated with Suspended particles. This primary treated effluent shall be neutralized by using acid and alkali dosing before sending to secondary treatment system.

3.3 SECONDARY TREATMENT SYSTEM:
   The overflow / outlet from the primary treatment unit shall be transport to Secondary treatment unit. It consists of aeration systems with clarifiers envisage for BOD and COD reduction. In aeration tank, effluent containing organic matter is aerated in an aeration basin in which micro-organisms
metabolize the suspended and soluble organic matter. Part of organic matter is synthesized into new cells and part is oxidized to CO2 and water to derive energy. The new cells formed in the reaction are removed from the liquid stream in the form of a flocculent sludge in clarifier tanks. A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge. The extended aeration tank shall be of type diffused aeration system. This system shall be suitably designed considering influent quality, quantity of air required, solid loading rate etc. Suggested ratio of air volume to mass of solid shall be suitable selected for effective performance of diffused aeration system. The tank depth shall be suitably selected based on SOI. The tank shall be provided with inlet, outlet, overflow and drain. The tank shall be of RCC construction. The final clarified water effluent shall be collected in Clarified water storage tank.

Chlorine is dosed in Clarified water storage tank prior to Tertiary treatment. Chlorination shall be provided to avoid microbiological growth and to maintain residual chlorine content in water.

3.4 TERTIARY TREATMENT SYSTEM:

Secondary treated effluent shall be pumped to the Tertiary treatment system. This tertiary treatment system shall consists of Media Filtration, Ultrafiltration unit & Reverse Osmosis plant. Description of the each tertiary unit as given below.

3.4.1 FILTRATION:
Secondary Clarified water shall be filtered through Dual Media Filter (DMF) for filtration. DMF shall be designed on the basis of 22 hours operation. DMF shall contain graded filter media & Anthracite with suitable supporting bed. DMF outlet filtered water shall be stored in Filter water storage tank (FWST).

DMF backwash shall be carried out along with air scouring for a period of maximum 10-15 minutes.
1 no. (1W) DMF backwash pumps of suitable capacity along with 1 no. (1W) Air blowers shall be provided. DMF shall be backwashed by using filtered water from "Filtered water storage tank" and backwash waste water shall be routed to Backwash waste water storage tank. The backwash operation of DMF shall be carried out after fixed time interval or after the pressure drop across filter exceeds differential pressure limit.

3.4.2 ULTRAFILTRATION (UF) SYSTEM:

Filtered water from filtered water storage tank shall be fed to UF Unit through basket strainer by using UF feed pump. Ultra Filtration will be carried out with the help of membranes located in vertical pressure tubes. The flow to the membranes can be in to out or out to in. Once, the water passes through the membrane, the particles / bacteria will stick to it and filtered water shall flow through perforated tubes given in the membranes. Since colloidal particles shall increase adhering to the membranes, backwash/ fast flush is required for the system. The same shall be carried out by back flush pumps.

The back flushing / fast flushing shall be carried out once in hour depending on the parameters of feed water. For back flushing, UF treated water shall be used & back flush will be chemically
enhanced if necessary. Similarly cleaning in place system will be used for cleaning the UF membranes periodically if required. Treated water shall be stored in UF permeate water storage tank.

3.4.3 REVERSE OSMOSIS (RO) SYSTEM:
Configuration of RO System shall be as follows:
RO feed water pumps + Sodium meta-bisulphite (SMBS) Dosing + Anti-salant Dosing + Ph Correction Dosing + Cartridge Filter + RO High Pressure Pumps + RO System + RO Permeate storage tank
RO Reject RO +Reject water storage tank + MEE Feed pump + Multi effect evaporator

3.5 MULTI EFFECT EVAPORATOR:
This unit shall be primarily used for removal of high total dissolved solids content in effluent. This unit consists of a no. of calandria with set of vapour separator, condenser, pumps, pusher centrifuge etc. Steam is supplied to the jacket of evaporator unit and the vapour from heated effluent shall be condensed in surface condenser. The condensed effluent shall be collected in RO permeate tank. The concentrated sludge having very high total dissolved solids shall be suitably disposed off outside the plant or further treatment shall be provided.

3.6 SLUDGE HANDLING SYSTEM:
The sludge from Primary & secondary clarifiers and excess sludge from aeration tank as well as sludge will be collected in sludge holding tank and will be pumped with help of sludge pumps to Sludge dewatering unit. The recovered water (filtrate) will be sent to equalization tank of ETP and the sludge can be disposed off.
1. OBJECTIVE

The scheme proposed is to treat Sea Water to remove the dissolved solids from the treated seawater and to produce 2 MLD-Potable water required in Process & Utility Applications.

The proposed scheme is broadly as per following treatment steps:

a) Sea Water Intake Pump House
b) Electro chlorination System for Sea Water Intake
c) Pretreatment System for SWRO
d) Chemical Dosing for Pre-4treatment System
e) Reverse Osmosis System
f) Carbonation System
g) Chlorination System for Potable Water
h) Remineralization system for Potable water

2. DESIGN OBJECTIVES

The Sea Water desalination plant shall be designed:

a) To meet the performances in terms of desired production and treated water quality.
b) Lower operating cost and power consumption.
c) Minimize wastages.
d) To ensure reliability of overall treatment process.
e) Safe working conditions and ease of operation and maintenance for the operating personnel.

3. DESCRIPTION:

3.1 INTAKE WELL & PUMP HOUSE

It is proposed to have an intake approximately 500 m away from the proposed desalination plant which is within the port premises. The sea water intake pump station will extract water from the sea and bring it to desalination plant for further treatment. The overall treatment process is described in the further sections. The rejected water will be disposed in the sea at a distance of approximate 4 km from the desalination plant.

3.2 PIPELINE WORK

Following are the pipelines proposed for the safe working of the system. The selection of the pipe material depends on the quality of water being conveyed, and its overall life.

Pipeline from Intake to Desalination Plant.
It is proposed to have sea water pipeline along the jetty. On the shore, the pipelines from the jetty will lay above ground and aligned parallel to the approach road leading to the jetty, upto desalination plant along with power and other pipeline. Since, the saline water will be pumped
from the sea up to the desalination plant, Glass Reinforced (GRP) plastic pipe will be laid for a length of 500 m.

**Pipeline from Desalination Plant to outfall point.**
The rejected water after treatment from the desalination plant needs to be disposed off at an appropriate place. In this case, the rejected water will be having high TDS value which is not possible to directly dispose off in the sea shore. Hence, to maintain the equilibrium of the sea water, the rejected water is being disposed off at a distance of approximately 4 km inside the sea via Glass Reinforced plastic pipeline.

### 3.3 REMOVAL OF BACTERIA & ALGAE:
Depending on the seawater temperature various bio-organisms grow in the seawater intake and then in the treatment equipments. To avoid the bio-contamination of inlet & pre-treatment section Seawater Electro chlorination is considered. Strictly Monitored for presence of oil & grease. If pollution by oil is detected, the operators shall be warned and the plant will be stopped.

The pre-treatment process is as follows:

- **Electro chlorination** → **Coagulant Dosing**
- **Seawater intake system** — **Sea water storage tank — Clarifier / HRSCC—** Multigrade Sand Filtration— Pressure Sand Filtration— Filtered Water Storage Tank.

### 3.4 SEAWATER PRE-TREATMENT
As Sea water (TDS about 35,000 mg/l) will be used as source, the treatment scheme shall comprise desalination system using SWRO membranes. The operating pressure of the SWRO membranes shall be 60-70 kg/cm2 and the system shall have to be designed for a recovery of 40%.

The concentrated brine having a TDS substantially higher than sea water will have to be conveyed 4 km into the sea and dispersed at the bottom of the sea.

To avoid deterioration of RO performance by fouling or scaling, it is necessary to remove these potential foulants before the RO process. Appropriate and adequate pre-treatment ensures avoiding fouling or scaling.

### 3.5 COAGULATION/ FLOCCULATION:
Seawater from intake well will be chlorinated by electro chlorination system and will be pumped to HRSCC/Clarifier through flash mixer/flocculation tank. Where FeCl3 shall be dosed as a coagulant and synthetic polymer shall be added as a flocculent. Treated clarified overflow water shall be transferred to Clarified water storage tank from where this clarified water shall pump to Filtration system.
3.6 FILTRATION

The reverse osmosis membranes are very sensitive to suspended matters and especially to the fouling index or SDI (Silt Density Index), which affects the clogging of the membranes. Series of Pressure Sand Filters are considered for the purpose of maintaining SDI of seawater at RO inlet always less than. Surface filtration, enabling the whole volume of the filter to be effective. Depth of media layer and net available clogging designed for the retention of a high quality of floc, enabling extended filter runs between washings. Every bed shall be backwashed once a day. Filtered water shall be used for backwash. The waste generated during backwashing shall be transfer back to sea with SW/RO reject water.

3.7 DE-CHLORINATION:

Water feeding R. O. membranes must be free of chlorine or any oxidizing agent since it chemically attacks the thin film composite membranes. Dechlorination will be used as a reducing agent to fully neutralize the free chlorine and thus to avoid the attack of the membranes. It will be injected both at the inlet of the cartridge filters.

Injection will be automatically adjusted as a function of water flow rate to be treated just before the RO membranes. To fully protect the membranes, oxidation-reduction potential measurement (ORP meter) with dump valve arrangement in case of high chlorine content in water. Alarm will continuously check efficiency of de-chlorination.

All chemicals shall be stored in the chemicals building. The storage capacity will correspond to one months of operation.

3.8 SCALING-INHIBITION:

Anti-scalant shall be used to avoid scaling on the RO membrane. It will be injected at the inlet of the cartridge filters.

Filtration through micron cartridge filters:

Fine particles that could leak from the sand filters may damage the membranes. In order to retain those particles, and as an ultimate protection of R.O. membranes against fouling, pre-treated water flows through cartridges having a nominal mesh of 5 microns. When the pressure drop through the cartridge filters reaches a preset limit the cartridges must be replaced. A differential pressure switch is connected between the inlet and the outlet of each filter to measure the drop in pressure across individual cartridge filter.

3.9 R.O. FEED WATER QUALITY:

In the treatment line, the following water characteristics must be measured just upstream the membranes:
- SI R Density Index (SDI)
- pH
- Temperature
- Oxidation Reduction Potential (ORP)
If the above parameters are not within the limits, the water will not be allowed to enter the membranes.

### 3.10 SEA WATER REVERSE OSMOSIS (SWRO)

The SWRO plant is designed to produce the desired quantity and quality of water under the following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seawater salinity (nominal)</td>
<td>35,000 mg/l</td>
</tr>
<tr>
<td>Temperature</td>
<td>(35 – 40 Deg. C)</td>
</tr>
<tr>
<td>Design average age of membranes</td>
<td>(3 years)</td>
</tr>
<tr>
<td>Plant capacity</td>
<td>2000 m³/day product</td>
</tr>
</tbody>
</table>

All R.O. membrane elements will be spiral wound 40" long TFC (Thin Film Composite) type having a diameter of 8". The R.O. racks will be fitted with “seawater” membrane elements having a high level of rejection.

The pre-treated water feeds the Reverse Osmosis Plant, which includes:

- The High-pressure pumps
- The Energy Recovery turbine / Pressure Exchanger
- The Reverse Osmosis Skids
- The Cleaning & flushing system

To ensure a monitoring of the performances of the R.O. system, the production of each pressure vessel as well as the main headers (feed, brine, permeate), are connected to a sampling panel fitted with quick plug connections.

Each RO skid is provided with following instruments to monitor various parameters:

To monitor the permeate quality, to control the flux and the recovery rate of each rack and to ensure a safe and reliable operation, a complete set of the following field instruments is provided per rack:

- Flow meter at the suction of the high-pressure pump.
- Low Pressure switch at the suction of the high-pressure pump.
- Conductivity meter at the outlet of permeate.
- Differential pressure transmitter between feed and reject.
- Flow meter at reject outlet
- High Pressure switch at HPP outlet
- Conductivity meter cartridge filter inlet
- pH meter at cartridge filter inlet
- ORP meter at HPP outlet.
- Temp. indicator at RO inlet.
3.11 ENERGY RECOVERY DEVICE

The pressure drop over the RO membranes is about 1.5 to 2 bar, depending on the number of element per pressure vessel, so the concentrate is released at high pressure.

With Energy Recovery Devices, it is possible to reuse the energy from the concentrate flow. The concentrate is directed to the ERD, where it directly transfers its energy to part of the incoming feed water.

3.12 REMINERALIZATION SYSTEM

Reverse Osmosis is not a selective ion removal process. After the common 2-pass RO process dealkalinated water is poor in minerals. Lime stone filter shall be used for remineralization.
1. OBJECTIVE
The scheme is proposed to treat Raw Sewage of capacity 22 m³/day. The proposed scheme is broadly as per following treatment steps.

   a) Screening  
   b) Oil & Grease trap  
   c) Equalization Tank  
   d) Bio reactor  
   e) Secondary Settling unit  
   f) Disinfection System  
   g) Multi-grade filter  
   h) Activated carbon filter  
   i) Sludge Handling System

2. DESIGN OBJECTIVES
The STP Plant shall be designed:

   a) To meet the performances in terms of desired production and treated water quality.  
   b) Lower operating cost and power consumption.  
   c) Minimize wastages.  
   d) To ensure reliability of overall treatment process.  
   e) Safe working conditions and ease of operation and maintenance for the operating personnel.

3. DESCRIPTION:
The sewage generated (Total capacity: 22 m³/day) from entire factory shall be collected by gravity sewers leading to the sewage collection pit of STP.

   Sewage treatment plant unit Sequence:  

3.1 SEWAGE COLLECTION PIT :  
The sewage generated from various locations in factory shall be collected in sewage collection pits. This pit shall be provided with sewage transfer pump to transport sewage from Sewage collection pit to STP screen chamber.

3.2 SCREEN CHAMBER:
3.3 OIL AND GREASE SKIMMER:
The overflow from the bar screen chamber after screening enters into the oil and grease chamber. The belt type oil skimmer shall be provided to remove the oil and grease content present in the sewage before biological treatment as it may cause problem for biological treatment. The highly oleophilic endless belt rotates touching the sewage. Belt comes into contact with the oil floating on the surface of the liquid and picks up the oil. The belt carries the oil on its surface to the top end of the machine where a set of scrapers remove the oil from the belt surface and deposits into a collection tray from where it is drained by means of gravity into slop oil tank. Further it shall be disposed off along with STP sludge.

3.4 EQUALIZATION TANK:
The sewage from O&G skimmer shall be collected into an equalization tank. The equalization tank shall have 6 – 10hrs retention time at average flow rate. The sewage are homogenized in equalization tank by having provision of coarse bubble aeration grid at the bottom of the equalization tank. This tank acts as a buffer tank to take care of organic and hydraulic shock loads during plant operation. The equalised sewage from this tank shall be fed to biological tank for further treatment. Biological tank feed pump (BTFF) shall be provided to transport sewage from equalization tank to Biological System.

3.5 BIOLOGICAL SYSTEM:
Biological System consists of Biological tank for removal of organic matter (BOD, COD) & Secondary clarifier. These units shall be placed inside a single MSEP tank. Each of these components as described below.

**Biological (MBBR) Tank**
This tank shall be filled with floating bio media of cylindrical shaped polyethylene carrier elements for biological growth. In this process biomass shall be in the attached as well as in suspended form. Therefore more surface area shall be available for bacteria to grow on, thereby maintaining and retaining maximum possible bacterial population in a limited volume. As a result volume required for biological tank in this process is less than biological tank of conventional process.

The sewage shall enter at the top of the MBBR tank. Air is introduced at the bottom of the tank through fine bubble diffusers. Bio media will be in suspension because of the turbulence created by the air. The bacteria required for the oxidation of the organic matter is attached to the media and some part is suspended in the tank. After oxidation, the bacteria grow in number and need to be separated from the MBBR tank liquor. Hence biologically treated effluent then gravitates into the Secondary clarifier through overflow weir. Wire mesh shall be attached with overflow weir to trap and retain plastic media into MBBR tank.
3.6 SECONDARY SETTLING CLARIFIER:

The effluent from Bio reactor contains some amount of MLSS & suspended solids which need to be removed before tertiary treatment of the effluent. This purpose shall be served by the Secondary settling clarifier. The Secondary settling clarifier has plates inclined at 15deg. which act as settling surface. The overall settling area of the Secondary clarifier is greater than that of a conventional clarifier of similar size. Thus efficient removal is achieved in a smaller footprint. The clarifier system helps in clarification and separation of the bacteria (sludge) and clear overflow flows into chlorine contact tank.

3.7 CHLORINE CONTACT TANK:

In chlorine contact tank, Sodium hypo Chlorite (NaOCl) shall be added for disinfecting the mixture of treated sewage & trade effluent. Baffle plates shall be provided in chlorine contact tank to make better chlorine contact. The chlorinated treated effluent shall be further treated in MGF followed by ACF to meet the other consent parameter.

3.8 MULTI GRADE FILTER (MGF):

This unit shall be used for removal of total suspended solid content in treated sewage. It consists of vertical centrifugal FRP vessel with filter media consisting pebbles, gravel and fine sand. The accessories installed in vessel consists of frontal piping with valves, instrumentation etc. To achieve the desired filtered water quality. The filters shall be backwashed intermittently for removal of suspended solids trapped over a period of plant operation. Filter backwash shall be carried out for a period of maximum 10-15 minutes. MGF backwash flow rate shall be achieved by using both (working & standby) filter feed pump at a time. Accordingly, filter feed / backwash pump of suitable capacity along with blowers shall be provided. The filter backwash waste shall be drained off.

3.9 ACTIVATED CARBON FILTER (ACF):

This unit shall be used for removal of traces of colour, odour, free chlorine, COD and total suspended solid content in treated sewage. It consists of vertical centrifugal FRP vessel with filter media and activated carbon. The accessories installed in vessel consists of frontal piping with valves, instrumentation etc. The filters shall be backwashed intermittently for removal of suspended solids layer developed on top media layer over a period of plant operation. The filter backwash waste shall be drained off.

3.10 STP TREATED WATER COLLECTION TANK:

This tank shall have retention time sufficient to hold treated sewage when it is not utilized by the consumers. The treated sewage from this tank shall be pumped for green belt development and other purpose using STP treated water transfer pumps.
3.11 SLUDGE HANDLING SYSTEM

3.11.1 SLUDGE SUMP:
The sludge generated from clarifier of trade effluent treatment and lamella clarifier of sewage treatment shall be collected in this tank. From this tank the sludge shall be pumped to Basket centrifuge using sludge transfer pumps. Provision of air grid is to be made using Equalisation tank air blowers to avoid settling of solid in sludge collection tank.

3.11.2 SLUDGE DEWATERING SYSTEM:
The excess sludge generated in the plant due to incoming suspended solids & cellular growth is stored in a sludge storage tank shall have approx. 1% solid consistency. Sludge dewatering system shall be used to dewater this bio sludge to desired (i.e. 10 to 15%) solid content. The filtrate from Sludge dewatering system shall be recycled back to Sewage collection pit. The cake generated from Sludge dewatering system shall be disposed off.
Lifting & Conveying Machineries

<table>
<thead>
<tr>
<th>SL.</th>
<th>DESCRIPTION OF MACHINERY</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EOT Crane for workshop - 5 MT capacity</td>
<td>1 Nos.</td>
</tr>
<tr>
<td>2</td>
<td>Fork lift trucks -1 MT capacity</td>
<td>5 Nos.</td>
</tr>
<tr>
<td>3</td>
<td>Fork lift trucks -2 MT capacity</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>4</td>
<td>Battery operated pallet trucks</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>5</td>
<td>Hand operated pallet trucks</td>
<td>20 Nos.</td>
</tr>
</tbody>
</table>
### Mechanical Instrument & Electrical Repair Shops

#### Mechanical Repair Shop

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Machinery Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lathe (bed length 2500mm, max job dia 750mm)</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>2</td>
<td>Milling machine</td>
<td>1 No</td>
</tr>
<tr>
<td>3</td>
<td>Drilling machine</td>
<td>1 No</td>
</tr>
<tr>
<td>4</td>
<td>Grinding machine (bench grinders)</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>5</td>
<td>Portable grinders</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>6</td>
<td>Welding machine</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>7</td>
<td>Band saw</td>
<td>1 No</td>
</tr>
<tr>
<td>8</td>
<td>Carpentry shop with hand tools like flat files, round files, hack saw work table, vice etc.</td>
<td>1 lot</td>
</tr>
<tr>
<td>9</td>
<td>Forging/ black smithy shop complete with hand tools, induction furnace etc.</td>
<td>1 lot</td>
</tr>
</tbody>
</table>

#### Instrument Repair Shop: For calibration & testing of field instruments

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Instruments</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dead weight tester</td>
<td>1 No.</td>
</tr>
<tr>
<td>2</td>
<td>Digital multimeter</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>3</td>
<td>Storage type digital oscilloscope</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>4</td>
<td>Temperature standard probe</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>5</td>
<td>Digital pressure gauge</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>6</td>
<td>Universal calibrator</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>7</td>
<td>Hand pump</td>
<td>1 No.</td>
</tr>
<tr>
<td>8</td>
<td>Dry bath and control system</td>
<td>1 No.</td>
</tr>
</tbody>
</table>
## Electrical Repair shop:

### MAINTENANCE TOOLS

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set of wrenches, spanners (adjustable, box type, fixed, ring, ratchet type), screw drivers and special tools</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>2</td>
<td>Hydraulic crimping tool with dyes of different sizes</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>3</td>
<td>Hammer (ball pen &amp; cross pen)</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>4</td>
<td>Crimping pliers</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>5</td>
<td>Wire stripper</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>6</td>
<td>Hack saw (normal and small size)</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>7</td>
<td>Hydraulic bearing pullers (small, medium and large)</td>
<td>2 Sets</td>
</tr>
</tbody>
</table>

### TESTING INSTRUMENTS

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>500V Megger</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>2</td>
<td>1000V Megger</td>
<td>1 No.</td>
</tr>
<tr>
<td>3</td>
<td>2500V Megger (motorised)</td>
<td>1 No.</td>
</tr>
<tr>
<td>4</td>
<td>Digital multimeter</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>5</td>
<td>AC/DC HV tester</td>
<td>1 No.</td>
</tr>
<tr>
<td>6</td>
<td>Wattmeter</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>7</td>
<td>Digital tachometer</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>8</td>
<td>Earth resistance tester (digital, battery operated)</td>
<td>1 No.</td>
</tr>
<tr>
<td>9</td>
<td>Tong tester (AC): 250A max</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>10</td>
<td>Tong tester (AC): 10A max</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>TESTING INSTRUMENTS</td>
<td>Qty</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>1 Tong tester (DC)</td>
<td>2 Nos.</td>
<td></td>
</tr>
<tr>
<td>2 Digital oscilloscope</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td>3 Functional generator</td>
<td>2 Nos.</td>
<td></td>
</tr>
<tr>
<td>4 Digital Micro-Ohm meter</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td>5 SCR and diode tester (precision grade multimeter)</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td>6 Battery maintenance kit</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td>7 Regulated power supply</td>
<td>2 Nos.</td>
<td></td>
</tr>
<tr>
<td>8 Lux meter</td>
<td>2 Nos.</td>
<td></td>
</tr>
<tr>
<td>9 Power analyzer</td>
<td>2 Nos.</td>
<td></td>
</tr>
<tr>
<td>10 Line tester</td>
<td>10 Nos.</td>
<td></td>
</tr>
</tbody>
</table>
Tanks & Vessels

1.0 Introduction:

VERITAS Polychem Private Limited integrated project consisting of the following static equipments:

1.1 6 nos. of VCM (Vinyl Chloride Monomer) mounted bullets of capacity 2500 m3 each.
1.2 2 nos. of LPG mounted bullets of capacity 2500 m3 each.
1.3 8 nos. of Propylene mounted bullets of capacity 2500 m3 each.
1.4 2 nos. of Bitumen storage tanks of capacity 2500 m3 each.
1.5 2 nos. of PMB storage tanks of capacity 2500 m3 each.
1.6 1 no. of DM water storage tanks of capacity 500 m3.
1.7 1 no. of Bitumen vessel of capacity 151 m3.

2.0 Design Standards are as follows:

2.1 Bullets shall be designed & fabricated as per PD 5500 Latest edition, SMPV Rules 1981, OISD 150 codes.
2.2 Storage tanks shall be designed & fabricated as per API 650, 12th edition.
2.3 Pressure vessel shall be designed & fabricated as per ASME section VIII div. I, latest edition.

3.0 Assumptions & Considerations:

3.1 Following sizes & material of construction are considered for bullets & storage tanks:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item description</th>
<th>Size</th>
<th>Qty.</th>
<th>Material of construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500 m3 VCM Bullets</td>
<td>7.4 m. dia. x 63 m length</td>
<td>6</td>
<td>SA 537 Cl 1</td>
</tr>
<tr>
<td>2</td>
<td>2500 m3 LPG bullets</td>
<td>7.4 m. dia. x 54 m length</td>
<td>2</td>
<td>SA 537 Gr 1</td>
</tr>
<tr>
<td>3</td>
<td>2500 m3 Propylene bullets</td>
<td>7.4 m. dia. x 79 m length</td>
<td>8</td>
<td>SA 537 Cl 1</td>
</tr>
<tr>
<td>4</td>
<td>2500 m3 Bitumen tanks</td>
<td>14 m. dia. x 17 m length</td>
<td>2</td>
<td>A-516 Gr 70/ A 36</td>
</tr>
<tr>
<td>5</td>
<td>2500 m3 PMB tanks</td>
<td>14 m. dia. x 17 m length</td>
<td>2</td>
<td>A-516 Gr 70/ A 36</td>
</tr>
<tr>
<td>6</td>
<td>500 m3 DM water tank</td>
<td>8.65 m. dia. x 10 m length</td>
<td>1</td>
<td>A-516 Gr 70/ A 36</td>
</tr>
<tr>
<td>7</td>
<td>151 m3 Bitumen vessel with agitator</td>
<td>2.77 m. dia. x 8.024 m length</td>
<td>1</td>
<td>SA 516 Gr 70</td>
</tr>
</tbody>
</table>

4.0 Horizontal Mounded Bullets:
Horizontal Mounded Bullets are for bulk storage of VCM (Vinyl Chloride Monomer), liquefied petroleum gas (LPG) & Propylene. These mounded bullets are buried, horizontal cylindrical steel tanks with hemispherical dished ends of sizes mentioned above. These mounded bullets allow storage of large quantities of gases up to 2500 m3. These mounded bullets are designed & fabricated as per code PD 5506. The design pressure ranges from 10.0 Kg/ cm² to 23.0 Kg/ cm² depending on product stored. Design Temperature ranges from -27° C to +50° C (Atmospheric). These bullets are 100 % radio graphed & post weld heat treated. Material of bullets is SA 537 Cl 1 which is impact tested. Bullets will be hydro tested as per code. All openings will be of flanged type with nozzle construction. The design & fabrication of bullets will have statutory approval from PESO / CCOE.

5.0 Storage tanks:
Storage tanks are for storage of Bitumen, PN8 & DM water. These storage tanks are vertical, cylindrical above ground steel tanks with flat bottom and supported conical roof of sizes mentioned above. These storage tanks allow storage of liquids from 500 m3 to 2500 m3. These tanks are designed & fabricated as per code API 650, 12th edition. The design pressure is atmospheric. Design Temperature ranges from ambient to +200° C. These tanks will be hydrostatically tested with water. Material of tanks is A 516 Gr 70 / A 36. All openings will be of flanged type with nozzle construction.

6.0 Bitumen vessel with agitator:
Bitumen vessel is for storage & mixing of Bitumen. This vessel is vertical cylindrical steel pressure vessel with semi ellipsoidal dished ends of size mentioned above. The capacity of vessel is 151 m3. This vessel is designed & fabricated as per code ASME section VIII div. 1. The design pressure ranges from 4.5 Kg/ cm² to Full vacuum. Design Temperature is +200° C. This vessel is 100 % radio graphed. Material of vessel is SA 516 Gr 70. Vessel will be hydro tested as per code. All openings will be of flanged type with nozzle construction. Vessel will have agitator for mixing bitumen. This vessel will be lug / leg supported.
Fire Protection System

1.0 Introduction

It is proposed to have a comprehensive fire protection system for the VERITAS Polychem Private Limited Integrated project consisting of the following systems:

1.1 Fire hydrant system.

1.2 Automatic medium velocity Spray System for Chemical Storage, 2x4 bays of Tanker Loading facility, Tanks PMB-1/2, Tanks B-1/2 and 16nos. Mounded Bullets.

1.3 Automatic Sprinkler system for Admin. Building, Fire water pump house, Drumming facility & Storage and Loading Bay.

1.4 Portable fire extinguishers throughout the plant.

2.0 Input Reference:

2.1 Plot Plan

3.0 Design Standard followed are as below:

3.1 Hydrant System - IS 13039- 2014

3.2 Spray System - IS 15325-2003

3.3 Sprinkler System - IS:15105 -2002


4.0 Assumptions & Considerations:

4.1 The plant is considered as Moderate hazard occupancy as per IS 13039

4.2 The height of the chemical storage tank is considered to be 15m.

4.3 Fire Protection system inside Main PVC Manufacturing Building + Product warehouse (i.e. SUIS PVC Resin Plant of 150,000TPA, Product warehouse) is not considered. Only tap-off with gate valve for internal hydrant is considered along with hydrant header along the periphery of this area.

4.4 The Product warehouse is considered as High Hazard (Manufacturing Occupancies) under Category-II as per IS: 15105 2002.

4.5 Sprinkler system in Admin. Building is considered for ground floor only.
5.0 Fire hydrant system:

5.1 The fire hydrant system will be the backbone of the entire fire protection system. There shall be a network of pipes run above in the form of connected rings to cover the entire premises.

5.2 The proposed hydrant system mainly consists of Fire Water Tanks, Fire Water Pumps, Pipe & Fittings, isolation valves, external hydrants, fire escape hydrants, hose cabinets & hydrant accessories, water cum foam monitors.

5.3 The number of hydrants will be based on the perimeter of the buildings, on the basis of one hydrant for every 30 meters for tank farm, process plant, storage buildings (Product Warehouse) and 45 metres for admin. Building.

5.4 Tank wagon and tank lorry loading/unloading to be provided with alternate fire hydrants and water cum foam monitors placed at 30m from each other. Foam drum of 100 litres cap. will be near water cum foam monitors for initial operation.

5.5 Single head hydrant conforming to IS: 5290 type A (ISI marked) at stand post of 80 NB is considered. Near each hydrant point, a hose-box containing two lengths of hose pipes and one branch pipe with nozzle shall be located.

5.6 Fire escape hydrants (landing valves) of single head hydrant shall be provided on risers for protection of multi-storied buildings / elevated platforms. Hose reel shall be provided for each fire escape hydrants.

5.7 It is proposed to install minimum 2 monitors for the protection of chemical storage tank to be operated in case of fire. Foam concentrates filled foam trolleys of 200 liters cap. will be located at 2 or 3 points and these can be taken to the aqua-foam monitor being operated in order to feed foam to the monitor.

5.8 The fire hydrant piping layout is designed to supply water from two or more routes to each area. Adequate numbers of isolation valves shall be provided to ensure that when a particular section of piping to be isolated for maintenance work, the rest of the system remains in working condition all the time.

5.9 Underground pipe shall be externally wrapped with ready-made tapes (single tape of 4mm thick) as per IS 10221. This wrapping shall be continued for a length of 500 mm after the pipe emerges from ground or till the upstream flange of the isolation valve in the riser (whichever is higher).

5.10 Fire water pressure at the remote hydrant point shall be minimum 5.25 Kg/cm² and rate of flow of water does not exceed 5m/s anywhere in the system.
5.11 One no. fire brigade inlet connection to be provided at suitable locations on hydrant main near main entrance/exit.

6.0 Automatic Velocity Water Spray system:
6.1 Automatic medium velocity water spray System is considered for Chemical Storage, 2x4 bays of Tanker Loading facility, Tanks PMB 1/2, Tanks B 1/2 and 16nos. Mounded Bullets.
6.2 In Automatic System Deluge valve along with by-pass line, wet detection line carrying QB detectors shall be provided in addition to strainer and a network of piping with open spray nozzles covering the product pump house.
6.3 These deluge valves shall be located in the vicinity of risk to be protected. Water is held under pressure up to deluge valve. The downstream side of the deluge valve remains dry. The seat of deluge valve remains in closed position due to water pressure acting on the other side of the seat.
6.5 This water is tapped from the main line on the upstream side of the deluge valve. This line is also connected to detector network. The thermal detector sprinklers (79°C rating) network remains charged with pressurized water. In case of fire when the surrounding temperature rise more than the rated temperature of the detector, the glass bulb of the detector shatters resulting in drop of pressure in detector pipe net work. Fall in pressure in detector pipe causes reduction of pressure in deluge valve upper chamber allowing deluge valve seat to get lifted up thus opening the deluge valve and allow the water to spray over the area protected through open spray nozzles.
6.6 MVWS system piping shall be designed such that minimum pressure at the remotest nozzle is not less than 1.4 kg/cm2(g) and the maximum pressure in the network is not more than 3.5 kg/cm2(g); and the maximum velocity in distribution pipes shall not exceed 5 m/s.
6.7 The material of the pipe downstream of isolation valve or deluge valve (which remains empty in normal conditions) shall be of Galvanized Carbon Steel.
6.8 Pressure Switches shall be provided in the discharge line of the deluge valve & wet detection line for Automatic system. In case of fire & spray system activation, the signal shall be sent to Fire Protection panel at the Fire Water Pump house.

7.0 Automatic Sprinkler System:
7.1 It is envisaged for Admin. Building, Fire water pump house, Drumming facility & Storage and Loading Bay.
7.2 Sprinkler system shall be tapped from Hydrant main & will consist of alarm valve, isolation valve at the upstream of alarm valve and a network of piping in the area to be protected with quartzoid bulb type sprinkler heads.

7.3 Piping material specifications shall be similar to hydrant system.

7.4 The sprinkler pipe network remains filled with water under pressure. When the temperature in the vicinity of a sprinkler head reaches the rated temperature, the quartzoid bulb breaks and water is sprayed from the sprinkler. The release of water reduces the pressure in the network downstream of the alarm valve and disturbs the hydraulic balance resulting in opening of the alarm valve and sounding of water motor gong.

7.5 The temperature rating of the Sprinkler head shall be 30°C above ambient temperature.

7.6 Flow switch shall be provided at the downstream of the alarm valve to relay the annunciation at the Fire Protection Panel in case the sprinkler actuates.

8.0 Foam System:
8.1 Foam chambers are envisaged for Chemical storage tank.
8.2 Mobile foam tender will be used to supply foam concentrate for foam chambers.
8.3 Foam drum of 100 litres cap. will be near water cum foam monitors for initial operation.

9.0 Portable Extinguisher:
The portable extinguisher shall be distributed throughout the plant. The location of the same shall be decided based on following considerations:
9.1 Travel distance of 15 meters maximum,
9.2 Uniform distribution,
9.3 Easy accessibility,
9.4 Neatness to doors, windows, emergency doors and escape routes.

10.0 Brief Specifications of Major Components
10.1 Pipes up to and including 150 mm NB shall conform to IS: 1239 Part-1 (Heavy) and pipes of 200mm NB and above shall conform to IS: 3589. Black pipes shall be used for hydrant system and sprinkler system. For spray system, the pipes downstream of isolation valve/deluge valve shall be galvanized.
10.2 Fire water pumps shall be as per relevant Indian Standard.
10.3 Isolating valves shall be gate valves of cast iron construction as per IS: 14846.
10.4 Hydrant valves shall be 63mm SS-304 ISI marked oblique pattern conforming to IS: 5290 Type A.

10.5 Monitor shall be as per IS: 8442.

10.6 Branch pipes with nozzle shall be 63mm SS-304 ISI marked short pattern (other than fog nozzles) conforming to IS: 903.

10.7 Fire hoses for hydrants shall be 63mm Reinforced Rubber-lined, with SS-304 instantaneous couplings duly bound at either end and conforming to IS: 636 Type A.

10.8 Hose cabinet shall be fabricated out of Galvanized 16 SWG CIRCA sheet, with 3mm thick glass fronted doors suitable for holding Two nos. fire hoses, one branch pipe with nozzle and one no. nozzle spanner.

10.9 First aid hose reel shall conform to IS:884 and be provided with 35m long x 20mm dia. rubber hose pipe and gun metal shut-off nozzle.

10.10 Deluge valve, Alarm valve, Spray Nozzles, Sprinklers shall be UL listed or FM approved.

11.0 Pumping arrangement & fire water reservoir capacity:

11.1 Following Fire Water Pumps & fire water storage tank shall be provided

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Name</th>
<th>Qty</th>
<th>Major Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Electric Motor driven Main Pump - Horizontal Centrifugal Split casing type</td>
<td>02</td>
<td>410 m³/hr @ 8.8 kg/cm²(g)*</td>
</tr>
<tr>
<td>(ii)</td>
<td>Diesel Engine driven Stand by Fire Pump - Horizontal Centrifugal Split casing type</td>
<td>01</td>
<td>410 m³/hr @ 8.8 kg/cm²(g)*</td>
</tr>
<tr>
<td>(iii)</td>
<td>Electric Motor Jockey Pump – Vertical inline type</td>
<td>02(1W+1S)</td>
<td>25 m³/hr @ 8.8 kg/cm²(g) *</td>
</tr>
<tr>
<td>(iv)</td>
<td>Above Ground Fire Water Tank (MOC- Structural steel) of effective capacity 1650 m³</td>
<td>2</td>
<td>Total storage effective capacity - 3300m³</td>
</tr>
</tbody>
</table>

* Pump head shall be finalized during detail engineering.

11.2 Above ground Steel tanks are recommended with an adjacent aboveground fire water pump house. The 2 nos. tank of equal capacity is recommended to facilitate periodic cleaning (in case of maintenance of one tank, water from other tank will be available for use).
11.3 Fire Water pumps shall be capable of furnishing 150% flow at head not less than 65% of the rated head. Shut off head shall not exceed 120% of the rated head for horizontal centrifugal Fire pumps.

12.0 Estimated Electrical Power Requirement

Estimated electrical power requirements are given below for the pumps listed under Table 1. These are for preliminary engineering only. Exact power requirement shall be obtained from respective equipment supplier during detail engineering.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description of Equipment</th>
<th>Quantity (Nos.)</th>
<th>Motor Rating / Power Input, each unit (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electric Motor driven Main Pump</td>
<td>02</td>
<td>150</td>
</tr>
<tr>
<td>2</td>
<td>Electric Motor driven Jockey Pump</td>
<td>02</td>
<td>12.5</td>
</tr>
</tbody>
</table>
1. **ELECTRICAL SYSTEM (OSBL)**

1.1. Power to the entire plant load is available from 15MW Gas based power plant (CPP) at 11kV voltage. Fault current of 26.3kA for 1 sec considered as per SLD provided by VPPL.

1.2. CPP power will be fed to entire plant through 2nos. 1250A, VCB feeders of HT switchgear located in CPP area.

1.3. ISBL load of PVC plant will be fed from PVC plant HT switchgear located in Substation building.

1.4. Based on the load list furnished by VPPL, power for utility loads shall be made available by adding 2 nos. of feeder in existing HT switchgear of PVC plant located in Substation building.

1.5. From PVC plant Substation building, 11kV supply will be taken to Utility Substation through HT cable routed on Cable rack. This utility substation is proposed near compressor area where all utility loads are nearby.

1.6. 1 nos. HT switchgear is proposed in Utility Substation and same will feed to 8 nos. of 11/0.433kV, 2500kVA, Dyn11, Distribution Transformers.

1.7. Loading of Distribution Transformer will be considered as 50% during normal condition.

1.8. Distribution Transformer will feed power to LV switchgear which will further supply power to respective package vendors PMCC panel.

1.9. Utility systems such as Boilers, Nitrogen Gas plant, DM water plant, SWRO system, Fire protection system, Compressed Air system, Boiler, ZLD, STP, Desalination Plant, Cooling tower & Zero liquid discharge plant shall have their own PMCC panels for distribution of power to each Motors/equipments & other miscellaneous items. The PMCC panels shall be kept within the vicinity of respective utilities system.

2. **LV switchgear**

2.1. MCCs will be suitable for 50kA for 1 sec. and 4000A rated current, indoor, compartmentalised, free standing, IP54, single front.

2.2. 415V PCC panel will be suitable for Top Bus duct entry and cable exit.

3. **Cabling System**

3.1. Cables from PVC plant Substation building to proposed Utility Substation will be laid in cable trays on proposed pipe rack.

3.2. Cables from Utility Substation to respective utility plants are considered in overhead cable trays on proposed pipe rack.

4. Cables from Utility Substation to Jetty are considered.
5. **Earthing System & Lightning Protection system**

5.1. Material of main earthing conductor shall be of G.I and size of conductor shall be designed for 50 kA for 1 sec.

5.2. All areas (i.e. Utility Plant, Tank farm area, Workshops etc.) will be provided with internal and external earthing grids with sufficient number of electrodes so that resistance will be less than one ohm.

6. **Lighting system**

6.1. Lighting in plant will be adequate to provide of visibility for work, tasks and objects, and to ensure safe working conditions.

6.2. Outdoor lighting will be provided for all Tank farm areas, Street lighting, including all other areas of the plant.

7. **Miscellaneous Items**

7.1. Local push button stations, Power receptacles, Structural steel, Safety equipments in panel room are considered.

**% Basis of Cost Estimate**

1. Cost of equipments like HT switchgear, LT switchgear, Distribution Transformer...etc has been considered based on TCE in-house data.

2. Cost of Electrical system (PMCC Panel, cabling, Earthing etc.) for Utility packages has been considered in respective package vendor cost.

3. An erection contract is considered for Installation of electrical system of the project. The erection contract will comprise of supply of miscellaneous items and erection hardware, structural Steel for Electrical system, erection & commissioning of total Electrical system equipment, Cabling system, Lighting system, Earthing and Lightning Protection system.

4. 15 % cost of the complete Electrical system supply cost is considered as the cost of Electrical system erection contract.

5. Cost for obtaining statutory clearances from electrical inspectorate and other statutory authorities are not included.

**% Codes and Standards:**

1. All Electrical equipments, accessories and installation shall be in accordance with latest Indian/International Standards.
AIR CONDITIONING & VENTILATION SYSTEM

1.0 SCOPE
This report mentions about the air conditioning and mechanical ventilation system deployed in the plant, meeting human comfort or process requirements. The report is bifurcated between air conditioning and mechanical ventilation systems for ease of understanding and clarity.

2.0 AIR CONDITIONING SYSTEM

2.1 AIR-CONDITIONING SYSTEM DESIGN INPUTS

2.1.1 Dighi (the plant site) does not have the design ambient data in established standards and hence the ambient design data considered for HVAC design is that of Mumbai, which is the closest location, whose design data is available in ASHRAE Fundamentals 2013 edition. Following are the design ambient conditions considered.

<table>
<thead>
<tr>
<th></th>
<th>Summer</th>
<th>Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry bulb temperature (°C)</td>
<td>36</td>
<td>32</td>
</tr>
<tr>
<td>Wet bulb temperature (°C)</td>
<td>23</td>
<td>26</td>
</tr>
</tbody>
</table>

2.1.2 Areas considered for air conditioning are as mentioned below.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Area Description</th>
<th>Width</th>
<th>Depth</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Administration Building</td>
<td>43</td>
<td>18</td>
<td>G + 1 floors considered</td>
</tr>
<tr>
<td>2</td>
<td>Laboratory and Engineering Workshop</td>
<td>37</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Central Control Building</td>
<td>27</td>
<td>17</td>
<td>G + 1 floors considered</td>
</tr>
<tr>
<td>4</td>
<td>O&amp;M and Shift office</td>
<td>40</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Engineering Stores and Staff Canteen</td>
<td>43</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

2.1.3 The indoor conditions for which the air conditioning system is designed shall be 23±1°C temperature and 50±5% relative humidity.

2.1.4 Areas considered for air conditioning are as mentioned below.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Area Description</th>
<th>Occup.</th>
<th>Heat dissip. (kW)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Administration Building</td>
<td>200</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Laboratory &amp; Engg. Workshop</td>
<td>50</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Central control building</td>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.2 AIR CONDITIONING SYSTEM OUTPUT PARAMETERS

<table>
<thead>
<tr>
<th>St. No.</th>
<th>Area Description</th>
<th>Cooling Load (TR)</th>
<th>Air Flow (m³/hr)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Administration Building</td>
<td>210.0</td>
<td>180,000</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Laboratory &amp; Engg. Workshop</td>
<td>65.0</td>
<td>54,000</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Central Control Building</td>
<td>120.0</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>O&amp;M and SH office</td>
<td>45.0</td>
<td>30,000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Engineering stores and Staff Canteen</td>
<td>70.0</td>
<td>60,000</td>
<td></td>
</tr>
</tbody>
</table>

2.3 AIR CONDITIONING SYSTEM DESCRIPTION

2.3.1 Central chilled water plant is proposed for the air-conditioning the areas requiring controlled indoor environment. This chilled water plant shall be centrally located in the plant and shall supply chilled water to all air conditioning areas through chilled water piping network. The plant shall comprise of following equipment.

2.3.2 Water cooled screw type chillers shall be installed for chilled water generation.

2.3.3 Horizontal end suction type chilled water recirculation pumps shall be provided for transferring generated chilled water from Chiller to the AHUs located near the air conditioning zones. The pumping system is divided between primary chilled water circuit and secondary chilled water circuit. Primary chilled water circuit shall ensure the continuous flow of chilled water in the plant and shall work on constant speed. The secondary chilled water circuit shall work based on varying load requirements of the zones and shall be of variable speed controlled by VFD on secondary chilled water pump motors.

2.3.4 For condenser cooling, a single cooling tower with 3 cell (2 working and 1 standby) arrangement shall be provided having cooling water flow rate of 205 m³/hr per cell. The operating temperature of cooling water through the cooling towers shall be 37º at inlet and 32º at outlet. This cooling water shall be supplied to be condensers of Chillers as cooling medium for refrigerant condensation.

2.3.5 Condenser cooling water pumps shall recirculate the cooling water from condenser of the chiller to the cooling tower and vice versa. The cooling tower shall be located at relatively higher elevation from chillers to have gravity flow and hence flooded suction in these pumps. The flow capacity shall be 205 m³/hr (2 working and 1 standby).

2.3.6 Air Handling Unit (AHUs) in each air conditioning zone are of double skin type housing filters, chilled water cooling coil, supply air DIW backward curved centrifugal fans and
outlet supply air damper. The air distribution system shall comprise of supply air GSS supply air ducting, volume control dampers (VCD), powder coated extruded aluminum diffusers / grilles for supply air and return air, plenums and duct supports.

2.3.7 Independent AHU shall be provided for each air conditioned area.

2.4 AIR CONDITIONING SYSTEM EQUIPMENT LIST

<table>
<thead>
<tr>
<th>SL No.</th>
<th>Equipment Description</th>
<th>Technical Parameters</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water cooled Screw Chillers</td>
<td>280 TR capacity, 12ºC in &amp; 7ºC out chilled water, 32ºC in &amp; 37ºC out cooling water</td>
<td>W: 2, S: 1, T: 3</td>
</tr>
<tr>
<td>2</td>
<td>Primary chilled water pumps</td>
<td>170 m³/hr @ 20 mWC head</td>
<td>W: 2, S: 1, T: 3</td>
</tr>
<tr>
<td>3</td>
<td>Secondary chilled water pumps</td>
<td>170 m³/hr @ 50 mWC head</td>
<td>W: 2, S: 1, T: 3</td>
</tr>
<tr>
<td>4</td>
<td>Cooling water pumps</td>
<td>205 m³/hr @ 30 mWC head</td>
<td>W: 2, S: 1, T: 3</td>
</tr>
<tr>
<td>5</td>
<td>FRP cooling tower (3 cells)</td>
<td>205 m³/hr, 37ºC in &amp; 32ºC out cooling water, with 675 TR heat rejection</td>
<td>W: 2, S: 1, T: 3</td>
</tr>
<tr>
<td>6</td>
<td>AHU</td>
<td>Refer to table of output parameters</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Expansion Tank for chilled water closed loop circuit</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Air distribution system</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Instrumentation and control system</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

2.5 AIR CONDITIONING SYSTEM ESTIMATE

Indicative price for the above described air conditioning system (excluding piping and pipe insulation along with valves and accessories of piping) shall be INR 3.5 Crore.

3.0 MECHANICAL VENTILATION SYSTEM

3.1.1 Following areas shall be provided with mechanical ventilation system.

3.1.2 Suitable exhaust fans shall be provided for mechanical ventilation system.

3.1.3 The mechanical ventilation system is designed for number of air changes per hour of
fresh air considering 4.25 m height in the buildings, as per NBC 2005 standard.

3.1.4 Fresh air shall be drawn through louvers / window openings.

3.1.5 Based on the building sizes, fan capacities are calculated and tabulated as below.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of the Area</th>
<th>Area (m²)</th>
<th>Air change per hour</th>
<th>Fan cap. (CMH)</th>
<th>Number of fans</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Compressor House</td>
<td>297</td>
<td>12</td>
<td>4,000</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Fire Station &amp; Pump House</td>
<td>1,550</td>
<td>12</td>
<td>7,000</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Plant water Pump House &amp; Storage Facility</td>
<td>840</td>
<td>12</td>
<td>5,700</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Boiler House</td>
<td>925</td>
<td>25</td>
<td>7,000</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>15 MW Gas Based Power Plant</td>
<td>4,200</td>
<td>25</td>
<td>16,000</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>Substation Bldg</td>
<td>525</td>
<td>25</td>
<td>6,000</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Product Warehouse-01</td>
<td>3,150</td>
<td>8</td>
<td>9,500</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>Product Warehouse-02</td>
<td>630</td>
<td>8</td>
<td>5,700</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Desalination Plant (Future)</td>
<td>2,438</td>
<td>20</td>
<td>11,000</td>
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</tr>
<tr>
<td>10</td>
<td>Drivers Canteen</td>
<td>846</td>
<td>12</td>
<td>9,200</td>
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</tr>
</tbody>
</table>

3.2 MECHANICAL VENTILATION SYSTEM ESTIMATE

Indicative price for the above described mechanical ventilation system shall be INR 11.0 Lakhs.
1.0 Introduction:

VERITAS Polychem Private Limited integrated project consisting of the following static equipments:

1.1 6 nos. of VCM (Vinyl Chloride Monomer) mounted bullets of capacity 2500 m³ each.
1.2 2 nos. of LPG mounted bullets of capacity 2500 m³ each.
1.3 8 nos. of Propylene mounted bullets of capacity 2500 m³ each.
1.4 2 nos. of Bitumen storage tanks of capacity 2500 m³ each.
1.5 2 nos. of PNB storage tanks of capacity 2500 m³ each.
1.6 1 no. of DM water storage tanks of capacity 500 m³.
1.7 1 no. of Bitumen vessel of capacity 151 m³.

2.0 Design Standards are as follows:

2.1 Bullets shall be designed & fabricated as per PD 5500 Latest edition, SMPV Rules 1981, OISD 150 codes.
2.2 Storage tanks shall be designed & fabricated as per API 650, 12th edition.
2.3 Pressure vessel shall be designed & fabricated as per ASME section VIII div. I, latest edition.

3.0 Assumptions & Considerations:

3.1 Following sizes & material of construction are considered for bullets & storage tanks:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item description</th>
<th>Size</th>
<th>Qty.</th>
<th>Material of construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2500 m³ VCM bullets</td>
<td>7.4 m. dia. x 63 m length</td>
<td>6</td>
<td>SA 537 Cl 1</td>
</tr>
<tr>
<td>2</td>
<td>2500 m³ LPG bullets</td>
<td>7.4 m. dia. x 63 m length</td>
<td>2</td>
<td>SA 537 Cl 1</td>
</tr>
<tr>
<td>3</td>
<td>2500 m³ Propylene bullets</td>
<td>7.4 m. dia. x 70 m length</td>
<td>8</td>
<td>SA 537 Cl 1</td>
</tr>
<tr>
<td>4</td>
<td>2500 m³ Bitumen tanks</td>
<td>14 m. dia. x 17 m length</td>
<td>2</td>
<td>A 516 Gr 70/ A 36</td>
</tr>
<tr>
<td>5</td>
<td>2500 m³ PNB tanks</td>
<td>14 m. dia. x 17 m length</td>
<td>2</td>
<td>A 516 Gr 70/ A 36</td>
</tr>
<tr>
<td>6</td>
<td>500 m³ DM water tank</td>
<td>8 m. dia. x 10 m length</td>
<td>1</td>
<td>A 516 Gr 70/ A 36</td>
</tr>
<tr>
<td>7</td>
<td>151 m³ Bitumen vessel with agitator</td>
<td>6.77 m. dia. x 8.94 m length</td>
<td>1</td>
<td>SA 516 Gr 70</td>
</tr>
</tbody>
</table>

4.0 Horizontal Mounded Bullets:
Horizontal Mounded Bullets are for bulk storage of VCM (Vinyl Chloride Monomer), liquefied petroleum gas (LPG) & Propylene. These mounded bullets are buried, horizontal cylindrical steel tanks with hemispherical dished ends of sizes mentioned above. These mounded bullets allow storage of large quantities of gases up to 2500 m³. These mounded bullets are designed & fabricated as per code PD 5500. The design pressure ranges from 10.0 Kg/cm² to 23.0 Kg/cm² depending on product stored. Design Temperature ranges from -27°C to +50°C (Atmospheric). These bullets are 100% radio graphed & post weld heat treated. Material of bullets is SA 537 CL 1 which is impact tested. Bullets will be hydro tested as per code. All openings will be of flanged type with nozzle construction. The design & fabrication of bullets will have statutory approval from PESO / CCOE.

5.0 Storage tanks:

Storage tanks are for storage of Bitumen, PN& DM water. These storage tanks are vertical, cylindrical above ground steel tanks with flat bottom and supported conical roof of sizes mentioned above. These storage tanks allow storage of liquids from 500 m³ to 2500 m³. These tanks are designed & fabricated as per code API 650, 12th edition. The design pressure is atmospheric. Design Temperature ranges from ambient to + 200°C. These tanks will be hydrostatically tested with water. Material of tanks is A 516 Gr 70 / A 36. All openings will be of flanged type with nozzle construction.

6.0 Bitumen vessel with agitator:

Bitumen vessel is for storage & mixing of Bitumen. This vessel is vertical cylindrical steel pressure vessel with semi ellipsoidal dished ends of size mentioned above. The capacity of vessel is 151 m³. This vessel is designed & fabricated as per code ASME section VIII div. 1. The design pressure ranges from 4.5 Kg/cm² to Full vacuum. Design Temperature is +200°C. This vessel is 100% radio graphed. Material of vessel is SA 516 Gr 70. Vessel will be hydro tested as per code. All openings will be of flanged type with nozzle construction. Vessel will have agitator for mixing bitumen. This vessel will be lug / leg supported.
AUXILIARIES SYSTEMS

x Monitoring & control of Process systems shall be carried out using DCS based control system.

x Utility systems such as Compressed Air system, Boiler, Nitrogen Plant, STP, WTP. Cooling tower & Effluent treatment plant with zero liquid discharge shall have respective system control panels for monitoring & control of the systems. The Utility system control panels shall be interfaced either by communication link or hardwired with the Plant DCS for monitoring of necessary parameters.

x Existing DCS of the plant will be used. New DCS will be not procured. The existing DCS system will be augmented for any additional process systems control and monitoring. The dedicated control system to be provided for all utilities shall be interfaced with DCS system for centralized monitoring of data. Necessary I/Os and required Hardware will be added in the Existing DCS.

x All the field instruments/junction boxes located in the areas where Class A/B fluids are present shall be ex-proof or intrinsically safe for the area classification.

x Weatherproof protection for all outdoor located instruments/junction boxes shall be minimum IP65.

x Wetted parts for all instruments & valves shall be SS 316 as a minimum.

x Instrument cables shall be armored with FRILS PVC sheath. For analog signals cables shall be stranded twisted pair individual pair screened and overall screened.

x For digital signals cables shall be stranded multi core with overall screening.

x All Instrument cable trays shall be of GI 2.0 mm thick perforated type and hot dipped galvanized (GI). Outdoor cable trays will be provided with cover.

x Cable entry in to all the control room will be through Multiple Cable Transit (MCT) blocks.

x Following auxiliary systems shall be provided in plant.

  o Fire Detection and Alarm System (FDAS) – It shall be provided for annunciation and alarm verification in case of any fire occurs in the various parts of the plant like office area, admin area, control room, process area, substations and in utility area. Addressable FDAS shall consist of Fire alarm panel, Repeater panel, various types of detectors and devices and associated cables. It will be integrated with 3rd party systems like Fire protection, Access control, HVAC, PAS etc. FDAS will be provided in ISBL as well as OSBL area.
- **Closed Circuit Tele-Vision System (CCTV)** - The CCTV System shall be based on IP (LAN) and shall provide live viewing and recording of all the cameras for post event analysis. It shall consist of various types of IP cameras which shall be mounted at strategic locations which mainly include, administrative block, control room, plant entrance, plant periphery etc., Ethernet switches, management, recording and analytics servers, monitors and associated cables. It can be integrated with ACS.
- **Access Control System (ACS)** - ACS shall be installed at strategic locations which mainly include, administrative block, control room, plant entrance to grant access to the authorized personnel to enter in the premises and restrict unauthorised entries. It shall consist of access cards, card readers, controllers, servers, visitor management system, alongwith turnstiles/ flap barriers, boom barriers/ tyre killer and associated cables.
- **Electronic Automatic Private Branch Exchange (EPABX)** - It shall be provided in various plant buildings, office building, process areas to establish communication between the internal areas as well as outside plant. It consists of various types of telephones, terminal boxes, EPABX and associated cables. It shall be integrated with plant LAN.
- **Public Address System (PAS)** - The primary objective of the PA system shall be to provide clear announcements during public addressing and two-way voice communication during an emergency. The PA system shall be designed to make manual and automatic public broadcasts of routine, situational, important and emergency announcements and also to broadcast background music to all or selected zones. It shall consist of various types of loudspeakers, Field call station, Master call station, PA system controller and associated cables. Loudspeakers will be provided in plant area, office area, control room, substation. Master call stations will be in control room and Field call station in process area.
1. OBJECTIVE
Raw water treatment plant scheme is proposed to treat raw water of 5 MLD capacity for Potable &
Industrial utility application. Source of Raw water is from Kudki Dam. MUP will bring water up Diggi
port from Kudki dam. Raw water pumping station of capacity 5 MLD shall be constructed at Diggi
port for raw water transportation up to site. Raw water transportation pipe line (Approximate 1.5
Km) shall be laid between Diggi port to Raw water treatment plant located in Main plant. The
proposed scheme is broadly as per following treatment steps:
a) Aeration
b) Chlorination
c) Coagulation & Flocculation
d) Sedimentation / Clarification
e) Sludge Treatment

2. DESCRIPTION:
The principle objectives of Raw water treatment plant is to remove turbidity and disinfection to kill
pathogens. Each treatment units operation / process is briefly described below.

2.1 AERATION
Raw water will be provided at inlet of Cascade aerators. Cascade aerators will be provided for
primary removal of iron. Cascade aerators will be provided with an adequate internal cross
sectional area to handle the required flow at minimum velocity to removal of iron up to specified
limit. Raw water from cascade aerators will be routed through stilling chamber of R.C.C.
construction. Stilling chamber will be provided to remove turbulence in raw water. Suitable
draining arrangement will be provided for stilling chamber.

Pre-chlorination of raw water shall be carried out at respective stilling chamber by injecting
chlorinated water solution in to the raw water by means of diffuser.

2.2 COAGULATION & FLOCCULATION :
Coagulation and Flocculation is chemical / physical process of blending or mixing a coagulating
chemical into a stream and then gently stirring the blended mixture. The overall purpose is to
improve the particulate size and colloid reduction efficiency of the subsequent settling and or
filtration processes.

2.3 SEDIMENTATION / CLARIFICATION :
Clarifier will be solid contact reactor type with integral variable speed impeller to internally
recirculate sludge water at adjustable rate to produce consistent water quality. The clarifier unit
will be circular, central feed type with reaction zone & clarification zone in R.C.C. Bridge type arm
rack mechanism will be provided for internal sludge recirculation. The bottom of Clarifier will be sloped towards the center & mechanically driven sludge scraper and collector shall be used to remove the settled sludge down sloping bottom to center sludge area. The sufficient detention time and area will provide to remove suspended solid.

2.4 SLUDGE DEWATERING:
Underflow sludge from Clariflocculator and Stilling chamber will be led to sludge tank. Sludge from Clariflocculator will be disposed of by pump to mechanical sludge dewatering system.
## Pipeline Specifications

**3 Nos. - 8” for gases and 1 No. - 12” for bitumen, 2 Nos. - utility/compressed air and nitrogen, 2.2 km.**

<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A.</strong> Service gas</td>
<td>12” Bitumen pipe line from jetty to terminal</td>
</tr>
<tr>
<td>1. Material</td>
<td>A 106 Gr.B seamless</td>
</tr>
<tr>
<td>2. Pipe sch./thk.</td>
<td>Sch. STD</td>
</tr>
<tr>
<td>3. Design/dimensions</td>
<td>ANSI B 36.10</td>
</tr>
<tr>
<td>4. Lengths</td>
<td>In 5 to 6 m lengths</td>
</tr>
<tr>
<td>5. End finish</td>
<td>Bevelled end as per ANSI B 16.25</td>
</tr>
<tr>
<td>6. Pressure Rating</td>
<td>Class 150#</td>
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<tbody>
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<td><strong>B.</strong> Service</td>
<td>8” LPG pipe line from jetty to gas terminal</td>
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<td>2. Pipe sch./thk.</td>
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<td>4. Lengths</td>
<td>In 5 to 6 m lengths</td>
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<th>Description</th>
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<td><strong>C.</strong> Service</td>
<td>8” VCM pipe line from jetty to gas terminal</td>
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<tr>
<td>2. Pipe sch./thk.</td>
<td>Sch. 40</td>
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<td>3.</td>
<td>Design/dimensions</td>
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<td>4.</td>
<td>Lengths</td>
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<td>Pressure Rating</td>
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**D. Service gas**

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<tbody>
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<td>2. Pipe sch./thk.</td>
<td>Sch. STD</td>
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**E. Service gas**

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<td>3. Design/dimensions</td>
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<td>4. Lengths</td>
<td>In 5 to 6 m lengths</td>
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<td>5. End finish</td>
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**F. Service**

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<td>1. Material</td>
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<td>4. Lengths</td>
<td>In 5 to 6 m lengths</td>
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<tr>
<td>5. End finish</td>
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<td>6. Pressure Rating</td>
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</tr>
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<td>6.</td>
<td>Pressure Rating</td>
<td>Class 150#</td>
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**1 NO. - 12" FOR RAW WATER PIPELINE FROM DIGGI PORT TO PLANT, 1.5 km.**

**A. Service**

<p>| | | |</p>
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<td>2.</td>
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CHAPTER Z
NON PLANT FACILITIES
The proposed plant complex comprises of utility structures as listed below:

<table>
<thead>
<tr>
<th>Sr No</th>
<th>List of Structures</th>
<th>Type of Structures</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Utility Building</td>
<td>RCC</td>
</tr>
<tr>
<td></td>
<td>x Compressed Air System</td>
<td>RCC</td>
</tr>
<tr>
<td></td>
<td>x Steam Boler</td>
<td>RCC</td>
</tr>
<tr>
<td>2</td>
<td>Product Warehouse</td>
<td>STEEL STRUCTURE</td>
</tr>
<tr>
<td>3</td>
<td>Weigh Bridge &amp; Cabin</td>
<td>RCC</td>
</tr>
<tr>
<td>4</td>
<td>DG Shed and Stack.</td>
<td>STEEL STRUCTURE</td>
</tr>
<tr>
<td>5</td>
<td>Admin Office and Canteen</td>
<td>RCC</td>
</tr>
<tr>
<td>6</td>
<td>Raw Water cum Fire Water tank and Pump House</td>
<td>RCC</td>
</tr>
<tr>
<td>7</td>
<td>Security Room</td>
<td>RCC</td>
</tr>
<tr>
<td>8</td>
<td>Substation Building</td>
<td>RCC</td>
</tr>
<tr>
<td>9</td>
<td>Pipe rack, Instrumentation and Cable Rack</td>
<td>RCC</td>
</tr>
<tr>
<td>10</td>
<td>Engineering Workshop</td>
<td>STEEL STRUCTURE</td>
</tr>
<tr>
<td>11</td>
<td>Fire Station &amp; Safety training Center</td>
<td>RCC</td>
</tr>
<tr>
<td>12</td>
<td>Compound Wall</td>
<td>RCC / Brickwork</td>
</tr>
<tr>
<td>13</td>
<td>Roads</td>
<td>RCC</td>
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<tr>
<td>14</td>
<td>Storm Water Drainage</td>
<td>Brickwork</td>
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<tr>
<td>15</td>
<td>Laboratory</td>
<td>RCC</td>
</tr>
<tr>
<td>16</td>
<td>Central Control Room</td>
<td>RCC</td>
</tr>
<tr>
<td>17</td>
<td>VCM Mounded Bullets</td>
<td></td>
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</tbody>
</table>
2. **SCOPE**

This Design Basis Report is intended to provide general guidelines for selection of materials, design loads, load combinations and design philosophy for all structures which are part of this plant.

3. **GEO-TECHNICAL INVESTIGATION**

3.1. Geotechnical Investigation will be conducted and the foundation system will be designed according to the recommendations given in the investigation report.

4. **INPUT PARAMETERS**

The site data are as follows:

- Wind Speed: 39 m/s as per IS: 875 (Part 3) - 1987
- Seismic Classification: Zone III as per IS: 1893 (Part-I)
- Rainfall Design Intensity: 50mm per hour (Considered for Design)

5. **STANDARDS, CODES AND SPECIFICATIONS**

This section lists out the codes and standards which shall be used for design and construction. In all cases, the latest revisions of the codes shall be referred to.

The list given here is not an exhaustive list.

<p>| IS: 456 - 2000 | Plain and Reinforced Concrete - Code of Practice |
| IS: 800 - 2007 | Code of Practice for General Construction in Steel |
| IS: 808 - 1989 | Dimensions for hot rolled steel beam, column, channel and angle sections. |
| IS: 814 - 2004 | Covered electrodes for manual metal arc welding of carbon and carbon manganese steel specifications |
| IS: 816 - 1969 | Code of Practice for Welding for general construction in mild steel, First Revision, Bureau of Indian Standards (BIS) |
| IS: 875 (Part 1) - 1987 | Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 1 – Dead Loads) |
| IS: 875 (Part 2) - 1987 | Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 2 – Imposed Loads) |
| IS: 875 (Part 3) - 2015 | Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 3 – Wind Loads) |
| IS: 1080: 1985 | Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell) |
| IS: 1893 (Part 1) | Criteria for Earthquake Resistant Design of Structures |</p>
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<tr>
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<th>IS / Title</th>
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<tr>
<td>2002</td>
<td>IS: 1893 (Part 2) - 2002 Criteria for Earthquake Resistant Design of Structures (Part 2 - General Provisions for Liquid retaining structures)</td>
</tr>
<tr>
<td>2005</td>
<td>IS: 1893 (Part 4) - 2005 Criteria for Earthquake Resistant Design of Structures (Part 4 - Industrial Structures including Buckle like Structures)</td>
</tr>
<tr>
<td>2008</td>
<td>IS: 1786 - 2008 Specification for high strength deformed steel bars and wires for concrete reinforcement</td>
</tr>
<tr>
<td>1980</td>
<td>IS: 2974 (Part 2) - 1980 Code of practice for design and construction for machine foundations - Foundation for impact type machines (Hammer foundations)</td>
</tr>
<tr>
<td>1992</td>
<td>IS: 2974 (Part 3) - 1992 Code of practice for design and construction for machine foundations - Foundation for rotary type machines (Medium and high frequency)</td>
</tr>
<tr>
<td>1979</td>
<td>IS: 2974 (Part 4) - 1979 Code of practice for design and construction for machine foundations - Foundation for rotary type machines of low frequency</td>
</tr>
<tr>
<td>1987</td>
<td>IS: 2974 (Part 5) - 1987 Code of practice for design and construction for machine foundations - Foundation for impact machines other than hammer (Forging and stamping press, pig breaker, Drop crusher and others)</td>
</tr>
<tr>
<td>2009</td>
<td>IS: 3376 (Part 1) - 2009 Concrete structures for storage of liquids – General requirements</td>
</tr>
<tr>
<td>2009</td>
<td>IS: 3376 (Part 2) - 2009 Concrete structures for storage of liquids – Reinforced concrete structures</td>
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<tr>
<td>2009</td>
<td>IS: 10262 - 2009 Guidelines for Concrete mix design proportioning</td>
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<td>2016</td>
<td>IS: 13920 - 2016 Code of practice for ductile design and detailing of reinforced concrete structures subjected to seismic forces</td>
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<table>
<thead>
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<th>Description</th>
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<tr>
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<td>Handbook on Structural Steel.</td>
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<tr>
<td>SP: 16 - 1980</td>
<td>Design Aids for Reinforced Concrete to IS 456.</td>
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<td>SP: 24 - 1987</td>
<td>Handbook on Concrete Reinforcement and Detailing.</td>
</tr>
<tr>
<td>SP: 40 (S &amp; T): 1987</td>
<td>Handbook on Structures with Steel Portal Frames (Without Cranes)</td>
</tr>
<tr>
<td>IRC: 21-2000</td>
<td>Standard Specification and Code of Practice for Road Bridges (Third Revision) Section: III, Cement Concrete (Plain and Reinforced)</td>
</tr>
<tr>
<td>IRC: 37-2012</td>
<td>Guidelines for the Design of Flexible Pavements (Third Revision)</td>
</tr>
<tr>
<td>IRC: 78 – 2014</td>
<td>Standard specifications and code of practice for road bridges</td>
</tr>
<tr>
<td>IRC: SP42</td>
<td>Guidelines for the design of road drainage</td>
</tr>
<tr>
<td>IRC: SP13</td>
<td>Design of small culverts and small bridges</td>
</tr>
</tbody>
</table>

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required.

### 6. UNITS

Units shall be in accordance with the metric (SI) system:

- **Elevations**: metre (m)
- **Dimensions**: millimetre (mm)
- **Force**: Ton (T)
- **Mass**: kilogram (kg)
- **Moment**: kilo Newton – metre (kN-m)
- **Stress**: Newton / mm² (N/mm²)
- **Pressure**: kilo Newton / m² (kN/m²)

For simplification purposes, one (1) kg mass shall be taken as equal to 10 N (0.010 kN) force. (i.e. Gravitational acceleration ‘g’=9.81 m/s² is taken as 10m/s²)
7. DESIGN LOADS

In general different loading conditions have to be considered for the design of the plant and other structures.

Following loads shall be considered in the design:

- Dead load (DL)
- Live load (LL)
- Wind load (WL)
- Seismic load (SL)
- Impact Load (IL)
- Equipment loads (EL)
  - Equipment Empty Load (ELe)
  - Equipment Operating Load (ELo)
  - Equipment Test Load (ELt)

7.1. DEAD LOAD (DL)

Dead load is the self weight of the structure and the weight of all materials permanently fastened there to or supported thereby, such as fireproofing, pipes, insulations and walkways, weight of empty equipment, ducts, trays and vessels.

Unit weight to be considered for various materials shall be as follows:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Material</th>
<th>Unit weight (kN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reinforced concrete</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Plain cement concrete</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>Structural steel</td>
<td>78.5</td>
</tr>
<tr>
<td>4</td>
<td>Concrete block masonry</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>Brick masonry</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Wet soil weight</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>Fully saturated soil weight</td>
<td>21</td>
</tr>
<tr>
<td>8</td>
<td>Aerated concrete block masonry</td>
<td>9.0</td>
</tr>
<tr>
<td>9</td>
<td>Cement Plaster</td>
<td>20.40</td>
</tr>
</tbody>
</table>

The flooring load shall be calculated for 50thk floor finish with a dead load of 1.20kN/m² unless noted otherwise.

The water proofing flooring load for the terrace shall be for 150thk brickbat coba, therefore dead load shall be 3 kN/m².
### 7.2. **LIVE LOAD (LL)**

Live load shall be the maximum loads expected by the intended use or occupancy and consists of the following loads:

- Person, portable machinery and tools.
- Materials temporarily stored during maintenance such as moulds, finished goods, raw material and scrap material.
- Materials normally stored during operation.
- Moving or standby vehicles.

Live loads shall be uniformly distributed/concentrically applied over the horizontal projection of the specified area.

Following live loads shall be the minimum considered in structural design as specified in IS: 875 (Part 2) unless noted otherwise.

<table>
<thead>
<tr>
<th>Loading Area</th>
<th>Load Intensity (kN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessible Roof</td>
<td>1.5</td>
</tr>
<tr>
<td>Inaccessible Roof</td>
<td>0.75</td>
</tr>
<tr>
<td>For Sloping Roof with slope greater than 10 degrees</td>
<td>0.75 kN/m², less 0.02 kN/m² for every degree increase in slope over 10 degrees, subject to a minimum of 0.40 kN/m²</td>
</tr>
<tr>
<td>Staircase</td>
<td>5.0 or As specified in the layout</td>
</tr>
<tr>
<td>Ground floor live loads</td>
<td>5.0 or As specified in the layout</td>
</tr>
<tr>
<td>Typical floor slab</td>
<td>5.0 or As specified in the layout</td>
</tr>
<tr>
<td>Storage area - Ground slab</td>
<td>10 or As specified in the layout</td>
</tr>
<tr>
<td>AHU, Control Room (Equipment load shall be considered additional to live load)</td>
<td>5 or As specified in the layout</td>
</tr>
<tr>
<td>Raw material storage</td>
<td>2.4 kN/m² per metre of storage height with a minimum of 7.5 kN/m²</td>
</tr>
<tr>
<td>Maintenance Platforms</td>
<td>7.5 or As specified in the layout</td>
</tr>
<tr>
<td>Operating Platform</td>
<td>5.0 or As specified in the layout</td>
</tr>
<tr>
<td>Access Platform, Walkways</td>
<td>3.0 or As specified in the layout</td>
</tr>
<tr>
<td>Handrails</td>
<td>0.75 kN/m Linear load</td>
</tr>
<tr>
<td>Loading Area</td>
<td>Load Intensity (kN/m²)</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Toilets</td>
<td>2.0</td>
</tr>
<tr>
<td>Loading and unloading bay</td>
<td>15.0</td>
</tr>
<tr>
<td>Other Loads</td>
<td>Any other loads for partition walls, ducting, false ceiling/ flooring shall be added as actual</td>
</tr>
</tbody>
</table>

*Note: All the equipment loads are considered in addition to live loads.*

Where actual load is more than the load given in the above table, design shall be based on actual loadings. For various mechanical handling equipments which are used to transport goods to storage, workshop etc, the actual load coming from the use of such equipment shall be ascertained and design should cater to actual loading.

### 7.3. EQUIPMENT LOAD (EL)

Equipment Loads can be divided in following types:

- Empty
- Operating
- Test

Equipment loads along with attached piping and platform shall be taken as given in mechanical loading data.

#### 7.3.1. Equipment Empty Load (ELa)

This shall mean the weight of equipment during erection and exclude the weight of internal fluids, solids within equipment, platforms, insulation and piping attached to the equipment. Equipment empty load shall be considered as per the details provided by the equipment manufacturer.

#### 7.3.2. Equipment Operating Load (ELO)

This shall mean the weight of equipment during normal operating conditions including the weight of internal fluids, solids within equipment and all materials permanently attached to the equipment such as platforms, piping and insulation. Equipment empty load shall be considered as per the details provided by the equipment manufacturer. If piping weight is not indicated separately or included in the weight of the equipment, the same shall be taken as 10% of the weight of the equipment.

Impact allowance for crane shall be as per clause 6.3 of IS: 875 Part-2 and for crane load combinations refer clause 6.4 of IS: 875 Part-2.

#### 7.3.3. Equipment Test Load (ELt)

This shall mean the weight of equipment, piping during hydrostatic testing after erection / installation including the weight of water within the equipment piping and all materials
permanently attached to equipment such as platforms, insulations and piping. Equipment
test load shall be considered as per the equipment manufacturer’s data.

### 7.4. Wind Load (W)

All buildings and structures shall be designed to withstand the forces of wind pressure,
assumed in any horizontal direction with no allowance for the effect of shielding by other
adjacent structures, in accordance with the appropriate provisions of IS: 875 Part 3.

<table>
<thead>
<tr>
<th>Basic Windspeed at 10m Height for Nagpur</th>
<th>$V_b = 39 \text{ m/s}$</th>
<th>m/sec</th>
<th>Appendix A, IS:875 Part 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Windspeed at any height:</td>
<td>$V_e = V_b \times K_1 \times K_2 \times K_3$</td>
<td>m/sec</td>
<td>Clause 5.3, IS:875 Part 3</td>
</tr>
</tbody>
</table>

Where: $K_1 =$ Probability factor = 1.00

(Mean probable life of structure 50 years)

- $K_2 =$ Terrain height & structure size factor
- For Category – 2, Values of Table 2 of IS: 875- Part 3 to be referred.
- $K_3 =$ Topography factor = 1.0
- $K_4 =$ Importance Factor for Cyclonic Region = 1.15

Design Wind Pressure at any height:

$P_e = 0.6 \times V_e^2$ N/m² | Clause 5.4, IS:875 Part 3 |

Based on the above wind pressure and exposure of the building as per IS: 875 (Part-3),
further load calculations will be carried out with respect to profile of structure.

### 7.5. Seismic Load (Sl)

All structures & foundations shall be designed to resist the effects of earthquakes in
be designed for Design Basis Earthquake (DBE). Response spectrum method will be used
to carry out seismic analysis.

#### 7.5.1. Categorization of structures

Structures/equipments shall be classified into the four categories as per clause 7.1, IS
1893 (Part-4).

#### 7.5.2. Design acceleration due to earthquake

Horizontal acceleration co-efficient $A_h = (Z/2)^* (1/R) (Sa/g)$

Seismic parameters $Z$, $I$, $R$ and $Sa/g$ are obtained as per table below.
Seismic parameters:
Seismic design forces shall be determined based upon the following parameters.

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic Zone</td>
<td>Zone – III</td>
<td>ANNEX – E of IS: 1893 (Part-1)</td>
</tr>
<tr>
<td>Zone Factor (z)</td>
<td>0.16</td>
<td>Table 2 of IS: 1893 (Part-1)</td>
</tr>
<tr>
<td>Importance Factor “I”</td>
<td>2.00 for structures in category 1 1.75 for structures in category 2 1.50 for structures in category 3 1.00 for structures in category 4</td>
<td>Table 2 of IS: 1893 (Part-4)</td>
</tr>
<tr>
<td>Damping</td>
<td>5 % for RCC Structure</td>
<td>Clause 7.8.2.1 of IS: 1893 (Part-1)</td>
</tr>
<tr>
<td></td>
<td>2 % for Steel Structure</td>
<td></td>
</tr>
<tr>
<td>Average response</td>
<td>( S_{\text{g}}/g )</td>
<td></td>
</tr>
<tr>
<td>acceleration coefficient</td>
<td>( 1 + 15T )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 0.00 \leq T \leq 0.10 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 2.5 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 0.10 \leq T \leq 0.55 )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 1.36 / T )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( 0.55 \leq T \leq 4.00 )</td>
<td></td>
</tr>
<tr>
<td>Response reduction factor</td>
<td>3 for Ordinary Moment Resisting Frame (OMRF) 5 for Special Moment Resisting Frame (SMRF) 4 for concentrically braced steel frames 5 for eccentrically braced steel frames</td>
<td>Table 3 of IS: 1893 (Part-4)</td>
</tr>
</tbody>
</table>

For other damping values, the values of Average Response Acceleration Coefficient shall be multiplied by a factor as given in Table 3 - Ref. Clause 6.4.5 of IS : 1893 (Part 1). For steel structures, the above multiplying factor shall be 1.40 for 2% damping as per Table-3, IS: 1893 (Part 1).

The approximate fundamental natural period of vibration of a moment resisting frame building without brick infill panels shall be calculated as per IS:1893 Clause No. 7.6.

Contribution of permanent dead loads and live loads as specified in IS: 1893 (Part 1) shall be considered while calculating nodal masses. Live load on the roof shall not be accounted in the calculation of nodal masses.
7.3. Seismic weight calculation

Seismic weight of floor and building shall be calculated as per Cl. 7.40 of IS: 1893 (Part 1). The seismic weight of building includes all permanent and rigidly attached structural and non-structural components of a building, such as walls, floors, roofs, cladding, piping, duct load, cable tray load, total weight of permanent equipment, utility weight of permanent equipment, normal operating weight of contents in vessels and pipe etc and appropriate amount of live load.

While computing the seismic weight of each floor, the weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey.

The contribution of live load to be considered in the seismic weight calculation shall be taken as per the Clause 7.3.1 and as specified in Table – 8 of IS: 1893 (Part 1).

<table>
<thead>
<tr>
<th>Imposed Uniformly Distributed Floor Loads (kN/m²)</th>
<th>Percentage of Imposed load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to and including 3.0</td>
<td>25%</td>
</tr>
<tr>
<td>Above 3.0</td>
<td>50%</td>
</tr>
</tbody>
</table>

7.4. Method of Dynamic Analysis

Response spectrum method shall be applied for seismic analysis. The peak response quantities shall be combined as per Complete Quadratic Combination (CQC) method.

7.5. Combination of Responses Due To Multi Component Seismic Accelerations

All types of structures and equipments shall be designed for multi-component earthquake as per IS: 1893.

7.6. Ductile Detailing

The ductility details of reinforced concrete members should be provided as per the provisions of IS: 13920 to avoid premature failure during earthquake.

In steel structures, members and their connections should be so proportioned that high ductility is obtained to ensure that premature failure due to elastic or inelastic buckling does not occur. Ductile detailing of steel structures should be carried out as per the provisions of IS: 4326 and IS: 1893.

7.7. Increase in Permissible Stresses

When earthquake forces are included, the allowable bearing pressure in soils shall be increased as per Table 1 of IS: 1893 (Part1), depending upon type of foundation of the structure and the type of soil.

7.8. Hydro Dynamic Forces On Liquid Retaining Structures

Hydro dynamic forces exerted by liquid on tank wall during earthquake shall be considered in the analysis in addition to hydro static forces. These hydro dynamic forces namely convective and impulsive forces are evaluated with the help of spring mass model of tanks. For load combination with seismic load, the amount of liquid considered in the tank shall be normal liquid level under service condition only. For tank full as well
as empty conditions, tank shall be designed as per IS: 3370 (Part 4) and analyzed for all the load combinations as per IS: 1893 (Part 1).

7.6 IMPACT LOADS

All structural framing and concrete foundations subject to vibration, impact, impulse, shock, etc., shall be designed to withstand the generated forces within the limits of acceptable stress, deflection, and/or amplitude of vibration as per provision of IS: 875 (Part 2) & IS: 2974 (Part 2).

All structures supporting reciprocating equipment or rotating equipment with excessive imbalance shall be analyzed for both strength and response.

All structures supporting moving or stationary equipment shall be designed for static loads plus appropriate impact factors as defined by the equipment manufacturer or IS 800, whichever is stringent.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Equipment Description</th>
<th>Impact Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monorails</td>
<td>25% Vertical</td>
</tr>
<tr>
<td>2</td>
<td>EOT Crane</td>
<td>As per IS: 875-(Part 2) and IS: 807, Accidental loads as per IS: 875 Part-5</td>
</tr>
</tbody>
</table>

7.7 CONSTRUCTION LOADS

Loads produced by the materials of construction plus the equipment required to construct the facility (crane loads, rigging loads, earth moving equipment, etc.) as applicable shall be considered. When the sequencing of construction will not permit the lateral force resisting system of the structure to be constructed first, the engineer shall make provisions for temporary lateral bracing and clearly identify these requirements on the design drawings and contract documents. The Contractor shall coordinate the sequence of building erection and the types and quantity of construction equipment to be used.

All structures shall be checked and designed to satisfy the worst load combination that produces maximum forces and effects and consequently maximum stresses. Apart from the specified live loads, any other equipment load or possible overloading during construction/hydro-test/maintenance/erection shall also be considered in the design. Under hydro test condition the wind force shall be taken as 25% of normal loading.

Design of all structures shall also consider any other relevant and consequential load/stress imparted to structure.

All liquid retaining/storage structures shall be designed assuming liquid up to the full height of wall irrespective of provision of any over flow arrangement.
8. **LOAD COMBINATIONS**

Each element of a building or structure shall be provided with sufficient strength to resist the most critical effects resulting from the following combination of loads.

8.1. **For Foundation Siting**

<table>
<thead>
<tr>
<th>LOAD CONDITION</th>
<th>LOAD COMBINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATING</td>
<td>DL + LL</td>
</tr>
<tr>
<td></td>
<td>DL + LL + ELo</td>
</tr>
<tr>
<td></td>
<td>0.9(DL + ELo + SL)</td>
</tr>
<tr>
<td></td>
<td>DL = LL ± WL</td>
</tr>
<tr>
<td></td>
<td>DL = ELo ± WL</td>
</tr>
<tr>
<td></td>
<td>0.9(DL + ELo ± WL)</td>
</tr>
<tr>
<td>ERECTION</td>
<td>DL = ELo ± WL</td>
</tr>
<tr>
<td>TESTING</td>
<td>DL + ELo ± WL</td>
</tr>
<tr>
<td></td>
<td>0.9(DL + ELo) ± SL</td>
</tr>
</tbody>
</table>

8.2. **For Concrete Design: Limit State Of Collapse**

<table>
<thead>
<tr>
<th>LOAD CONDITION</th>
<th>LOAD COMBINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATING</td>
<td>1.5(DL = LL)</td>
</tr>
</tbody>
</table>