# CHAPTER - 1
# PREAMBLE, WATER SOURCE & AVAILABILITY AND SELECTION OF WATER INTAKE LOCATION

## I. PREAMBLE AND WATER SOURCE :

M/S Welspun Energy Uttar Pradesh Pvt. Ltd. is developing a 2X660 MW Thermal Power Project at village Dadri Khurd, District Mirzapur, UP. The Plant Make Up Water requirement of is around 36 Million Cubic Meters per Annum ( 36 MCM PA).

Initially, WAPCOS has worked on identifying the source for the requirement of water for the Plant in which various options and possibilities were explored. The options included seeking water from nearby existing WRD Dam reservoirs and / or from the proposed Bansagar Dam Feeder Channel and from River Ganga.

It is found that the various WRD Dams in Mirzapur & adjoining district are not suitable due to reasons of non-reliability of availability of water. All these dams are purely rain fed and in the years of scanty monsoon these are barely filled even up to 50% of their capacity. Sometimes they have gone dry in the draught periods.

The option of water allocation from Bansagar Feeder Channel was discussed with WRD UP in detail. A high level meeting was held with Engineer-in-Chief of Irrigation Department, UP at Lucknow on 26.05.2011 which was also attended by the Chairman & other officials of WEUPPL & WAPCOS. In the meeting it was informed by the E-in-C that the water from Bansagar Feeder Channel cannot be utilised for any Industrial or Thermal Power Project.

Therefore, finally the only source possible was Ganga River. As the Ganga River is administered at Central Government Level, M/S WEUPPL has approached CWC, and have got clearance from the CWC authorities for utilization of 36 MCM water per year for the Mirzapur Thermal Power Project (Ref : CWC letter No. 7/2/18/UP/2008/IP(N)/804 DT. 12.10.2011). Based on the CWC clearance and consent from the local WRD offices, Water Use Agreement is drafted between the parties ‘Govt. of UP, Irrigation Department’ & ‘WEUPPL’ and submitted to Govt. of UP. This agreement is at Cabinet level for approval in Uttar Pradesh Government. Thus, the source has been fixed at Ganga River for Mirzapur Thermal Power Project (MTPP).

**II. WATER USE AGREEMENT (WUA) – System Design aspects :**

The WUA is specifies the General Terms & Conditions for water Drawl to Mirzapur Thermal Power Project (MTPP) from River Ganga.

The terms & conditions specifically related with Design & Sizing of water drawl/abstraction system are listed at below.

1. 36 MCM PA is allowed to be lifted from Intake at Ganga for Make UP water requirement of the Plant.
2. Withdrawal of water from Ganga Intake is allowed in the restricted period of 1$^{st}$ June to 31$^{st}$ December (7 months, in the lean season) only. No water drawl shall take place during period 1$^{st}$ January to 31 st May (5 months).
3. The water transport from Ganga Intake to Plant site is to be routed through Upper Khajuri Dam (UKD), which will act as balancing reservoir for the water storage between the period 1$^{st}$ January to 31$^{st}$ May.
4. The water abstracting/drawl system/scheme shall envisage pumping of water from River Ganga to de-silting arrangement (i.e. Settling Pond) and pumping of water from de-silting basin to the Project as well as to UKD after reduction of silt content and the drainage of silt laden water back to the river Ganga.
5. 9.5 MCM water will be reserved in UKD for irrigation purpose in lean season (January to May) from the total storage made at UKD.
6. The water abstraction system shall provide the pumping capacity from Ganga to UKD taking into account the supply of this additional 9.5 MCM of water per year for irrigation in lean season over and above the WEUPPL Plant requirement of 36 MCM, plus minor losses in the system if any.
7. WEUPPL shall install one set of water measuring device in the pipeline at the downstream of de-silting chamber and another device in the pipeline from UKD to Plant site.
8. No withdrawal is allowed from UKD Reservoir below level RL 155.60m
9. During the pumping period, WEUPPL shall design the pumping rate to meet Project requirement and irrigation requirement of 9.5 MCM (for the period January to May) or to fill up UKD up to FSL at RL 163.07m as on 31$^{st}$ December whichever is lower.

## III. FIXING OF WATER DRAWL LOCATION IN GANGA RIVER :

1. Identification of Intake Location :

The proposed MTPP Plant site is at village Dadri Khurd, at a distance about 28 kms from Mirzapur city in south direction. The general co-ordinates of the Power Plant location are, 24 58 59.76 N, 82 40 7.84 E. The Survey Of India toposheet maps and Google images are studied for searching the suitable location in Ganga for identifying the lifting point. It is observed that Ganga is nearer to Plant location at around Mirzapur city. The Reports on studies conducted by WAPCOS, TCE & CETEST for the Water Drawl location at Ganga River for MTPP and pipeline alignment for water conveyance are studied for their content and observations.

The Plant location is on the right bank of Ganga River. Therefore, a field visit on right bank of Ganga river near Mirzapur city for physical inspection of ground realities is carried out by PMG senior experts in the last week of May 2015. The river bank length of about 10 kms upstream and downstream of Mirzapur city along right bank is inspected for the suitable location. It is seen that a location about 500m upstream of the present site of CWC River Gauging Station is quite suitable for water drawl / lifting location. It is about 130m upstream of the confluence of a small local stream – Ojhala Nalla – to main course of Ganga. The global co-ordinates of this location are 25 09 23.43 N, 82 31 37.73 E.

On the downstream of this location there is urban development of Mirzapur city for about 5 kms and after that the river changes its direction and meanders away from the Plant location. On upstream of this location, the major road from Mirzapur to Vindhyavasini runs parallel to river just side by side of river bank, leaving practically no distance between river and road. On the other side of road, there is continuous habitation development. Further to that, the river course goes away from Plant site.

Therefore, the location as selected at above is appropriate and the only possible one. The location details are indicated in drawing plate No. DWG 01 enclosed. The features of the location are briefed at below -

1. The CWC River Gauging Station is existent just at 500m downstream of proposed intake location where the authentic river flow data is available for more than 50 years based upon which our intake arrangement can be planned.

2. The river regime is straight in this reach for about 10kms and hence the 'Stable Bank' position.
3. The minimum water flow / discharge of the river recorded in last 30 years at this location is 105.70 cumec on 9$^{th}$ July 2010. The maximum Plant water requirement of MTPP is 1.415 cumec. Hence, the source is 100% assured of supply requirements.
4. Near Mirzapur, the normal water course width of the river is about 1.2 kms with high floods plains extending much beyond. The river bed / width is full of sand and the deep water flow course is meandering in the bed from one bank to other. At the selected location, the meandering deep bed is touching the right bank of the river which is a very advantageous position in planning the access to Intake Structure. The minimum water level recorded at this location is at RL 62.490m in July 2004.
5. The right bank of river is reasonably steep at the selected location resulting in less length of Approach Bridge / embankment to Intake Jack well at elevation above HFL of river. This sort of topography enables to plan the River Intake structure on bank of the river without any sort of hindrance to Inland Water Navigation activities.
6. The Navigation Charts of Inland Waterways Authority of India (IWAI), particular to our study area are procured (15 km Upstream & 15 km Downstream). The navigation routes recommended by IWAI are studied; the proposed intake location is also verified with reference to these charts. It is observed that near Up-stream to the intake location the Navigation route deviates to the left bank of Ganga River. Therefore, the intake location (situated on the right bank) will not create any restriction to the Navigation routes identified by IWAI. The IWAI Navigation Chart NW-1/47 marked with proposed Intake location is presented in Annexure XX.
7. The site is just near the CWC River Gauging Station. This station has a control bench marks on the upstream of the confluence point, exactly at the Intake location under evaluation. This control bench mark & its importance to CWC station measurement is discussed with the local CWC staff. The Bench mark is being used as 'Reference Line' by CWC during the river gauge measurements. The Highest Flood Level Mark at RL 80.34m is demarcated by paint at CWC Station. This Benchmark is used by us for surveying and planning the controlling levels of our

scheme. It is ensured that our Intake location point and proposed structure do not interfere with the CWC gauging activities.

It is verified that there is no water drawl system in operation at present in between the CWC gauging station and the intake location proposed. Therefore, the controlling levels / flow parameters observed at CWC station can be assumed to be the same for the proposed intake structure, too.

8. The proposed intake location is at upstream of confluence of local Ojhala nalla to the river. Hence, there will not be any obstruction or hindrance of the flow of this nalla to MTPP intake structure.
9. It is observed that required land space / area is available on the bank near the location which is above Normal Water Level for providing Pre Settling Tank, Clear Water Pump House, Electrical substation , and other auxiliary / ancillary facilities.

2. <u>Topographic and Hydrographical Survey :</u>

The highest flood level of the river observed at this location is at RL 80.340m on 09.09.1978. The topographical survey of land on the right bank is carried out from water level on the day of survey i.e. at RL 63.550m on date 01.06.2005 up to RL 80.500m i.e. the highest flood level and beyond that up to Mirzapur – Vindhyavasini road running parallel to the river course. The land width surveyed is about 400m sufficient to cover all the impeding intake structure components such as Jack well, Pump House, Rising Main pipeline, PST, Electrical Suu station, etc. required at Ganga Intake premises.

The hydrographical survey is carried out in the standing river water for the bed level of the river over the total flow width on that day. This Hydrographical survey is carried out for the reach about 100m upstream to 250 downstream of the proposed location of the intake structure. The Permanent Benchmark for reference level used is the same which is being used for CWC river gauging. The Mirzapur Ganga River Gauging Station is located at 500m downstream of the selected intake location.

A total survey map comprising of Topographic and Hydrographical Survey is enclosed as Drawing plate No. DWG 01.

3. <u>Water Intake Structure in Ganga River :</u>

The Controlling physical parameters at the location are -

1. Normal Annual Flood levels observed are in the range of RL 74 to RL 78 M level. (Ref : CWC data in Vol III/III of this report)
2. Highest Flood Level Observed is at RL 80.34 M ( Date - 09.09.1978),
3. The highest ground level on the bank is at RL 80.901m which is above highest flood level. The General Ground Levels on the bank beyond this point are in the range RL 74 - RL 75 M increasing to RL 80.0 m till the crossing of Mirzapur-Vindhyachal road.
4. The road top Levels of the asphalted Mirzapur-Vindhyachal road are around RL 80.5 M adjacent to this location. Distance between the river course to the Vindhyachal road is around 400 m. The ground levels beyond this road are above RL 81m.

   As seen from the survey drawing, the bank topography is reasonably steep within first 200 meters rising from the deepest river level to the highest flood level mark. The river at this location is having very Firm & Established bank. It is a good topography to plan an intake structure in the river course or near bank, without requiring any approach or intake channel for taking the water to shore.

   Accordingly, an intake conduit of 60 m connecting to a circular Jackwell-cum-Pump House at Bank is proposed as the Intake Arrangement. An approach bridge of length 50 m will connect the Jackwell Pump House to shore facilities.

   The surveyed cross section of river at the intake location is produced in drawing plate No. DWG 02.

## IV. GROSS WATER DEMAND FOR THE WATER DRAWL SYSTEM :

The primary source of water drawl is River Ganga. The water lifted from River Ganga is to be transported & stored in the reservoir of Upper Khajuri dam and then to be re-lifted & conveyed to MTPP Plant Site. As per the Water Use Agreement with UP WRD, the lifted water quantum from Ganga River has to cater for Plant water requirement ( 36 MCM PA ) plus Irrigation Requirement under Upper Khajuri Dam (limited to 9.5 MCM PA) plus the incidental losses in the system. Therefore, the overall Water Demand is evaluated in three Stages.

Stage 3 – MTPP Plant Water Demand.

Stage 2 – Water down-stream of Pre-Sedimentation Tank to UKD

Stage 1 – Water from River Ganga to Pre-Sedimentation Tank

The water demand is worked out up-stream, 'Plant to Source' as follows,

- Stage 3 : Plant water requirement : 36.00 MCM/Yr
  - Pumping Days in Year : 365 Days
  - Pumping Hours per Day : 16 Hours
  - Water requirement in $m^3$/sec : 1.712 $m^3$/sec
    i.e. 6163.20 $m^3$/Hr
- Stage 2 : D/S of PST to UKD : 52.315 MCM/Yr
  - Plant Requirement - 36 MCM
  - Irrigation Requirement at UKD - 9.5 MCM
  - Evaporation losses at UKD - 3.937 MCM
  - Misc. losses at UKD - 0.494 MCM
  - MDDL make up requirement at UKD - 2.36 MCM
  - **Total** **- 52.315 MCM**
  - Pumping Days in Year : 210 Days
  - Pumping Hours per Day : 16 Hours
  - Water requirement in m3/sec : 4.325 m3/sec
    i.e. 15,570 m3/H

  (For Water Balance calculations & Evaporation losses at UKD, please refer Chapter 4)

- Stage 1 : @ Source, River Ganga to PST : 53.383 MCM/Yr
  - Stage II pumping requirement : 52.315 MCM
  - Water lost in de-sludging at PST : 2%
  - Therefore, water to lifted from River ganga : 52.315 x (100/100-2)
    = **53.383 MCM**
  - Pumping Days in Year : 210 Days
  - Pumping Hours per Day : 16 Hours
  - Water requirement in m3/sec : 4.413 m3/sec
    i.e. 15,887 $m^3$/Hr

The lifting from River Ganga will be to the extent of 53.383 MCM per Annum during period 1st June to 31st December every year.

## V. COMPONENTS OF OVERALL WATER DRAWL SYSTEM :

It is proposed to prepare the Water Drawl System to draw water from Ganga River and convey it to MTPP Plant site, complying with the various conditions / stipulations laid down in the Water Use Agreement. The formulation of the total scheme is envisaged in the following sequence.

Stage 1 : Water Drawl from Ganga River Intake Structure to Pre Sedimentation Tank to Clear Water Tank at the River bank –

This stage will consists of following components -

- Submerged Intake Well in Ganga River.
- Water Intake conduit connecting Intake Well to Jackwell.
- Circular Jackwell
- Raw Water Pump House on Jack Well
- Raw Water Pumps – Mechanical & Electricals
- Approach Bridge to Raw Water Pump House
- Raw Water Conveyance Pipeline (around 572 m)
- Surge Control Device
- Pre Settling / Pre Sedimentation Tank
- Clear Water Tank (CWT)

Stage 2 : Water Pumping from Clear Water Tank to Upper Khajuri Dam (UKD) Reservoir –

This stage will consists of following components -

- Clear Water Pump House
- Clear Water Pumps – Mechanical & Electrical
- Electrical Switchgear Room & Substation for River Water & Clear Water Pumping Stations.
- Service Buildings at Ganga Intake Campus
- Development of Intake Campus at Ganga River bank.
- Clear Water (CW) conveyance Pipeline from Clear Water Sump to Outfall Point in UKD (length - 24.32 km)
- Surge Control Device for Clear Water Pipeline.
- Pipeline outfall Structure in UKD

Stage 3 – Water conveyance from UKD Reservoir to MTPP Plant site –

This stage will consists of following components -

- Water Planning of UKD.
- Intake Jack well in UKD
- Pump House Over Jack well in UKD
- Pumps in PH of UKD – Mechanical & Electrical
- Conveyance Pipeline from UKD to MTPP Plant location
- Electrical Substation for PH in UKD
- Service Building at UKD
- Development of Campus at UKD
- Surge Control Device for Pipeline UKD to Plant site

The Basic Engineering Report submitted here presents Concept and Basic Sizing & Layouts of each of these system/scheme components sequentially.

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# CHAPTER 2

## STAGE 1 - GANGA INTAKE, JACKWELL & PUMP HOUSE, APPROACH BRIDGE AND PIPELINE TO PST

### I. GENERAL :

This chapter contents details regarding Ganga River Intake Well, Intake Conduit, Jackwell, Raw Water Pump House on Jackwell, Approach Bridge to Jackwell, Rising Main pipeline from Jackwell to PST, Approach Embankment towards Approach Bridge from Intake Campus and Planning for Intake Campus Area.

The "Mechanical Design of Pumping Machinery and Instrumentation & Control" is presented separately in Chapter No 5, and the Details regarding "Electrical Installations" in Chapter No. 6.

### II. PLANNING FOR INTAKE WELL & JACKWELL :

1. <u>Water Intake Arrangement –</u>

The surveyed cross section of river at the intake location duly marked with selected location of jack well is produced in drawing plate No. DWG 02. The jack well is proposed on the edge of main river course just near the deepest point on the river right bank. The minimum water level of the river recorded at this place is at RL 62.490m. Therefore, the minimum water level in the jack well is kept at RL 62.50m. The jack well shape is selected circular and the internal diameter proposed is 16m. The wall thickness is considered as 1m for the present which may change slightly after detail structural design. A pump house of the same shape and size is proposed over the Jack well. The highest flood water level of the river recorded at this location is at RL 80.34m. The pumps need to be installed at level at least 1.5m above the highest flood level. Hence, pump floor is proposed at level RL 82.00m. The bottom level of jack well sump is proposed at RL 58.10m which provides distance between minimum water level and sump bottom level to the extent of 4.40m (The calculations for Submergence required are presented in the Sump Planning & in the Chapter on Pumping Machinery).

The deepest bed level in the river is at RL 61.60m and the recorded minimum water level is at RL 62.49m. Therefore, there is hardly 0.89m water depth in river at its lowest status. If the inlet opening sill of jack well is kept at this Low Water Level (LWL), there will be practically no flow into the well due to lack of driving head in stream flow and there is every possibility of sand over the bed being drawn towards the well which will block the inlet opening.

Therefore, it is proposed to provide two level openings to the jack well for inlet flow. One opening will be with sill level at RL 65m level which will be in a position to tap water from RL 65m upwards. And, the second low level entry is planned from the lowest river bed level at RL 61.60m by providing an Intake Conduit from Intake well to Jack well. The low level inlet will be operated to draw the water from Minimum Water Level (RL 62.49m) to RL 65m. This planning of the intake conduit has also made it possible to push the jack well a little towards river bank shortening the length of approach bridge required to access the pump house from the banks.

2. Intake Well & Intake Conduit Sizing –

Refer to drawing Plate No. DWG 02 & DWG 03.

The intake well is planned at location where the river bed level is at it's lowest i.e. at RL 61.60m. The flow depth available when the water is at recorded minimum level at RL 62.49m is 0.89m. The top of intake well is planned at RL 62.30m leaving flow depth of about 0.2m for driving head. The top of well will be fully open and the entry of water in to the well will take place from this top opening. A MS mesh screen of 25mm x 25mm size clear opening is proposed over the entry area covering the entire top surface. The water so collected in the intake well will be conveyed to the jack well sump through an underground intake conduit. The Intake well and the Intake Conduit both are proposed to be constructed in RCC.

The velocity in the approach / intake channel to a pump sump is kept limited to 0.50 m/sec. The size of well and the conduit is designed for this velocity.

(With ref to IS 1710 (Fig 8), AND w.r.t. ANSI/HI- Pump Intake Design Cl. 9.8.2.4.4, the inlet approach velocity to Pump Sump is restricted to max. 0.6m/sec),

Total Intake discharge required - 4.413 cumec.

The approach velocity - 0.50 m/sec.

∴ Cross sectional area required = 4.413 / 0.5 = 8.826 sqm.

The Intake Well is proposed in round / circular shape with internal diameter as 4m.

∴ Cross sectional area of flow $= \pi /4\ D^2 = 0.786\ (4)^2 = 12.576\ m^2$

∴ Actual velocity of flow that will develop = 4.413 / 12.576

= 0.35 m/sec < 0.5 m/sec, safe.

The intake conduit (to take water from Intake Well to Jackwell) is proposed in twin boxes of rectangular shape. Each box will have size 2m (W) x 2.5m (H). The length of the conduit will be around 60m and it will be constructed fully underground.

Total flow area of two boxes = 2 x 2 x 2.5 = 10 sqm.

∴ Actual velocity of flow that will develop in to the conduit

= 4.413 / 10= 0.44 m/sec < 0.5 m/sec, safe.

The invert level of intake well, the invert level of conduit and floor level of jack well sump are kept at the same level of RL 58.10m. There will be a sluice gate at the entry of conduit in to the Jackwell to control / close the flow from intake well to jack well for any eventuality.

3. Selection of Type of Pumps –

The water levels in the river will be fluctuating from the minimum water level at RL 62.490 to the highest flood level at RL 80.34m.

Self-lubricated, wet pit, Vertical Turbine Pumps are for the Raw Water Pumping in Jackwell. These Vertical Turbine Pumps are selected mainly for the reasons –

- Water levels are varying in the Ganga River.
- Prime mover will be located at safe levels above maximum water levels / High Flood Levels.
- Required suction piping can be provided to avoid NPSH, and cavitation possibilities.

4. Pump Capacity Calculations –

Referring to Chapter 1, Para IV, 'Overall Water Demand For The Water Drawl System', the total quantum of water required to be lifted in Stage I i.e. from Ganga Intake is

53.383 MCM PA. This quantum is to be lifted seven months period from 1st of June to 31st of December i.e. in 210 days.

The pumping ours specified by WEUPPL are 16 hours per day.

∴ Stage I Design Discharge Design,

= 53.383 MCM / (16 hours x 210 days)

= 15888 cum/hour

i.e. 4.413 cum/sec.

The water is to be pumped from the lowest observed water level in Ganga at RL 62.490m. It is to be delivered in to Pre Sedimentation Tank (PST) proposed near the jack well location on right Bank of river. As the highest flood level observed at this location is at RL 80.34m, the top of side walls/Structure Top of PST is kept at RL 82.00m.

| | |
|---|---|
| Minimum Water Level at River Ganga /MDDL | : RL 62.50 m |
| Delivery Level at Pre Settling tank | : RL 82.0 m |
| Static Head on Pumps (RL 82.0 m – RL 62.5 m) | : 19.50 m |
| Length of Pipeline | : 572 m |
| Frictional Head Loss in the Pipeline | : 0.59 m |
| (Considering 10% minor losses in Bends, etc.) | $H_f$ = 0.59 x 1.1 = 0.649 m |
| Pump Assembly losses @ 1% of Static head | : 0.195 m |
| Exit Head | : 2 m |
| ∴ Gross Head on Stage I Pumps | :22.344 |

(19.5 + 0.649 + 0.195 + 2 = 22.344)

*P*ump Capacity, HP required = (w x Q x H ) / (75 x n)

Where – w – unit weight of water = 1000 kg/m$^3$

Q – Design Discharge – 4.413m$^3$/sec

H – Design Gross Head – 22.5m

N – Efficiency of pumps – 85%

HP required = (1000 x 4.413x 22.5) / (75 x 0.85 )

= 1557.53 HP

Electric Motors required = HP x 0.746 kW

= 1162 kW

Considering Power Margin at 15%, net Motor Capacity required

= 1.15% of 1139 kW

= 1336 kW

*(Refer to Chapter 5, 'Mechanical Design of Pumping Machinery of detail Calculations)*

*With reference to the Mechanical Design, Duty points are finalised as.*

- Number of Pumps : 2 Working + 1 Stand by
- Discharge Per Pump : 2.2065 cum/sec
- Motor rating for each Pump : 700 kW i.e. 940 HP

5. Jackwell Pump Sump Parameters –

There will be total three pumps installed in the jack well out of which two will be in continuous operation and one in standby mode. Therefore, hydraulically the jack well is a Multiple Pumps Sump.

In all the standard references of IS Codes, HIS 9.8 Manual and CPHEEO, the various sump parameters are expressed / worked out related to the diameter of Bell Mouth (D) provided at the end of suction pipe of the pump for / at the entry of flow.

(Following Parameters are planned as per IS 15310 & ANSI/HI- Pump Intake Design)

- **D – Bell Mouth Diameter**

  *The velocity of flow at the entry of bell mouth shall not exceed 1.3 m/sec.*

  ∴ Taking velocity at entry as 1.2 m/sec,

  C. S. area of bell mouth = Q / V = (2.2065 / 1.2)

  = 1.83 $m^2$

  ∴ D, diameter of Bell Mouth = 1.5264 say 1.53m.

  The diameter proposed is 1.5m. It produces velocity = 1.244 m/sec < 1.3 m/sec admissible.

- **S – Submergence**

  It is the distance from minimum water level in Jackwell to bottom of bell mouth.

  Minimum specified = 1.5D = 1.5 x 1.5m = 2.25m

  Actual S provided = 4.5 m > 2.25m admissible.

  (Sump Floor Level is at RL 58.0m, MDDL at RL 62.5m)

*(The actual provided Submergence is with reference Parameters specified at above & the NPSH calculations presented in the Chapter of Mechanical Design)*

- **C – Bottom Clearance**

It is the distance between bottom of bell mouth and sump floor bottom level.

Minimum D required = D / 2 = 1.5m / 2
= 0.75m.

Actual distance provided = 0.75m = 0.75m minimum required.

- **MWL -Minimum Water Level**

It is the distance between sump bottom and minimum water level in jack well.

Minimum specified = C + Min S + Safety Margin
= 0.75 + 2.25 + Safety Margin

No specific figure is stipulated for minimum Safety Margin. We have adopted it 0.50m as adequate.

∴ Minimum WL required = sump bed level + C + S + SM
= RL 58.0 + 0.75 + 0.5 + 2.25
= RL 61.50m.

Actually provided is at RL 62.50m. > RL 61.60m, safe.

- **W – Width of Sump**

Minimum specified = 2 ND + (N-1)T,

where N is the number of pumps and T is the pier wall thickness between two pumps. In the present case, the sump is a circular common jack well and no pier is proposed in between pumps. So, it is an open sump and not unitised sump. Hence, T = 0.

∴ W = 2 ND = 2 x 3 x 1.5
= 9m

Therefore, from the consideration of minimum requirements of sump dimensions, 9m internal diameter of jack well is sufficient. But considering the implications of arranging pumps at pump floor level, the internal diameter of jack well is proposed to be 16m.

- **SWC – Side Wall Clearance**

  It is the clear distance between the vertical wall of sump and edge of end side bell mouth

  In case of Jackwell Sump = Clear Distance = 0.25D

  = 0.375

  The internal diameter of jack well is 16m. Three number of pumps installed in Pump House / Jack well with 3.5m distance centre to centre. The diameter of bell mouth is 1.5m.

  ∴ Actual SWC provided from nearest Column = 0.60 m > 0.375m

  & SWC provided from nearest Jackwell Wall = 3.60 m

- **B – Back Wall Clearance**

  It is the distance between the bell mouth and back wall of the sump.

  Minimum specified = between ¾ D to D

  = between ¾ of 1.5m and 1.5m

  = between 1.125m and 1.50 m

  Actual B provided = 9.08m for central pump and 8m for end pump

  OR equivalent to side clearance for Circular Jackwell

  = 4.35 m

6. Sizing of Gates & Trashrack –

6.1 Inlet Opening Distance :

(Ref: ANSI/HI 9.8-1998 Table – 9.8.1)

It is the distance from the pump inlet bell centre line to the intake structure entrance

Minimum specified = 5 D = 5 x 1.5m

= 7.5m

It is proposed to provide inlet opening in the Jack well wall to let the water enter from Ganga river flow in to the Jack well. The inlet structure gate is provided on the outer surface of jack well. The internal diameter of jack well is 16m and the thickness of jack well wall is about 1 m. The pump suction columns are located at the centre of jack well.

∴ Actual A provided = ½ of jack well diameter + wall thickness of jack well

= (0.5 x 16m) + 1.0m = 9.0 m > 7.5m

6.2 Inlet Gates Size :

(Ref: ANSI/HI 9.8 – 1998, para 9.8.2.1.4 and Table 9.8.2)

As stated earlier at above, high level openings are proposed at sill RL 65.00m to receive water directly from river flow and the low level openings are proposed at sump bottom level i.e. at sill level RL 58.10m, to receive water through Intake conduit. The discharge to be received in both the cases is the same and the maximum limitations on the approach velocity are also the same. Hence, the inlet opening size required is equal at both the levels. As such, the number of openings and the size of each opening are proposed the same for both the levels.

Maximum pump approach velocity in pump bay specified = 0.5 m/sec.

∴ The area of inlet gate opening required

= Design Discharge of all working pumps / Max. Approach velocity, 0.5m/sec

= 4.413cum / sec ÷ 0.5 m/sec

= 8.826 $m^2$

It is proposed to provide two inlet openings at each level (high & low) of equal size – 2.0 m (width) x 2.5m (height)

∴ Total inlet opening area provided at each level,

= 2 Nos. x 2.0m x 2.5m

= 10 $m^2$

Actual approach velocity, V, developed,

= 4.413 $m^3$/sec / 10 $m^2$

= 0.4413 m/sec < 0.5 m/sec.

These two inlet openings shall be provided side by side in the direction of flow at sill level RL 65m and at sill level RL 58.10m.

It is proposed to provide Sluice Type Fixed Wheel Gates for these inlet openings at both the levels which are located on outer surface of jack well wall. These will be operated from pump floor level.

The maximum water column/ maximum static pressure on the gates will be on the upstream face of gate when the river has highest recorded water level at RL 80.34m.

Max hydraulic pressure on low level gate = RL 80.34m – RL 58.10m = 22.24m.

Max hydraulic pressure on high level gate = RL 80.34m – RL 65.00m = 15.34m.

With reference to IS 4622 : 2003, clause 3 – Recommendations for structural design of fixed wheel gates.

The said clause classifies the type of gate on the basis of water head above sill level as below.

A. High head Gate – Gate which operates under a head of 30m and above.
B. Medium head gate - Gate which operates under a head 30m and15m.
C. Low head gates - Gate which operates under a head less than 15m.

In the present case, the maximum head on sill of both the level gate is more than 15m. Hence, both the level gates are of medium head gate. The detail design procedure / requirements for such type of gates, embedded parts and hoisting arrangement is given in IS 4622. These gates are proposed on outer surface of jack well and shall be operated by hoist kept at Pump House floor level.

6.3 Screen Requirement :

(Ref: IS 15310, Clause 4.2.1.7)

As per Codal requirements - Screens should be provided at the inlet of pump bay in order to arrest all trash and floating material and straighten the flow.

In case of high level gates, it is proposed to provide a MS mesh screen removable type Trash Rack on the inlet opening of jack well. For low level entry, through intake well, the mesh has been proposed to be foxed on the face of Intake well opening. For the Higher level opening, -

Screen location as per (Ref: ANSI/HI 9.8-1998 Table – 9.8.1)

It is the distance from the pump inlet bell centre line to the through flow screen.

Minimum specified = 4 D = 4 x 1.5m
= 6m

In case of high level gates, a MS mesh screen removable type Trash Rack is proposed on the outer side of inlet structure sluice gate at a distance 0.9m from it.

∴ Actual Y provided = 8.8m + 0.9m

= 9.7m > 6m

For the low level opening, the screen mesh is at a distance of 60m from bell mouth, Which is > 6m minimum required.

6.4 Details of Trash Rack (provided for high level opening):

(Ref: IS 11388 : 2012)

IS 11388 : 2012 deals with 'Recommendations on Design of Trash Racks for Intakes'. In case of high level gates, it is proposed to locate the trash rack screen on the outer side of the inlet gate. The trash rack will cover the entire area of inlet opening / gate. It will be a removable section rack which will be installed by lowering the sections between the side guides or grooves provided in the trash rack structure so that the sections will be readily removed by lifting them through / from guides. These will be side bearing type. These will be operated by winch/ hoist arrangement installed in Pump House at Motor floor level.

In the present case, the trash rack is of size {2.0m (w) x 2.50 m (H)], for which manual cleaning is proposed.

Referring to Clause 6.1 of IS 11388 : 2012),

Maximum velocity through screen = 0.75 m/sec

The trash rack area provided = 2 Nos x 2.0m x 2.50m

= $10m^2$

As per clause 10.2.1 of the said IS, not more than 33 pc of trash rack area is allowed to be clogged.

Therefore, the clog free / open area of screen = 67 % of 10 $m^2$

= 0.67 x 10 $m^2$

= 6.70 $m^2$

∴ Actual Velocity that will develop through screen

= 4.413 cumec / 6.70 $m^2$

= 0.66 m/sec < 0.75 m/sec max. limit.

In the case of low level gate ,the mesh is provided on top of Intake well opening all over the upward/Top surface.

Internal Diameter of Intake well = 4m

∴ Gross Area of screen $= \pi /4\ D^2 = 0.786\ (4)^2$

$= 12.576\ m^2$

Non clogged area = 0.67 x 12.576 = 8.425 sqm.

∴ Velocity through screen = 4.413 / 8.425

= 0.52 m/sec < 0.75 m/sec max. limit

Therefore, the Trashrack inlet areas provided are OK for openings at both the levels.

7. Foundations for Intake Well, Intake Conduit & Jackwell –

The detail geo-technical investigation at the jack well site is yet awaited. However, from the visual inspection of the adjacent topographic / geomorphic/ surface geology, local enquiry and our experience of working in similar locations elsewhere on Ganga, the ground strata is sandy / alluvial without any hard strata to a reasonable depth, even up to 40m depth. Therefore, cast in situ friction piles are proposed for foundation of Jackwell, Intake well, Intake conduit and Approach Bridge Piers. The structure footing will rest on the pile cap of group of piles.

The Maximum Scour Depth considering discharge of river and silt factor ($K_{sf}$ ) of the soil sub stratification will be worked to decide the depth of piles required. The size of piles, number of piles and other details required for each foundation will be designed after availability of results of geo-technical explorations.

For the present, the foundations are specified as pile foundation in drawings as in indicative provision / requirement.

## III. DETAILS OF PUMP HOUSE STRUCTURE :

The Jackwell is circular and the internal diameter proposed is 16m. The wall thickness is considered as 1m for the present which may vary as per detail structural design. A pump house of the same shape and size is proposed over the Jack well. The highest flood water level of the river recorded at this location is at RL 80.34m. The Prime Movers / Motors need to be installed at level at least 1.5m above the highest flood level. Hence, pump floor top is proposed at level RL 82.00m.

There will be three numbers Vertical Turbine (VT) Pumps with their Electrical Motors mounted on the pump floor. Each pump is of capacity of 940 HP and motor of 700 kW rating.

**The overall Pump House consisting of Prime Movers /Motors to VT Pumps And the Delivery Pipes of each pump & Manifold arrangements is divided on Two Floors, Motor Floor and Delivery Floor. The Motor Floor Level is planned at RL 82.0m and the Delivery Floor Level at RL 78.0 m.**

The Motor floor level area is planned to provide space for -

- The base plate size of standard similar motor installation is around 3m x 3m. This will imply the centre to centre distance between two pumps to be at least 3.5m.
- The soft starter devices for each pump and the electrical control panel are housed on this floor.
- In addition, space is kept for repairs and maintenance activities.

(Refer Drawing Plate No. 03)

The Delivery floor level area is planned to provide space for -

- The delivery pipe of each Pump accommodating MEJ, NRV, BFV & ARV, which will be around 5m.
- The manifold of diameter 1800 mm. The manifold diameter is kept same as conveyance pipeline. All the delivery pipes will connect to Manifold in Right Angle.

The Jackwell area at this level of RL 78.0 m will be provided water tight.

The motors are mounted on upper floor at RL 82m which is called pump floor level as well as motor floor level. The pump assembly component is distributed on both the floors. Each pump / motor assembly has total weight of around 15 MT. About 60% load of this assembly is borne by Delivery Level floor and balance 40% load is taken by Motor Level floor. The floor thickness cannot take this load. Also, conventional type pump supporting beams planned from one end of wall to other end of Jackwell wall will not be sufficient to carry this heavy load. Hence, it is proposed to provide eight numbers of additional columns inside the Jackwell from sump floor to delivery floor level. Out of these, 4 Nos. will be terminated at this level and 4 Nos. will continue up to motor floor level. The pump bearing beams will be supported on these columns and Jackwell wall at either ends. These columns will be braced intermittently for lateral support.

The Delivery Floor will accommodate the pump, the delivery pipe of pump, the various control valves on the delivery pipe, pipe manifold, the butterfly valve at the start of rising main and the RCC Anchor blocks at the bend of junction of suction pipe and delivery pipe required to take the unbalanced force due to change of direction of flow. The valve controls on the delivery pipe will be operated from motor floor level. It will be the entire RCC floor.

The Motor Floor will be covering Motors, soft starter devices, valve control equipment, electrical control panel, space for repairs and maintenance. The central portion of the floor will be formed of strong MS Grating sheets which can be opened as and when required for lifting the components from the delivery floor using OHT crane to bring these to motor floor for maintenance and repairs and to reinstall these again. The floor space on the sides of grating portion will be in RCC.

The height of Pump House room above motor floor is kept 11m. The Gantry beam will be placed at height 8m over motor floor. The corbel level of gantry rails is at RL 90m. A circular moving over head EOT Crane of capacity 17.5T / 5T is proposed in the Jackwell.

- Pump Delivery Level : RL 78.0 m
- Motor Floor Level : RL 82.0 m
- Gantry Corbel Top : RL 90.0 m
- Pump House Roof bottom level : RL 93.0 m

Twelve numbers of columns proposed to support the Gantry Girder. These columns will start from Motor Floor and will go up to roof slab of pump house. The clearance between Gantry Girder top and roof slab is kept 3m.

The Jackwell inlet gates and the trash rack in front of these are arranged on the outer surface of jack well wall. These are proposed to be operated from Motor Floor level. Hence, the floor slab at this level is extended about 7m at outside Jackwell to use the space for operating these gates. An EOT Gantry of 7.5 T capacity is proposed over this space for lifting the gates. To support the gantry girder, columns are proposed starting from this floor up to roof slab level.

The external wall of pump house is proposed in brick work duly plastered on both sides. There will be one MS rolling shutter of size 3.5m(W) x 5m(H) as entrance door towards approach bridge The other small door of size 1.5m(W) x 2.5m(H) will be for entering in to gallery of gate operating area.

## IV. WATER CONVEYANCE PIPELINE :

The water from River Ganga is transported to Pre Sedimentation Tank (PST) located in Ganga Intake Campus area by Stage I Rising Main Pipeline.

The pipeline distance from pump manifold to the Intake Chamber of PST is 572m. The first 50m length of pipe travels over lower level slab of Approach Bridge. For further 242m length the pipes are laid underground under the approach embankment and the remaining 280m also laid underground in campus area through reclaimed ground. The route / alignment of pipeline in plan or on map are shown in Drawing Plate No. DWG 01 and the alignment in L-section is seen DWG 02. The pipeline at its entire length is, more or less, at the same elevation. The design of pipe section and details of laying the line are dealt with here follow.

1. Pipeline Project parameters :

- Route length of pipeline : 572m
- Design discharge through pipeline : 4.413 $m^3$/sec
- No. of rows of pipeline : 1 No.
- Motor floor level : RL 82m
- Delivery Floor level / Valve Operating level : RL 78 m
- Delivery point elevation at PST : RL 81.0m
- Exit head : 2m
- Highest GL elevation on pipeline route : RL 80.78m
- Minimum River water level / Pump MDDL : RL 62.50m
- Frictional losses in pipeline : 0.590m
  (Calculated using Hazen Williams formula))
- Misc. / Other losses in pipeline for bent, etc. : 10% of frictional loss

= 0.059m

- Pipe material : Mild Steel

  (Refer Annexure __ 'Selection of Pipeline Material)

2. Selection of Pipeline Diameter and Thickness :

   The range of appropriate diameters is explored by considering the pipe flow velocity range between 1.2 m/sec to 2.1 m/sec. The corresponding diameters found out are – 2000mm, 1950mm, 1900mm, 1850mm, 1800mm, 1750mm, 1700mm & 1650mm. These diameters are checked for the Techno-Commercial appraisal i.e. Optimisation of Economical Diameter, considering capital cost of pumps & pipes and capitalised energy cost for the design period of 25 years. The project data, design parameters and the process sheet of this exercise is kept in Annexure III.

   The thickness for various diameters of pipeline are worked out on the design basis given in IS 5822, IS 3589, IS 2062 & M11 of AWWA.

   It is observed from the output sheet that from diameter 1650mm to 2000mm the total /final capitalised cost of scheme operation for 25 years period goes on diminishing as diameter increases. However, the incremental increase in each successive diameter is very marginal and, therefore, all the costs are at par.

   Considering the above Techno-Economic Analysis, the diameter of the pipeline is selected as 1800 mm (Thickness 14.2 mm), keeping it same as the Diameter (1800 mm) selected for Stage 2 Pipeline. However, the thickness provided for stage 2 Pipeline is 17.5 mm

3. Structural Analysis and Design of Pipeline Shell Thickness :

   The pipeline diameter and the shell thickness under consideration are checked for the following stress conditions –

   1. Pipe laid in Trench Condition (Laid Under Ground) :

      A. Check for Deflection –

         i. Partial Vacuum without side support.

         ii. Partial Vacuum with side support.

         iii. Pipe full with side support.

      B. Stresses for Partial Vacuum Condition (Total Compressive Stress)

i. Without side supports.

ii. With side supports.

iii. Buckling under Partial Vacuum Condition.

C. Stresses for pipe full and side support (Total Tensile Stress).

2. Pipe laid on Chair Condition (Laid Above Ground with Chair to Chair Dist. 6 m) :

A. Check for Deflection.

B. Total Hoop Stress.

C. Total Longitudinal Stress.

A note on MS Pipeline Shell Thickness Design is given in Annexure IV. The calculations for Stress Analysis for 1800mm diameter 14.2-mm shell thickness for pipes laid in ‘Trench condition’ are produced in Annexure IV.

The sample calculations for Techno- economic analysis are produced in Annexure V.

The pipeline thickness is also verified for additional Surcharge Load of 2 T/$m^2$ for any incidental vehicle/tractor loadings. (Ref Annexure V)

Therefore, considering the techno-economic analysis and structural viability, 1800 mm diameter Mild Steel pipe of 14.20 mm shell thickness is selected for the Stage 1 Rising Main pipeline.

4. Pipeline Route & Pipe Laying :

A single row MS 1800mm internal diameter with 14.20 mm shell thickness is proposed all along the route length from Stage 1 Jackwell Pump House in Ganga River to the Intake Chamber of Pre Sedimentation Tank. The pipeline route length is 572m. The breakup of route length and its features are described as follow.

- Ch. 78m (Pumps Manifold) to 128m (start of Approach Embankment) – 50m : This length passes over lower tier of super structure of Approach Bridge. The pipes will be laid on chairs constructed on solid RCC slab.
- Ch. 128m to Ch. 370m – 242m : This length is the pipeline laid underground below the road carriage way proposed over approach earth embankment. The pipes are laid below earth formation level with 1.5m clear soil depth cover.

The pipes in this length are likely to be partly submerged during highest flood eventuality. Therefore, it is proposed to provide Gravity Anchor Blocks in RCC along this length at spacing 8m c/c for safety against buoyancy.

- Ch. 370m to Ch.650m- 280m : This length is in PST campus area. The ground level of campus area is proposed to be raised up to RL 81m by earth filling. For this length also the pipeline is proposed to be laid underground i.e. through formation earth filling with 1m clear soil cover.

Pipeline length laid underground or in earth embankment will be laid on 20 cm thick sand cushion / boxing. The laying of the pipes will be fully in compliance of procedures and stipulations given under IS 5822 : 1994.

The pipeline length laid underground will be wrapped by Tape Coat as per IS 3589 – 2001(Annx. D), to act against mechanical abrasion, corrosion / rusting due to soil components and salinity of subsoil water. The pipeline length laid over ground or on concrete surface will be rested on chairs and will be painted by Epoxy Paint as per provisions under IS 3589 : 2001(Annx. B).

The pipes will be provided with internal surface lining of Epoxy Coating minimum 406 µm thick.

There is no crossing structure anticipated in Stage I RM pipeline route.

The provisions of pipeline accessories such as Expansion Joints, Washout Valves, Control Sluice Valves, Air Valves, Anchor Blocks, Thrust Blocks, Chairs, etc. as per norms given in CPEEHO Manual will be made while preparing the details design of pipeline where kilometre wise planning / designs / drawing will be provided.

The length of pipeline is very limited and practically there is no elevation variation along the route. Therefore, no appreciably water hammer or surge pressure is anticipated. In the design of Shell thickness of the pipeline, 50% of anticipated Surge Pressure is already considered. Hence, no anti-surge device except Zero Velocity Valve will be required. Detail assessment can be worked out in Detail Engineering.

## V. APPROACH BRIDGE TO JACKWELL :

Refer to Drawing Plate No. DWG 01, DWG 02 and DWG 03.

The pump house floor level is at RL 82m. The ground level of river bank at this location equal to this elevation of RL 82.0m is at a distance of about 150m from the Jackwell / Pump House. In between is the flood zone of the river. Approach arrangements at RL 82m are necessary to approach the pump house during even maximum floods, too. This necessity is proposed to be fulfilled by constructing an Approach Embankment in part length and a high level Bridge in part length near Jackwell.

The Approach Bridge is proposed for 50m length. Total 4 numbers of intermediate pier and one abutment are proposed.

<u>SUPER STRUCTURE :</u>

There will be three intermediate spans - each of 12m length and two landing slabs at each end (6m span near Jackwell and of 8m span near embankment.

The bridge super structure is proposed in two levels. Upper Level at RL 82.0m & Lower Level at RL 78.0 m.

- The Upper level is at RL 82m i.e. at par with Motor floor level of pump house. The super structure at this top level is proposed in <u>Steel Truss Through Type Bridge</u>. This through type bridge will provided for The Approach road way and the space for electrical cable gangway. The RCC Deck slab will be cast on lower chord of the bridge for the roadway. The width of this super structure is kept 6m.
- The lower level passage way at RL 78.0m is proposed for carrying the water conveyance pipeline. This passage from jack well to abutment will be in RCC slab with top level at RL 78m. The pipeline of diameter 1800mm will be laid over this slab. The slab will rest on the supporting beam constructed between two bridge piers. In the intermediate spans where span length is 12m, the pipe will be additionally supported (if necessitated in detail design) at 6 m c/c with either ring girders or Chairs.

<u>SUB STRUCTURE :</u>

Bridge super structure will be supported by Frame of Twin Columns spaced at 12 m c/c.

The maximum height of substructure will be near Jackwell, around 12.9 m, and the shortest height is around 4m at abutment.

FOUNDATION :

The ground sub soil strata is sandy / alluvial without any hard strata to a reasonable depth, even up to 40m depth. Therefore, cast in situ friction piles are proposed for foundation of all bridge piers. The column footing will rest on the pile cap of group of piles.

The size of piles, number of piles and other details required for each foundation will be designed after availability of results of geo-technical explorations. For the present, the foundations are specified as pile foundation in drawings as an indicative provision / requirement.

## VI. APPROACH EMBANKMENT FOR APPROACH BRIDGE :

Refer to Drawing Plate No. DWG 01 and DWG 02

The Approach Bridge of length 50m ends at Ch. 128m. The road deck top level of bridge is at RL 82m. The highest ground level in river cross section on right bank is at RL 80.78m at Ch.230m. However, the ground levels in the area further remain below this level up to the PST campus area. The ground levels at PST campus are proposed to be raised/made-up by earthwork reclamation up to RL 81m. Therefore, it is necessary to have an approach way towards Jackwell and for that purpose an approach embankment at level RL 82m from the location of Approach Bridge to the campus area is proposed. The length of Approach Embankment will be from Ch. 128m to Ch. 370m i.e. 242m.

The top of embankment is kept at RL 82m i.e. above recorded highest river flood level of RL 80.34m. Therefore, nearly 1.5m free board is available over river water even at highest flood level conditions. As such, the approach to Jackwell will be possible round the year.

A road way is proposed over the embankment for access to Jaclwell pump house. The width of carriage way is kept 3.5m with 1m earth shoulders on either side of it. 1m width is spared for power cable duct. Therefore, the total top width of embankment works out to 6.5m. The side slopes of embankment are proposed 2H : 1V. The MS 1800mm diameter Stage I Rising Main pipeline coming out over the bridge will be passed through this approach embankment at depth 1.5m below the roadway / top of embankment. The side slopes of the earth section are will be provided with dry rubble / stone pitching for Stability & protection against flood waters. All these details are incorporated in the earthwork cross section produced on drawing sheets.

The earthwork of the approach embankment will be constructed duly watered, rolled, consolidated and compacted as per specifications applicable to road embankment.

The approach embankment crosses a small nalla or local depression at Ch. 340m. It is proposed to provide across drainage work of slab drain or Hume Pipe culvert to pass the said Nalla flow.

## VII. PLANNING FOR INTAKE CAMPUS :

Refer to Drawing Plate No. DWG 01 and DWG 02.

The Gaga River Intake Water works Campus near Mirzapur town will comprise of the following structures and facilities – Intake Well, Intake Conduit, Jack well, River / Raw Water pump House, Approach Bridge, Approach Embankment, Stage I RM pipeline, Pre Sedimentation Tank, Clear Water Tank, Clear Water Pump House, Electric Switchgear Room, Electric Substation, Anti – Surge Devices, Material Open Yard, Administrative Block, etc. All these structures are located just adjacent to each other and the area enclosing all of these forms a campus area.

The space required for Intake Well, Intake Conduit, Jack Well, River / Raw Water Pump House And Approach Bridge comes within the Government land under Ganga river bed. The area required for all other structures require acquisition of private land. The area so required is shown by an enclosing compound wall boundary which measures to 4.573 Ha. The revenue record / title details of the private land required are already furnished to WEUPPL for information and further processing.

The ground levels under approach embankment and campus area are below the recorded highest river flood level of RL 80.34m. It is proposed to raise the approach road embankment to RL 82m and to Made Up the entire campus area by earth filling to formation level RL 81m. The Structure Top / Plinth Levels for all the facilities are proposed to be kept 1m above formation i.e. to level RL 82m.

The internal road layout for connecting various units in the campus and for access from State Highway main road is indicated in campus map. The campus will be illuminated by street lights and flood lights wherever necessary.

It is to observed that the ground level and sub soil strata all over the area covered under Ganga Intake Campus and surrounding, as seen from physical inspection, is made of silt and sand. Therefore, is no possibility of meeting any hard strata to a depth of 10m or below. Therefore, the foundation for all the structures will be required to be rested on Friction Piles which can be designed after getting the geo-technical investigations of this area.

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# CHAPTER 3

## STAGE 2 – PRE-SEDIMENTATION TANK, CLEAR WATER TANK & PUMP HOUSE, PIPELINE TO UKD & OUTFALL IN UKD

### I. GENERAL :

This chapter contents details regarding Pre-Sedimentation Tank, Clear Water Tank & Pump House, Rising Main Pipeline to Upper Khajuri Dam (UKD) and Outfall in UKD.

The “Mechanical Design of Pumping Machinery and Instrumentation & Control” is presented separately in Chapter No. 5, and the Details regarding “Electrical Installations” in Chapter No. 6.

### II. PLANNING & DESIGN OF PRE-SEDIMENTATION TANK (PST) :

1. Necessity/Requirement of PST –

River Ganga carries considerable quantity of Suspended Sediment Load throughout the year. The sediment data of Ganga river flow observed at Mirzapur CWC river gauging station for the period 1981 – 2011 is enclosed in Volume III of this Report. It is analysed that average annual maximum sediment load is 3.55 gm/lit, vide Sediment Load Abstract provided in Annexure VIII (the Highest incidental concentration was observed in the August 2008, to the value of 6.631 gm/lt). The sediment load has blending of fine, medium and course size particles at various / varying proportions.

As the sediment percentage is high, it is necessary to provide suitable sediment reducing device / structure to minimize the Sediment Load from the pumped water to avoid damages to the various system components such as pump impellers, conveyance pipes, etc. Therefore, it is necessary to provide some sort of de-silting arrangement near Ganga Intake Works before the water is further transported towards MTPP Plant site. Also, In the Water Use Agreement with WRD, UP, it has been specifically mentioned to make such a provision as a part of the Water Drawl System. It is practicable to remove the discrete non flocculent sediment particles up to size 75 µ by plane sedimentation method in PST. The removal of the further size necessitates deflocculating process and the sludge waste to be disposed will contain the chemical residues which will not be allowed to be disposed-off near Ganga River from the considerations of environmental pollution aspect. Therefore, in the meeting with WEIPPL project authorities on 07.09.2015, it is decided to remove the sediment size up to 75 μ size.

The alternative way of employing 'forced' sedimentation using mechanical means such as Cyclone Separators, etc. instead of effecting the de-silting by conventional method of 'Gravity' type Plain Sedimentation, is assessed. A note on features of Cyclone Separator and comparison of both the processes is enclosed as Annexure VII. After the Technical & Financial due diligence, it is proposed to provide for Plain Gravity Sedimentation using Pre-Settling Tank to reduce the Slit Content in the Ganga River water.

2. Project Parameters :

Refer to the earlier paragraph on 'Overall Water Demand on the Water Drawl System'. I The river water lifted from Ganga through Stage I pumping is conveyed by Rising Main to feed to the Pre Sedimentation Tank proposed on the right bank of Ganga in the intake campus. The settled/clear water discharged collected/accrued in to the clear water sump of the PST will be conveyed through Stage II Pumping to Upper Khajuri Dam reservoir.

The output demand on stage I pumps, which is the input demand of PST, is worked out to 53.383 MCM per annum. This quantum is to be processed in 210 days at pumping rate 16 hours per day. Therefore, the input discharge works out to 15,587. 75 cum/Hr i.e. 4.33 cum/sec. Considering 2% water quantity lost in PST in de-sludging, the output discharge from PST is contemplated to be 15,570 cum/Hr i.e. 4,325 cum/sec i.e. 52.2913 MCM PA at 16 hours /day for 210 days.

The Minimum size of particle to be removed – 0.075mm

Specific Gravity of particles – 2.65

The ground levels in the area proposed for PST area are at average RL 75m. It has been proposed to Made-Up and raise the formation level of entire campus at Ganga Intake campus by earth filling to level RL 81m. The top of outer walls / Structure Top of PST structure will be kept 1m above formation level i.e. at RL 82m.

3. Design Procedure:

Design procedure and standards are followed as per CPHEEO Manual Issued by Govt. of India, Chapter No. 7, Water Treatment, Pg. 219 - 232 and Appendix 7.4, Pg 626 – 629.

The General Layout Drawing and sectional details of Pre Sedimentation Tank designed here follow are given in Drawing Plate No. DWG 04

The procedure undertaken is - for the given diameter and specific gravity of minimum size of particle to be removed in the settling tank, vertical settling velocity of the particle is calculated initially using Stokes' Law. The computed Settling Velocity is used to determine the Reynolds number to check whether the Stokes' law is applicable. If Reynolds Number exceeds 1, Hazen's formula is used to determine the settling velocity of the particle. The settling velocity thus calculated is employed for computation of surface overflow rate for expected removal efficiency of the minimum size of the particles and assumed performance of the settling basin. Also, reference is taken for the recommended 'Common Surface Loadings and Detention Periods' in Table 7.5.6 of the CPHEEO manual. The plan area is determined so and next followed by tank dimensions. The depth of the tank is determined using detention period. Sizing of components of inlets and outlets is done using relevant design criterions & assumptions.

4. Design Parameters:

| | |
|---|---|
| Desired Average Outflow from settling tank | : 15,570 cum/Hr |
| | i.e. 4.325 cum/Sec |
| Water Lost in De-sludging | : 2% |
| Design Average In Flow | : (15,570x100)/(100-2) |
| | : 15,887.75 cum/Hr. |
| Minimum size of particle to be removed | : 0.075 mm |
| Expected removal efficiency of minimum size particles | : 75% |
| Nature of particles | : Discrete and non-flocculating. |
| Specific gravity of particles | : 2.65. |
| Assumed performance of settling tank | : Good (n=1/4) |

| | |
|---|---|
| Kinematic viscosity of water at 20˚C (ц) | : $1.01 \times 10^{-6}$ m²/s. |
| Surface loading rate | : 25 to 75 m³/m²/d. |
| Detention time | : 2 to 2.5 Hrs. |
| Weir loading rate | : 1500 m³/m/d. |

5. Design of Pre-Sedimentation Tank

**A. Calculation of Vertical Settling Velocity (Vs) using Stokes Law :**

$V_S$ = g (Ss-1) x d² / (18 x ц)

Where:

Vs = Settling velocity.

g = Acceleration due to gravity.

Ss = Specific gravity of suspended particles.

d = minimum diameter of particles to be settled.

Ц = kinematic viscosity of water at 20˚C.

$$Vs = \frac{9.81\,(2.65-1) \times (0.075 \times 10^{-3})^2}{18 \times 1.01 \times 10^{-6}}$$

$Vs = 5.008 \times 10^{-3}$ m/sec

Check for Reynolds number:

(If Reynolds number is greater than 1 then use Hazen's formula)

Reynolds number (Re) = Vs x d/ Ц

$= (5.008 \times 10^{-3} \times 0.075 \times 10^{-3}) / (1.01 \times 10^{-6})$

= 0.3718 < 1 ………HENCE USING STOKE'S FORMULA IS OK.

**B. Determination of Surface Loading Rate / Surface Overflow rate :**

For Ideal Settling Basin and complete removal of minimum size particles, equate settling velocity to theoretical surface over flow rate for 100% removal.

Vs = Vo

Vo $= 5.008 \times 10^{-3}$ m/sec

$= 5.008 \times 10^{-3} \times 3600 \times 24$ m/day

= 432.69 m/day

However, due to short circuiting, there is reduction in efficiency and decrease in surface overflow rate, which would give expected removal efficiency of minimum size particles in real basin, using following relationship,

$y / y_0 = 1 – (1 + n(Vo / (Q/A)))^{-1/4}$

$y / y_0 = 0.75$ & n = 1/4 (good performance tank)

We get, Vo / (Q/A) = 1.66

Hence, Design Surface overflow rate at average design flow, Q/A

(Q/A) = Vo / 1.66 = 432.69 / 1.66

= 260.657 m/day

Also, referring to the Typical Values of surface overflow rate from Table 7.5.6 of CPHEEO as referred at above, surface-loading rate shall be in the range of 25 to 75 $m^3/m^2$/day for Horizontal Flow Settling tanks.

Therefore, selecting the Surface Overflow Rate as 75 $m^3/m^2$/day

**C. Determination of Dimension of the Tank :**

Surface area of Tank, A = Q / (Q/A)

= (15, 887.75 $m^3$/Hr x 24) / 75

= 5,084.08 $m^2$

Taking, Width, B = 40 m

Length of Tank will be, L = 125 m

However, considering the Criterion for Detention Time as 2 Hrs.,

Tank Volume for 2 Hrs. = 15887.75 x 2

= 31,775.50 $m^3$

Taking, Depth of Tank, D = 4 m

Width, W = 40 m

Length works out to, L = 198.6 m

Say 200 m

Therefore, Settling Tank Dimensions adopted will be,

= 200 m (L) x 40 m (W) x 4 m (D)

With, this proposed volume,

Surface overflow rate works out = 48 $m^3/m^2$/day

Which is in the range of 25 to 75, therefore, OK.

Now, for this surface overflow rate, minimum particle size that will be removed is 0.0325 mm which is less than 0.075 mm envisaged in the Project, therefore, OK..

For Particle Size 0.0325mm,

| | | |
|---|---|---|
| Vertical Settling Velocity, Vs | : | $9.40 \times 10^{-4}$ m/sec |
| Reynolds Number, Re | : | 0.0302 < 1 |
| Surface loading rate, | | |
| Vo | : | 81.216 m/day |
| Design Surface Overflow Rate works out to, | | |
| (Q/A) = Vo / 1.66 | : | 48.92 ≈ 48, selected for the present PST |

**D. Check against re-suspension of Deposited Particles, calculation of Critical Velocity, Vc :**

Using Darcy- Weisbach equation:

$$Vc = \sqrt{\left(\frac{8k}{f}\right) * g\ (Ss - 1) * d}$$

For Uni-granular particles k=0.04 & Darcy-Weisbach friction factor f = 0.03

$$Vc = \sqrt{\left(\frac{8 \times 0.004}{0.03}\right) \times 9.81\ (2.65 - 1) \times 0.075} \times 10^{-3}$$

Vc = 0.113 m/sec.

To avoid re-suspension, the critical displacement velocity shall not be exceeded, and horizontal velocity of flow in basin should be less than critical displacement velocity.

Horizontal velocity of flow in settling basin at average flow, Vh

Vh = Q / (B x D) = 4.413 / (40 m x 4 m)

= 0.02758 m/s < Vc, 0.113 m/s

Hence, OK

**E. Design of Influent Structure :**

The influent structure is designed to minimize the turbulence and avoid deposition of silt in influent structure. The velocity of flow in the influent structure should not exceed 0.3 m/s.

Q = A x V

Cross sectional Area of influent channel, A = Q/V

= 4.413 / 0.3

= 14.710 m².

Hence provide influent channel of width = 3.75 m

and flow depth in channel = 4.0 m

Hence cross sectional area A provided = 3.75 x 4.0 = 15 $m^2$ > 14.71 $m^2$ ….Hence OK.

Provide 0.75 m x 0.75 m size submerged orifice in such a way so as to distribute the flow equally.

Total area of opening required = 15 $m^2$.

No. of orifices required = 15 / (0.75 x 0.75) = 26.6

We will provide 26 Orifices in Single Layers,

Spacing of orifices = Length of Inlet Chanel / No. of orifices

= 40 m / 26 Nos.

= 1.54 m c/c

Also, provide a baffle wall of height 2.25 m at a distance of 1 m away from the orifices.

**F. Design of Outflow arrangement:**

Taking weir loading rate of 1500 $m^3$/d/m length

Weir length = Desired Output Flow/Weir loading rate

= 15570 x 24/ 1500

= 249.12 m

This weir length is provided is 230 (= 4 Nos x [25+25+7.5]) meters (due to restrictions of the Tank Shape Geometry) (vide Layout on Drawing Plate DWG 04)

<u>Design of weir plate:</u>

A weir plate in stainless steel will be provided along the 230 m weir length.

The top of this weir plate shall be at a depth (d’) from the FSL of Settling Basin tank to allow water to fall freely inside the launder.

Q’ = 15570 $m^3$/Hr

i.e 4.413 cum/sec

Limiting velocity over the weir is V= 0.6m/s.

Hence Area = Q’/V

= 4.413 / 0.6

= 7.355 $m^2$.

Length of the weir L = 230 m

Hence d’ = 7.355 / 230

= 0.031 m i.e. 31 mm

Say 30 mm

Hence the top of the weir plate shall be 30 mm below the FSL of Settling Basin tank.

Launder:

Taking Launder section as

1.0 m (B) x 1.0 m (D)

Design for side opening in the Launder for outflow into clear Water Sump :

With reference to the particular 230 m Weir Length Provided, the outfall side openings to the Launders are provided in 8 numbers.

The desired flow of 15570 $m^3$/Hr will be divided into 8 equal sections.

| | |
|---|---|
| Flow on each section | = 15570 / 8 |
| | = 1946.25 $m^3$/ Hr |
| Limiting velocity in launder V | = 0.6 m/s |
| Cross sectional area of side opening, A | = 1946.25 / (0.6 x 3600) |
| | = 0.901 $m^2$ |
| Provide width of side opening, B | = 1.0 m |
| Hence Side water depth D required | = 0.901 / 1 = 0.901 |
| | Actual D provided is 1.0m, Hence OK. |

## G. Designs for Silt Trap Volume :

**CWC** Silt Load data at Mirzapur Gauging Station for the period 1981 to 2010 (30 years) is used to get the Sediment Concentration in the Ganga River Water.

It is observed that generally the maximum silt concentration observed in the Ganga River water is 3.55 gm/lit (August 1982) and below. However, an extraordinarily high concentration was observed in the August 2008, to the value of 6.631 gm/lt. (Refer to Abstract of the Sediment Load given in Annexure VIII.) Therefore, the silt trap sizing is done considering the average concentration at 3.55 gm/lit, and it is checked for incidental value of 6.631 gm/lt.

| | |
|---|---|
| The sediment concentration in the incoming flow is observed to be | = 3.55 gm/lit = 3.55 kg/$m^3$ |
| Design incoming discharge | = 15887.75 $m^3$/Hr |
| Consider efficiency of Settling Basin | = 75% |
| For 24 Hrs Operation, | |
| Total Sediment Load collected /day | = 15887.75 x 24 x 3.55 x 0.75 |
| | = 1015227 kg/day |
| Silt mass density | = 1600 kg/$m^3$ |

| | |
|---|---|
| Total sediment Volume collected / day | = 1015227 /1600 |
| | = 634.51 $m^3$ |

If sludge removal periodicity is kept once in a Week,

| | |
|---|---|
| The sludge accumulation space required | = 634.51 x 7 |
| | = 4441.62 $m^3$ |

Assuming 30% silt spread over Basin bed and 70% is collected in silt trap.

| | |
|---|---|
| The Silt Trap volume required | = 0.7 x 4441.62 |
| | = 3109 $m^3$ |
| The length of Basin bed along trap | = 40 m |
| Area available for Silt Trap | = 40 m x 25 m = 1000 $m^2$ |
| Therefore, Depth of Silt Trap required | = 3109 / 1000 |
| | = 3.109 |

<u>For 16 Hrs Operation,</u>

| | |
|---|---|
| Total Sediment Load collected /day | = 15887.75 x 16 x 3.55 x 0.75 |
| | = 676818.15 kg/day |
| Silt mass density | = 1600 kg/$m^3$ |
| Total sediment Volume collected / day | = 676818.15 /1600 |
| | = 423.01 m3 |

If sludge removal periodicity is kept once in a Week,

| | |
|---|---|
| The sludge accumulation space required | = 423.01 x 7 |
| | = 2961 $m^3$ |

Assuming 30% silt spread over Basin bed and 70% is collected in silt trap.

| | |
|---|---|
| The Silt Trap volume required | = 0.7 x 2961 |
| | = 2072 $m^3$ |
| The length of Basin bed along trap | = 40 m |
| Area available for Silt Trap | = 40 m x 25 m = 1000 $m^2$ |
| Therefore, Depth of Silt Trap required | = 2072 / 1000 |
| | = 2.07 |

Considering, both the operations scenario at above,

| | |
|---|---|
| Provide Silt Trap of size | = 25 m (W) x 40 m (L) x 3 m (D) |

For the worst case scenario of silt concentration at 6.631 gm/lt,

| | |
|---|---|
| Total Sediment Load collected /day | = 15887.75 x 24 x 6.631 x 0.75 |
| | = 1896330 kg/day |

| | |
|---|---|
| Silt mass density | = 1600 kg/$m^3$ |
| Total sediment Volume collected / day | = 1896330 /1600 |
| | = 1185.20 $m^3$ |
| Provided Silt trap Volume | = 25 x 40 x 3 = 3000 cum |
| De-Silting required will be required | = 3000 / 1185.20 |
| | = 2.5 Days |
| | i.e. @ 3 days interval. |

6. <u>Removal of Sludge from PST</u>

As stated earlier, the average ground at PST location are at RL 75m and the top of outer walls of PST structure are proposed at RL 82m.

Refer to layout of PST in Drawing Plate DWG 04. A central sludge flushing channel/trough of 2m width and is provided all along the length of settling basin. The drain out pipes are provided to this trough at 50m interval to let out / flush out the sludge from the trough. These drain pipes are 5 Nos. on either side with each 300mm diameter. When the river water level is below RL 74m or so, it is possible to flush the sludge hydraulically under the head present in settling basin.

The layout of drain pipe network out side PST for disposal of sludge flow by gravity in to the nearby Ojhala nalla is given in Drawing Plate No. DWG 04A.

When the river water level exits higher than the floor level of PST tank, the sludge removal is proposed by employing pumping. For that 4 Nos. of de-Sludging pumps are proposed to be mounted over the Floor/Platform located over Silt Trap area. The requirement and capacity of pumps is worked out at below –

| | |
|---|---|
| Silt Trap volume Provided | : 25 m (w) x 40 m (L) x 3 m (D) |
| | : 3000 cum |
| No. of Pumps Provided | : 4 Nos. |
| Time duration for De-silting | : 4 Hrs. |
| Discharge Per Pump | : 187.5 cum/Hr |
| Total Head on pumps | = Static head 7m (RL 82 – RL 75) |
| | + 5 m Friction & other losses = 12m |

Capacity / Rating = (Q x H)/(367.2 x efficiency)

= (187.5 x 12) /(367.2 x 0.75)

= 8.167 kW

= (8.167 x 1.1=) 9 kW say 10 kW i.e. 12.73 HP

It is proposed to provide 4 (working) + 1 Stand by 15 HP Pumps for De-Sludging at PST.

The mechanical / electrical specifications of these pumps are given elsewhere in this Report under the Chapter on 'Mechanical Design of Pumping Machinery'.

The layout of disposal of pumped out sludge in to Ojhala nalla is shown in Drawing Plate No. DWG 04A.

7. Foundation to PST Structure

As stated in the earlier paragraph on 'Ganga Intake Campus', PST structure will be required to be rested on friction pile foundation.

**III. DETAILS OF CLEAR WATER TANK (CWT) AND PUMP HOUSE :**

1. Clear Water Tank

Refer to Drawing Plate No. DWG 05.

Referring to Chapter 1,the water quantum to be Pumped & Conveyed from the Clear Water Sump of Pre Sedimentation Tank (PST) for Upper Khajuri Dam Reservoir is to the extent of 52.315 MCM PA. This quantity is to be lifted in 7 months' time at pumping rate of 16 Hr/day. The discharge works out to 15570 cum/hour i.e. 4.325 cum/sec. The PST is accordingly designed for Outflow of 4.325 cum/sec. The clear water from the PST will overflow into the Clear Water Tank (CWT) proposed at the end of PST.

The water collected in CWT is to be pumped out immediately for further transportation to UKD reservoir. Therefore, CWT acts as balancing sump for a short duration. Indian Standard IS 15310 specifies under clause 5.1 that the detention period for such a transient sump shall be minimum between 7 to 10 minutes. However, in the discussions with WEUPPL officials, it is decided to keep the detention period of 20 to 30 minutes.

As stated earlier, the ground levels in the PST campus area are around RL 76m and the formation level is proposed to be raised to RL 81m by earth filling. The top of outer walls of PST structures are proposed to be kept at RL 82m. As such, top of CWT outer/ side walls are also proposed to be at RL 82m. The FSL of CWT is proposed at RL 81m leaving 1m free board below top of side walls. The bottom of CWT is proposed at RL 76m at par with the plot ground level. This provides 5m gross water storage depth for CWT structure.

Therefore, It is proposed to have the CST dimensions as 80m(L) x 25m(W) x 6m(D). Considering the free board of 1m, the depth of water will be 5m and the gross volume of water in the tank works out to 10,000 cum. However, bottom 2m water depth is required for minimum submergence for the pump operation. Hence, only 3m water depth remains available for live storage of the tank. The live storage works out to 80m x 25m x 3m = 6000cum equivalent to 23.12 minutes which is in the range of 20 to 30 minutes of requirement. Hence, the said size / dimensions are adopted for CWT.

2. Stage 2 Pumps :

The water collected in CWT will be pumped and transported to by water conveyance pipeline to Upper Khajuri Dam (UKD) reservoir. Therefore, pumps and pump house are proposed over part area of CWT.

For this Stage of Pumping also Vertical Turbine Pumps are proposed over Horizontal Pumps. As the Dry Pit required for Horizontal Pumps will be River Flood Plain Below RL 80.34 m.

The FSL of CWT is at RL 81m and the depth of live storage in CWT is kept 3m. Hence, minimum water level for Pump Operation in CWT is at RL 78m. The discharge on pumps is at 4.325 cumec.

The delivery point is UKD reservoir. The delivery level Elevation is planned above the Full Reservoir Level of UKD (RL 167.03 m), therefore the delivery elevation is kept at level equivalent to top of dam level at RL 168.55m. The exit head planned is minimum 2m.

The length of stage II Rising Main pipeline from manifold of Stage II pumps to the exit point in UKD reservoir, = 23. 050 km.

| | |
|---|---|
| Minimum Water Level at Pumping Station /MDDL | : RL 78.00 m |
| Maximum Water level in the Clear Water Tank | : RL 81.00 m |
| Diameter of pipeline | : 1800 mm |
| Delivery Level at UKD Reservoir | : RL 168.55 m |

Static Head on Pumps considering delivery level,

= RL 168.55 m – RL 78.0 m

= 90.55 m

Static Head on Pumps derived from Hydraulic Gradient line,

= 93.758 m

| | |
|---|---|
| Station Losses | : Approx. @ 1.5 m |
| Exit Head | : 2.0 m |
| Frictional Head loss in Pipeline, | |
| Head Loss by Hazen William Formula. | : 22.50 |
| Add 10% losses for bends | : 2.25 M |
| Total head loss in Pipeline | : 24.75 M |
| Gross Head on Pumps | : 122.0 M |

= 93.758 m + 24.75 m + 1.5 m + 2.0 m

= 122.0 m

Pump Capacity, HP required = (w x Q x H ) / (75 x n)

Where – w – unit weight of water = 1000 kg/$m^3$

Q – Design Discharge – 4.325$m^3$/sec

N – Efficiency of pumps – 85%

H – Design Gross Head

∴ HP required = (w x Q x H ) / (75 x n)

= (1000 x 4.325 x 122) / (75 x 0.85)

= 8276.86 HP

Electric Motors required = HP x 0.745 kW

= 6174.54 kW

Considering Power Margin at 15%, net Motor Capacity required

= 1.15% of 6174.54 kW

= 7100 kW

*(Refer to Chapter 5, 'Mechanical Design of Pumping Machinery of detail Calculations)*

*With reference to the Mechanical Design, Duty points are finalised as.*

- Number of Pumps : 4 Working + 1 Stand by
- Discharge Per Pump : 1.1081 cum/sec
- Motor rating for each Pump : 1800 kW i.e. 2415 HP

3. Stage 2 Pump Sump Parameters :

There will be total five pumps installed in the CWT out of which four will be in continuous operation and one in standby mode. Therefore, hydraulically the jack well is a Multiple Pumps' Sump. The pump type selected is Vertical Turbine Pumps. The pumps will be installed on floor proposed at elevation RL 82m. The suction pipes / columns will be suspended from pumps in to the sump pit below the pumps. The floor level of sump pit is kept at RL 75m i.e. 1m below the floor level of CWT. The Minimum Water Level (MWL) in the sump is proposed at RL 78m. Hence, water depth available in the sump below MWL is 3m. The suction pipes / bell mouth of each pump is separated from others by providing a full height curtain wall. Therefore, it is described as 'Unitised Sump'.

In all the standard references of IS Codes, HIS 9.8 Manual and CPHEEO, the various sump parameters are expressed / worked out related to the diameter of Bell Mouth (D) provided at the end of suction pipe of the pump for / at the entry of flow. The various sump parameters for the present case are worked out as follow. These Paramters are planned as per IS 15310 & ANSI/HI- Pump Intake Design.

- **D – Bell Mouth Diameter**

*The velocity of flow at the entry of bell mouth shall not exceed 1.3 m/sec.*

∴ Taking velocity at entry as 1.2 m/sec,

| | |
|---|---|
| The discharge per pump | = 4.325 / 4 |
| | = 1.081 cumec |
| C.S. area of bell mouth | = Q / V = (1.081 $m^3$/sec / 1.2 m/sec) |
| | = 0.900 $m^2$ |
| ∴ D, diameter of Bell Mouth | = 1.070m |

It is proposed to provide D = 1.05m

The actual velocity produced with D = 1.05m will be

= Q / A = 1.2475 m/sec

< 1.3 m/sec admissible.

- **S – Submergence**

It is the distance from minimum water level in sump to bottom of bell mouth.

Minimum specified = 1.5D = 1.5 x 1.05m

= 1.575 m

Actual S provided = 3.0 m > 1.575m minimum required.

(Sump Floor Level is at RL 75.0m, MDDL at RL 78.0 m)

*(The actual provided Submergence is with reference Parameters specified at above & the NPSH calculations presented in the Chapter of Mechanical Design)*

- **C – Bottom Clearance**

It is the distance between bottom of bell mouth and sump floor bottom level.

Minimum D required = D / 2 = 1.05m / 2

= 0.0.525m.

Actual distance provided = 0.60 m > 0.525m minimum required.

- **MWL - Minimum Water Level**

It is the distance between sump bottom and minimum water level in jack well.

Minimum specified = C + S + Safety Margin

= 0.60 + 1.70 + Safety Margin

No specific figure is stipulated for minimum Safety Margin. We have adopted it 0.50m as adequate.

∴ Minimum WL required = sump bed level + Min. C + Min. S + SM

= RL 75 + 0.525 + 1.575 +0 .5

= RL 77.60m.

Actually provided is at RL 78.00m. > RL 77.60m, safe.

- **W – Width of Sump**

  Minimum specified W = 2 ND + (N-1)T

  where N is the number of pumps and

  T is the pier wall thickness between two pumps.

  W = 2 x 5 x 1.05 + (5 -1 ) x 1m

  = 14.40m.

  Actually provided =( 5 x 2.1) + (4 x 1)

  = 14.5 m

  ≈ 14.40 minimum required

- **SWC – Side Wall Clearance**

  It is the clear distance between the vertical wall of sump and edge of end side bell mouth

  Minimum Specified = between D/3 and D/2

  = between (1.05m /3) and (1.05m/2)

  = between 0.35m and 0.525m

  Actual SWC provided = (2.2m – 1.05m) / 2 = 0.575 m > 0.525m , OK

- **B – Back Wall Clearance**

  It is the distance between the bell mouth and back wall of the sump.

  Minimum specified = between ¾ D to D

  = between ¾ of 1.05m and 1.05m

  = between 0.0.7875m and 1.05 m

  Actual B provided = 0.90 m , OK

- **H – Channel Width**

  Minimum specified = 2D = 2 x 1.05m

  = 2.10m per pump

  Actual H provided = 2.1m = 2.1m minimum required, OK

- **L- Approach Channel Length**

The unobstructed channel length up to bell mouth needs to be minimum 5D

5 D = 5 x 1.05

= 5.25m

The inlet gates provided will be sliding through the slots provided in the walls of piers. Hence, there is no obstruction to flow at this location. The obstruction to flow may be treated at the location of screen of Trash Rack.

The distance from trash rack to bell mouth provided = 7.9m

> 5.25m minimum required. OK.

- **A - Inlet Opening Distance** (Ref: ANSI/HI 9.8-1998 Table – 9.8.1)

It is the distance from the pump inlet bell centre line to the intake structure entrance

Minimum specified = 5 D

= 5 x 1.05m = 5.25m

In the present case, it is the distance from Inlet Gate opening to Bell Mouth.

Distance A, actually provided = 8m > 5.25m minimum required.

- **Inlet Gates Size** (Ref: ANSI/HI 9.8 – 1998, para 9.8.2.1.4 and Table 9.8.2)

Maximum pump approach velocity in pump bay specified = 0.5 m/sec.

∴ The minimum area of inlet gate opening required = Design discharge / permissible velocity

Design Discharge per pump = 1.081 cumec

∴ The minimum area of inlet gate opening required,

= 1.081cum / sec ÷ 0.5 m/sec = 2.162 $m^2$

The pump bay width for each pump provided is 2.1m.

Hence, the minimum gate height required = 2.162 / 2.1

= 1.03m.

The size of inlet gate proposed for each bay = 2.1 m(W) x 1.2 m(H)

∴ Actual approach velocity, V, developed = 1.081cumec / (2.1 x 1.2) $m^2$

= 0.0.429 m/sec < 0.5 m/sec, acceptable.

- **Inlet Gate Details**

  The gate will be installed between two successive piers of the pump bay with sill level at Sump Floor level i.e. RL 75m.

  The maximum water column/ maximum static pressure on the gates will be on the upstream face of gate when the CWT water is at FSL at RL 81m.

  ∴ Max hydraulic pressure = RL 81m – RL 75m = 6.0m

  As per IS 4622 : 2003, clause 3, the gate which operates under a head of less than 15m is classified as 'Low Head Gate'. In the present case the maximum head is 6m above sill level of the gate. Hence, it is a 'Low Head Gate'. These gates are 'slide gates' in which the operating member – Gate Leaf – slides on the sealing surface provided on the frame. The total gate assembly incorporates gate leaf, guide groove, sealing surface, embedded parts, tie rod, hook, lifting frame & hoist. These gates are generally operated by screw / winch type mechanical hoists. This gate shall be operated at Pump House floor level.

  The structural design of this gate is to be worked out as per IS 5620 : 1985 during detail design phase.

- **Screen Requirement** (Ref: IS 15310, Clause 4.2.1.7)

  Codal requirement - Screens should be provided at the inlet of pump bay in order to arrest all trash and floating material and straighten the flow.

  In the present case, it is proposed to provide a MS mesh screen removable type Trash Rack just before the inlet gates of sump pit.

- **Y - Screen Location** (Ref: ANSI/HI 9.8-1998 Table – 9.8.1)

  It is the distance from the pump inlet bell centre line to the through flow screen.

  Minimum specified = 4 D = 4 x 1.05m

  = 4.20m

  The MS mesh screen removable type Trash Rack is proposed on the outer side of inlet sluice gate at a distance 1.25m from it.

∴ Actual Y provided = 8.0m + 1.25m

= 9.25 m > 4.20 m minimum required. OK

- **Trash Rack Details** (Ref: IS 11388 : 2012)

IS 11388 : 2012 deals with 'Recommendations on Design of Trash Racks for Intakes'. It is proposed to locate the trash rack screen on the outer side of the inlet gate. The trash rack will cover the entire area of inlet opening / gate. It will be a removable section rack which will be installed by lowering the sections between the side guides or grooves provided in the trash rack structure so that the sections will be readily removed by lifting them through/from guides. These will be either Slide of Side Bearing type. These will be operated by winch/ hoist arrangement installed in Pump House at pump floor level.

In the present case, the unit of trash rack is of size 2.1m (w) x 1.20 m (H), for which manual cleaning is proposed.

Ref Clause 6.1 of IS 11388 : 2012)

Maximum velocity through screen = 0.75 m/sec

The trash rack area provided = 2.1m x 1.2m

= 2.52 sqm

As per clause 10.2.1 of the said IS, not more than 33 pc of trash rack area is allowed to be clogged.

Therefore, the clog free / open area of screen required,

= 0.67 x 2.52 $m^2$ = 1.69 $m^2$

∴ Actual Velocity that will develop through screen,

= 1.081 cumec / 1.69 $m^2$

= 0.64 m/sec

< 0.75 m/sec max. Limit. OK.

4. Details of Pump House Structure :

The water collected in CWT is pumped and transported by a pipeline to Upper Khajuri Dam (UKD) reservoir. The Vertical Turbine Pumps and Pump House Structure is proposed over part area of CWT.

As worked out at above, total five number – ‘4 Working and 1 Stand By’ pumps are proposed for this pumping. Each pump is of 2400 HP capacity and each motor of 1800 kW rating.

These pumps are to be mounted on the floor proposed at RL 82m, at par level with the top of external walls of PST & CWT. This pump floor will be supported by columns & Piers constructed on CWT floor. Refer details in Drawing Plate No. DWG 05. The floor bed below pump house is depressed to level RL 75m to form the Sump Pit. The divide/curtain walls are proposed in between the Pump Installations in flow direction to separate out the pump bays. These walls will be from sump pit floor level to pump floor level. The Motors and the delivery pipes of the Pump and their controlling valves are all proposed on the same floor at RL 82m. Therefore, the pump floor level and the delivery level are the same. The floor space is kept sufficient to accommodate the Service Bay and Control Panels to operate the pumps & its auxiliaries.

The Manifold is planned outside the Pump House Structure. The Manifold will be at Made-Up Ground level at RL 81m, resting on ground. The individual delivery pipes of each pump will connect to the manifold horizontally at $90^0$ and in elevation at a $45^0$ angle.

The height of Pump House room above motor floor is kept 11m. The Gantry beam will be placed at height 8m over motor floor. The corbel level of gantry rails is at RL 90m. An over-head EOT Crane of capacity 15MT/5MT is proposed in the Pump House.

- Rectangular Pump House : 12.5 m x 27.6 m
- Motor Floor Level : RL 82.0 m
- Gantry Corbel Top : RL 90.0 m
- Pump House Roof bottom level : RL 93.0 m

Fourteen numbers of columns (7 in each line) are proposed to support the Gantry Girder. These columns will start from Sump Floor and will go up to roof slab of pump house. The clearance between Gantry Girder top and roof slab is kept 3m.

The inlet gates and the trash rack in front of the pump bays are arranged in the outer space of pump house. These are proposed to be operated from Motor Floor level. Hence, the floor slab of the pump house at this level is extended about 5m at outside pump house for operation of Gates & Trashrack. One EOT of 5 MT capacity is proposed over this space for lifting the gates. To support the gantry girder of Gates & TR, columns are proposed starting from sump floor up to roof slab level.

The external wall of pump house is proposed in brick work duly plastered on both sides. There will be one MS rolling shutter of size 3.5m (W) x 5m (H) at entrance door towards the entry from Main Road (West) side. Also, there will be one more entry to pump house by a service gate from CWT floor. There will be one door opening in pump house outer wall for entering in to gallery of gate operating area.

5. Foundation to CWT & Pump House Structure :

As stated in the earlier paragraph on 'Ganga Intake Campus', these structure will be required to be rested on friction pile foundation.

## IV. DETAILS OF RISING MAIN PIPELINE FROM CWT PUMP HOUSE TO UPPER KHAJURI DAM (UKD) RESERVOIR :

Refer to Drawing Plate No. DWG 06A, 06B & 06C.

Water from Clear Water Tank will be pumped & conveyed to UKD reservoir by Stage-2 Rising main pipeline.

This pipeline route has been previously surveyed for its Topography & Land Details by a separate Agency and the survey data is provided by WEUPPL to Project Management Group for undertaking of planning and designing of the pipeline from Ganga Intake Works to UKD reservoir. The said survey has been used by us in this report for the design processing here after.

The length of Stage-2 Rising Main pipeline from CWT Pump House to UKD reservoir is 23050m. First 186m length will be in Intake campus at Ganga Intake. The next 12164m, the route travels cross country through agriculture fields and meets SH 5 Highway at Ch. 12350m. Then the pipeline route travels along SH5 up to Ch. 22500m where it turns right along a cart track for UKD reservoir.

The route of this pipeline and consolidated L-section along ground level is shown in Drawing Plate No. DWG 06A, 06B & 06C. The basic engineering of the pipe section and the pipeline route is worked out as follow.

1. Pipeline Project parameters

- Route length of pipeline : 23050m
- Design discharge through pipeline : 4.325 $m^3$/sec
- No. of rows of pipeline : 1 No.
- Motor Floor level / Valve Operating level : RL 82m
- Delivery point elevation : RL 168.55
- Exit Head proposed at delivery point : 2m
- Highest GL elevation on pipeline route : RL 174.815m
- Minimum Water Level at CWT Pump House : RL 78m
- Gross Head on Pipeline : 118 m

  (As worked out in previous Paras)

  (When the Hydraulic Gradient Line (HGL) along the flow of pipeline route is plotted considering the elevation difference at pump point and delivery point, , it is seen that it is cutting the ground between Ch. 22715m and Ch. 23000m. Therefore, modified HGL is plotted keeping 2m minimum hydraulic head at the highest intersection point in elevation (at Ch. 22750m). The modified HGL necessitates Static head elevation required at pump point as RL 199.08m which provides static Head on pumps as 95.758m)
- Pipeline material : Mild Steel

  ((Refer Annexure I ‘Selection of Pipeline Material)

2. Selection of Pipe Diameter and thickness

The range of appropriate diameters is explored by considering the pipe flow velocity range between 1.2 m/sec to 2.1 m/sec. The corresponding diameters found out are – 2000mm, 1950mm, 1900mm, 1850mm, 1800mm, 1750mm, 1700mm & 1650mm. These diameters are checked for the Techno-Commercial appraisal i.e. Optimisation of Economical Diameter, considering capital cost of pumps & pipes and running energy cost for the design period of 25 years. The project data, design parameters and the process sheet of this exercise is kept in Annexure IX. It is observed that 1800 mm diameter with shell thickness 17.5 mm is most economical.

3. Structural Analysis and Design for shell thickness

The pipeline diameter and the shell thickness under consideration are checked for the following stress conditions –

1. Pipe laid in Trench Condition (Laid Under Ground) :
   - A. Check for Deflection –
     - i. Partial Vacuum without side support.
     - ii. Partial Vacuum with side support.
     - iii. Pipe full with side support.
   - B. Stresses for Partial Vacuum Condition (Total Compressive Stress) –
     - i. Without side supports.
     - ii. With side supports.
     - iii. Buckling under Partial Vacuum Condition.
   - C. Stresses for pipe full and side support (Total Tensile Stress).
2. Pipe laid on Chair Condition (Laid Above Ground with Chair to Chair Dist. 6 m) :
   - A. Check for Deflection.
   - B. Total Hoop Stress.
   - C. Total Longitudinal Stress.

A note on MS Pipeline Shell Thickness Design is given in Annexure II. The calculations for Stress Analysis for 1800mm diameter 17.5mm shell thickness for pipes laid in 'Trench condition' are produced in Annexure X and for pipes laid 'above ground' are produced in Annexure X. The sample calculations for Techno-economic analysis are produced in Annexure XI.

Therefore, considering the techno-economic analysis and structural viability, 1800 mm diameter Mild Steel pipe of 17.5 mm shell thickness pipes are selected for the conveyance pipeline from CWT to UKD reservoir.

4. Pipeline line route and Pipe Laying

Refer to Drawing Plate No. DWG 06A, 06B & 06C for Pipeline route drawings.

The pipeline alignment route, Ground level L-section along route, pipeline marking, Hydraulic Gradient Line, various crossings anticipated, etc. are shown in these drawings. The broad break up of pipeline route is as below –

- Stage II pumps manifold to the exit of WEUPPL Ganga Campus : 186m
- The length from campus to Mirzapur bound SH5 State highway : 12,164m
- The length along SH5 to the point where it turns right towards UKD : 10,150m
- The length From SH5 up to Outfall Point in UKD reservoir : 550m

Total route length :23.050 km

The pipeline length in the campus will be underground i.e. through the Made-Up earthwork. The route from campus up to SH5 travels cross country over agricultural fields. In this length the pipeline is proposed underground. In the length along SH5, it is observed in the field visits that length from Ch. 12350m to Ch. 13600m. runs over exposed hard rock ground surface. In this length the pipes will be required to be laid over ground on chairs. The balance length along SH5 will be underground. Also, the length from SH5 to UKD reservoir will be laid underground.

Wherever the pipeline is laid underground, it will be laid in excavated trench and trench backfilled with soil. The minimum soil cover over crown of the pipe will be maintained 1m. The pipes will be laid on 20 cm thick sand cushion / boxing. The laying of the pipes will be fully in compliance of procedures and stipulations given under IS 5822 : 1994.

The pipeline length laid underground will be wrapped by Tape Coat as per IS 3589 – 2001 (Annx. D) to act against mechanical abrasion, corrosion / rusting due to soil components and salinity of subsoil water. The pipeline length laid over ground on chairs or otherwise will be painted by Epoxy Paint as per provisions under IS 3589 : 2001, (Annx. B).

The pipes will be provided with internal surface lining of Epoxy Coating minimum 406 µm thick.

The pipe laying cross section for underground laying in 'Trench position' and for over ground laying 'On Chairs' are shown in drawing sheets.

There will be following crossings along the route, at these crossings the pipe will be mainly laid underground with Casing Pipes / concrete encasing as per the particular site condition –

| Sr. | Chainage (m) | Crossing Detail | Sr. | Chainage | Crossing Detail |
|---|---|---|---|---|---|
| 1 | 200 | Mirzapur – Vindhyavasin Road | 20 | 11425 | Nalla |
| 2 | 300 | Railway | 21 | 11575 | Nalla |
| 3 | 750 | Small Nalla | 22 | 14560 | High Tension Line |
| 4 | 1200 | Ojhala Nalla | 23 | 14750 | High Tension Line |
| 5 | 1350 | Civic Drainage Line | 24 | 15400 | Village Road SH5 To Bhu |
| 6 | 2850 | Rajapur – Chandvadi Village Road | 25 | 15750 | High Tension Line |
| 7 | 3150 | Small Nalla | 26 | 16350 | Village Road Sh5 To Hardibhali |
| 8 | 4000 | Majhigavah – Sabrigave Village Road | 27 | 17100 | Village Road |
| 9 | 5000 | Etua – Mirzapur Major Road | 28 | 17425 | Road SH5 To Upper Khajuri River |
| 10 | 4500 | Etua – Jangipra Village Road | 29 | 18000 | Nalla |
| 11 | 6900 | River | 30 | 18525 | Small Road To Dispesary |
| 12 | 7100 | River | | 18500 | Road SH5 To Upper Khajuri River |
| 13 | 7800 | Nalla | 31 | 19150 | Village Road |
| | 8200 | High Tension Line | 32 | 20350 | Small Nalla |
| 14 | 8700 | High Tension Line | 33 | 20400 | Road SH5 To Sirsi |
| 15 | 9300 | Mirzapur – Chitpur Road | 34 | 21150 | High Tension Line |
| 16 | 9840 | Village Road | 35 | 21750 | Nalla |
| 18 | 9850 | Nalla | 36 | 22950 | Dam Top Road |
| 19 | 11200 | High Tension Line | | | |

The specific nature of crossing and its structural details will be attended in Detail Designs.

The provisions of pipeline accessories such as Expansion Joints, Washout Valves, Control Sluice Valves, Air Valves, Anchor Blocks, Thrust Blocks, Chairs, etc. will be made while preparing the details design of pipeline where kilometre wise planning / designs / drawing will be provided.

5. Water Hammer / Surge Protection Device

In this Basic Engineering assessment, the fundamental Joukowaski's Law (equation) for preliminary evaluation of maximum internal pressures is used, which is -

$\Delta H = (a \times V_0) / (g)$

$\Delta H$ is Rise in Pressure above normal, 'a' is Pressure wave velocity, $V_0$ is flow velocity & 'g' is gravitational acceleration.

For Design of Shell thickness of the pipeline, 50% of anticipated Surge Pressure calculated by above equation is considered (vide calculations produced in Annexure X & XI). As Water Hammer is a very complex phenomenon, advanced computer programs are developed for Transient Analysis evaluations. The detail processing will be undertaken by using 'Water Hammer' Software Program (Version – V8i) developed by M/S Bentley Systems, in the Detail Engineering phase of this assignment. In the analysis, various operational & accidental scenarios will be developed, and the Positive & Negative Transient Pressure situations will be evaluated. Based on the analysis, for control of Negative Pressures, Air Valves (Kinetic / single) or Vacuum Breaker Valves, etc., and for Positive Pressures, Air Vessels, Air Cushion Valves, Zero Velocity Valves, One way surge Tank, etc. equipment will be selected suitable to our site conditions.

The location of the Anti- Surge Devices will be in the initial reaches of the pipeline i.e. in the Ganga Intake Campus. The space for the same is shown in Drawing Plate No. DWG 01.

## V. STAGE-2 PIPELINE OUTFALL STRUCTURE IN UKD RESERVOIR :

The Stage 2 Rising Main pipeline carrying water from Clear Water Tank discharges in to the reservoir of Upper Khajuri Dam (UKD). As the pipeline will discharge with a exit velocity, it is proposed to build an RCC Outfall Structure at the exit point of the pipeline to avoid any erosion of the reservoir bed due to discharging flow.

This structure is proposed on the lines of functioning of 'Baffle Apron Drop Spillway' (Ref : 'Design of Small Dams' – Chapter IX, Section 193 (h) published by (USBR) United States Department of the Interior Bureau of Reclamation). Baffled aprons or chutes are used in flow ways where water is to be lowered from one level to another or velocities are to be lowered and where it is desirable to avoid stilling basin. The baffle piers partially obstruct the flow, dissipating the energy as the water flows down the chute so that the flow velocities entering the downstream channel are relatively low. Advantages of baffled aprons include economy, low terminal velocity of the flow regardless of the height of the drop, there are no requirements for initial tail water depth and the downstream erosion / degradation is minimised / avoided.

| | |
|---|---|
| Exit discharge from the pipeline | : 4.325 $m^3$/sec |
| Pipe diameter | : 1800 mm ID. |
| Hence, pipe section area | : 2.54 sqm |
| ∴ Approach Velocity, $V_1$ through pipe | = Q / A |
| | = 4.325 cumec / 2.54 sqm = 1.70 m/sec |
| Chute Width selected | = 5 times the diameter of pipe |
| | = 5 x 1.8m = 9m |
| ∴ unit design discharge, q | = 4.325 cumec / 9m |
| | = 0.48 $m^3$/sec |
| Critical Velocity, $V_c$ | = $\sqrt[3]{g * q} = \sqrt[3]{(9.81 * 0.48)}$ |
| | = 1.676 m/sec |

Entrance velocity, $V_1$, should be as low as possible. Ideal conditions exist when $V_1 = V_c$

Here, $V_1$ & $V_c$ are nearly equal i.e. 1.70 m/sec ≈ 1.676 m/sec.

∴ Width of chute selected is appropriate.

The baffle pier height, H, is specified to be to be about $0.8D_c$ to $0.9D_{c,}$

Where, $D_c = \sqrt[3]{(q^2 / g)}$

$\therefore D_c = \sqrt[3]{(0.48^2 / 9.81)}$

$= 0.286$ m

$\therefore H = 0.8\ D_c = 0.8 \times 0.286$

$= 0.2288$m

OR $H = 0.9\ D_c = 0.9 \times 0.286$

$= 0.2574$m

$\therefore$ The value of H i.e. height of baffle pier / block is selected to be 0.25m

The baffle pier width and the clear spacing between two successive piers is specified = 1.5 H = 1.5 x 0.25

= 0.375m say 0.4m

Row spacing of baffle piers along the chute slope should be H divided by the slope. The chute is normally constructed on a slope of 2 : 1 or flatter extending below the outlet channel floor. In the present case, the chute slope selected is 2:1.

$\therefore$ Row spacing = H / 0.5

= 2H = 2 x 0.25

= 0.5m

The length of sloping chute required is minimum providing 4 rows of baffle piers

= (4 +4 ) x 0.5m

= 4m.

Actual provided is = 6m.

The dimension details of the Outfall Structure so designed are produced in Drawing Plate No. DWG 06C.

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# CHAPTER - 4

## STAGE 3 – WATER ASSESSMENT AT UKD, INTAKE JACKWELL, PUMP HOUSE, APPROACH BRIDGE & CAMPUS AT UKD, PIPELINE FROM UKD TO MTPP PLANT

### I. GENERAL :

This chapter contents details regarding Water Storage Assessment & Water Balance at Upper Khajuri Dam (UKD), Intake Jaskwell & Pump House in UKD Reservoir, Appraoch Bridge to Jackwell, Intake Campus at UKD, and Rising Main pipeline from UKD to MTPP Plant.

The "Mechanical Design of Pumping Machinery and Instrumentation & Control" is presented separately in Chapter No 5, and the Details regarding "Electrical Installations" in Chapter No. 6.

### II. STORAGE ASSESSMENT AND WATER PLANNING OF UPPER KHAJURI DAM (UKD) RESERVOIR :

1. Project Parameters –

The water Conveyed from Clear Water Tank at the Ganga River Intake will be first released in the reservoir of Upper Khajuri Dam, and onwards it is further Pumped & conveyed from UKD Reservoir to to MTPP Plant location. As per the 'Water Use Agreement' between WEUPPL & WRD, UP - Water from River Ganga will be lifted for the restricted period of 7 months ($1^{st}$ June to $31^{st}$ December of every year). The UKD reservoir is to act as balancing reservoir for the Plant water storage of five months (December $31^{st}$ to May $31^{st}$ of every year) plus reservation of 9.5 MCM for Irrigation in this period. Therefore, assessment of UKD for its storage capacity to act as balancing tank in wet and dry years is attempted as follow.

The Salient Features of Upper Khajuri Dam (UKD) Project and the Stage – Capacity curve of UKD Reservoir as collected from Water Resources Department, Uttar Pradesh (WRD UP) are enclosed as Annexure XII and Annexure XIII of this Report.

The following data is extracted from the Salient Features Statement.

- Gross Storage capacity : 44.74 MCM
- Dead storage : 2.36 MCM
- Live storage : 44.74 – 2.36 = 42.39 MCM
- Evaporation losses : 2.832 MCM
- The net water utilisation : 42.39 – 2.83 = 39.56 MCM
- Proposed irrigation : 8466 Ha CCA

Considering the storage capacity characteristics of UKD and the conditions laid down in WUA, the water planning of UKD needs to be worked out for two extreme hydrological / meteorological situations.

2. Situation 1 – Very Good rainy season in catchment – Wet / Rich Year

Due to very good rains the inflow of natural precipitation is high and the dam gets completely filled at FSL by 31st of December by way of natural run off and inflow from water conveyance system of WEUPPL together. The evaporation during this rich period gets compensated by the natural inflow. Then the reservoir starts depleting since 1st January due to water withdrawal for MTPP Plant plus Irrigation utilisation and evaporation losses. The evaporation losses for the lean period with UKD at FSL as on 1st January are worked out at below -

Evaporation losses

Considering that UKD is filled up to FSL level RL 167.03m as on 1st January.

The water withdrawal for plant will be at uniform rate – 3 MCM per month

The irrigation withdrawal is also considered uniform per month = 9.5 / 5 = 1.9 MCM / month.

Therefore, Total water drawl per month = 3 + 1.9 = 4.9 MCM

A Table is prepared at below where monthly storage, water surface area and evaporation losses are given. Storage volume corresponding to different lake levels is taken from the Storage-mass curve referred in Annexure XIII. The unit evaporation rate is used from IMD data on Internet for the relevant regions.

Scenario - UKD reservoir is full to FSL as on 31st December

Period – 1st January to 31 st May

| Date | Storage Volume | Volume Withdrawn in the month | Balance Volume | Reservoir Level | Differenc e in Level | Average Surface Area in the Month | Rate of Evaporation in the Month | Evaporation in the Month |
|---|---|---|---|---|---|---|---|---|
| | MCM | MCM | MCM | RL-m | M | M. Sqm | mm/sqm/month | MCM |
| 01/01 | 44.74 | | | 167.03 | | | | |
| | | 4.9 | 39.84 | | 0.50 | 9.8 | 71.07 | 0.696 |
| 01/02 | 39.84 | | | 166.53 | | | | |
| | | 4.9 | 34.94 | | 0.86 | 5.70 | 89.55 | 0.510 |
| 01/03 | 34.94 | | | 165.67 | | | | |
| | | 4.9 | 30.04 | | 1.02 | 4.80 | 136.56 | 0.655 |
| 01/04 | 30.04 | | | 164.65 | | | | |
| | | 4.9 | 25.14 | | 1.13 | 4.34 | 173.15 | 0.751 |
| 01/05 | 25.14 | | | 163.52 | | | | |
| | | 4.9 | 20.24 | | 1.22 | 4.02 | 204.26 | 0.821 |
| 01/06 | 20.24 | | | 162.30 | | | | |
| **Total – January to June** | | | | | | | | **3.433 MCM** |

The reservoir storage condition as on 31st May due all the withdrawals will be as below –

1. Plant water withdrawal : 3MCM x 5 : 15 MCM
2. Irrigation water Withdrawal : 9.5 MCM
3. Evaporation : 3.433 MCM
4. Miscellaneous losses on account seepage below dam, unauthorised use by near by habitants, etc. : 0.224 MCM
   At 0.5% of total storage as on 31st Dec i.e. 44.74 MCM
   (Losses in 5 months period)

-----------------------------

Total Depletion from 1st Jan. to 31 st May : 28.157 MCM

Therefore, balance storage in reservoir as on 1st June

= 44.74 – 28.157 = 16.583 MCM.

i.e. The reservoir capacity is sufficient to cope with the storage requirements under the ‘Situation I’

3. Situation 2 – Very Bad rainy season / Drought Year in catchment – Dry Year

Considering Dry year in which rains are less than 50% dependability value and there is very marginal or even no precipitation inflow into the dam and the dam is at MDDL as on 1st June of the year. In this scenario, the inflow in to the reservoir will be only by way of pumping resorted by the WEUPPL from Ganga Intake.

Plant water requirement : 36 MCM

Reservation for Irrigation requirement in lean season : 9.50 MCM

-----------------------------------

Total : 45.5 MCM

This quantity is to be pumped in seven months.

Hence, quantity of in flow in UKD per month = 45.5 / 7 = 6.5 MCM per month.

There will be an outgoing flow of 3 MCM per month from UKD to Plant site. Therefore, the net retention in UKD per month = 6.5 - 3 = 3.5 MCM from 1st June to 31st December.

From 1st January on wards, there will be no inflow from Ganga water Intake . But only out flow for Plant water with drawl plus Irrigation demand plus Evaporation losses.

Evaporation Losses

The evaporation losses will take place from 1st June to 31st May of succeeding year exclusively from the inflow through WEUPPL water carriage system.

As stated at earlier, the Water Level is assumed at MDDL as on 1st June. The water levels at each month end and the estimated evaporation losses in the month are calculated in the table at below -

Scenario - When Reservoir is at MDDL on 01st June and there is practically No Rainfall yield into the Reservoir during the succeeding year

Period –June to December

| Date | Storage Volume | Net Volume Added in the month | Cumulative Balance Volume | Reservoir Level | Difference in Level | Average Surface Area in the Month | Rate of Evaporation in the Month | Evaporation in the Month |
|---|---|---|---|---|---|---|---|---|
| | MCM | MCM | MCM | RL-m | M | M. Sqm | mm/sqm/month | MCM |
| 01/06 | 2.36 Dead Storage | | 2.36 | 155.50 | | | | |

| Date | Storage Volume | Net Volume Added in the month | Cumulative Balance Volume | Reservoir Level | Difference in Level | Average Surface Area in the Month | Rate of Evaporation in the Month | Evaporation in the Month |
|---|---|---|---|---|---|---|---|---|
| | MCM | MCM | MCM | RL-m | M | M. Sqm | mm/sqm/month | MCM |
| | | 3.5 | 5.86 | | 2.50 | 1.40 | 155.63 | 0.218 |
| 01/07 | 5.86 | | | 158.00 | | | | |
| | | 3.5 | 9.36 | | 1.25 | 2.80 | 108.46 | 0.304 |
| 01/08 | 9.36 | | | 159.25 | | | | |
| | | 3.5 | 12.86 | | 1.15 | 3.04 | 99.48 | 0.302 |
| 01/09 | 12.86 | | | 160.40 | | | | |
| | | 3.5 | 16.36 | | 1.05 | 3.33 | 97.41 | 0.324 |
| 01/10 | 16.36 | | | 161.45 | | | | |
| | | 3.5 | 19.86 | | 1.00 | 3.50 | 96.97 | 0.338 |
| 01/11 | 19.86 | | | 162.45 | | | | |
| | | 3.5 | 23.36 | | 0.95 | 3.68 | 76.82 | 0.282 |
| 01/12 | 23.36 | | | 163.40 | | | | |
| | | 3.5 | 26.86 | | 0.80 | 4.38 | 63.65 | 0.279 |
| 01/01 | 26.86 | | | 164.20 | | | | |
| | | | | | | | | |
| **Total – June to December** | | | | | | | | **2.047 MCM** |

Period - January to May :

| Date | Storage Volume | Volume Withdrawn in the month | Cumulative Balance Volume | Reservoir Level | Difference in Level | Average Surface Area in the Month | Rate of Evaporation in the Month | Evaporation in the Month |
|---|---|---|---|---|---|---|---|---|
| | MCM | MCM | MCM | RL-m | M | M. Sqm | Mm/Sqm/Month | MCM |
| 01/01 | 26.86 | | | 164.20 | | | | |
| | | 4.9 | 21.96 | | 1.20 | 4.08 | 71.07 | 0.289 |
| 01/02 | 21.96 | | | 163.00 | | | | |
| | | 4.9 | 17.06 | | 1.30 | 3.77 | 89.55 | 0.338 |
| 01/03 | 17.06 | | | 161.70 | | | | |
| | | 4.9 | 12.16 | | 1.45 | 3.38 | 136.56 | 0.461 |
| 01/04 | 12.16 | | | 160.25 | | | | |
| | | 4.9 | 7.26 | | 1.85 | 2.64 | 173.15 | 0.457 |
| 01/05 | 7.26 | | | 158.40 | | | | |
| | | 4.9 | 2.36 | | 2.90 | 1.69 | 204.26 | 0.345 |
| 01/06 | 2.36 | | | 155.50 | | | | |
| | | | | | | | | |
| Total for January to May | | | | | | | | **1.890 MCM** |

| | |
|---|---|
| Total for June to December | **2.047 MCM** |
| Grand Total for June to May | **3.937 MCM** |

The statement at above gives the total evaporation losses during year at the worst water storage scenario.

Also, it indicates that the cycle of inflow quantum and out flow quantum starting from 1st of June to next year's 31st of May is balanced as the starting and ending storage volume / level is the same. The planning is sufficient to tackle the conditions under 'Situation 2'.

4. Inference & Planning :

A. The evaporation loss of 3.937 MCM/yr in the worst case scenario worked out at above needs to be incorporated/covered in the total volume of water lifted from Ganga River.

(This quantity is considered in total water demand – Ref Chapter 1, Para IV "Overall Water Demand of the System')

B. The analysis worked out under situation I and Situation II that the inflow and out flow discharges planned are fulfilling the conditions stipulated in WUA and the capacity of UKD is sufficient to operate as Balancing Reservoir for the Project Activities under consideration.

## III. PLANNING & DETAILING OF INTAKE JACKWELL & PUMP HOUSE AT UKD RESERVOIR :

1. Exploring Intake Structure Locations :

As per the directives mentioned in the 'Water Use Agreement', WEUPPL can lift water till the minimum reservoir level at RL 155.60 M. Water below this level cannot be pumped for Plant use.

As per the site Topographical & Hydrographical Survey, it is observed that the lowest water accumulation in the reservoir is near the dam embankment in the river gorge portion where there was the flow of erstwhile parent river. Therefore, Intake structure needs to be located inside the dam around this location.

TThe Plant location of MTPP is located on right bank side of this River/Dam. Therefore the Intake Structure needs to be planned on the right bank/side of this River course inside the dam.

As the water is to be drawn from the reservoir up to RL155.600m (MDDL), the obvious location of Jack well is at the point where ground levels are below this level. Therefore, a location is selected near the deepest portion of reservoir where the water can be drawn through the inlet gate opening of jack well directly from the reservoir storage without the requirement of any intake channel to fetch the water towards the jack well. As this location is near the deepest gorge portion, the dam section is maximum and the upstream toe of dam wall/embankment is at a distance more than 50m from the centre of dam. As the reservoir will always remain filled with water, an approach bridge is necessary to approach the pump house from the top of dam. The piers for the bridge cannot be constructed in the upstream slope of dam embankment as it will disturb the settled earth embankment status. Therefore, it is not possible to provide any intermediate pier between top of dam and the jack well. As such, the bridge super structure can have only one span for the full length (> 50m) of the bridge. It is required to transport pump machinery and cranes over this bridge and frequent movement of heavy vehicles during construction, commissioning, running and maintenance activities. Therefore, the bridge needs to be designed for 'Class A' loading. The bridge of single 50m span with 'Class A' loading will be very heavy and not practicable to a certain extent.

Therefore, to avoid the necessity of very long span approach bridge, another location for the jack well inside the reservoir near the Head regulator of Irrigation Right Bank Canal (RBC) is assessed. The RBC outlet level is RL 155.448 m, this is equivalent/just below the permissible water drawl level of RL 155.60 m. There is an existing approach channel for this outlet from the lowest reservoir levels. If we plan intake location near this channel, additional inlet channel towards the jackwell location from this approach channel of RBC will be required. At this location, the dam section is smaller and the approach bridge of length 20m or less is possible. The first location in gorge portion is named as '<u>Intake Structure – Alternative Location No.1</u>' and the other location near HR of RBC is termed as '<u>Intake Structure –</u>

Alternative Location No. 2’. The viability of both the locations is worked out independently.

2. Intake Structure – Alternative Location No.1

This location is situated in gorge portion of the reservoir on right side of original River flow. The ground levels at the selected location are around RL 152.5m. The location of Intake Structure is shown in Drawing Plate No. DWG 10.

The water levels in the reservoir will be fluctuating from RL 155.6m (MDDL) to RL 167.03m (FSL). The Motor Floor & Valve Operation installation position needs to be located above FSL to avoid the submergence at any instance. Considering the water level variation, location of Prime Movers above FSL & requirement of Suction piping for NPSH criterion, for this Stage of Pumping also Vertical Turbine Pumps are proposed.

3. Stage-3 Pumps Capacity Calculations :

As per the terms of WUA, all the water for Plant is to be lifted from UKD and it is to be limited to 36 MCM per Annum.

| | |
|---|---|
| Water requirement | : 36 MCM/Year |
| Pumping Days in Year | : 365 Days |
| Pumping Hours per Day | : 16 Hours |
| Water requirement in $m^3$/sec | : 1.712 $m^3$/sec<br>i.e. 6163.20 $m^3$/Hr |
| Minimum Water Level at Pumping Station /MDDL | : RL 155.60 m |
| Pump Sump / Jackwell Floor Level | : RL 152.00 m |
| Maximum Water level in UKD | : RL 167.03 m |
| Motor Floor Level & Pump Delivery Level | : RL 170.05 m |
| (1.5 m above Dam Top Level of RL 168.55 m) | |
| Rising/Pumping Main Pipeline | |
| Length of Pipeline | : 7.000 km |
| Diameter of pipeline | : 1200 mm |
| Material of pipeline | : MS |
| Delivery Level at MTPP Plant | : RL 194.20 m |
| Static Head calculation | |
| Static Head on Pumps considering delivery level | |

= RL 194.20 m – RL 155.60 m

= 38.60 m

Static Head on Pumps derived from Hydraulic Gradient line*

= 49.15 m

| | |
|---|---|
| Station Losses | : Approx. @ 1.5 m |
| Exit Head | : 2.0 m |
| Frictional Head loss in Pipeline, $H_f$ | : 8.84 m |
| (Head Loss by Hazen William Formula). | |
| Add 10% losses for bends | = 0.884 M |
| Total head loss in Pipeline | = 8.84 + 0.884 = 9.724 M |

Gross Head on Pumps = 49.15 m + 9.724 m + 1.5 m + 2.0 m

= 62.374 m, Say 63.0 m

Pump Capacity, HP required = (w x Q x H ) / (75 x n)

Where –
w – unit weight of water = 1000 kg/m3
Q – Design Discharge – 1.712 m3/sec
H – Design Gross Head – 63m
N – Efficiency of pumps – 85%

HP required = (1000 x 1.712 x 63) / (75 x 0.85 )

= 1691.85 HP

Electric Motors required = HP x 0.746 kW

= 1691.85x 0.746

= 1262 kW

Considering Power Margin at 15%, net Motor Capacity required

= 1.15% of 1262 kW

= 1451 kW

*(Refer to Chapter No. 5, 'Mechanical Design of Pumping Machinery of detail Calculations)*

*With reference to the Mechanical Design, Duty points are finalised as.*

- Number of Pumps : 2 Working + 1 Stand by
- Discharge Per Pump : 0.856 cum/sec
- Motor rating for each Pump : 725 kW i.e. 975 HP

*(Hydraulic Gradient Line -

Refer to Drawing Plate No. DWG 15. The Hydraulic Gradient Line plotted on the L-section along ground levels of the pipeline route, indicates that the HGL intersects the GL profile between Ch.4500 m to Ch. 6000 m and the maximum negative pressure encountered is 3.1 m at Ch. 5350m. To solve the situation of negative hydraulic pressure, it is required either to provide a Break Pressure at this location or to increase the pressure head on pumps to raise HGL elevation value in this length.

Taking the detention period at BPT 15 minutes. The detention volume required = 6164 m3 / hour ÷ 15 mins = 1,541 m3. If depth of storage is kept 3.3m, the storage area of BPT works out to 440 m2. The gross area for BPT structure required will not be less than 350m x 350m. This location is in Forest Department land and, hence, it will be difficult to get land to this extent for such type of structure.

Therefore, the alternative of increasing pressure head on pumps is proposed. A revised HGL with increase in head on pumps such that minimum positive pressure of 2m is achieved at the highest elevation point at Ch. 5350m is indicated in DWG 02. As per the Revised HGL, the HGL elevation value required at pumps location of UKD jack well is RL 218.5 including friction in pipeline.)

4. <u>Jack Well & Pump Sump Parameters :</u>

<u>For Alternative 1 Location -</u>

The location of Jack well is selected inside UKD reservoir near the dam embankment at approximate dam chainage 600m and offset 60m upstream. The reservoir bed level at this location is at RL 152.5m. The exact location is indicated in DWG 10. The inside diameter of Jack well is kept 10m. Sump Floor level is worked out to RL 152.00m. There are three VT pumps of each 975 HP are provided on pump floor proposed at RL 170.050m. Therefore, the depth of Jack well = 170.05 – 152.0 = 18.05m. The codal stipulations as regards to various design parameters for the pump sump and the actual provisions made are discussed here follow.

In all the standard references of IS Codes, HIS 9.8 Manual and CPHEEO, the various sump parameters are expressed / worked out related to the diameter of Bell Mouth (D) provided at the end of suction pipe of the pump for / at the entry of flow. The various sump parameters for the present case are worked out as follow. These Parameters are planned as per IS 15310 & ANSI/HI- Pump Intake Design.

- **D – Bell Mouth Diameter**

  *The velocity of flow at the entry of bell mouth shall not exceed 1.3 m/sec.*

  ∴ Taking velocity at entry as 1.2 m/sec,

  The discharge per pump = 1.712 / 2

  = 0.856 cumec

  C.S. area of bell mouth = Q / V = (0.856 $m^3$/sec / 1.2 m/sec)

  = 0.713 $m^2$

  ∴ D, diameter of Bell Mouth = 0.9530m

  It is proposed to provide D = 0.950 m

  The actual velocity produced with D = 0.950 m will be

  = Q / A = 1.207 m/sec

  < 1.3 m/sec admissible.

- **S – Submergence**

  It is the distance from minimum water level in sump to bottom of bell mouth.

  Minimum specified = 1.5D = 1.5 x 0.950 m

  = 1.425 m

  Actual S provided = 3.60 m > 1.425 m minimum required.

  (Sump Floor Level is at RL 152.0m, MDDL at RL155.60 m)

  *(The actual provided Submergence is with reference Parameters specified at above & the NPSH calculations presented in the Chapter of Mechanical Design)*

- **C – Bottom Clearance**

  It is the distance between bottom of bell mouth and sump floor bottom level.

  Minimum D required = D / 2 = 0.950 m / 2

  = 0.475 m.

  Actual distance provided = 0.60 m > 0.475 m minimum required.

- **MWL - Minimum Water Level**

  It is the distance between sump bottom and minimum water level in jack well.

  Minimum specified = C + Min S + Safety Margin

= 0.60 + 1.425 + Safety Margin

No specific figure is stipulated for minimum Safety Margin. We have adopted it 0.50m as adequate.

∴ Minimum WL required = sump bed level + Min. C + Min. S + SM

= RL 152 + 0.6 + 1.425 +0 .5

= RL 154.525 m.

Actually provided is at RL 155.6 m. > RL 154.525 m, safe.

- **W – Width of Sump**

Minimum specified W = 2 ND + (N-1)T

where N is the number of pumps and T is the pier wall thickness between two pumps. In the present case, the sump is a circular common jack well and no pier is proposed in between pumps. So, it is an open sump and not unitised sump. Hence, T = 0.

∴ W = 2 ND = 2 x 3 x 0.950

= 5.7 m

Therefore, from the consideration of minimum requirements of sump dimensions, 5.7 m internal diameter of jack well is sufficient. But considering the implications of arranging pumps at pump floor level, the internal diameter of jack well is proposed to be 10.0 m.

- **SWC – Side Wall Clearance**

It is the clear distance between the vertical wall of sump and edge of end side bell mouth

In case of Jackwell Sump = Clear Distance = 0.25D

= 0.25 x 0.95 = 0.2375

The internal diameter of jack well is 10 m. Three number of pumps installed in Pump House / Jack well with 3.5m distance centre to centre. The diameter of bell mouth is 0.950 m.

∴ SWC provided from nearest Jackwell Wall = 1.03 m > 0.2375 m

& from nearest column edge = 1.13 m > 0.2375 m

- **B – Back Wall Clearance**

It is the distance between the bell mouth and back wall of the sump.

Minimum specified = between ¾ D to D

= between ¾ of 1.05m and 1.05m

= between 0.0.7875m and 1.05 m

Actual B provided = 1.505 m , OK

(For Circular Jackwell it will be clearance from nearest Wall)

- **L- Approach Channel Length**

The unobstructed channel length up to bell mouth needs to be minimum 5D / Distance from the pump inlet bell centreline to the intake structure entrance

5 D = 5 x 0.95

= 4.75 m

The inlet gates provided outside the Jackwell Wall. There is no obstruction to flow at this location. The obstruction to flow may be treated at the location of screen of Trash Rack.

The distance from trash rack to bell mouth provided = 7.9m

OR Distance from Jackwell Wall to Bell Mouth Centre = 5.0 m

> 4.75 m OK.

- **Y – Distance from Screen**

Distance from the pump inlet bell centreline to the through flow screen

= 4 D Min = 4 x 0.95m

= 3.8m

In the present case, this distance

= 5m (dia. Of well) + 0.8m wall thickness

= 5.8m > 3.8m minimum required

- **Inlet Gates Size** (Ref: ANSI/HI 9.8 – 1998, para 9.8.2.1.4 and Table 9.8.2)

Maximum pump approach velocity in pump bay specified = 0.5 m/sec.

∴ The minimum area of inlet gate opening required = Design discharge / permissible velocity

Design Discharge per pump = 1.712 cumec

∴ The minimum area of inlet gate opening required,

= 1.712cum / sec ÷ 0.5 m/sec = 3.424 $m^2$

It is proposed to provide two gate openings of equal size.

Hence, area reqd. per gate = 3.424 / 2

= 1.712 $m^2$

Proposed gate size – 1.35m (W) x 1.35m (H)

= 1.8225 $m^2$ > 1.712 $m^2$

∴ Actual approach velocity, V, developed = 1.712 cumec / (2 x 1.35 x 1.35) $m^2$

= 0.47 m/sec < 0.5 m/sec, acceptable.

- **Inlet Gate Details**

These two gate openings shall be provided side by side in the direction of flow. The top of opening will be at level with MDDL 155.60m i.e. gate sill level at level = 155.6 – 1.35 = RL 154.25m

The maximum water column/ maximum static pressure on the gates will be on the upstream face of gate when the reservoir water is at FSL at RL 167.03m.

∴ Max hydraulic pressure = 167.03 – 154.25 = 12.78m

As per IS 4622 : 2003, clause 3, the gate which operates under a head of less than 15m is classified as 'Low Head Gate'. In the present case the maximum head is 12.78 m above sill level of the gate. Hence, it is a 'Low Head Gate'. These gates are 'slide gates' in which the operating member – Gate Leaf – slides on the sealing surface provided on the frame. The total gate assembly incorporates gate leaf, guide groove, sealing surface, embedded parts, tie rod, hook, lifting frame & hoist. These gates are generally operated by screw / winch type mechanical hoists. This gate shall be operated at Pump House floor level.

The structural design of this gate is to be worked out as per IS 4622 : 2003 / IS 5620 : 1985 during detail design phase.

- **Screen Requirement** (Ref: IS 15310, Clause 4.2.1.7)

  Codal requirement - Screens should be provided at the inlet of pump bay in order to arrest all trash and floating material and straighten the flow.

  In the present case, it is proposed to provide a MS mesh screen removable type Trash Rack just before the inlet gates of sump pit.

- **Y - Screen Location** (Ref: ANSI/HI 9.8-1998 Table – 9.8.1)

  It is the distance from the pump inlet bell centre line to the through flow screen.

  | | |
  |---|---|
  | Minimum specified | = 4 D = 4 x 0.95 m |
  | | = 3.80 m |
  | Actual Y provided | = 7.8 m |
  | | > 3.8 m minimum required. OK |

- **Trash Rack Details** (Ref: IS 11388 : 2012)

  IS 11388 : 2012 deals with ‘Recommendations on Design of Trash Racks for Intakes’. It is proposed to locate the trash rack screen on the outer side of the inlet gate. The trash rack will cover the entire area of inlet opening / gate. It will be a removable section rack which will be installed by lowering the sections between the side guides or grooves provided in the trash rack structure so that the sections will be readily removed by lifting them through/from guides. These will be either Slide of Side Bearing type. These will be operated by winch/ hoist arrangement installed in Pump House at pump floor level.

  In the present case, the unit of trash rack is of size 1.35m (w) x 1.35 m (H), for which manual cleaning is proposed.

  Ref Clause 6.1 of IS 11388 : 2012)

  | | |
  |---|---|
  | Maximum velocity through screen | = 0.75 m/sec |
  | The trash rack area provided | = 1.35m x 1.35m |
  | | = 1.8225 sqm |

As per clause 10.2.1 of the said IS, not more than 33 pc of trash rack area is allowed to be clogged.

Therefore, the clog free / open area of screen required,

$$= 0.67 \times 1.8225 \text{ m}^2 = 1.221 \text{ m}^2$$

∴ Actual Velocity that will develop through screen,

$$= 0.856 \text{ cumec} / 1.221\text{m}^2$$

$$= 0.701 \text{ m/sec}$$

$$< 0.75 \text{ m/sec max. Limit. OK.}$$

5. Details of Pump House Structure :

The jack well is proposed of circular shape with 10m internal diameter and 18.05m depth which satisfies the hydraulic requirements of sump for three pumps (2W + 1 SB) each having maximum discharge of 0.856 cumec. However, this shape and dimension is not sufficient and suitable for accommodating the Motor units and other essential components required in the pump house.. The general layout of pump house in plan and section is indicated in Drawing Plate No. DWG 11 & DWG 12.

An approach bridge of 51m length is proposed from top of dam to Pump House, vide the details elsewhere in this Report. The road top level of the approach is fixed at RL 170.05m. Therefore, the pump floor level of the pump house is proposed to be at par with bridge deck slab surface i.e. at RL 170.05m.

The shape of Pump House is kept rectangular with dimensions 12m X 14m.

| | |
|---|---|
| Rectangular Pump House | : 12 m x 14 m |
| Pump Sump / Jackwell Floor Level | : RL 152.00 m |
| Maximum Water level in UKD | : RL 167.03 m |
| Dam Top Level of UKD | : RL 168.55 m |
| Motor Floor Level | : RL 170.05 m |
| Gantry Corbel Top | : RL 178.05 m |
| Pump House Roof bottom level | : RL 181.05 m |

The Pump House will be supported on 8 No. of columns founded on reservoir bed around the jack well. There will be additional 4 No. of columns will be inside jackwell supporting the Pump & Motor assembly on the Pump Floor. The inside columns will terminate at Motor Floor Level.

Three number of pumps each of 975 HP & motors of 725 kw are arranged in single line on centre line of the pump floor. The size of base plate of each pump assembly is expected around 3m x 2m. The clear distance between base plates of individual pumps is kept 1.5m. End wall distance from edge of base plate is 0.5m to 1 m. The pump assembly will be fixed on pump supporting beams provided at floor level. The delivery pipes of pumps will provide ‘on floor’ delivery. The delivery pipes and all valves located on these will be at pump floor level. The delivery pipes will be connected to a common Manifold for all three delivery pipes. The manifold ends with connection to Rising Main pipeline through the isolation valve. The manifold pipe and rising main pipe are with the same internal diameter of 1200mm.

The pump house is to accommodate the Motor units, Pump delivery pipes, manifold, valves, gantry, control panels and a space for repair bay. All these requirements are attained in the layout produced in drawing Plate No. DWG 12. A Rolling Shutter door opening of size 3.5m (w) x 5m (h) is kept at approach bridge end for entry to pump house.

The eight numbers of columns coming from reservoir bed up to floor of pump house continue up to roof level. The corbels for supporting the overhead gantry crane are supported by these columns. The distance of lower gantry beam over pump floor is kept 8m. The clearance of roof slab over gantry beam required minimum is 3.0m. Hence, height of pump house from pump floor to roof slab works out to 11m. The Circular EOT Crane will be of capacity 15MT / 5 MT.

As stated earlier at above, there are sluice type inlet gate and removable type sliding trash rack sections are proposed on inlet opening of jack well. This gate and trash rack will be operated from pump floor level by employing 5-7.5 MT Gantry. This arrangement is provided out side the pump house room. This gantry will be supported on two columns resting on the Gates & TR walls.

6. Intake Structure – Alternative Location No. 2 :

As the Approach Bridge single Span Length for Alternative 1 is 50m plus, the Alternative location – 2 is explored, wherein the Approach Bridge Single Length is around 20 m.

This second alternative location is inside the reservoir near the Head regulator of Irrigation Right Canal (RBC). The jack well is proposed near the upstream toe of dam section. At this location the Ground Levels is at RL 160.5m which is higher than MDDL (i.e. RL 155.6m) and therefore, water is required to be fetched through an Intake Channel constructed up to MDDL (RL 155.60 M) level. There is an existing approach channel constructed by WRD for accessing reservoir water to Head Regulator of RBC when lake water levels are below RL 160m, the channel invert is at RL 155.448 m . The jack well location selected is just adjacent – at 10m distance – to this channel. As such, the existing channel can be utilised for fetching water to the proposed Jackwell by suitably modifying and remodelling. The details of all components of intake structure at alternative location No.2 are given Drawing Plate DWG 14. The various aspects involved in selection of this alternative location are briefly described as follow.

**Jack well & Pump House -**

The project parameters, design aspects, hydraulic sizing and structural arrangement of Jack well and pump house worked out for alternative location No.1 remains the same. Therefore, the same structure is planned at location No.2. The only difference is that the ground level at jack well location will change from RL 152.50m to RL 160.50m. This will necessitate excavation for Jackwell sump to the extent of 8m.

**Intake Channel -**

As the ground level at jack well location is higher than the MDDL RL 155.60m, an intake channel (around 10 m length) is necessary to connect the Jackwell inlet opening to the existing RBC approach channel already available /constructed by WRD. The location of jack well is selected just adjacent to RBC approach channel. Hence, the length of intake channel required from jack well to approach channel is only 10m.

The route / layout of RBC approach channel in the reservoir area are shown in drawing no. DWG 14. This RBC approach channel is currently in use and supplying water to RBC HR. As per Salient Features sheet of the dam, the sill level of canal sluice at RBC HR is at RL 155.448m. The channel is rock excavation and in unlined status. The exact present section of the channel could not be ascertained as it was under water on the date of survey. However, it is possible to be in silted condition and with irregular profile.

As it is proposed to use this channel as approach channel to jack well of this project, too, it is necessary to modify and remodel to carry the required discharge i.e. 1.712 cumec, even at the lowest reservoir level of RL 155.60m. The length of the RBC approach channel is approximately 400m. It is proposed to remodel the section as trapezoidal section with bed width 1m, side slopes at 1:1 and longitudinal gradient 1:200. The section is to be lined with in situ cement concrete lining.

With these section parameters, the flow depth required is 0.75m to carry the required discharge of 1.712 cumec plus certain margin. The approach channel needs to start from the point where the ground level is at MDDL i.e. at RL155.60m and the depth of channel at this point will be minimum 0.75m. The channel will run from this point up to upstream head wall of RBC HR with the section parameters stated at above. The depth of channel will increase gradually as it progresses towards dam. The ground level at location where intake channel (for Jackwell) takes-off from approach channel is at RL 160m. Hence, the depth of excavation at this location is 7.15m and top width 8.70. The RBC Approach Channel details as proposed with remodelling are as follow.

- Length : 400m
- Bottom width : 1m
- Side slopes : Till RL 155.60 m – 1H : 1V
  RL 155.60 m above 1H : 0.25 V
- Nature of section : Bed and sides Lined with in situ CC lining
- Bed gradient : 1:200
- Minimum Depth of flow expected : 0.75m
- Velocity at minimum flow depth : 1.96 m/sec

- Discharge at minimum depth of flow : 2.57 cumec
  > maximum required 1.712 cumec

The details of entry of Jackwell intake channel and its connection with inlet opening of jack well are given at section B-B in Drawing Plate No. DWG 14.

The Jackwell intake channel is proposed as RCC trough. The length is 10m. At the entry, the width of channel is 5.7m at the entry of inlet opening of jack well. The bed gradient is nominal i.e. 0.05m in 10m. The velocity of in the intake channel at minimum depth of flow works out to 0.46 m/sec which is within maximum limit of 0.6 m/sec

((With ref to IS 1710 (Fig 8), AND w.r.t. ANSI/HI- Pump Intake Design Cl. 9.8.2.4.4, the inlet Approach velocity to Pump Sump is restricted to max. 0.6m/sec).

No controlling gate is proposed on approach channel at the entry of intake channel because when the irrigation Head Regulator gate is closed, there is no possibility of water going elsewhere than the intake channel. At the end of intake channel, there is control of inlet gates of jack well.

## IV. APPROACH BRIDGE :

The intake Jackwell Pump House is located on the Up-Stream of Dam wall, therefore, an Approach Bridge is planned for the Jackwell Access.

Typically in this case, the piers for the bridge cannot be constructed in the upstream slope of dam embankment as it will disturb the settled earth embankment status. Therefore, it is not possible to provide any intermediate pier between top of dam and the jack well. As such, the bridge super structure can have only one span for the full length of the bridge.

For the Jackwell at Alternative location 1, the single span length works out to around 51 m. And for Jackwell at Alternative location 2, the single span length works out to around 20 m.

The UKD Dam Top level is at RL 168.55 m., considering support pedestal of depth 1.50m at the Dam Top Level (on Dam wall top), the Bridge deck level is proposed at RL 170.05 m

The bridge is proposed to be designed for ‘Class A’ loading.

- The super structure will be provided as open Truss Frame Through Bridge.
- The deck slab in RCC shall be provided on the lower tier of Steel frame
- The deck slab will carry 1200 mm diameter MS water conveyance pipeline rested on chairs, Cable tray RCC trough for carrying electrical cables of pumps from pump house to Switch Gear Room located at downstream area of dam and the road carriage way of width 3.5m.
- The dam wall side bridge super structure end will be rested on a concrete bearing block/Pedestal constructed on top of dam.
- The jack well side super structure will be rested on a RCC pier constructed adjacent to Jackwell wall.

The details of the RCC pier and super structure arrangement are shown in Drawing Plate DWG 13.

## V. INTAKE CAMPUS AT UKD :

It is proposed to establish the following Structure / facilities at UKD site -

1. Intake Jackwell (10m ID) & Pump House (12m x 14m)
2. Approach Bridge to Pump House from top of dam
3. Cable Trench / Trough from Pump House to Switchgear Room : Length 44 m
4. The overall area fenced / demarcated campus area - 90 m (L) x 32 (W) m - housing the following facilities -
   A. Switchgear Room Building : 23 m x 9 m, consisting of -
      I. Switchgear Panel Room : 19 m x 9 m
      II. Store Room : 4 m x 6 m
      III. Operator Room : 4 m x 3 m
   B. Electrical Sub Station (33 kV) Campus – Area - 26 m length x 17 m width
   C. Space for Anti-Surge Device, Material Yard, miscellaneous facilities, etc. Area - 33.5 m x 32 m
   D. Internal roads in the campus.
5. Approach road to Campus.
6. Incoming pipeline from Ganga Intake Works

7. Outgoing pipeline from UKD to Plant site.

The proposed locations of all these structures and facilities at UKD dam site are indicated in Drawing Plate No. DWG 11.

Foundation :

The general geological features of the UKD area shows rocky ground conditions. Therefore, on preliminary assessment shows open foundation conditions for all structures in the UKD area.

## VI. DETAILS OF RISING MAIN PIPELINE FROM UKD INTAKE PUMP HOUSE TO MTPP PLANT RAW WATER RESERVOIR :

Refer to Drawing Plate No. DWG 12.

Water from UKD Reservoir will be pumped & conveyed to MTPP Plant Raw Water Reservoir by Stage-3 Rising main pipeline.

1. Pipeline Project parameters

- Route length of pipeline : 7000m
- Design discharge through pipeline : 1.712 $m^3$/sec
- No. of rows of pipeline : 1 No.
- Motor Floor level / Valve Operating level : RL 170.05m
- Plant site Ground Level (Average) : RL 191.50
- Gross Head on Pipeline : 38.23 m
  (As worked out at above & Chapter 5, Mech. Design)
- Pipeline material : Mild Steel
  ((Refer Annexure I 'Selection of Pipeline Material)

2. Selection of Pipe Diameter and thickness

The range of appropriate diameters is explored by considering the pipe flow velocity range between 1.2 m/sec to 2.1 m/sec. The corresponding diameters found out are. These diameters are checked for the Techno-Commercial appraisal i.e. Optimisation of Economical Diameter, considering capital cost of pumps & pipes and running energy cost for the design period of 25 years. The project data, design parameters and the process sheet of this exercise is kept in Annexure XV. It is observed that 1200 mm diameter with shell thickness 11 mm is most economical.

3. Structural Analysis and Design for shell thickness

The pipeline diameter and the shell thickness under consideration needs to be checked for the following stress conditions –

1. Pipe laid in Trench Condition (Laid Under Ground) :
    A. Check for Deflection –
        i. Partial Vacuum without side support.
        ii. Partial Vacuum with side support.
        iii. Pipe full with side support.
    B. Stresses for Partial Vacuum Condition (Total Compressive Stress) –
        i. Without side supports.
        ii. With side supports.
        iii. Buckling under Partial Vacuum Condition.
    C. Stresses for pipe full and side support (Total Tensile Stress).
2. Pipe laid on Chair Condition (Laid Above Ground with Chair to Chair Dist. 6 m) :
    A. Check for Deflection.
    B. Total Hoop Stress.
    C. Total Longitudinal Stress.

A note on MS Pipeline Shell Thickness Design is given in Annexure II. The calculations for Stress Analysis for 1200mm diameter 11 mm shell thickness for pipes laid in ‘Trench condition’ are produced in Annexure XVI and for pipes laid ‘above ground’ are produced in Annexure XVI. The sample calculations for Techno-economic analysis are produced in Annexure XVII.

Therefore, considering the techno-economic analysis and structural viability, 1200 mm diameter MS pipe of 11 mm shell thickness pipes are selected for the conveyance pipeline from Upper Khajuri Dam to MTPP Plant site.

4. Pipeline line route and Pipe Laying

A single row MS 1200mm internal diameter with 11 mm shell thickness is proposed all along the route length from Pump House on jack well in UKD reservoir up to Plant site. The total route length from Manifold of the pumps to the raw water reservoir in Plant area is 6997m say 7000m. The entire route and L-section of the ground levels along the route is shown in Drawing Plate No. 12. This split up of the route length is as follow –

- Ch 0 to Ch. 122m : 122m - Over dam structure
  - 55m : From Pump House to top of dam over Approach Bridge.
  - 7.5m : Over top of dam wall width
  - 39.5m : Over downstream dam slope
  - 20m : D/s toe of dam to point beyond Toe Drain of dam
- Ch. 122m to Ch. 1600m : 1478m – UKD to SH5
- Ch 1600m to Ch.5300m : 3700m – Along SH5
- Ch. 5300m to Ch. 6997m : SH5 to MTPP Plant site.

The first 100m length pipeline till it comes out of dam structure will be laid on chairs. The pipeline will be laid underground for all the remaining length. It will be laid in excavated trench and trench backfilled with soil. The minimum soil cover over crown of the pipe will be maintained 1m. The pipes will be laid on 20 cm thick sand cushion / boxing. The laying of the pipes will be fully in compliance of procedures and stipulations given under IS 5822 : 1994.

The pipeline length laid underground will be wrapped by Tape Coat as per IS 3589 – 2001(Annx. D) to act against mechanical abrasion, corrosion / rusting due to soil components and salinity of subsoil water. The pipeline length laid over ground on chairs or otherwise will be painted by Epoxy Paint as per provisions under IS 3589 : 2001 (Annx. B).

The pipes will be provided with internal surface lining of Epoxy Coating minimum 406 µm thick.

There will be following crossing structures along the route –

- Right Bank Canal Crossing Structure at pipeline Ch. 500m. This crossing can be provided with pipes passing over the canal on concrete piers.
- Incoming pipeline from Ganga Intake to UKD at Ch. 1600m. This crossing can be provided with one pipeline crossing over other by raising either of it.
- Highway crossing at Ch.5300m. At this location pipeline will be passed below the road with concrete encasing.

The specific nature of crossing and its structural details will be attended in Detail Designs.

The provisions of pipeline accessories such as Expansion Joints, Washout Valves, Control Sluice Valves, Air Valves, Anchor Blocks, Thrust Blocks, Chairs, etc will be made while preparing the details design of pipeline where kilometre wise planning / designs / drawing will be provided.

5. Water Hammer / Surge Protection Device

In this Basic Engineering Report, the fundamental Joukowaski's Law (equation) for preliminary evaluation of maximum internal pressures is used which is -

$\Delta H = (a \times V_0) / (g)$

$\Delta H$ is Rise in Pressure above normal, 'a' is Pressure wave velocity, $V_0$ is flow velocity & 'g' is gravitational acceleration.

For Design of Shell thickness of the pipeline, 50% of anticipated Surge Pressure calculated by above equation is considered.

As Water Hammer is a very complex phenomenon, advanced computer programs are developed for Transient Analysis evaluations. The detail processing will be undertaken by using 'Water Hammer' Software Program (Version – V8i) developed by M/S Bentley Systems, in the Detail Engineering phase of this assignment. In the analysis, various operational & accidental scenarios will be developed, and the Positive & Negative Transient Pressure situations will be evaluated. Based on the analysis, for control of Negative Pressures, Air Valves (Kinetic / single) or Vacuum Breaker Valves, etc., and for Positive Pressures, Air Vessels, Air Cushion Valves, Zero Velocity Valves, One way surge Tank, etc. equipment will be selected suitable to our site conditions.

The location of the Anti- Surge Devices will be in the initial reaches of the pipeline i.e. near about Ch. 400m or so i.e. in the WEUPPL Intake Campus of UKD.

*** *** ***

# CHAPTER - 5

## MECHANICAL DESIGN OF PUMPING MACHINERY AND INSTRUMENTATION DETAILS

### I. PREAMBLE :

The Pumping Scheme is designed for Water Drawl to 1320 MW Mirzapur Thermal Power Project (MTPP) from River Ganga. The MTPP Plant is situated at village Dadri Khurd, Dist. Mirzapur which is around 29 km from the water intake location in River Ganga at the North of Mirzapur Town. The overall pumping scheme is divided in Three Stages/Parts, in Stage I water is lifted from River Ganga to Pre-Settling Tank (PST) located on the left bank of River Ganga, in Stage II, water is lifted from Clear Water Tank (at downstream of PST) to Upper Khajuri Dam (UKD), and in Stage III, pumping from UKD to MTPP Plant.

As per the ‘Water Use Agreement’ between WRD, Govt. of UP and WEUPPL, the water lifting from River Ganga is restricted for the period of 1$^{st}$ June to 31$^{st}$ December of every year. However, the pumping from UKD to Plant will be permissible for though out the year. Additionally, the water to be lifted from River Ganga to UKD will have total quantity for MTPP Plant (36 MCM) Plus Irrigation requirement (9.5 MCM) plus losses.

The pumping scheme designed here takes care for all the requirements as stated at above.

### II. SYSTEM PARAMETERS, CALCULATIONS FOR GROSS HEAD ON PUMPS & MOTOR RATING :

The Stage wise broad system parameters in rising order, from Plant to Intake is proposed as below –

**A. <u>STAGE III</u>**

| | |
|---|---|
| 1. Water requirement | : 36 MCM/Year |
| Pumping Days in Year | : 365 Days |
| Pumping Hours per Day | : 16 Hours |

Water requirement in $m^3$/sec : 1.712 $m^3$/sec
i.e. 6163.20 $m^3$/Hr

2. Type of Pump Sump & Pump House
   : Circular Jackwell/sump of 10 m ID with 12 m x 14 m Pump Hous
3. Minimum Water Level at Pumping Station /MDDL : RL 155.60 m
4. Pump Sump / Jackwell Floor Level : RL 152.00 m
5. Maximum Water level in UKD : RL 167.03 m
6. Motor Floor Level & Pump Delivery Level : RL 170.05 m
   (1.5 m above Dam Top Level of RL 168.55 m)
7. Rising/Pumping Main Pipeline
   Length of Pipeline : 7.000 km
   Diameter of pipeline : 1200 mm
   Material of pipeline : MS
8. Delivery Level at MTPP Plant : RL 194.20 m
9. Static Head calculation
   Static Head on Pumps considering delivery level
   = RL 194.20 m – RL 155.60 m
   = 38.60 m
   Static Head on Pumps derived from Hydraulic Gradient line
   = 49.15 m
10. Station Losses : Approx. @ 1.5 m
11. Exit Head : 2.0 m
12. Frictional Head loss in Pipeline,
    Head Loss by Hazen William Formula.

$$H_f = [6.84 \times (V/C_r)^{1.852} / D^{1.167}] \times L$$

Q = 1.712 $M^3$/sec (Discharge)
D = 1.20 M (Dia. of rising main)
V = Q / [($\pi$/4) x ($D^2$)]
V = 1.51 m/s
Cr = Pipe roughness Coefficient (140)
L = Length of Rising Main in M = 7000 M

$$H_f = [6.84 \times (1.51/140)^{1.852} / 1.20^{1.167}] \times 7000 = 8.84 \text{ M}$$

Add 10% losses for bends = 0.884 M

Total head loss in Pipeline = 8.84 + 0.884 = 9.724 M

13. Gross Head on Pumps = 49.15 m + 9.724 m + 1.5 m + 2.0 m

= 62.374 m, Say 63.0 m

14. Calculations for Motor Rating,

Electrical Power Calculation

Pump input kW = (Q x H) / (102 x $\eta$ )

Where, No. of Pumps = 2

Discharge PER Pump = (1762/2 =) 856 LPS

,$\eta$ efficiency of the pump =0.85

Pump input kW = (856 x 63) / (102 x 0.85)

= 622.00 kW

**Motor rating**

The CPHEEO manual recommends 10% margin, but considering the practical operations, the motor rating is decided by taking 15% margin over the power required at duty point.

Motor Rating = 622 x 1.15

= 715.30 kW

Therefore, we provide 725 kW Motor Rating. (with solid shaft motor running on 6.6 KV, 3 Ph, 50 Hz A.C. Supply.)

15. Pump Duty Point Parameters for **Stage III**:

With the above calculations following Duty Point parameters are selected,

| Sr. | Number of Pumps | Discharge per Pump in lps | Static Head | Friction & other losses | Total Head |
|---|---|---|---|---|---|
| 1 | 2 Working + 1 Stand By | 856 | 49.15 meter | 13.85 meter | 63.0 meter |

16. Pump House Dimensions & Levels,

| | |
|---|---|
| Rectangular Pump House | : 12 m x 14 m |
| Motor Floor Level | : RL 170.05 m |
| Gantry Corbel Top | : RL 178.05 m |
| Pump House Roof bottom level | : RL 181.05 m |

**B. <u>STAGE II</u>**

1. Water requirement : 52.315 MCM

| | |
|---|---|
| Plant Requirement | - 36 MCM |
| Irrigation Requirement at UKD | - 9.5 MCM |
| Evaporation losses at UKD | - 3.937 MCM |
| Misc. losses at UKD | - 0.494 MCM |
| MDDL make up requirement at UKD | - 2.36 MCM |
| <u>Total</u> | - <u>52.315 MCM</u> |

| | |
|---|---|
| Pumping Days in Year | : 210 Days |
| Pumping Hours per Day | : 16 Hours |
| Water requirement in $m^3$/sec | : 4.325 $m^3$/sec<br>i.e. 15,570 $m^3$/Hr |

2. Type of Pump Sump & Pump House

   : Rectangular individual bay configuration for Pump sump

   And 12.5 m x 30.6 m Pump House

3. Minimum Water Level at Pumping Station /MDDL : RL 78.00 m
4. Maximum Water level in the Clear Water Tank : RL 81.00 m
5. Pump Sump Floor Level : RL 76.00 m
6. Motor Floor Level & Pump Delivery : RL 82.0 m
7. Rising/Pumping Main Pipeline

| | |
|---|---|
| Length of Pipeline | : 23.050 km |
| Diameter of pipeline | : 1800 mm |
| Material of pipeline | : MS |

8. Delivery Level at UKD Reservoir : RL 168.55 m
9. Static Head calculation

   Static Head on Pumps considering delivery level

= RL 168.55 m – RL 78.0 m

= 90.55 m

Static Head on Pumps derived from Hydraulic Gradient line

= 93.758 m

10. Station Losses : Approx. @ 1.5 m

11. Exit Head : 2.0 m

12. Frictional Head loss in Pipeline,

Head Loss by Hazen William Formula.

$H_f = [6.84 \times (V/C_r)^{1.852} / D^{1.167}] \times L$

Q = 4.325 $m^3$/sec (Discharge)
D = 1.80 M (Dia. of rising main)
V = Q / [(π/4) x ($D^2$)]
V = 1.70 m/s
Cr = Pipe roughness Coefficient (140)
L = Length of Rising Main in M = 23050 M

$H_f = [6.84 \times (1.70/140)^{1.852} / 1.80^{1.167}] \times 23050$

= 22.50 M

Add 10% losses for bends = 2.25 M

Total head loss in Pipeline = 22.50 + 2.25 = 24.75 M

13. Gross Head on Pumps = 93.758 m + 24.75 m + 1.5 m + 2.0 m

= 122 m

14. Calculations for Motor Rating,

Electrical Power Calculation

Pump input kW = (Q x H) / (102 x מ )

Where, No. of Pumps = 4
Discharge PER Pump = (4325/2 =) 1081.25 LPS
,מ efficiency of the pump =0.85

Pump input kW = (1081.25 x 122) / (102 x 0.85)

= 1521.48 kW

**Motor rating**

The CPHEEO manual recommends 10% margin, but considering the practical operations, the motor rating is decided by taking 15% margin over the power required at duty point.

Motor Rating = 1521.48 x 1.15

= 1749.70 kW

Therefore, we provide 1800 kW Motor Rating. (with solid shaft motor running on 6.6 KV, 3 Ph, 50 Hz A.C. Supply.)

15. Pump Duty Point Parameters for **Stage II** :

With the above calculations following Duty Point parameters are selected,

| Sr. | Number of Pumps | Discharge per Pump in lps | Static Head | Friction & other losses | Total Head |
|---|---|---|---|---|---|
| 1 | 4 Working + 1 Stand By | 1081.25 | 93.76 meter | 29.60 meter | 122.0 meter |

16. Pump House Dimensions & Levels,

Rectangular Pump House : 12.5 m x 27.6 m

Motor Floor Level : RL 82.0 m

Gantry Corbel Top : RL 90.0 m

Pump House Roof bottom level : RL 93.0 m

## C. STAGE I

1. Water requirement : 53.383 MCM

Stage II pumping requirement - 52.315 MCM

Water lost in de-sludging at Pre-Settling Tank - 2%

Therefore, water to lifted from River ganga - 52.315 x (100/100-2)

= 53.383 MCM

Pumping Days in Year : 210 Days

Pumping Hours per Day : 16 Hours

Water requirement in $m^3$/sec : 4.413 $m^3$/sec i.e. 15,887 $m^3$/Hr

2. Type of Pump Sump & Pump House
   : Circular Jackwell Pump sump of 16 m ID in River Ganga,
   And 16 m circular Pump House on top of the jackwell.
3. Minimum Water Level at River Ganga /MDDL : RL 62.50 m
4. Pump Sump Floor Level : RL 58.00 m
5. Maximum Flood Level in Ganga River : RL 80.34 m
6. Danger Level marked for Ganga River : RL 77.724
7. Motor Floor Level : RL 82.0 m
8. Pump Delivery Level : RL 78.0 m
   (In this case, Sub Floor Delivery is planned)
9. Rising/Pumping Main Pipeline
   Length of Pipeline : 0.590 km
   Diameter of pipeline : 1800 mm
   Material of pipeline : MS
10. Delivery Level at Pre Settling tank : RL 82.0 m
11. Static Head calculation
    = RL 82.0 m – RL 62.5 m
    = 19.50 m
12. Station Losses : Approx. @ 1.5 m
13. Exit Head : 1.5 m
14. Frictional Head loss in Pipeline,
    Head Loss by Hazen William Formula.

$$H_f = [6.84 \times (V/C_r)^{1.852} / D^{1.167}] \times L$$

| | |
|---|---|
| Q | = 4.412 $m^3$/sec (Discharge) |
| D | = 1.80 M (Dia. of rising main) |
| V | = $Q / [(\pi/4) \times (D^2)]$ |
| V | = 1.73 m/s |
| Cr | = Pipe roughness Coefficient (140) |
| L | = Length of Rising Main in M = 590 M |

$$H_f = [6.84 \times (1.73/140)^{1.852} / 1.80^{1.167}] \times 590$$

$$= 0.59 \text{ M}$$

Add 10% losses for bends = 0.059 M

Total head loss in Pipeline = 0.59 + 0.059 = 0.649 M

15. Gross Head on Pumps = 19.5 m + 0.649 m + 1.5 m + 1.5 m
= 23.149 m,

16. Calculations for Motor Rating,

Electrical Power Calculation

Pump input kW = (Q x H) / (102 x $\eta$ )

Where,
No. of Pumps = 2
Discharge PER Pump = (4413/2 =) 2206.5 LPS
,$\eta$ efficiency of the pump =0.85

Pump input kW = (2206.5 x 23.149) / (102 x 0.85)
= 589.14 kW

**Motor rating**

The CPHEEO manual recommends 10% margin, but considering the practical operations, the motor rating is decided by taking 15% margin over the power required at duty point.

Motor Rating = 589.14 x 1.15
= 677.511 kW

Therefore, we provide 700 kW Motor Rating. (with solid shaft motor running on 6.6 KV, 3 Ph, 50 Hz A.C. Supply.)

17. Pump Duty Point Parameters for **Stage I** :

With the above calculations following Duty Point parameters are selected,

| Sr. | Number of Pumps | Discharge per Pump in lps | Static Head | Friction & other losses | Total Head |
|---|---|---|---|---|---|
| 1 | 2 Working + 1 Stand By | 2206.5 | 19.5 meter | 3.65 meter | 23.15 meter |

18. Pump House Dimensions & Levels,

| | |
|---|---|
| Circular Pump House | : 16 m ID |
| Pump Delivery Level | : RL 78.0 m |
| Motor Floor Level | : RL 82.0 m |
| Gantry Corbel Top | : RL 90.0 m |
| Pump House Roof bottom level | : RL 93.0 m |

## III. PROPOSED PUMPS :

Self-lubricated, wet pit, Vertical Turbine Pumps are selected for all the three stages of Pumping system. All these pumps will be mixed flow type.

These Vertical Turbine Pumps are selected mainly for the following reasons –

1. Water levels are varying in the Ganga River water as well as at UKD location.
2. Prime mover will be located at safe levels above maximum water levels / High Flood Levels.
3. Required suction piping can be provided to avoid NPSH, and cavitation possibilities.

## IV. SELECTION OF PUMPS :

Particular Pump Selection is done on the basis of Head, Discharge, Specific Speed, and the cavitation aspect based on Net Positive Suction Head (NPSH).

1. Stage I Pumps :

| | |
|---|---|
| No of Working Pumps | : 2 |
| Discharge Per Pump | : 2.2065 $m^3$/sec |
| Total Head on Pumps | : 23.15 m |

| Sr. | Description | Pump – 500 rpm Single Stage | Pump – 600 rpm Singe Stage | Pump – 750 rpm Singe Stage |
|---|---|---|---|---|
| 1 | Pump rpm | 500 | 600 | 750 |
| 2 | Specific Speed (MKS system) Ns = 3.65 x N x √Q / $H^{3/4}$ | = 3.65 x 500 x √2.206 / $(23)^{3/4}$ = 258.09 | = 3.65 x 600 x √2.206 / $(23)^{3/4}$ = 309.71 | = 3.65 x 600 x √2.206 / $(23)^{3/4}$ = 387.13 |
| 3 | Specific Speed (FPS system) | = 51.65 x 500 x √2.206 | = 51.65x 600 x √2.206 | = 51.65x 750 x √2.206 |

<table>
<tr><th>Sr.</th><th>Description</th><th>Pump –<br>500 rpm Single Stage</th><th>Pump –<br>600 rpm Singe Stage</th><th>Pump –<br>750 rpm Singe Stage</th></tr>
<tr><td></td><td>Ns = 51.65 x N x √Q / $H^{3/4}$</td><td>/ $(23)^{3/4}$<br>= 3652.14</td><td>/ $(23)^{3/4}$<br>= 4382.57</td><td>/ $(23)^{3/4}$<br>= 5478.20</td></tr>
<tr><td colspan="4">The specific speed shall be selected between 150 – 200 (MKS) as efficiency is maximum in this band. (Refer CPHEEO figure 11.1<br>- In this case all the above Pumps are having specific speed above the range of 150-200. However, if the number of ‘Stages’ are increased the specific speed will increase further. The issue is discussed with the Manufacturers, as per their recommendations, for the particular head & discharge, 600 rpm & 750 rpm pumps are selected for further evaluation.</td><td></td></tr>
<tr><td>4</td><td>NPSH AVAILABLE –<br>$NPSH_a$ =<br>$P_s - H_{fs} - ( V_s^2 / 2g ) - Z_s - V_p$<br>Where $P_s$ = Suction pressure (i.e. Atmospheric pressure on surface of water ) i.e. 10.3 Mtr.<br>$H_{fs}$ = Frictional losses in suction<br>$V_s^2 / 2g$ =Velocity head loss in suction<br>= 0.079<br>V = 1.25 M/Sec<br>g = 9.81 gravitational constant<br>$Z_s$ = Potential energy equal to the diff. between water level at the pump center and water level in the sump<br>(Sump Bottom + Bottom clearance + ht. of bell mouth – MDDL)<br>$V_p$ =Vapour pressure at $30^0$C (0.427 m)</td><td colspan="3"><table>
<tr><td></td><td></td><td></td></tr>
<tr><td>1.</td><td>$H_{fs}$ = Frictional losses in suction</td><td>0.004 m</td></tr>
<tr><td>2.</td><td>Velocity V</td><td>1.25 m/s</td></tr>
<tr><td>3.</td><td>$V_s^2$ / 2g =Velocity head loss in suction</td><td>0.08 M</td></tr>
<tr><td>4.</td><td>$Z_s$ = Sump Bottom + Bottom clearance + ht. of bell mouth – MDDL</td><td>(59 + 0.8 + 1.00 - 62.5) = (-) 1.7</td></tr>
<tr><td>5.</td><td>$V_p$ (at $30^0$ C)</td><td>0.427</td></tr>
<tr><td>6.</td><td>$NPSH_a$</td><td>10.3 – 0.004 – 0.08 + 1.7 – 0.427<br>=11.489 Mtr.</td></tr>
</table>
The Sump Floor considered for Pump selection at RL 59.0 M<br>This value is arrived at from the consideration of Thoma Critical & Thoma Available, as calculated in the following calculations.<br>However, Sump floor actually provided is at RL 58.0, corresponding to the Intake pipe profile.<br>This will provide more $NPSH_a$, therefore, OK.</td></tr>
<tr><td>5</td><td>Suction Specific Speed, Nss = (N*SQRT(Q))/(NPSH)^0.75</td><td>-</td><td>= 600√2.206 X 51.65/ $11.489^{0.75}$<br>= 7363.84</td><td>= 750√2.206 X 51.65/ $11.489^{0.75}$<br>= 9204.80</td></tr>
<tr><td colspan="4">As per HIS recommendations, the Suction Specific Speed shall be less than 8500.<br>- In this case for the Pump of 600 rpm the Suction Specific Speed is less than 8500, therefore, it is evaluated further.</td><td></td></tr>
<tr><td>6</td><td>For Cavitation Criterion,</td><td>-</td><td>For Single Stage</td><td>-</td></tr>
</table>

| Sr. | Description | Pump – 500 rpm Single Stage | Pump – 600 rpm Singe Stage | Pump – 750 rpm Singe Stage |
|---|---|---|---|---|
| | Thoma Available = $NPSH_a$ / Head | | = 11.489 / (23)<br>= 0.499 | |
| 7 | Thoma Critical<br>= $6.3 \times N_s^{(4/3)} \times 10^{-6}$ | - | = $6.3 \times 4382.57^{(4/3)} \times 10^{-6}$<br>= 0.452 | - |
| | | | Thoma Available > Thoma Critical | |
| For Cavitation to be avoided, the Thoma Available shall be Greater than the Thoma Critical.<br>- In this case 600 rpm Pump satisfy this condition, therefore it is selected for our installation. | | | | |
| | | | | |

2. <u>Stage II Pumps :</u>

No of Working Pumps : 4

Discharge Per Pump : 1.08125 $m^3$/sec

Total Head on Pumps : 124 m

| Sr. | Description | Pump – 1000 rpm Two Stage | Pump – 750 rpm Three Stage |
|---|---|---|---|
| 1 | Pump rpm | 1000 | 750 |
| 2 | Specific Speed (MKS system)<br>Ns = $3.65 \times N \times \sqrt{Q} / H^{3/4}$ | = $3.65 \times 1000 \times \sqrt{1.08125} / (124/2)^{3/4}$<br>= 158.87 | = $3.65 \times 750 \times \sqrt{1.08125} / (124/3)^{3/4}$<br>= 174.62 |
| 3 | Specific Speed (FPS system)<br>Ns = $51.65 \times N \times \sqrt{Q} / H^{3/4}$ | = $51.65 \times 1000 \times \sqrt{1.08125} / (124/2)^{3/4}$<br>= 2430.75 | = $51.65 \times 750 \times \sqrt{1.08125} / (124/3)^{3/4}$<br>= 2470.98 |
| The specific speed shall be selected between 150 – 200 (MKS) as efficiency is maximum in this band. (Refer CPHEEO figure 11.1<br>- In this case both the Pumps is having specific speed in the range of 150-200, therefore both are further evaluated. | | | |

<table>
<tr><th>Sr.</th><th>Description</th><th>Pump –<br>1000 rpm Two Stage</th><th>Pump –<br>750 rpm Three Stage</th></tr>
<tr><td>4</td><td>NPSH AVAILABLE –<br>$NPSH_a$ =<br>$P_s - H_{fs} - ( V_s^2 / 2g ) - Z_s - V_p$<br><br>Where $P_s$ = Suction pressure (i.e. Atmospheric pressure on surface of water ) i.e. 10.3 Mtr.<br>$H_{fs}$ = Frictional losses in suction<br>$V_s^2 / 2g$ =Velocity head loss in suction = 0.079<br>V = 1.25 M/Sec<br>g = 9.81 gravitational constant<br>$Z_s$ = Potential energy equal to the diff. between water level at the pump center and water level in the sump<br>(Sump Bottom + Bottom clearance + ht. of bell mouth – MDDL)<br>$V_p$ =Vapour pressure at $30^0$C (0.427 m)</td><td colspan="2"><table>
<tr><td></td><td></td><td></td></tr>
<tr><td>1.</td><td>$H_{fs}$ = Frictional losses in suction</td><td>0.004 m</td></tr>
<tr><td>2.</td><td>Velocity V</td><td>1.25 m/s</td></tr>
<tr><td>3.</td><td>$V_s^2$ / 2g =Velocity head loss in suction</td><td>0.08 M</td></tr>
<tr><td>4.</td><td>$Z_s$ = Sump Bottom + Bottom clearance + ht. of bell mouth – MDDL</td><td>(75 + 0.7 + 1.00 - 78) = (-) 1.3</td></tr>
<tr><td>5.</td><td>$V_p$ (at $30^0$ C)</td><td>0.427</td></tr>
<tr><td>6.</td><td>$NPSH_a$</td><td>10.3 – 0.004 – 0.08 + 1.3 – 0.427 =11.089 Mtr.</td></tr>
</table>The Sump Floor Bottom will be at RL 75.0 M<br>This value is arrived at from the consideration of Thoma Critical & Thoma Available, as calculated in the following calculations.</td></tr>
<tr><td>5</td><td>Suction Specific Speed,<br>Nss = (N*SQRT(Q))/(NPSH)^0.75</td><td>= 1000√1.08125 X 51.65 / $11.089^{0.75}$<br>= 8838.20</td><td>= 750√1.08125 X 51.65/ $11.089^{0.75}$<br>= 6628.65</td></tr>
<tr><td colspan="4">As per HIS recommendations, the Suction Specific Speed shall be less than 8500.<br>- In this case for 750 rpm Pump the Suction Specific Speed is less than 8500, therefore, it is evaluated further.</td></tr>
<tr><td>6</td><td>For Cavitation Criterion,<br>Thoma Available = $NPSH_a$ / Head</td><td>-</td><td>For Three Stage<br>= 11.089 / (124/3)<br>= 0.268</td></tr>
<tr><td>7</td><td>Thoma Critical<br>$= 6.3 \times N_s^{(4/3)} \times 10^{-6}$</td><td>-</td><td>$= 6.3 \times 2470.98^{(4/3)} \times 10^{-6}$<br>= 0.210</td></tr>
<tr><td></td><td></td><td></td><td>Thoma Available<br>> Thoma Critical</td></tr>
<tr><td colspan="4">For Cavitation to be avoided, the Thoma Available shall be Greater than the Thoma Critical.<br>- In this case 750 rpm Pump satisfy this condition. Therefore, the 3 Stage 750 rpm Pump is selected for our installation.</td></tr>
</table>

3. Stage III Pumps :

No of Working Pumps : 2

Discharge Per Pump : 0.856 $m^3$/sec

Total Head on Pumps : 63 m

<table>
<tr><td>Sr.</td><td>Description</td><td>Pump –<br>1000 rpm Single Stage</td><td>Pump –<br>750 rpm Two Stage</td></tr>
<tr><td>1</td><td>Pump rpm</td><td>1000</td><td>750</td></tr>
<tr><td>2</td><td>Specific Speed (MKS system)<br>Ns = 3.65 x N x √Q / $H^{3/4}$</td><td>= 3.65 x 1000 x √0.856 / $(63)^{3/4}$<br>= 151.02</td><td>= 3.65 x 750 x √0.856 / $(31.50)^{3/4}$<br>= 190.48</td></tr>
<tr><td>3</td><td>Specific Speed (FPS system)<br>Ns = 51.65 x N x √Q / $H^{3/4}$</td><td>= 51.65 x 1000 x √0.856 / $(63)^{3/4}$<br>= 2136.98</td><td>= 51.65x 750 x √0.856 / $(31.50)^{3/4}$<br>= 2695.47</td></tr>
<tr><td colspan="4">The specific speed shall be selected between 150 – 200 (MKS) as efficiency is maximum in this band. (Refer CPHEEO figure 11.1<br>- In this case both the Pumps is having specific speed in the range of 150-200, therefore both are further evaluated.</td></tr>
<tr><td>4</td><td>NPSH AVAILABLE –<br>$NPSH_a$ =<br>$P_s – H_{fs} – ( V_s^2 / 2g ) – Z_s - V_p$<br>Where $P_s$ = Suction pressure (i.e. Atmospheric pressure on surface of water ) i.e. 10.3 Mtr.<br>$H_{fs}$ = Frictional losses in suction<br>$V_s^2$ / 2g =Velocity head loss in suction = 0.07<br>V = 1.20 M/Sec<br>g = 9.81 gravitational constant<br>$Z_s$ = Potential energy equal to the diff. between water level at the pump center and water level in the sump<br>(Sump Bottom + Bottom clearance + ht. of bell mouth – MDDL)<br>$V_p$ =Vapour pressure at $30^0$C (0.427 m)</td><td colspan="2"><table>
<tr><td></td><td></td><td></td></tr>
<tr><td>7.</td><td>$H_{fs}$ = Frictional losses in suction</td><td>0.004 m</td></tr>
<tr><td>8.</td><td>Velocity V</td><td>1.2 m/s</td></tr>
<tr><td>9.</td><td>$V_s^2$ / 2g =Velocity head loss in suction</td><td>0.07 M</td></tr>
<tr><td>10.</td><td>$Z_s$ = Sump Bottom + Bottom clearance + ht. of bell mouth – MDDL</td><td>(152 + 0.7 + 1.00 -155.6) = (-) 1.9</td></tr>
<tr><td>11.</td><td>$V_p$ (at $30^0$ C)</td><td>0.427</td></tr>
<tr><td>12.</td><td>$NPSH_a$</td><td>10.3 – 0.004 – 0.07 + 1.9 – 0.427<br>=11.699 Mtr.</td></tr>
</table>The Sump Floor Bottom will be at RL 152.0 M<br>This value is arrived at from the consideration of Thoma Critical & Thoma Available, as calculated in the following calculations.</td></tr>
<tr><td>5</td><td>Suction Specific Speed,<br>Nss = (N*SQRT(Q))/(NPSH)^0.75</td><td>= 1000√0.856 X 51.65 / $11.699^{0.75}$<br>= 7554.32</td><td>= 750√0.856 X 51.65/ $11.699^{0.75}$</td></tr>
</table>

| | | | |
|---|---|---|---|
| | | | = 5665.70 |
| As per HIS recommendations, the Suction Specific Speed shall be less than 8500.<br>- In this case for both the Pumps the Suction Specific Speed is less than 8500, therefore, both are evaluated further. | | | |
| 6 | For Cavitation Criterion,<br>Thoma Available = $NPSH_a$ / Head | For Single Stage<br>= 11.699 / 63<br>= 0.186 | For Two Stage<br>= 11.699 / (63/2)<br>= 0.371 |
| 7 | Thoma Critical<br>= 6.3 x $N_s^{(4/3)}$ x $10^{-6}$ | = 6.3 x $2137.98^{(4/3)}$ x $10^{-6}$<br>=0.173 | = 6.3 x $2695.42^{(4/3)}$ x $10^{-6}$<br>= 0.236 |
| | | Thoma Available<br>> Thoma Critical | Thoma Available<br>> Thoma Critical |
| For Cavitation to be avoided, the Thoma Available shall be Greater than the Thoma Critical.<br>- In this case both the Pumps satisfy this condition, therefore both the Pumps are suitable.<br>- However, we select the lesser rpm Pump. i.e. 750 rpm Two Stage Pump for our installation. | | | |
| | | | |

## V. PUMP OPERATION AND SYSTEM RESISTANCE CURVES :

Parallel operation –

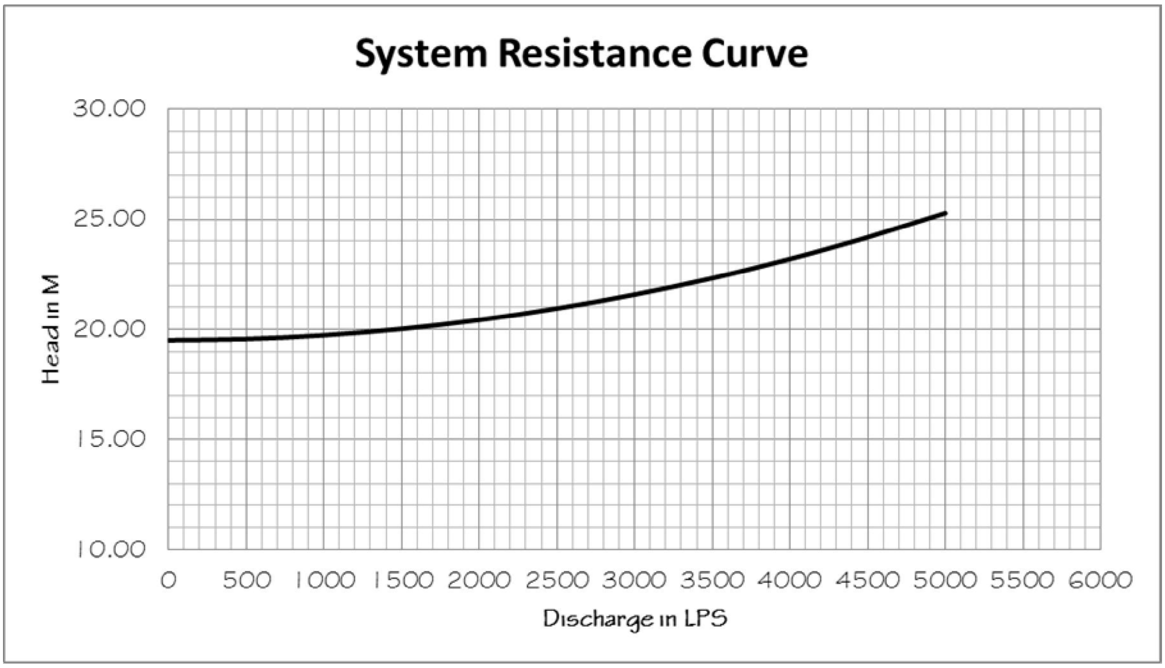
| Pump Location | No. of Pumps | Discharge of each Pump ($m^3$/sec) | Total Discharge |
|---|---|---|---|
| Stage I | 2 W + 1 S | 2.2065 | 4.413 |
| Stage II | 4 W + 1 S | 1.08125 | 4.325 |
| Stage III | 2 W + 1 S | 0.856 | 1.712 |

For all the three stages of the Pumping system, the Pumps will operate in Parallel to achieve the total system discharge.

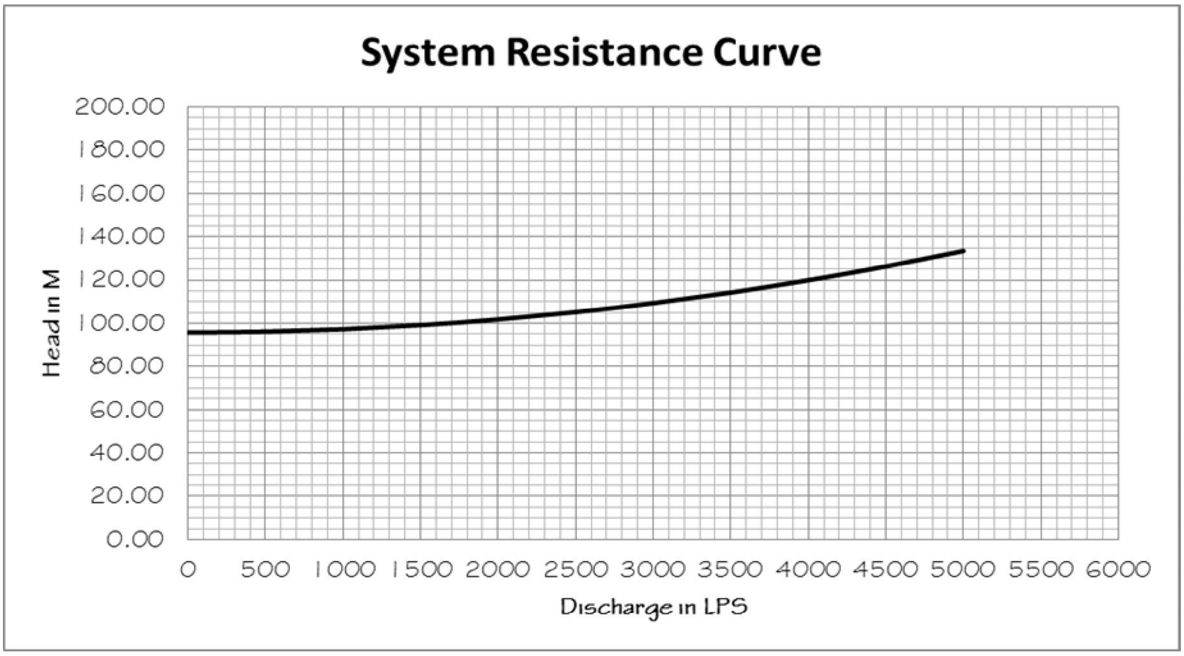
System Resistance Curve –

The design duty head of the pumps will be the head required to achieve the desired flow rate based upon the design system characteristic. The pumps, either working in solo or parallel operation, are to be capable of operating through the entire range bounded by system characteristics without risk of cavitation, overloading and vibration.

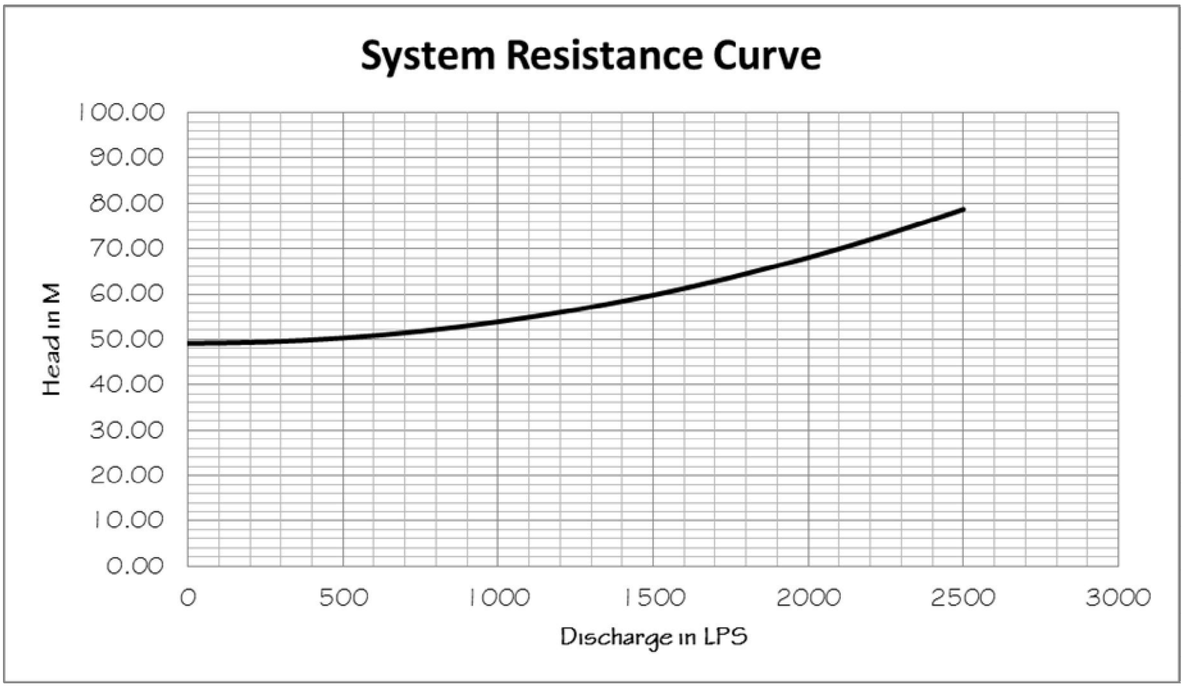
- <u>System Resistance Curve for Stage I</u>




- <u>System Resistance Curve for Stage II</u>



- System Resistance Curve for Stage III




## VI. DETAILS OF PUMP ASSEMBLY :

The overall Vertical Turbine Pump Assembly will consists of

1. Pump Unit (Bowl Assembly) -

The bowl assembly will consist of rotating impellers, housed in stationery bowls having guide vanes. The bowl will also include the housing of the pump shaft bearing. Adequate number of properly designed bearings will be provided for smooth and trouble-free operation of the pump. These bearings shall be Thordon or equivalent. These bearings shall have low coefficient of friction and good abrasion resistance. equipped with replaceable wearing rings. Liquid passage will be smooth finished and the bowl will contain bushes to serve as bearings for the impeller shaft.

The pump casing will be painted inside and outside with anti corrosive epoxy based primer and paint

2. Column Unit (Column Assembly)

The column assembly consist of the column pipe to convey the liquid handled from bowl assembly to column assemblies and shaft bearings, discharge elbow. Column pipes will be designed for full internal vacuum.

Column Pipe

The standard lengths of column pipe will be min. 1.5 Mtr. The column pipe will be welded flanged design.

Head Unit (Head Assembly)

Head unit gives support to the suspended column and pump unit sub-assembly.

3. Suction strainer and suction bell :

Each pump will be provided with suction strainer to prevent entry of floating materials and debris, which can damage the pump. The strainer will be fabricated from S. S. 304. The net opening area of the strainer will be 4 times the area of the bell mouth. It will be designed such that, it will cause minimum choking or clogging.

## VII. SIZING OF PUMP ASSEMBLY :

1. Suction Bell –

The Suction Bell is provided such that, the velocity at entrance is limited to 1.2 to 1.3 m/sec. (Ref : HIS Fig. 9.8.25A, BHRA, IS 15310:2003 Cl. 4.2.1.3)

| Pump Location | Discharge of each Pump ($m^3$/sec) | Velocity at Bell Mouth (m/sec) | Bell Mouth Diameter (meter) |
|---|---|---|---|
| Stage I | 2.2065 | 1.25 | 1.500 |
| Stage II | 1.08125 | 1.25 | 1.050 |
| Stage III | 0.856 | 1.207 | 0.950 |

2. Column Pipe Diameter –

The Column Pipe diameter is provided such that, the velocity in it is limited to 2.5 m/sec. (Ref : CPHEEO Cl. 11.3.2, IS 15310.2003 Cl. 4.2.1.3)

| Pump Location | Discharge of each Pump ($m^3$/sec) | Velocity in Column Pipe (m/sec) | Column Pipe Diameter (meter) |
|---|---|---|---|
| Stage I | 2.2065 | 2.32 | 1.100 |
| Stage II | 1.08125 | 2.15 | 0.800 |
| Stage III | 0.856 | 2.22 | 0.700 |

3. Delivery Pipe –

   The Delivery Pipe diameter is provided such that, the velocity in it is limited to 2.5 m/sec. (Ref : CPHEEO Cl. 11.3.2)

| Pump Location | Discharge of each Pump ($m^3$/sec) | Velocity in Column Pipe (m/sec) | Delivery Pipe Diameter (meter) |
|---|---|---|---|
| Stage I | 2.2065 | 2.32 | 1.100 |
| Stage II | 1.08125 | 2.15 | 0.800 |
| Stage III | 0.856 | 2.22 | 0.700 |

4. Valves of Delivery Pipe –

   The Mechanical Expansion Joint (MEJ), Non Return Valve (NRV), Kinetic Air Valve (KAV) will be provided on delivery side of each Pump.

   <u>Size of valves :</u>

   With ref : CPHEEO Cl. 11.3.3.2, The NRV shall be between the Pump and the Delivery Valve. The size of the valves shall match the size of opening.

   Therefore diameter of valves is kept same as delivery pipeline diameter.

   PN Rating of the Valves :

   The PN rating of the valves is to be selected as maximum of ‘Duty Head Pressure x 2’ or ‘Shut off head Pressure x 1.5’. Here, we have proposed the valve PN ratings based on ‘Duty Head Pressure x 2’.

| Pump Location | Discharge of each Pump ($m^3$/sec) | Duty Head Pressure (meter) | PN Rating of the Valves | Delivery Pipe Dia. (meter) | Dia. of NRV & BFV (meter) | Dia. of KAV (mm) |
|---|---|---|---|---|---|---|
| Stage I | 2.2065 | 23 | 10 Bar | 1.100 | 1.100 | 200 |
| Stage II | 1.08125 | 124 | 25 Bar | 0.800 | 0.800 | 150 |
| Stage III | 0.856 | 63 | 16 Bar | 0.700 | 0.700 | 150 |

## VIII. MANIFOLD DETAILS :

For all the three stages the Manifold diameters are kept same as Pumping main pipeline, with velocity restricted less than 2.5 m/sec.

| Pump Location | No. of Pumps | Discharge of each Pump ($m^3$/sec) | Total Discharge | Manifold Diameter (meter) | Velocity in Manifold (m/sec) |
|---|---|---|---|---|---|
| Stage I | 2 W + 1 S | 2.2065 | 4.413 | 1.800 | 1.734 |
| Stage II | 4 W + 1 S | 1.08125 | 4.325 | 1.800 | 1.70 |
| 2 W + 1 S | 2 W + 1 S | 0.856 | 1.712 | 1.200 | 1.513 |

## IX. MATERIAL HANDLING EOT CRANE :

1. Stage 1 Pump House –
   A. Pump House EOT - For stage 1 Pump House 16 m Span Circular movement EOT crane is proposed. Capacity of the crane will be around 17.5/5 Ton capacity. In Stage 1 Pump House, it is planned for Sub-Surface delivery at RL 78.0m and the Motor Floor will be at RL 82.0 m, therefore, in this case the EOT shall be provided with sufficient hoisting/lifting to operate material handling at both the floors.
   B. EOT for Gates & Trashrack – 7.5 to 10 Ton capacity EOT is provided for operations of Stop Log Gates & Trashrack located at water inlet.

2. Stage 2 Pump House –
   A. For Stage 2 Pump house, 10.5 m span straight girder, 15/5 Ton capacity EOT crane is proposed.
   B. EOT for Gates & Trashrack – 7.5 to 10 Ton capacity EOT is provided for operations of Stop Log Gates & Trashrack located at water inlet.
3. Stage 3 Pump House –
   A. For Stage 3 Pump house, 12.0 m span straight girder, 15/5 Ton capacity EOT crane is proposed.
   B. EOT for Gates & Trashrack – 5 to 7.5 Ton capacity EOT is provided for operations of Stop Log Gates & Trashrack located at water inlet.

## X. DEWATERING & DE-SLUDGE PUMPS :

1. Dewatering & de-sludging Pumps in Pump sumps :

   These pumps will be submersible type pumps to dewater/de-sludge the Pump Sumps. These Submersible Pumps will be of a single Monoblock type with Non-Clog design. The operating speed of pumps will be 1450 rpm maximum. These pumps will be able to pass through soft solids of size 80 mm.

   The Pump Motor of sludge pump will be squirrel cage type, suitable for three-phase 415 + 10% V supply. The motors should be rated for continuous duty & should be with IP 68 protection & Class 'F' insulation. However the motor frame size should be liberally designed to restrict the Temperature rise as per Class 'B' insulation

   A. Stage 1 Pump House –

| | |
|---|---|
| Volume of Water Below MDDL | : $(\pi/4)\times16^2$(Dia) x4.5(water Depth) |
| | : 905 cum |
| Time for complete de-water | : 1 Hr. |
| Number of Pumps | : 2 Nos. |
| Discharge capacity of each pump | : 452.5 cum/Hr |
| Head | : 28 m (= 25 Static head + 3 m Friction & other losses) |

| | |
|---|---|
| Rating | : (46 x 1.1 =) 50.6 kW |
| = (Q x H)/(367.2 x efficiency) | i.e. 65 HP |
| = (452.5 x 28) /(367.2 x 0.75) | |
| = 46 kW | |

We Provide, 2 (working) Nos. of 65 HP Pumps for Pump Sump De-watering.

B. Stage 2 Pump House –

| | |
|---|---|
| Volume of Water Below MDDL | : 8.8m x 2.10 x 3.0(water Depth) |
| (Each Sump volume) | : 55.44 cum |
| Number of Sumps | : 5 Nos. |
| Time for complete de-water each Sump | : ½ Hr. |
| Discharge capacity of each pump | : 111 cum/Hr |
| Head | : 12 m (= 10 Static head + 2 m Friction & other losses) |
| Rating | : 6 kW |
| = (Q x H)/(367.2 x efficiency) | i.e. 7.5 HP |
| = (111 x 12) /(367.2 x 0.75) | |
| = 4.83 kW | |

As there are 5 sumps, we provide 2 Number of Pumps, each of 7.5 HP for Pump Sump De-watering.

C. Stage 3 Pump House –

| | |
|---|---|
| Volume of Water Below MDDL | : $(\pi/4)x10^2$(Dia) x3.6(water Depth) |
| | : 282.74 cum |
| Time for complete de-water | : 1 Hr. |
| Number of Pumps | : 1 Nos. |
| Discharge capacity of each pump | : 283 cum/Hr |
| Head | : 23 m (= 20 Static head + 3 m Friction & other losses) |
| Rating | : (23.26 x 1.1=) 25.6 kW |
| = (Q x H)/(367.2 x efficiency) | i.e. 33 HP |

= (283 x 23) /(367.2 x 0.75)

= 23.26 kW

We Provide, 1 (working) + 1 Stand by 35 HP Pumps for Pump Sump De-watering.

2. <u>De-sludging Pumps at Pre-Settling Tanks :</u>

Ref : Design of Pre-Settling Tank (Chapter __ ) of this report.

| | |
|---|---|
| Silt Trap volume Provided | : 25 m (w) x 40 m (L) x 3 m (D) |
| | : 3000 cum |
| No. of Pumps Provided | : 4 Nos. |
| Time duration for De-silting | : 4 Hrs. |
| Discharge Per Pump | : 187.5 cum/Hr |
| Head | : 12 m |
| (RL 82 – RL 75) = 7m Static | |
| Head + 5 m Friction & other losses | |
| Rating | : (8.167 x 1.1=) 9 kW |
| = (Q x H)/(367.2 x efficiency) | say 10 kW |
| = (187.5 x 12) /(367.2 x 0.75) | i.e. 12.73 HP |
| = 8.167 kW | |

We Provide, 4 (working) + 1 Stand by 15 HP Pumps for De-Sludging at PST.

**P.T.O.**

## XI. INSTRUMENTATION & CONTROL DETAILS :

A. General :

Control & Instrumentation to all the three Pumping Stations will be provided through independent local SCADA system.

The system will be provided for –

- Monitoring Discharge, Head & Energy Parameters at the Pump Station.
- Control of Pump Station through PLC kiosk placed at Operator's Desk at Switchgear Room.
- Data of Flow, Pressures, Levels will be available on SCADA

B. Equipment to be provided :

The Instrumentation & Control System will mainly consists of –

- Pressure monitoring (Delivery of each pump and manifold)
- Level monitoring in sump
- Flow monitoring in Manifold / rising main

This will be provided through the following Instruments –

1. Pressure Gauge
2. Pressure Transmitter
3. Level Transmitter
4. Level Switches
5. Level Gauge
6. Temperature Elements / Gauge
7. Position Transmitter
8. Torque Switch
9. Flow Transmitter
10. RTD Bearing & Winding
11. Vibration Element

The complete Instrumentation & Control scheme is presented in the P&ID in DWG NO.__

C. Data Logging :

Following information shall be continuously recorded as a minimum requirement.

1. Pump pressure.

2. Frequency
3. Power input
4. Voltage, current, power factor etc.
5. Levels in the Sump.
6. Pressure on individual delivery & Common Header.
7. Flow in rising main.
8. Bearing and Winding temperature for pump and motor.

## XII. PUMP OPERATION PHILOSOPHY :

It is proposed to operate the Pumping Stations through local PLC System. The following points are considered as minimum requirement.

- All the pumps operate in parallel.
- The pumps are to be started manually from the control panel / MMI of PLC.

MODE OF OPERATION

The **3 Position Selector Switch** is provided on 6.6 kV switchgear panel for motor feeder. The 3 positions are as follows

1. Local
2. Pump House Remote
3. PLC / SCADA

LOCAL

- This mode means **3 Position Selector Switch** of each motor is in **LOCAL** mode.
- The start permissive as listed elsewhere, which is common for all modes, shall be in the circuit.
- Delivery side Butterfly Valve is in full **CLOSED** Condition.
- Operator will give start command for pump motor from switchgear panel.
- Immediately the operator will give open command to BFV.

REMOTE

- This mode means **3 Position Selector Switch** of each motor is in **REMOTE** mode.

- The start permissive as listed elsewhere, which is common for all modes, shall be in the circuit.
- Delivery side Butterfly Valve is in full **CLOSED** Condition.
- Operator will give start command for pump motor from local Push button station placed in pump house.
- Immediately the operator will give open command to BFV.

MASTER CONTROL CENTER

- This mode means **3 Position Selector Switch** of each motor is in **PLC / SCADA** mode.
- The decisions will be preprogramed based on the final requirement of the scheme and start permissive given below are fulfilled.
- The system will check the Butterfly Valve is in full **CLOSED** Condition and if not, it will give command to close the Valve.
- After pre-defined time **START COMMAND** for pump motor will be initiated.
- Immediately the OPEN command to BFV will be given.

**START PERMISSIVE FOR PUMPS**

The pumps will start only if following conditions are satisfactorily met with

1. The water level in the sump is above or equal to the minimum water level required for safe operation of pump. This is to avoid cavitation.
2. The discharge butterfly valve is fully closed. This will ensure starting under lowest load condition. This will also ensure lower starting power and smooth starting for pumps.
3. Bearing Temperature is Normal.
4. Motor winding temperature is normal. This is to avoid unnecessary stress on motor and also to avoid damage.
5. Emergency Stop PB is not operated.
6. Motor is not tripped due to some fault. This will ensure elimination of reason of fault and hence pumps can be started in system healthy condition.
7. Any other permissive recommended by manufacturer.

Pump start command can be given after all the above conditions are satisfied. The pump discharge valve will start opening after the motor start command. Alarm and trip will be provided if butterfly valve does not open fully in prescribed time. Starting command to second pump can be given after 90 seconds (as per Manufacturer's recommendation) to that of first pump.

**NORMAL STOP**

In case of normal stop, when the pump OFF command is given, the pump discharge butterfly valve first closes and after pre-defined time (approximately to 75% valve closure), respective motor is de-energized. Finally Butterfly valve will be fully closed.

**ALARM / TRIPPING CONDITIONS**

1. The Pump shall trip if the winding or bearing temperatures exceed the limits. An Alarm shall be initiated at pre define setting (low) enabling operator to take necessary action. If the temperature increases beyond the pre-defined set point (High) the trip command will be initiated.
2. A pressure transmitter, fitted on individual pump delivery, will issue trip command, if pump runs at shut off for more than pre-defined time.
3. A pressure transmitter, fitted on individual pump delivery, will issue trip command, if pump runs at Low head than pre-defined setting.
4. Limit switches will be provided to ensure full opening / closing of butterfly valve.
5. Pumps shall trip if Common Header discharge pressure is too low.
6. An alarm will be initiated if water level in the sump goes below pre-defined level (Low). Pumps shall trip if water level in sump goes further below allowable minimum level (Low Low).
7. Pumps shall trip in case of any fault as sensed by motor protection relay or any electrical trip condition.
8. Emergency stop push button, placed near pump is operated.

Under any of the above conditions, the pump will trip immediately and a command will be initiated to CLOSE the discharge BFV.

## CONTROLS

The control details are tabulated as below.

| Sr. No. | Condition | Alarm | Trip | Annunciation |
|---|---|---|---|---|
| 1. | Sump level low (Low limit) | Yes | | Yes |
| 2. | Sump level low (Low Low Limit) | | Yes | Yes |
| 3. | Bearing temperature High (First limit) | Yes | | Yes |
| 4. | Bearing temperature high (Second Limit) | | Yes | Yes |
| 5. | Motor winding temperature high (First Limit) | Yes | | Yes |
| 6. | Motor winding temperature high (Second Limit) | | Yes | Yes |
| 7. | Motor tripped due to external fault | | | Yes |
| 8. | Discharge BFV fully closed (do not start opening in pre- decided time) | | | Yes |
| 9. | Discharge BFV fully open (do not get close in pre- decided time) | | | Yes |
| 10. | Discharge BFV Does not open fully in predefined time while starting | Yes | Yes | Yes |
| 11. | Delivery Pressure too low | | Yes | Yes |

Refer Drawing Plate Number DWG 16 for P&ID of the Complete Water Drawl System.

*** *** ***

# CHAPTER - 6

# ELECTRICAL DETAILS OF PUMP HOUSES AND SUB-STATIONS

## I. PREAMBLE :

Ganga River Water Intake Scheme for the Mirzapur Thermal Power Project (MTPP) will be fed Power principally from the MTPP Plant itself. However, as may be required for initial commissioning, and in case of incidental/accidental requirements the power will also be sourced from State Electricity Board Sub Station at Natwa village.

The MTPP Plant is situated at village Dadri Khurd, Dist. Mirzapur which is around 29 km (south of Mirzapur Town) from the water intake location in River Ganga (East of Mirzapur Town). The overall pumping scheme is divided in Three Stages/Parts. In Stage I water is lifted from River Ganga to Pre-Settling Tank (PST) located on the left bank of River Ganga - 53.383 MCM, in Stage II, water is lifted from Clear Water Tank (at downstream of PST) to Upper Khajuri Dam (UKD) – 52.315 MCM, and in Stage III, pumping from UKD to MTPP Plant – 36 MCM.

The Electrical Scheme for the Intake System will have Load mainly from the Pump Installations.

The Pump configuration at each stage is planned as below –

| Sr. | Pump Station Location | Pump Configuration | Motor Rating of Each Motor (kW) | Total Working Load of Pumps (kW) |
|---|---|---|---|---|
| 1 | Stage 1 | 2 Working + 1 Standby | 700 | 1400 |
| 2 | Stage 2 | 4 Working + 1 Standby | 1800 | 7200 |
| 3 | Stage 3 | 2 Working + 1 Standby | 725 | 1450 |

It is proposed to avail Power on 33 kV Voltage Transmission Line. The Voltage Drop calculations are done for the scenario when all the load at all the Pumping Stations is running. The philosophy & calculations for Voltage Drop are submitted in Annexure XVIII.

The distances of Sub-Stations from Pumping Stations is as Below –

| Sr. | Plant | Source | Distance in km (B-Line) |
|---|---|---|---|
| 1 | Substation at Ganga Intake | MTPP Plant | 20 (B-Line) |
| 2 | Substation at UKD | MTPP Plant | 5 |
| 3 | Substation at Ganga Intake | SEB S/S @ Natwa | 3 |
| 4 | Substation at UKD | SEB S/S @ Natwa | 23 |

The Stage 1 & Stage 2 Pumping Stations are in the Single Premises at Ganga Intake location, therefore a single Sub-Station & combined Switchgear Room is planned for Stage 1 & Stage 2 Pumping Stations. For the Stage 3 Pumping Station located at UKD, separate Sub-Station & Switchgear Rooms is planned.

The details of Design Basis & Basic Engineering for these to Electrical Installations is presented at below, Part I for Installations at Ganga River Bank for Stage 1 plus Stage 2 Pumping, and Part II for Switchgear & Substation at UKD –

(Some text of Design Philosophy is repeated in both the Parts, it is however, to maintain the reference & sequence of Report)

## II. PART I – SWITCHGEAR ROOM & SUB-STATION AT GANGA RIVER INTAKE FOR STAGE 1 & STAGE 2 PUMPING :

**Introduction -**

The Intake Stage 1 pumping station and Clear Water Pumping station at stage-2 are @ 500m apart from each other. The Intake Stage 1 pumping station and Clear Water Pumping station at stage-2 are @ 500m apart from each other.

The Power will be available at 33 kV level. Accordingly there will be one common 33/6.9 kV Sub-station for Stage 1 & Stage 2 Pumping Station, comprising of Breakers, LAs, CTs, PTs, Isolators, etc. The function of the sub-station is stepping down the voltage from 33 kV to 6.6 kV. There will be 2 incomers of 33 kV in the sub-station. There will be 2 Nos. of 33/6.9 kV transformers in the sub-station.

The motor will be of 6.6 kV rating for both the pumping stations. So the 33/6.6 kV substation will supply the load through 6.6 kV cables to the 6.6 kV indoor switchgear. There will be 1 no of 6.6 kV indoor switchgears. This 6.6 kV indoor switchgear will receive power from 33/6.6 kV substation and supply power to pump motors at stage-1 and stage-2 through 6.6 kV cables. There will be 2 incomers of 6.6 kV, and bus coupler. Outgoing feeders of 6.6 kV will be for 6.6 kV motors and 6.6/0.433 kV Auxiliary transformer. Auxiliary transformer is provided to cater all LT load of both the pumping stations like EOT crane, Lighting, Valve actuators etc.

**33/6.6 KV SUB-STATION & PUMPING STATION**

At the Sub-Station :

- Tapping power.
- Sub-station comprising of two incoming feeders from 33 kV double circuit transmission line. Incoming feeders comprising of LA, CT, PT, Isolators, CBs, etc. and connected to two nos. of 33/6.9 kV transformers.
- Provision of 2 Nos. 33/6.9 kV transformers
- Earthing and lightning protection systems
- Lighting system
- Provision of Auxiliary transformer to cater all LT load of Substation and Pumping station.
- Provision of Switchgear / control room including 6.6 kV panels, 0.433 kV panels, batteries, battery charge etc.
- All associated civil engineering works, fencing, gates and ancillary items

**Availing Electric Power**

The power for pumping station will be drawn from power plant / from nearby substation through 33 kV doubles circuit transmission line (as discussed at above).

**Selection of distribution Voltages**

The maximum load at the pump house will be the induction motors, the standard voltages for induction motors are as following

11 kV, 6.6 kV, 3.3 kV, 415 V.

As the motor rating will be @ 700 kW for stage-1 and 1800 kW for stage-2 (16 hrs. pumping), the motors proposed are of 6.6 kV.

Range of motors at different voltage levels is as follows :-

i) Motors upto 250 kW – 415 Volts;
ii) Motors upto 250-500 kW – 3.3 kV
iii) Motors upto 400-2000 kW –6.6 kV
iv) Motors above 2000 kW – 11 kV

These rating motors are, generally, available with all the reputed manufacturers.

**Fault Level**

The fault level on the 33 kV side is considered as 25 kA for 3 Sec. for equipment selection.

The fault level on 6.6 kV side will be mainly decided on the rating of the 33/6.6 kV transformer and impedance of the transformer.

At present transformer rating woks out to be 12500 kVA. According to IS 2026, the impedance of the 12500 kVA transformer is 8 % so fault level on 6.6 kV side is @ 13.67 kA. Generally the short time rating of all the 6.6 kV as well as 33 kV equipment will be taken as 25 kA.

**A. PUMPING STATION :**

**1. Electrical Motors**

I. 6.6 KV MOTORS

For the pump application slip-ring or squirrel cage induction motors may be used.

Slip-ring induction motors are expensive and complex in manufacture and construction. They also require frequent maintenance and skilled personnel to operate and maintain. The starting mechanism for slip-ring motors can also be difficult because starting can be done by either grid rotor resistance (GRS), or by liquid rotor resistance starting (LRS), both of which require more maintenance and operator starting skill.

Squirrel cage induction motors are simple in construction, easy to maintain, cheaper than the slip-ring motors and the starting method is much easier. Therefore, it is proposed that motors for all types of pumps, shall be squirrel cage induction motors.

The motors shall be Vertically mounted. The motors shall be of CACA type at stage -1 and CACA or CACW type at stage-2 pumping station. The insulation shall be of Class F and temperature rise shall be restricted to Class B. This will ensure longer life and better performance of the motor. The motors will be provided with adequate no. of Simplex RTDs.

The motors details are as follows:

| Name | Motor kW | Rated Voltage | Type of Motor & motor cooling | Method of starting |
|---|---|---|---|---|
| Stage - 1 (Intake) | 700 kW (2 Working + 1 Standby) | 6.6kV | CACA Squirrel cage Induction Motor | Through Soft Starter |
| Stage - 2 | 1800 kW (4 Working + 1 Standby) | 6.6kV | CACA/CACW Squirrel cage Induction Motor | Through Soft Starter |

II. L V MOTORS

All the motors below 200 kW will be LT induction motors of squirrel cage type. The starting of motors upto 7.5 kW will be DOL type and above 7.5 kW will be star delta type. Crane motors will be decided by crane supplier.

The class of insulation of the above motors will be `F'.

III. APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS: 325 | Three Phase Induction Motors. |
| 2 | IS: 4889 | Method of determination of efficiency of rotating electrical machines. |
| 3 | IS:4029 | Guide for testing three phase induction motors. |

**2. 6.6 kV Indoor Switchgear**

The following table describes the various circuit breakers available for indoor duty.

I. INDOOR CIRCUIT BREAKERS

| Type | Remarks |
|---|---|
| Sulphur hexa fluoride circuit breaker (SF6CB) | Available upto 33 kV indoor duties. |
| Vacuum circuit breaker (VCB) | Available upto 33 kV indoor duties. |
| Minimum oil circuit breaker (MOCB) | Old technology, poor reliability, complicated operation and maintenance. |
| Bulk oil circuit breaker (BOCB) | Old technology, poor reliability, complicated operation and maintenance. |

It is feasible that the SF6 / Vacuum CB type can be used, but, as all outdoor breakers are VCB, it is preferred to use Vacuum Circuit Breakers for indoor purpose also.

So Vacuum Circuit Breakers will be provided at each incomer and motor feeders.

The 6.6 kV switchgear will consist of VCB, CT, PT, meters, relays, busbars, etc.

Switchgear will be made out of sheet steel in compartmentalized design and will be suitable for bottom cable entry on rear side. The main incomer from transformer will be through XLPE insulated Al conductor cable. The horizontal bus bar chamber will be on the top.

The Vacuum Circuit Breakers will be provided on the incomer and all outgoing feeders for the protection and isolation of the system.

For 6.6 kV Panel, breakers on the incomer will be of 6.6 kV, 25 kA, 1250 A. and 6.6 kV, 25kA, 630A will be on all outgoing feeders.

II. OTHER 6.6 KV COMPONENT

In addition to 6.6 kV breakers following Components will be provided in the 6.6 kV panel

A. Current Transformer (CT)

CTs will be provided with each 6.6 kV breaker for protection and metering. The protection will be provided with Protection class CTs and metering will be provided with the CTs of class 1.0, with 1 Amp secondary current. The rating of the CTS will suit the FLC of the connected equipment.

Details of the CT (6.6 kV PMCC)

| **Location** | **Rating** | **No. of Core** | **Class** | **VA Burden** | **Purpose** |
|---|---|---|---|---|---|
| Incomer | 1250/1 | 3 | Core 1 : Cl 1.0<br>Core 2 : 5P20<br>Core 3 : CLPS | 15 VA<br>15 VA | Metering<br>O/C, E/F Protection<br>Diff and REF Protection |
| Outgoing (Motor feeder Stage-1) | 100/1 | 2 | Core 1 : CL 1.0<br>Core 2 : 5P20 | 15 VA<br>15 VA | Metering<br>Motor protection. |
| Outgoing (Motor feeder Stage -2) | 250/1 | 2 | Core 1 : CL 1.0<br>Core 2 : 5P20 | 15 VA<br>15 VA | Metering<br>Motor protection. |
| LT X’mer Feeder | 50/1 | 2 | Core 1 : CL 1.0<br>Core 2 : 5P20 | 15 VA<br>15 VA | Metering.<br>O/C, E/F Protection |

B. Potential Transformer (PT)

The line PTs on each panel incomer shall be installed for protection and metering. The protection will be provided with PTs of class 3P and metering will be provided with the PTs of class 1.0.

Details of the PT (6.6 kV)

| **Location** | **Rating** | **No. of Core** | **Class** | **VA Burden** | **Purpose** |
|---|---|---|---|---|---|
| 6.6 kV Incomer | (6.6/√3 kV) / (110/√3 V) | 2 | Core 1 : Cl 1.0 | 50 VA | Metering |
| | | | Core 2 : Cl 3P | 50 VA | UV / OV Protection |

C. Protections

1. Incomer feeder : An IDMTL overload and earth fault (with s/c feature) protection will be provided on each incomer.
2. Outgoing feeders
   i. Outgoing motor feeders for Stage 1 and Stage 2 motors : A comprehensive motor protection relay will be provided on each of the motor feeders. In addition, there will be instantaneous earth fault protection for capacitors with the help of CBCT.

   Comprehensive Motor Protection relay will have following features.

   - Three phase over current protection with instantaneous high and low set (50-51)
   - Negative phase sequence protection (46)
   - Start up supervision for motor (48, 14, 66)
   - Under voltage protection (27)
   - Lock out relay (86)
   - Relay is suitable for communication.

   ii Outgoing Auxiliary Transformer feeder : An IDMT Overload and earth fault protection (with s/c feature) will be provided.

Refer Single Line Diagram (Drawing Plate No DWG 17) for other details.

D. EARTHING TRUCK

A separate earthing truck will be provided for maintenance work. This truck will be suitable for earthing the switchgear busbars as well as outgoing/incoming cables. The trucks will have a voltage transformer and an interlock to prevent earthing of any live connection. The earthing trucks will have a visual and audible annunciation to warn the operator against earthing of live connections.

III. APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS: 1248 (Part-1) | Direct acting indicating analogue electrical measuring instruments and their accessories: General requirements |
| 2 | IS: 2099 | Bushings for alternating Voltages above 1000 Volts |
| 3 | IS: 2147 | Degrees of protection provided by enclosures for low voltage switchgears & control gear |
| 4 | IS: 2705 (Part-1) | Current transformers: General requirements |
| 5 | IS:3043 | Code of practice for earthing |
| 6 | IS: 3156 (Part-1) | Voltage transformers: General requirements |
| 7 | IS: 3231 | Specification for electrical relays for power system protection |
| 8 | IS: 3427 | A.C. metal enclosed switchgear and control gear for rated voltages above 1 KV & up to & including 52 KV |
| 9 | IS:9385 | High voltage fuses |
| 10 | IS: 12729 | General requirements for switchgear & control gear for voltages exceeding 1000 V |
| 11 | IS: 13118 | Specification for High Voltage A.C. Circuit breaker |
| 12 | IS:13703 | Specification for low voltage for voltages not exceeding 1000V |
| 13 | IS:13947 | Specification for low voltage switchgear and control gear assemblies |

**3. Battery, Battery Charger and D.C.D.B. :**

2 sets of Lead Acid Batteries (maintenance free) with charger will be provided.

The 33 kV and 6.6 kV circuit breakers will be given 110 V DC supply for control circuit. Under normal conditions this supply will be taken from DCDB but in the event of a power failure, tripping will be ensured from a battery supply.

The battery and charger unit shall be self contained in a sheet steel cabinet suitable for floor mounting. The batteries shall be of lead acid Cells in series/parallel arrangement to provide the rated voltage.

The Battery charger system shall be of solid state constant voltage type with automatic control for float charging of the batteries and shall incorporate boost charging facilities.

The unit shall have the controls and indication on front side. The indication includes voltmeter, indication lamps showing supply ON, float charging and boost charging supply, ON/OFF switch and float/boost charge switch.

The unit shall be suitable for operation from 240/415 V AC supply. The batteries shall have sufficient capacity for tripping and control duties associated with sub-station and pumping station.

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | DIN 40736 | Lead Acid Batteries-Part-I Stationary vented cells with plastic tubular plates in plastic containers |
| 2 | IS : 8320 | General requirements and methods of tests for lead-acid storage batteries |
| 3 | IS : 1146 | Rubber and plastic containers for lead-acid storage batteries |
| 4 | IS : 6619 | Safety code for semiconductor rectifier equipment |
| 5 | IS : 6071 | Synthetic separators for lead acid batteries |
| 6 | IS : 2147 | Degrees of protection provided by enclosures for low voltage switchgear and control gear |
| 7 | IS : 4237 | General requirements for switchgear for voltages not exceeding 1000 V AC |
| 8 | IS : 8623 | Specification for factory built assemblies of switchgear and control gear (up to 1000 volts) |
| 9 | IS : 9224(II) | Fuses with breaking capacity for industrial application |
| 10 | IS : 4064 | Specification for air break switches, disconnector and |

| | | |
|---|---|---|
| | | fuse combination units |
| 11 | IS : 266 | Battery Grade Sulphuric Acid |
| 12 | IS : 266 | Water for Storage Batteries |
| 13 | IS : 6071 | Synthetic Separator for Lead-Acid Batteries |

## 4. Auxiliary Transformer

I. DETAILS OF THE AUXILIARY TRANSFORMER

The load connected to this transformer will be valve actuators of both pumping stations, lighting of both pump houses and offices, EOT cranes, Misc. load like welding socket, power socket, etc.

Transformers will be copper wound, oil natural air natural (ONAN) cooled, Dyn11 vector group. The transformer kVA rating will suit the condition when all the elements are operating at full load. This transformer will have Off Load Tap Changing facility ranging +5% to –5% in step of 2.5% each.

The rating of the transformer proposed as 6.6/0.433 kV, 315 kVA, Dyn11 with OCTC range –5 % to +5 % in step of 2.5 % each.

II. APPLICABLE STANDARDS

| Sr.No. | IS/IEC code | Description |
|---|---|---|
| 1 | IS 2026 Part I | Specification of Power Transformers |
| 2 | IS 2026 Part 2 | Temperature Rise |
| 3 | IS 2026 Part 3 | Insulation levels and Dielectric Tests |
| 4 | IS 2026 Part 4 | Terminal Markings, Tapping and connections |
| 5 | IS 2026 Part 5 | Transformer / Reactor Bushings - Minimum External clearance in Air Specification |
| 6 | IS 6600 | Guide for Loading of Oil Immersed Transformer |
| 7 | IS 335 | Specification for New Insulating Oil for Transformers and Switchgears |
| 8 | IS 1666 | Copper conductors for transformer Windings |

## 5. 415V LT Panel

There will be 2 Nos. of incomers from two 6.6/0.433 kV Transformers. Each incomer will have 0.433 kV, 500 A MCCB. This will be provided with releases for overload and short circuit. The voltmeter, ammeter, kWh, etc. meters will be provided on incoming feeder.

A 315 A MCCB will be provided as a bus coupler. In. regular operating conditions, this will be kept open. Under opening of either of the incomers, this will be closed.

The outgoing feeders will be provided with adequate rating MCCBs and MCBs. For motor feeders MCCBs with starters will be provided.

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS 2147 | Degree of Protection provided by enclosure for low voltage switchgear and control gear |
| 2 | IS 13947 | Specification for low voltage switchgear and control gear |
| 3 | IS 2705 | Specification for current Transformers |
| 4 | IS 3156 | Specification for voltage transformer |
| 5 | IS 1248 | Specification for direct acting indicating analogue electrical measuring instrument and their accessories |
| 6 | IS 8623 | Specification for low voltage switchgear and control gear assemblies |
| 7 | IS 3231 | Specification for electrical relays for power system protection |
| 8 | IS 5578 | Guide for marking of insulated conductors |
| 9 | IS 11353 | Guide for uniform system of marking and identification of conductors and apparatus terminals |
| 10 | IS 13703 | Specification for Low-voltage fuses not exceeding 1000V AC or 1500V DC |

## 6. Soft Starters

In both the pumping stations, the Soft Starters will be used to limit the starting current and to minimize the voltage drop in the system. These starters will be installed in pump house and will be suitable for connecting on neutral side of the motors. The Soft Starters will limit the starting current up to 2 times of the full load current of the motor. The soft starter shall be having the facility of bypassing after reaching the full speed.

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS 4029 | Guide for testing three phase induction motors |
| 2 | IS 5553 [ part 3 ] | Reactor Specifications – current Limiting reactors for 3 Phase motors |
| 3 | IS 2071 (Part1) | High voltage test techniques |
| 4 | IS 5553 part 3 | Current limiting reactors and Neutral earthing reactors |
| 5 | IEC 60076 -6 Part 6 | Power transformers (Reactors) |
| 6 | IS10118 | Code of practice for selection , installation and maintenance of switchgear and control gear |
| 7 | IS3427 | Specification for metal enclosed switchgear and control gear for voltage above 1000V but not exceeding 11000 V |
| 8 | IEC 289 | Reactors |
| 9 | IS3427 IEC 298 | AC metal enclosed switchgear and control gear for rated voltages above 1 KV and up to and including 52 KV |
| 10 | IS 2147 | Degree of protection provided by Industrial enclosure |

## 7. Selection Of HT/ LT Cables and Laying Methods

I. HT CABLES

The cables shall be 6.6 kV (UE) grade, aluminium conductor, cross linked polythene (XLPE) insulated, PVC inner and outer sheath, GI strip armoured, FRLS type cables. These cables will be laid in the trenches on cable trays or on the suspended cable trays. Cables may run through pipe sleeves wherever required. The cables will be selected on the following basis

**1.** Rated current of the equipment.

**2.** Fault level of the system.

**3.** Steady state Voltage drop (should be below 3 %)

II. LT POWER AND CONTROL CABLES

All LT power cables shall be Aluminium conductor, 1.1 kV grade XLPE Insulated, FRLS type.

The cables upto the main Panel from Auxiliary transformer will 3 ½ Core, whereas from Panel to individual equipment the cable can be of 3 C, 3 ½ C, 4 C, etc. as per requirement.

All control cables shall be copper multi strand conductor, 1.1 kV grade, XLPE Insulated, FRLS type.

III. Cable Laying

These cables will be laid in the trenches on cable trays or on the suspended cable trays as specified in the cable layout drawing. Cables may run through pipe sleeves wherever required. Cable routings given on the drawings will be checked at site to avoid interference with structures, piping and ducting. Minor adjustments shall be made to suit the field/site conditions. There should be different treys in one trench for HT Power, LT power and Control cables.

**8. Earthing System**

Earthing will be designed in accordance with IS 3043 and IEEE-80.

An earthing grid will be formed around the Switchgear room and both the pumping station and these grids are interconnected by minimum two separate earthing conductors and finally it will be connected to switchyard earthing grid . The conductor of the grid shall be buried not less than 600 mm below ground and connected to earth electrode as specified by IS. All grids will have a minimum of two connections to other grids and all equipment will be connected to the grid by two separate earthing strips.’

**9. Lightning Protection System**

Lightning protection system for pump house and switchgear room will be designed in accordance with IS 2309. Lightning protection system will be comprise of roof conductors, down conductors, test links, earth electrodes etc.

25 x 6 mm GS strip is used as lightning conductor. Lightning down conductor will be cleated on outer side of building wall or welded to outside building columns and connected to earth electrode through test link located 1000 mm above ground level. For lightning conductor on roof supporting blocks of insulating compound will be used for conductor fixing.

## 10. Illumination of Pump House

The lighting system for the sub-station will be powered from a 240V AC supply with lux levels conforming to IS 3646. The required lux levels are presented in the following table.

**Lighting Levels**

| **Pump House Indoor Area** | **Average Illumination Level in Horizontal plane (in Lux)** | **Type of fitting** | **Lamps** |
|---|---|---|---|
| Main Pump house area | 200 | High Bay anodized Aluminum reflector assembly complete with control gear Box<br>To be supplemented with fluorescent tube lights if required. | 250/400 W HPSV Lamp<br><br>2 X 28 W T5 |
| Control Room/ Operators room | 300 | Mirror optic | 2x28 Watt T5 tube lights |
| Switchgear Room | 250 | Industrial Type | 2x28 Watt T5 tube lights |
| Store Room | 100 | Industrial Type | 1x28 Watt T5 tube lights |
| Battery Room | 150 | Corrosion proof luminaries cast Aluminium housing with specially designed vapour proof lamp holder | 2x40 Watt fluorescent tube lights |

## 11. Power Factor Improving Capacitors

The main load of the pumping station is of Vertical Pumps. The prime movers for these pumps are Induction motors. These motors will run at lagging power factor. So power factor improvement is proposed by connecting capacitors with each motor. The capacitors will be provided such that the individual motor power factor will be improved to 0.95.

The APFC panel is not proposed as majority of the load is main pumps, which is fixed. No variable load is envisaged.

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS 13585 | Capacitor designing |
| 2 | IS- 12672 | Internal fuses |
| 3 | IS 5553 ( part-3) | Reactors |

**12. LAYOUT of Electrical Control Equipment**

Electrical Equipment like DCDB, LT Panel, RTCC, Switchyard control panel, 6.6 kV H.T. Panels, etc. will be installed at Switchgear room which is located near switchyard and approximately 500m away from stage-1 pumping station. Soft starters will be installed in respective pump houses.

**B. 33 KV ELECTRICAL SWITCHYARD EQUIPMENT :**

**1. Proposed Scheme**

LOAD IN THE PUMP HOUSE

Major load of the pump houses is Pumps. In addition to that there will be additional load of Valve actuating motors, lighting, EOT, etc.

**2. Details of the Proposed Scheme**

The power would be available at 33 kV level, so there will be a 33/6.9 kV Sub-stations at stage-2 pumping station comprises of Breakers, LAs, CTs, PTs, Isolators, etc. The function of the sub-station is stepping down the voltage from 33 kV to 6.6 kV. There will be 2 incomers (from power plant) of 33 kV and 2 Nos. of 33/6.9 kV transformers in the sub-station. . The transformer will have capacity to supply the full load of pumping station.

| Feeder. | Description |
|---|---|
| Incomer - 1 | 33 kV line to be terminated on substation gantry with ACSR conductor. |
| Incomer - 2 | 33 kV line to be terminated on substation gantry with ACSR conductor. |
| Outgoing – 1 | For 33/6.9 kV transformer # 1 |
| Outgoing – 2 | For 33/6.9 kV transformer # 2 |

From 33/6.9 kV transformer, the power will be supplied to the indoor 6.6 kV switchgear. These connections will be made by 6.6 kV cables. From the indoor switchgear power will be supplied to the respective motors with help of 6.6 kV cables.

**3. Outdoor Vacuum Circuit Breaker**

The breakers are provided on incomers for protection and isolation of the system. Vacuum Circuit breakers will be rated for 36 kV with rated current of 630 Amp. rated breaking current of 25 kA suitable for rapid auto close operation

APPLICABLE STANDARDS

| Sr.No. | IS/IEC code | Description |
|---|---|---|
| 1. | IEC-62271/IS 13118 | Specification for alternating current Circuit breaker |
| 2. | IS: 375 | Marking and arrangement for switchgear bus-bar, main connections and auxiliary wiring |
| 3. | IS: 2516 | Specification for circuit breaker |
| 4. | IS: 2099 | High voltage porcelain bushing |
| 5. | IS: 2629 | Recommended practice for hot dip galvanizing of iron and steel |

**4. 33/6.9 kV Transformer**

The transformer shall be as per IS 2026. Transformers will be copper wound, oil natural air natural (ONAN) cooled type. The Ratio of the transformer is 33 kV on HT side and 6.9 kV (under no load conditions) on LV side. The windings will be Delta on 33 kV side and Star on 6.9 kV (Dyn11 vector group). The neutral will be brought outside the transformer on 6.9 kV side.

The transformer rating will be suitable to start the last motor with highest rating i.e 1800 kW motor in stage -2 pump house when all other motors of Stage-1 and Stage-2 pumping stations and all other auxiliary load is running.

The provision of an ‘on line tap changer’ (OLTC) ranging from -15% to +5%, in step of 1.25% each, is proposed on the 33/6.9 kV transformer.

While sizing the transformer, following condition is considered

- 3 motors of 1800 kW, 2 motors of 700 kW and all other auxiliary load of both the pumping stations is running
- 1 motor of 1800 kW is starting

It is considered that the motors will take 2 times of full load rated current at the time of starting with soft starters and 6 times of full load rated current at the time of DOL starting.

The suitable rating for transformer is selected after satisfying above consideration and the voltage drop at starting should be less than 10%.

| | |
|---|---|
| **Rating** | **33/6.9 kV, 12.5 MVA, Dyn11, %Z= 8% (As per IS-2026) with OLTC range +5% TO -15% tapping in step of 1.25% each.** |

APPLICABLE STANDARDS

| Sr.No. | IS/IEC code | Description |
|---|---|---|
| 1 | IS 2026 Part I | Specification of Power Transformers |
| 2 | IS 2026 Part 2 | Temperature Rise |
| 3 | IS 2026 Part 3 | Insulation levels and Dielectric Tests |
| 4 | IS 2026 Part 4 | Terminal Markings, Tapping and connections |
| 5 | IS 2026 Part 5 | Transformer / Reactor Bushings - Minimum External clearance in Air Specification |
| 6 | IS 6600 | Guide for Loading of Oil Immersed Transformer |
| 7 | IS 335 | Specification for New Insulating Oil for Transformers and Switchgears |
| 8 | IS 3639 | Specification for Fittings and Accessories for Power Transformers |
| 9 | IS 2099 | Bushings for alternating voltages above 1000 Volts |
| 10 | IS 3637 | Specification for gas operated relays |
| 11 | IS 1666 | Copper conductors for transformer Windings |
| 12 | IS 3347 | Dimensions for Porcelain and transformer bushing |
| 13 | IS 1271 | Thermal evaluation and classification of electrical insulation |

## 5. Neutral Grounding Resistor (NGR)

An outdoor NGR will be provided for each main 33/6.9 kV transformer. The transformer neutral will be earthed through the NGR. The value of the NGR will be decided such that the fault current will be restricted to the full load current of the transformer.

NGR will conform to the latest applicable Standards IEEE 32.

The rating of the NGR will be 6.6 kV, 3.5 Ohm

## 6. 33 kV Current Transformer (CT)

33 kV outdoor type CTs will be provided for protection and metering. Ratio of the CT is considered to satisfy full load current of the connected equipment (Transformer in this case). Protection class like 5P20, CLPS is provided for protection CTS and metering is done by CTs of 1.0 accuracy class with 1A secondary current.

The details are as below

DETAILS OF 33 KV CURRENT TRANSFORMER

| **Location** | **Rating** | **No. of Core** | **Class** | **VA Burden** | **Purpose** |
|---|---|---|---|---|---|
| Incomer | 250/1 | 3 | Core 1 : Cl 1.0<br>Core 2 : 5P20<br>Core 3 : CLPS | 20 VA<br>20 VA | Metering<br>Protection<br>Differential Protection |

Current Transformer (CT) will conform to the requirements of IS 2705.

## 7. Potential Transformer

The 33 kV PTs will be single phase, oil immersed, dead tank type. The voltage transformers will be suitable for mounting on steel structures. The potential Transformers will be provided on the 33 kV Incomer. Voltage measurement and Under voltage/Over voltage protection is provided with potential transformer.

DETAILS OF THE 33 KV POTENTIAL TRANSFORMER

| **Location** | **QTY** | **Rating** | **No. of Core** | **Class** | **VA Burden** | **Purpose** |
|---|---|---|---|---|---|---|
| 33 kV Line | 1 Set | (33/√3 kV) / (110/√3) | 2 | Core 1 : Cl 0.1<br>Core 2 : CL 3P | 100 VA<br>100 VA | Metering<br>Protection |

Voltage Transformer (VT) will conform to the requirements of IS 3156.

## 8. Lightning Arrestors (LA)

Lightning arrestors (LA) will be provided on each phase of the incoming (33 kV), lines and for transformers.

30 kV, 10 kA, Station class, gapless type LAs complete with line and ground terminal will be provided. The insulating base will be provided along with the LAs.

The assembly will be 30 kV, single phase, housed in a high strength porcelain insulator casing with metallic cover plates and terminal assemblies. The end casting will be well sealed to protect the unit from moisture.

The rating of the LA will be 30 kV, 10 kA, Station class

The lightening arrestors will comply with the requirements of latest, edition of IEC publication No. 60099 – 4.

### 9. Isolators

The isolators will be center post rotating double break, manually gang operated, air break, off load type. Interlock will be provided between isolator and circuit breaker. Interlock will be such that isolator will get opened only when the breaker is off.

The rating of the Isolator will be 33 kV, 400 A, 25 kA

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS 1818 | Specification for alternating current isolators (Disconnector) and earthing switches |
| 2 | IS 2544 | Specification for porcelain post insulators (3.3 KV and above) |
| 3 | IS 2099 | High voltage bushing |
| 4 | IS 9921 | Alternating current isolator (Disconnector) and earthing switches for voltage above 1000V |

### 10. Switchyard Control Panel

One indoor, simplex, floor mounted, compartmentalised type dust and vermin proof Switchyard Control Panel will provided for 33 kV sub-station. There will be Two compartments for incomer. The panel will have rear access. The mimic diagram will be provided on the same. The metering for 33 kV side will be housed in this panel. The measurement of current, voltage, power (active and reactive), power factor etc. will be done.

The relays for the protection will also be housed in the same panel. The protections like over-current, earth fault, etc and additional protections for transformers like restricted Earth fault, Transformer Differential and auxiliary relays for transformer mounted equipments are provided in this panel.

Annunciation and indication will also be provided. Every breaker will be provided with facility to monitor the healthiness of trip coil in both open and close position.

## 11. Lighting System in Switchyard

The lighting system for the sub-station will be powered from a 240V AC supply. As per CBIP manual, the required lux levels for switchyard illumination are presented in the following table.

**Lighting Levels**

| Area | Lux levels |
|---|---|
| Sub-station & outdoor lighting | 20 |

**Lighting Fixture**

| **Area** | **Type** |
|---|---|
| Outdoor lighting | High pressure sodium vapour lamps (HPSV) |

## 12. Earthing System and Lightning Protection.

Earthing and lightning protection will be designed in accordance with IS 3043, IEEE 80 and IS 2309 respectively.

A common earthing grid will be formed over the total area of the sub-station. The conductor of the grid shall be buried not less than 600 mm below ground and connected to earth electrode as specified by IS. All grids will have a minimum of two connections to other grids and all equipment will be connected to the grid by two separate earthing strips.

The earth grid shall be designed to achieve a values of $E_{stape}$, $E_{touch}$ and earth resistance in permissible limits. The design shall be based on the soil resistivity of the site.

The Lightning Protection for the Sub-Station will be provided by laying wire above the towers and for Pumping Station it will be done by providing 25 x 6 mm GI strips, laid on the roof of the structure.

## 13. Switchyard System

For the reference see Switchyard layout drawings. Fault level for the switchyard shall be 25 kA for 33 kV sub-station.

The switchyard equipment such as CT, PT, Isolator shall have sufficient cantilever strength to withstand fault level.

All structural supports in the switchyard shall be of hot dipped galvanised steel.

All structures shall be connected to earthing grid by at least 2 separate earth strips.

I. GALVANISED STEEL STRUCTURES

The galvanised steel structures shall be a lattice type of fabricated construction shall be hot dip galvanised. The quality of hot-dip galvanising shall be determined by sets given in IS : 728 - 1959. Methods for determination of weight, thickness and quantity of coating on galvanised articles other than wires and sheets. All gang/drilling work shall be completed and the burrs shall be removed before putting members for galvanising.

The structure for each equipment shall be complete with necessary bolts, nuts, washers etc. for foundation and also for mounting of equipment.

All the structures shall be designed to withstand for the required conditions like wind pressure, gravity loading, tension loading, etc.

II. BUS BAR MATERIAL

A. Conductor

The conductor shall be standard ACSR `ZEBRA'.

B. Clamps

The required clamps for connection of ACSR conductor will be provided as per the requirement of the system.

C. Insulators

All suspension and tension insulators as required, for switchgear and other connections shall conform to Indian Standard Specification No. 731: 1971 with latest amendment thereof. The tension and suspension fittings (Hardware) shall be as per IS: 2486 (Part I & II) 1971.

As the ACSR conductor is to be used for switchyard connections, the suspensions insulators, strings, clamps, jumper connection etc. shall be suitable for connections of ACSR conductor.

Refer Drawing Plate No. DWG 18 for Sub-Station & Switchgear Room Layout for Stage 1 & Stage 2 Pumping.

P.T.O.

## III. PART II – SWITCHGEAR ROOM & SUB-STATION AT UKD FOR STAGE 3 :

### Introduction

At Stage 3, water will be Pumped from Upper Khajuri Dam Intake to MTPP Plant. The Intake Jackwell Pump House will be constructed in the Dam Reservoir, on the Up-Stream of the Dam Wall. The Sub-Station & Switchgear will be established on the Down-Stream of the Dam Wall. The distance from Pump House & Switchgear will be around 100 m.

The Power will be available on 33 kV Level. Accordingly there will be one 33/6.9 kV Sub-station at Pumping Station, comprising of Breakers, LAs, CTs, PTs, Isolators, etc. The function of the sub-station is stepping down the voltage from 33 kV to 6.6 kV. There will be 2 incomers of 33 kV in the sub-station. There will be 2 Nos. of 33/6.9 kV transformers in the sub-station.

The motor will be of 6.6 kV rating for this pumping station. So the 33/6.6 kV substation will supply the load through 6.6 kV cables to the 6.6 kV indoor switchgear. The 6.6 kV indoor switchgear will supply the power to 6.6 kV motors. There will be 2 incomers of 6.6 kV, and bus coupler. Outgoing feeders of 6.6 kV will be for motors and 6.6/0.433 kV Auxiliary transformer. Auxiliary transformer is provided to cater all LT load of the pumping station like EOT crane, Lighting, Valve actuators etc.

### 33/6.6 kV SUB-STATION & PUMPING STATION

At the Sub-Station :

- Tapping power.
- Sub-station comprising of two incoming feeders from 33 kV double circuit transmission line. Incoming feeders comprising of LA, CT, PT, Isolators, CBs, etc. and connected to two nos. of 33/6.9 kV transformers.
- Provision of 2 Nos. 33/6.9 kV transformers
- Earthing and lightning protection systems
- Lighting system
- Provision of Auxiliary transformer to cater all LT load of Substation and Pumping station.
- Provision of Switchgear / control room including 6.6 kV panels, 0.433 kV panels, batteries, battery charge etc.
- All associated civil engineering works, fencing, gates and ancillary items

**Availing Electric Power**

The power for pumping station will be drawn from power plant / from nearby substation through 33 kV double circuit transmission line.

**Selection of distribution Voltages**

The maximum load at the pump house will be the induction motors, the standard voltages for induction motors are as following

11 kV, 6.6 kV, 3.3 kV, 415 V.

As the motor rating will be @ 700 kW for stage-1 and 1800 kW for stage-2 (16 hrs. pumping), the motors proposed are of 6.6 kV.

Range of motors at different voltage levels is as follows :-

v) Motors upto 250 kW – 415 Volts;
vi) Motors upto 250-500 kW – 3.3 kV
vii) Motors upto 400-2000 kW –6.6 kV
viii) Motors above 2000 kW – 11 kV

These rating motors are, generally, available with all the reputed manufacturers.

**Fault Level**

The fault level on the 33 kV side is considered as 25 kA for 3 Sec. for equipment selection.

The fault level on 6.6 kV side will be mainly decided on the rating of the 33/6.6 kV transformer and impedance of the transformer.

At present transformer rating woks out to be 2500 kVA. According to IS 2026, the impedance of the 2500 kVA transformer is 6.25 % so fault level on 6.6 kV side is @ 3.5 kA.

Generally the short time rating of all the 6.6 kV as well as 33 kV equipment will be taken as 25 kA.

**A. PUMPING STATION :**

**1. Electrical Motors**

I. 6.6 KV MOTORS

For the pump application slip-ring or squirrel cage induction motors may be used.

Slip-ring induction motors are expensive and complex in manufacture and construction. They also require frequent maintenance and skilled personnel to operate and maintain. The starting mechanism for slip-ring motors can also be difficult because starting can be done by either grid rotor resistance (GRS), or by liquid rotor resistance starting (LRS), both of which require more maintenance and operator starting skill.

Squirrel cage induction motors are simple in construction, easy to maintain, cheaper than the slip-ring motors and the starting method is much easier. Therefore, it is proposed that motors for all types of pumps, shall be squirrel cage induction motors.

The motors shall be Vertically mounted. The motors shall be of CACA type. The insulation shall be of Class F and temperature rise shall be restricted to Class B. This will ensure longer life and better performance of the motor. The motors will be provided with adequate no. of Simplex RTDs.

The motors details are as follows:

| Name | Motor kW | Rated Voltage | Type of Motor & motor cooling | Method of starting |
|---|---|---|---|---|
| Pumping Station at Khajuri Dam | 725 kW (2 Working + 1 Standby) | 6.6kV | CACA Squirrel cage Induction Motor | Through Soft Starter |

II. L V MOTORS

All the motors below 200 kW will be LT induction motors of squirrel cage type. The starting of motors upto 7.5 kW will be DOL type and above 7.5 kW will be star delta type. Crane motors will be decided by crane supplier.

The class of insulation of the above motors will be `F’.

III. APPLICABLE STANDARDS

| **Sr.No.** | **Codes** | **Description** |
|---|---|---|
| 1 | IS: 325 | Three Phase Induction Motors. |
| 2 | IS: 4889 | Method of determination of efficiency of rotating electrical machines. |
| 3 | IS:4029 | Guide for testing three phase induction motors. |

## 2. 6.6 kV Indoor Switchgear

The following table describes the various circuit breakers available for indoor duty.

I. INDOOR CIRCUIT BREAKERS

| **Type** | **Remarks** |
|---|---|
| Sulphur hexa fluoride circuit breaker (SF6CB) | Available upto 33 kV indoor duties. |
| Vacuum circuit breaker (VCB) | Available upto 33 kV indoor duties. |
| Minimum oil circuit breaker (MOCB) | Old technology, poor reliability, complicated operation and maintenance. |
| Bulk oil circuit breaker (BOCB) | Old technology, poor reliability, complicated operation and maintenance. |

It is feasible that the SF6 / Vacuum CB type can be used, but, as all outdoor breakers are VCB, it is preferred to use Vacuum Circuit Breakers for indoor purpose also.
So Vacuum Circuit Breakers will be provided at each incomer and motor feeders.
The 6.6 kV switchgear will consist of VCB, CT, PT, meters, relays, busbars, etc.

Switchgear will be made out of sheet steel in compartmentalized design and will be suitable for bottom cable entry on rear side. The main incomer from transformer will be through XLPE insulated Al conductor cable. The horizontal bus bar chamber will be on the top.

The Vacuum Circuit Breakers will be provided on the incomer and all outgoing feeders for the protection and isolation of the system.
The breakers on the incomer will be of 6.6 kV, 25 kA, 630 A.

II. OTHER 6.6 KV COMPONENT

In addition to 6.6 kV breakers following Components will be provided in the 6.6 kV panel

A. Current Transformer (CT)

CTs will be provided with each 6.6 kV breaker for protection and metering. The protection will be provided with Protection class CTs and metering will be provided with the CTs of class 1.0, with 1 Amp secondary current. The rating of the CTS will suit the FLC of the connected equipment.

Details of the CT (6.6 kV PMCC)

| **Location** | **Rating** | **No. of Core** | **Class** | **VA Burden** | **Purpose** |
|---|---|---|---|---|---|
| Incomer | 250/1 | 3 | Core 1 : Cl 1.0<br>Core 2 : 5P20<br>Core 3 : CLPS | 15 VA<br>15 VA | Metering<br>O/C, E/F Protection<br>REF Protection |
| Outgoing (Motor feeder) | 100/1 | 2 | Core 1 : CL 1.0<br>Core 2 : 5P20 | 15 VA<br>15 VA | Metering<br>Motor protection. |
| LT X'mer Feeder | 30/1 | 2 | Core 1 : CL 1.0<br>Core 2 : 5P20 | 15 VA<br>15 VA | Metering.<br>O/C, E/F Protection |

B. Potential Transformer (PT)

The line PTs on each panel incomer shall be installed for protection and metering. The protection will be provided with PTs of class 3P and metering will be provided with the PTs of class 1.0.

Details of the PT (6.6 kV)

| **Location** | **Rating** | **No. of Core** | **Class** | **VA Burden** | **Purpose** |
|---|---|---|---|---|---|
| 6.6 kV Incomer | (6.6/√3 kV) / (110/√3 V) | 2 | Core 1 : Cl 1.0 | 50 VA | Metering |
| | | | Core 2 : Cl 3P | 50 VA | UV / OV Protection |

C. Protections

**4.** Incomer feeder : An IDMTL overload and earth fault (with s/c feature) protection will be provided on each incomer.

**5.** Outgoing feeders

ii. Outgoing motor feeder : A comprehensive motor protection relay will be provided on each of the motor feeders. In addition, there will be instantaneous earth fault protection for capacitors with the help of CBCT.

Comprehensive Motor Protection relay will have following features.

- Three phase over current protection with instantaneous high and low set (50-51)
- Negative phase sequence protection (46)
- Start up supervision for motor (48, 14, 66)
- Under voltage protection (27)
- Lock out relay (86)
- Relay is suitable for communication.

ii Outgoing Auxiliary Transformer feeder : An IDMT Overload and earth fault protection (with s/c feature) will be provided.

Refer Single Line Diagram (Drawing Plate No. DWG 19) for other details.

D. EARTHING TRUCK

A separate earthing truck will be provided for maintenance work. This truck will be suitable for earthing the switchgear busbars as well as outgoing/incoming cables. The trucks will have a voltage transformer and an interlock to prevent earthing of any live connection. The earthing trucks will have a visual and audible annunciation to warn the operator against earthing of live connections.

III. APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS: 1248 (Part-1) | Direct acting indicating analogue electrical measuring |

| | | |
|---|---|---|
| | | instruments and their accessories: General requirements |
| 2 | IS: 2099 | Bushings for alternating Voltages above 1000 Volts |
| 3 | IS: 2147 | Degrees of protection provided by enclosures for low voltage switchgears & control gear |
| 4 | IS: 2705 (Part-1) | Current transformers: General requirements |
| 5 | IS:3043 | Code of practice for earthing |
| 6 | IS: 3156 (Part-1) | Voltage transformers: General requirements |
| 7 | IS: 3231 | Specification for electrical relays for power system protection |
| 8 | IS: 3427 | A.C. metal enclosed switchgear and control gear for rated voltages above 1 KV & up to & including 52 KV |
| 9 | IS:9385 | High voltage fuses |
| 10 | IS: 12729 | General requirements for switchgear & control gear for voltages exceeding 1000 V |
| 11 | IS: 13118 | Specification for High Voltage A.C. Circuit breaker |
| 12 | IS:13703 | Specification for low voltage for voltages not exceeding 1000V |
| 13 | IS:13947 | Specification for low voltage switchgear and control gear assemblies |

**6. Battery, Battery Charger and D.C.D.B.**

2 sets of Lead Acid Batteries (maintenance free) with charger will be provided.

The 33 kV and 6.6 kV circuit breakers will be given 110 V DC supply for control circuit. Under normal conditions this supply will be taken from DCDB but in the event of a power failure, tripping will be ensured from a battery supply.

The battery and charger unit shall be self contained in a sheet steel cabinet suitable for floor mounting. The batteries shall be of lead acid Cells in series/parallel arrangement to provide the rated voltage.

The Battery charger system shall be of solid state constant voltage type with automatic control for float charging of the batteries and shall incorporate boost charging facilities.

The unit shall have the controls and indication on front side. The indication includes voltmeter, indication lamps showing supply ON, float charging and boost charging supply, ON/OFF switch and float/boost charge switch.

The unit shall be suitable for operation from 240/415 V AC supply. The batteries shall have sufficient capacity for tripping and control duties associated with sub-station and pumping station.

APPLICABLE STANDARDS

| **Sr.No.** | **Codes** | **Description** |
|---|---|---|
| 1 | DIN 40736 | Lead Acid Batteries-Part-I Stationary vented cells with plastic tubular plates in plastic containers |
| 2 | IS : 8320 | General requirements and methods of tests for lead-acid storage batteries |
| 3 | IS : 1146 | Rubber and plastic containers for lead-acid storage batteries |
| 4 | IS : 6619 | Safety code for semiconductor rectifier equipment |
| 5 | IS : 6071 | Synthetic separators for lead acid batteries |
| 6 | IS : 2147 | Degrees of protection provided by enclosures for low voltage switchgear and control gear |

| | | |
|---|---|---|
| 7 | IS : 4237 | General requirements for switchgear for voltages not exceeding 1000 V AC |
| 8 | IS : 8623 | Specification for factory built assemblies of switchgear and control gear (up to 1000 volts) |
| 9 | IS : 9224(II) | Fuses with breaking capacity for industrial application |
| 10 | IS : 4064 | Specification for air break switches, disconnector and fuse combination units |
| 11 | IS : 266 | Battery Grade Sulphuric Acid |
| 12 | IS : 266 | Water for Storage Batteries |
| 13 | IS : 6071 | Synthetic Separator for Lead-Acid Batteries |

## 7. Auxiliary Transformer

I. DETAILS OF THE AUXILIARY TRANSFORMER

The load connected to this transformer will be valve actuators, lighting of pump house and offices, EOT cranes, Misc. load like welding socket, power socket, etc.

Transformers will be copper wound, oil natural air natural (ONAN) cooled, Dyn11 vector group. The transformer kVA rating will suit the condition when all the elements are operating at full load. This transformer will have Off Load Tap Changing facility ranging +5% to –5% in step of 2.5% each.

The rating of the transformer proposed as 6.6/0.433 kV, 200 kVA, Dyn11 with OCTC range –5 % to +5 % in step of 2.5 % each.

II. APPLICABLE STANDARDS

| Sr.No. | IS/IEC code | Description |
|---|---|---|
| 1 | IS 2026 Part I | Specification of Power Transformers |

| | | |
|---|---|---|
| 2 | IS 2026 Part 2 | Temperature Rise |
| 3 | IS 2026 Part 3 | Insulation levels and Dielectric Tests |
| 4 | IS 2026 Part 4 | Terminal Markings, Tapping and connections |
| 5 | IS 2026 Part 5 | Transformer / Reactor Bushings - Minimum External clearance in Air Specification |
| 6 | IS 6600 | Guide for Loading of Oil Immersed Transformer |
| 7 | IS 335 | Specification for New Insulating Oil for Transformers and Switchgears |
| 8 | IS 1666 | Copper conductors for transformer Windings |

## 8. 415V LT Panel

There will be 2 Nos. incomers from two 6.6/0.433 kV Transformers. Each incomer will be 0.433 V, 315 A MCCB. This will be provided with releases for overload and short circuit. The voltmeter, ammeter, kWh, etc. meters will be provided on incoming feeder.

A 315 A MCCB will be provided as a bus coupler. In regular operating conditions, this will be kept open. Under opening of either of the incomers, this will be closed.

The outgoing feeders will be provided with adequate rating MCCBs and MCBs. For motor feeders MCCBs with starters will be provided.

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS 2147 | Degree of Protection provided by enclosure for low voltage switchgear and control gear |
| 2 | IS 13947 | Specification for low voltage switchgear and control gear |
| 3 | IS 2705 | Specification for current Transformers |
| 4 | IS 3156 | Specification for voltage transformer |
| 5 | IS 1248 | Specification for direct acting indicating analogue electrical |

| | | |
|---|---|---|
| | | measuring instrument and their accessories |
| 6 | IS 8623 | Specification for low voltage switchgear and control gear assemblies |
| 7 | IS 3231 | Specification for electrical relays for power system protection |
| 8 | IS 5578 | Guide for marking of insulated conductors |
| 9 | IS 11353 | Guide for uniform system of marking and identification of conductors and apparatus terminals |
| 10 | IS 13703 | Specification for Low-voltage fuses not exceeding 1000V AC or 1500V DC |

## 9. Soft Starters

The Soft Starters will be used to limit the starting current and to minimize the voltage drop in the system. These starters will be installed in pump house and will be suitable for connecting on neutral side of the motors. The Soft Starters will limit the starting current up to 2 times of the full load current of the motor. The soft starter shall be having the facility of bypassing after reaching the full speed.

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS 4029 | Guide for testing three phase induction motors |
| 2 | IS 5553 [ part 3 ] | Reactor Specifications – current Limiting reactors for 3 Phase motors |
| 3 | IS 2071 (Part1) | High voltage test techniques |
| 4 | IS 5553 part 3 | Current limiting reactors and Neutral earthing reactors |
| 5 | IEC 60076 -6 Part 6 | Power transformers (Reactors) |
| 6 | IS10118 | Code of practice for selection , installation and maintenance of switchgear and control gear |
| 7 | IS3427 | Specification for metal enclosed switchgear and control gear for voltage above 1000V but not exceeding 11000 V |

| | | |
|---|---|---|
| 8 | IEC 289 | Reactors |
| 9 | IS3427 IEC 298 | AC metal enclosed switchgear and control gear for rated voltages above 1 KV and up to and including 52 KV |
| 10 | IS 2147 | Degree of protection provided by Industrial enclosure |

**10. Selection Of HT/ LT Cables and Laying Methods**

I. HT CABLES

The cables shall be 6.6 kV (UE) grade, aluminium conductor, cross linked polythene (XLPE) insulated, PVC inner and outer sheath, GI strip armoured, FRLS type cables. These cables will be laid in the trenches on cable trays or on the suspended cable trays. Cables may run through pipe sleeves wherever required. The cables will be selected on the following basis

**4.** Rated current of the equipment.

**5.** Fault level of the system.

**6.** Steady state Voltage drop (should be below 3 %)

II. LT POWER AND CONTROL CABLES

All LT power cables shall be Aluminium conductor, 1.1 kV grade XLPE Insulated, FRLS type.

The cables upto the main Panel from Auxiliary transformer will 3 ½ Core where as from Panel to individual equipment the cable can be of 3 C, 3 ½ C, 4 C, etc. as per requirement.

All control cables shall be copper multi strand conductor, 1.1 kV grade, XLPE Insulated, FRLS type.

III. Cable Laying

These cables will be laid in the trenches on cable trays or on the suspended cable trays as specified in the cable layout drawing. Cables may run through pipe sleeves wherever required. Cable routings given on the drawings will be checked at site to avoid interference with structures, piping and ducting. Minor adjustments shall be made to suit the field/site conditions. There should be different treys in one trench for HT Power, LT power and Control cables.

**11. Earthing System**

Earthing will be designed in accordance with IS 3043 and IEEE-80.

An earthing grid will be formed around the Switchgear room and pumping station and these two grids are interconnected by minimum two separate earthing conductors and finally it will be connected to switchyard earthing grid . The conductor of the grid shall be buried not less than 600 mm below ground and connected to earth electrode as specified by IS. All grids will have a minimum of two connections to other grids and all equipment will be connected to the grid by two separate earthing strips.'

**12. Lightning Protection System**

Lightning protection system for pump house and switchgear room will be designed in accordance with IS 2309. Lightning protection system will be comprise of roof conductors, down conductors, test links, earth electrodes etc.

25 x 6 mm GS strip is used as lightning conductor. Lightning down conductor will be cleated on outer side of building wall or welded to outside building columns and connected to earth electrode through test link located 1000 mm above ground level. For lightning conductor on roof supporting blocks of insulating compound will be used for conductor fixing.

**13. Illumination of Pump House**

The lighting system for the sub-station will be powered from a 240V AC supply with lux levels conforming to IS 3646. The required lux levels are presented in the following table.

**Lighting Levels**

| **Pump House Indoor Area** | **Average Illumination Level in Horizontal plane (in Lux)** | **Type of fitting** | **Lamps** |
|---|---|---|---|
| Main Pump house | 200 | High Bay anodized | 250/400 W |

| Pump House Indoor Area | Average Illumination Level in Horizontal plane (in Lux) | Type of fitting | Lamps |
|---|---|---|---|
| area | | Aluminum reflector assembly complete with control gear Box<br>To be supplemented with fluorescent tube lights if required. | HPSV Lamp<br>2 X 28 W T5 |
| Control Room/ Operators room | 300 | Mirror optic | 2x28 Watt T5 tube lights |
| Switchgear Room | 250 | Industrial Type | 2x28 Watt T5 tube lights |
| Store Room | 100 | Industrial Type | 1x28 Watt T5 tube lights |
| Battery Room | 150 | Corrosion proof luminaries cast Aluminium housing with specially designed vapour proof lamp holder | 2x40 Watt fluorescent tube lights |

## 14. Power Factor Improving Capacitors

The main load of the pumping station is of Vertical Pumps. The prime movers for these pumps are Induction motors. These motors will run at lagging power factor. So power factor improvement is proposed by connecting capacitors with each motor. The capacitors will be provided such that the individual motor power factor will be improved to 0.95.

The APFC panel is not proposed as majority of the load is main pumps, which is fixed. No variable load is envisaged.

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS 13585 | Capacitor designing |
| 2 | IS- 12672 | Internal fuses |
| 3 | IS 5553 ( part-3) | Reactors |

## 15. LAYOUT of Electrical Control Equipment

Electrical Equipment like DCDB, LT Panel, RTCC, Switchyard control panel, 6.6 kV H.T. Panels, etc. will be installed at Switchgear room which is located near switchyard and approximately 100m away from pumping station. Soft starters will be installed in pump house.

## B. 33 KV ELECTRICAL SWITCHYARD EQUIPMENT :

### 1. Proposed Scheme

LOAD IN THE PUMP HOUSE

Major load of the pump house is Pumps. In addition to that there will be additional load of Valve actuating motors, lighting, EOT, etc.

### 2. Details of the Proposed Scheme

The power would be available at 33 kV level, so there will be a 33/6.9 kV Sub-stations at pumping station comprises of Breakers, LAs, CTs, PTs, Isolators, etc. The function of the sub-station is stepping down the voltage from 33 kV to 6.6 kV. There will be 2 incomers (from power plant) of 33 kV and 2 Nos. of 33/6.9 kV transformers in the sub-station. . The transformer will have capacity to supply the full load of pumping station.

| Feeder. | Description |
|---|---|
| Incomer - 1 | 33 kV line to be terminated on substation gantry with ACSR conductor. |

| | |
|---|---|
| Incomer - 2 | 33 kV line to be terminated on substation gantry with ACSR conductor. |
| Outgoing – 1 | For 33/6.9 kV transformer # 1 |
| Outgoing – 2 | For 33/6.9 kV transformer # 2 |

From 33/6.9 kV transformer, the power will be supplied to the indoor 6.6 kV switchgear. These connections will be made by 6.6 kV cables. From the indoor switchgear power will be supplied to the respective motors with help of 6.6 kV cables.

The work in the 33/6.6 kV sub-station :

- Tapping power at 33 kV level.
- Provision of 2 Nos. 33/6.9 kV transformers
- Earthing and lightning protection systems
- Lighting system
- Provision of switchyard control panels, batteries, battery charge etc.
- All associated civil engineering works, fencing, gates and ancillary items

**3. Outdoor Vacuum Circuit Breaker**

The breakers are provided on incomers for protection and isolation of the system. Vacuum Circuit breakers will be rated for 36 kV with rated current of 630 Amp. rated breaking current of 25 kA suitable for rapid auto close operation

APPLICABLE STANDARDS

| **Sr.No.** | **IS/IEC code** | **Description** |
|---|---|---|
| 6. | IEC-62271/IS 13118 | Specification for alternating current Circuit breaker |
| 7. | IS: 375 | Marking and arrangement for switchgear bus-bar, main connections and auxiliary wiring |
| 8. | IS: 2516 | Specification for circuit breaker |
| 9. | IS: 2099 | High voltage porcelain bushing |

| Sr.No. | IS/IEC code | Description |
|---|---|---|
| 10. | IS: 2629 | Recommended practice for hot dip galvanizing of iron and steel |

**4. 33/6.9 kV Transformer**

The total load on the transformer will be Vertical Turbine pumps.

The transformer shall be as per IS 2026. Transformers will be copper wound, oil natural air natural (ONAN) cooled type. The Ratio of the transformer is 33 kV on HT side and 6.9 kV (under no load conditions) on LV side. The windings will be Delta on 33 kV side and Star on 6.9 kV (Dyn11 vector group). The neutral will be brought outside the transformer on 6.9 kV side. The transformer rating will be suitable to start the second motor when other motor and all other auxiliary load is running.

The provision of an 'on line tap changer' (OLTC) ranging from -15% to +5%, in step of 1.25% each, is proposed on the 33/6.9 kV transformer.

While sizing the transformer, following condition is considered

- 1 No. motor and all other auxiliary load is running
- 2nd motor is starting

It is considered that the motors will take 3 times of full load rated current at the time of starting with soft starters and 6 times of full load rated current at the time of DOL starting.

The suitable rating for transformer is selected after satisfying above consideration and the voltage drop at starting should be less than 10%.

| | |
|---|---|
| **Rating** | **33/6.9 kV, 2.5 MVA, Dyn11, %Z= 6.25% (As per IS-2026) with OLTC range +5% TO -15% tapping in step of 1.25% each.** |

<u>APPLICABLE STANDARDS</u>

| Sr.No. | IS/IEC code | Description |
|---|---|---|
| 1 | IS 2026 Part I | Specification of Power Transformers |

| Sr.No. | IS/IEC code | Description |
|---|---|---|
| 2 | IS 2026 Part 2 | Temperature Rise |
| 3 | IS 2026 Part 3 | Insulation levels and Dielectric Tests |
| 4 | IS 2026 Part 4 | Terminal Markings, Tapping and connections |
| 5 | IS 2026 Part 5 | Transformer / Reactor Bushings - Minimum External clearance in Air Specification |
| 6 | IS 6600 | Guide for Loading of Oil Immersed Transformer |
| 7 | IS 335 | Specification for New Insulating Oil for Transformers and Switchgears |
| 8 | IS 3639 | Specification for Fittings and Accessories for Power Transformers |
| 9 | IS 2099 | Bushings for alternating voltages above 1000 Volts |
| 10 | IS 3637 | Specification for gas operated relays |
| 11 | IS 1666 | Copper conductors for transformer Windings |
| 12 | IS 3347 | Dimensions for Porcelain and transformer bushing |
| 13 | IS 1271 | Thermal evaluation and classification of electrical insulation |

## 5. Neutral Grounding Resistor (NGR)

An outdoor NGR will be provided for each main 33/6.9 kV transformer. The transformer neutral will be earthed through the NGR. The value of the NGR will be decided such that the fault current will be restricted to the full load current of the transformer.

NGR will conform to the latest applicable Standards IEEE 32.

The rating of the NGR will be 6.6 kV, 17.5 Ohm

## 6. 33 kV Current Transformer (CT)

33 kV outdoor type CTs will be provided for protection and metering. Ratio of the CT is considered to satisfy full load current of the connected equipment (Transformer in this case).

Protection class like 5P20, CLPS is provided for protection CTS and metering is done by CTs of 1.0 accuracy class with 1A secondary current.

The details are as below

DETAILS OF 33 KV CURRENT TRANSFORMER

| **Location** | **Rating** | **No. of Core** | **Class** | **VA Burden** | **Purpose** |
|---|---|---|---|---|---|
| Incomer | 50/1 | 2 | Core 1 : Cl 1.0<br>Core 2 : 5P20 | 20 VA<br>20 VA | Metering<br>Protection |

Current Transformer (CT) will conform to the requirements of IS 2705.

**7. Potential Transformer**

The 33 kV PTs will be single phase, oil immersed, dead tank type. The voltage transformers will be suitable for mounting on steel structures. The potential Transformers will be provided on the 33 kV Incomer. Voltage measurement and Under voltage/Over voltage protection is provided with potential transformer.

DETAILS OF THE 33 KV POTENTIAL TRANSFORMER

| **Location** | **QTY** | **Rating** | **No. of Core** | **Class** | **VA Burden** | **Purpose** |
|---|---|---|---|---|---|---|
| 33 kV Line | 1 Set | (33/√3 kV) / (110/√3) | 2 | Core 1 : Cl 0.1<br>Core 2 : CL 3P | 100 VA<br>100 VA | Metering<br>Protection |

Voltage Transformer (VT) will conform to the requirements of IS 3156.

**8. Lightning Arrestors (LA)**

Lightning arrestors (LA) will be provided on each phase of the incoming (33 kV), lines and for transformers.

30 kV, 10 kA, Station class, gapless type LAs complete with line and ground terminal will be provided. The insulating base will be provided along with the LAs.

The assembly will be 30 kV, single phase, housed in a high strength porcelain insulator casing with metallic cover plates and terminal assemblies. The end casting will be well sealed to protect the unit from moisture.

The rating of the LA will be 30 kV, 10 kA, Station class

The lightening arrestors will comply with the requirements of latest, edition of IEC publication No. 60099 – 4.

**9. Isolators**

The isolators will be center post rotating double break, manually gang operated, air break, off load type. Interlock will be provided between isolator and circuit breaker. Interlock will be such that isolator will get opened only when the breaker is off.

The rating of the Isolator will be 33 kV, 200 A, 25 kA

APPLICABLE STANDARDS

| Sr.No. | Codes | Description |
|---|---|---|
| 1 | IS 1818 | Specification for alternating current isolators (Disconnector) and earthing switches |
| 2 | IS 2544 | Specification for porcelain post insulators (3.3 KV and above) |
| 3 | IS 2099 | High voltage bushing |
| 4 | IS 9921 | Alternating current isolator (Disconnector) and earthing switches for voltage above 1000V |

**10. Switchyard Control Panel**

One indoor, simplex, floor mounted, compartmentalized type dust and vermin proof Switchyard Control Panel will provided for 33 kV sub-station. There will be Two compartments for incomer. The panel will have rear access. The mimic diagram will be provided on the same. The metering for 33 kV side will be housed in this panel. The measurement of current, voltage, power (active and reactive), power factor etc. will be done.

The relays for the protection will also be housed in the same panel. The protections like over-current, earth fault, etc and additional protections for transformers like restricted Earth fault, auxiliary relays for transformer mounted equipments are provided in this panel.

Annunciation and indication will also be provided. Every breaker will be provided with facility to monitor the healthiness of trip coil in both open and close position.

## 11. Lighting System in Switchyard

The lighting system for the sub-station will be powered from a 240V AC supply. As per CBIP manual, the required lux levels for switchyard illumination are presented in the following table.

**Lighting Levels**

| Area | Lux levels |
|---|---|
| Sub-station & outdoor lighting | 20 |

**Lighting Fixture**

| **Area** | **Type** |
|---|---|
| Outdoor lighting | High pressure sodium vapour lamps (HPSV) |

## 12. Earthing System and Lightning Protection.

Earthing and lightning protection will be designed in accordance with IS 3043, IEEE 80 and IS 2309 respectively.

A common earthing grid will be formed over the total area of the sub-station. The conductor of the grid shall be buried not less than 600 mm below ground and connected to earth electrode as specified by IS. All grids will have a minimum of two connections to other grids and all equipment will be connected to the grid by two separate earthing strips.

The earth grid shall be designed to achieve a values of $E_{stape}$, $E_{touch}$ and earth resistance in permissible limits. The design shall be based on the soil resistivity of the site.

The Lightning Protection for the Sub-Station will be provided by laying wire above the towers and for Pumping Station it will be done by providing 25 x 6 mm GI strips, laid on the roof of the structure.

## 13. Switchyard System

For the reference see Switchyard layout drawings. Fault level for the switchyard shall be 25 kA for 33 kV sub-station.

The switchyard equipment such as CT, PT, Isolator shall have sufficient cantilever strength to withstand fault level.

All structural supports in the switchyard shall be of hot dipped galvanised steel.

All structures shall be connected to earthing grid by at least 2 separate earth strips.

### I. Galvanised Steel Structures

The galvanised steel structures shall be a lattice type of fabricated construction shall be hot dip galvanised. The quality of hot-dip galvanising shall be determined by sets given in IS : 728 - 1959. Methods for determination of weight, thickness and quantity of coating on galvanised articles other than wires and sheets. All gang/drilling work shall be completed and the burrs shall be removed before putting members for galvanising.

The structure for each equipment shall be complete with necessary bolts, nuts, washers etc. for foundation and also for mounting of equipment.

All the structures shall be designed to withstand for the required conditions like wind pressure, gravity loading, tension loading, etc.

### II. Bus Bar Material

#### A. Conductor

The conductor shall be standard ACSR `DOG’.

B. Clamps

The required clamps for connection of ACSR conductor will be provided as per the requirement of the system.

C. Insulators

All suspension and tension insulators as required, for switchgear and other connections shall conform to Indian Standard Specification No. 731: 1971 with latest amendment thereof. The tension and suspension fittings (Hardware) shall be as per IS: 2486 (Part I & II) 1971.

As the ACSR conductor is to be used for switchyard connections, the suspensions insulators, strings, clamps, jumper connection etc. shall be suitable for connections of ACSR conductor.

Refer Drawing Plate No. DWG 20 for Sub-Station & Switchgear Room Layout for Stage 3 Pumping Station.

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## REFERENCES


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3. CWC Ganga River Data at Station Mirzapur (Yr. 1981 to Yr. 2011) – Guage, Discharge, Silt & 24 Hr. Peak Flood.

4. Salient Features of Upper Khajuri Dam, WRD, Mirzapur.

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6. Report on Raw Water Intake & Water Transmission by TCE (November 2011) prepared for WEUPPL.

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8. ANSI/HI 9.8-1998 : American National Standard for Pump Intake Design

9. IS 1710 : Specifications for Pumps – Vertical Turbine Mixed and Axial Flow, For Clear Cold Water ($2^{nd}$ Rev)

10. IS 15310 : Hydraulic Design of pump Sumps and Intake – Guidelines.

11. IS 5822 : Code of Practice for Laying of Electrically welded Steel Pipes for Water Supply ($2^{nd}$ Rev)

12. IS 589 : Steel Pipes for Water & Sewage (168.3 to 2540 mm OD) – Specifications.

13. IS 2062 : Hot Rolled Low, Medium and High Tensile Structural Steel

14. IS 4622 : Recommendations for Structural Design of Fixed-Wheel Gates.

15. IS 5620 : Recommendations for Structural Design Criteria for Low Head Slide Gates.

16. IS 11639 Structural Design of Penstock – Criterion (Part 2 & Part 3)

17. IS 12967 : Analysis of Hydraulic Transients in Hydro-Electric and Pumping Plants – Code of Practice

18. IS 2062 : Power Transformers

19. M11, AWWA : Steel Water Pipe, A guide for Design and Installation, Manual for Water Supply Practices.

20. M1, IWWA : Design of Large Diameter Steel Pipelines.

21. Manual on Water Supply and Treatment by Central Public Health And Environmental Engineering Organisation, Ministry of Urban Development, Govt. of India.

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