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ASSAM POWER GENERATION CORPORATION LIMITED

BIDDING DOCUMENTS

(NATIONAL COMPETITIVE BIDDING)

FOR

HYDROMECHANICAL WORKS
CONTRACT PACKAGE FOR
KARBI LANGPI MIDDLE-II HYDRO POWERPROJECT (24 MW)

(ASSAM, INDIA)

Bid No: KLM-II-HPP/PKG- 2

HYDRO MECHANICAL WORKS

VOLUME-III

TECHNICAL SPECIFICATIONS

AUGUST 2025

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1. QUALIFYING REQUIREMENTS

The Bidder who wishes to participate in the bid shall satisfactorily establish the following Qualifying Requirements (QR):

1.1. DETAILED EVALUATION OF TECHNICAL BIDS

The Employer will carry out a detailed technical evaluation of the bids other than those rejected as being substantially non-responsive, in order to determine whether the technical aspects are in compliance with the Tender Document. In order to reach such a determination, the Employer will examine and compare the technical aspects of the bids on the basis of the information supplied by the Bidders, taking into account the following:

1. Overall completeness and compliance with the Employer's Requirements,
2. Deviations from the Employer's Requirements,
3. Conformity of the plant and services offered with specified performance criteria,
4. Suitability of the plant and services offered in relation to the environmental and climatic conditions prevailing at the site,
5. Quality, function and operation of any process control concept included in the bid.
6. Type, quantity and long-term availability of mandatory and recommended spare parts and maintenance services.
7. The bidder shall have design, manufacture, testing facility of major TG, C&I equipment's in India.
8. Other relevant factors, if any, are listed below.

The bid that does not meet minimum acceptable standards of completeness, consistency and detail will be rejected for non-responsiveness.

1.2. TECHNICAL REQUIREMENTS (Hydro-Mechanical)

The Bidder Company having ratings more than threshold value as below in preceding 20(Twenty) years. The beginning and end date should fall within the preceding 20(Twenty) years (start to finish) for specific experience reckoned from the last day of the month previous to the one in which applications are invited.

Radial Gate (Submerged/Crest)

Manufacturing, installation, testing and commissioning of Radial Gate operated by hydraulic hoist.

A x H = 757m^3.

Steel Liner for Pressure Shaft

Fabrication/manufacturing, erection, testing and commissioning of Steel liner for Pressure Shaft

D x H = 250m^2.

Vertical Lift Gate

Manufacturing, Installation, testing and commissioning of Fixed Wheel type Vertical Lift Gate operated by hydraulic hoist or rope drum hoist.

A x H =784m^3.

Where,

"A" denotes an area (Clear width by clear height) for one gate in m^2 .

"Clear Width" denotes distance between inner faces of two opposite piers.

"H" (for gates) denotes the normal design head at the bottom of the gate in meter.

"D" denotes maximum inside diameter in meter of steel liner.

"H" (for steel liner) denotes the maximum design head in meter.

Note: Please enclose copy of performance certificate/other testimonials as proof of claimed experience by the bidder without which it will be considered non-responsive and disqualified

1.3. FINANCIAL CRITERIA

Refer Volume I, Part I: "*Invitation for Tender*" clause 4 for Financial Qualification Criteria

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1. SCOPE

The Tenderer shall quote for the scope specified in the Contract including the "Technical Specifications" and shall include in the scope all the equipment and services required for the project in full and complete shape even though some of the equipment and services are not specifically mentioned (or) detailed here or elsewhere so that the units and auxiliaries are functionally complete in all respects. The Contractor shall perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract, as being required for attaining completion of the project, as if such work and/or items and materials were expressly mentioned in the Contract.

Bids are invited Design, manufacture, procurement, supply, fabrication, shop assembly, painting, shop testing, transportation & delivery to project site, receipt & storage at site, erection, testing & commissioning including packing & forwarding for shipment and trial operation of all Hydro-Mechanical Equipments and steel liner of pressure shaft including all associated works for 3 x 8 MW Karbi Langpi Middle II Hydro Power Project.

The Goods and Services shall meet the stipulations of the "Technical Specifications "and other requirements of the Contract.

The final destination for "Goods" to reach is: 24 MW Karbi Langpi Middle II Hydro Power Project Site, West Karbi Anglong

1.1. SALIENT FEATURES

Salient features of Karbi Langpi Middle-II HPP are presented in the following table below:

Table 0.1 Salient Features of Karbi Langpi Middle-IIHPP

1	**Head Works**	
1.1	**Barrage Complex (General)**	
1.1.1	Location	River Borpani West Karbi Anglong district of Assam.
1.1.2	Type of Barrage	Conventional Barrage
1.1.3	Top of Barrage (Pier)	EL 392.00 m
1.1.4	Full reservoir level	EL 385.50 m
1.1.5	Maximum Water level (1 in 100 year)	EL 389.00 m
1.1.6	Maximum Water level (1 in 500 year)	EL 390.40 m
1.1.7	Minimum draw down level	EL 385.50 m
1.1.8	Average reservoir level = MDDL +2/3x(FRL-MDDL)	EL 385.50 m
1.1.9	Flood (1 in 500 year)	4670 cumec
1.1.10	Flood (1 in 100 year)	3160 cumec
1.1.11	Crest Level	EL 375.00
1.1.12	No of Gates	4 No's
1.1.13	Gate Type	Radial Gate
1.1.14	Size	10.0 m (W) x 10.50 m (H)
1.1.15	Hoisting arrangement	Hydraulic Hoist
1.1.16	No of Stop log gates	1 Set of 4 Bays
1.2	**River Diversion Scheme**	

1.2.1	River Diversion Flood	360 Cumec (25 Years Return Period Non-Monsson Flood)
1.2.2	Diversion Channel	5 m wide
1.2.3	Height of Upstream side Coffer dam	8.50 m
1.2.4	Height of Downstream side Coffer dam	8.62 m
1.2.5	U/S Coffer dam top El	EL 383.65 m
1.2.6	D/S Coffer dam top El	EL 383.00 m
1.3	**Power Intake**	
1.3.1	Location	Right bank
1.3.2	Design discharge at Trash Rack	47.60 cumec (Design discharge) 52.36 Cumec (10% overload)
1.3.3	Design discharge for main Plant	52.36 Cumec (10% overload)
1.3.4	No of trash rack bays	3 No's
1.3.5	Trash rack sill level	EL 380.0 m
1.3.6	Trash rack opening size	4.2m (W) x 12.0m (H)
1.3.7	Type	Fixed
1.3.8	Trash rack inclination	12^{o}
1.3.9	TRCM	No
1.3.10	No. of gates	2no(1- Service & 1-
1.3.11	Gate size	6.2 m (W) x 4.0 m (H)
1.3.12	Crest Elevation	EL 377.00 m
1.3.13	Type of Intake Gate	Vertical slide
2	**Water Conductor System-Main plant**	
2.1	**Feeder Tunnel/Duct**	
2.1.1	No. of Feeder Tunnels	One
2.1.2	Feeder Tunnel	Transition+5.2m D-Shaped
2.1.3	Concrete lined	Yes
2.2	**Head Race tunnel**	
2.2.1	No.	One
2.2.2	Design discharge (Rated)	47.6 Cumec
2.2.3	Shape & Size of HRT	D-Shaped, 5.2 m Día
2.2.4	Length	3065.0 m
2.2.5	HRT invert elevation	EL 375.8 m
2.2.6	HRT invert elevation	EL 381.0 m
2.3	**Adit to HRT**	
2.3.1	No.	Two
2.3.2	Size & Shape	Adit- 1,: 4.5 m, Adit- 2: 4.5 m D-Shaped
2.3.3	Length of Adit	80.0 m,96.85 m
2.3.4	Adit gate - Hinge Type	No (concrete plugged)
3	**Surge Shaft**	
3.1	Type	Elevated, Restricted Orifice
3.2	Diameter	15.00 m (Finished)
3.3	Minimum Down surge level	EL 373.00 m not mention in dwgs
3.4	Maximum Up-surge level	EL 395.50 m / 394.20m
3.5	Reinforced concrete lining	Yes
3.6	Dia of Orifice (including gate grooves)	2.8 m
3.7	Surge shaft bottom elevation	EL 363.20 m
4	**Pressure shaft Embedded in Concrete**	
4.1	**Pressure Shaft**	

4.1.1	No.	One
4.1.2	Size & Shape	3.70 m, circular
4.1.3	Length (up to trifurcation)	43.8 m
4.1.4	Steel lined	Yes
4.1.5	Centre line of pressure shaft	EL 365.05 m
4.2	**Unit Pressure shaft (after trifurcation)**	
4.2.1	No.'s	Three
4.2.2	Diameter	2.2 m
4.2.3	Total length (Longest unit pressure shaft)	80.44 m
4.2.4	Concrete encasement	Yes
4.2.5	Centre line of trifurcation point	EL 365.05 m
4.3	**Inlet Pipe (reducer)**	
4.3.1	No.'s	Three
4.3.2	Diameter	2.2 m
4.3.3	Concrete encasement	Yes
4.3.4	Centre line of reducer	EL 315.55 m
5	**Power House Complex**	
5.1	**Main Power House**	
5.1.1	Type & Location	Surface & Right Bank
5.1.2	Type of turbine	Horizontal Francis
5.1.3	Installed Capacity	3 x 8 MW = 24 MW
5.1.4	Centre line of Turbine	EL 315.55 m
5.1.5	Normal TWL	EL 320.40 m
5.1.6	Min TWL (For one Unit)	EL 319.80 m
5.1.7	Top of Tail Race Channel Outlet Weir	EL 319.50 m
5.1.8	Minimum Size (Machine Hall including service bay)	52.0m (L) x 17.0 m (W)
5.1.9	Rated Gross Head = Average reservoir level - Normal TWL	=385.50 - 320.40 = 65.10 m
5.1.10	Head Loss through Water Conductor System	8.0 m
5.1.11	Rated Net Head = Rated Gross Head - Head Loss through Water Conductor System	57.10 m
5.1.12	Rated Discharge Per Unit	15.87 Cumec
5.1.13	Service Bay Level	EL 327.00m
5.1.14	HFL at Powerhouse	EL 325.50 m
6	**Tailrace**	
6.1	**Tailrace for Main Powerhouse**	
6.1.1	Width of Tailrace	33.2m
6.1.2	Tailrace Ducts	Three separate ducts merging into one common
7	**Switchyard**	
7.1	Voltage Level	33.0 kV
7.2	Minimum Size	33.0m x 40.10 m
7.3	Scheme	Outdoor
7.4	Finished Ground Level	EL 335.00m

1.2. TRANSPORT LIMITATIONS

The equipment shall be manufactured and supplied so as to suite transport limitations including Trailor weight and packing material for heaviest package. The bidders are advised to visit the site to have detailed information about roads, railways & bridges along with to have a detailed route survey plan from

manufactures point to the project site.

1.3. INTERCHANGEABILITY

All similar component parts of similar equipment supplied shall be interchangeable with one another.

1.4. DEVIATIONS FROM SPECIFICATIONS

1. Should the Tenderer wish to depart from these specifications, he shall submit a complete and itemized list of such departures together with full particulars of the reasons for the departures in a separate schedule with reference to section and paragraph numbers of these tender specifications along with this Bid.

2. Unless this is done the Goods offered shall be deemed to comply in every respect with this Tender document. The statement of departures shall be made as a separate Schedule to the Tender.

1.5. APPROVAL OF DRAWINGS

1. Successful Tenderer shall start submitting all relevant drawings for fabrication/ installation along with design calculations of components (four copies each for hard along with soft copy) of equipments within four (4) weeks from the issuance of NTP, for approval. The approval of the drawings shall be accorded within two (2) weeks to be checked of receipt of the drawings. After approval of the drawing by the Employer/Engineer, each drawing becomes a Contract drawing. Thecontractor shall thereupon furnish Employer/Engineer with four (4) prints and one reproducible/soft copy of the drawings, which shall include the appropriate revision number after incorporating all corrections. The Contractor shall not depart from contract drawings except by the written permission of the Employer/Engineer.

2. Manufacture of the Goods to commence only after receipt of drawing approval. Any manufacture performed prior to the approval of drawings will be at the Contractor's risk.

3. When revised drawings are submitted for approval, the changes from the previous submitted drawings shall be clearly identified on the drawings, with every revision made during the lifetime of the Contract shown by number, date and subject in a revision block and its notation shall be given in the drawing margin. The drawings shall be clear and legible in all respects.

4. The drawings shall be clear, facilitating easy identification of all parts with part number for ordering of spares by the Employer without referring to Contractor.

5. Approval of the drawings will not relieve the Contractor of hisresponsibility for the correctness of the design and construction of the plant, guarantees and warrantees on the performance of the Goods as per the terms and

conditions of the specifications.

6. All drawings must be prepared on AutoCAD 2002 or above and supplied in soft copy also along with six hard copies for each drawing.

1.6. TRAINING OF EMPLOYER PERSONNEL

The contractor shall give training to the Employer personnel in full, extend complete practical training for operation and maintenance, repair of equipment at its works as well as site also.

1.7. LOCATION AND PROJECT ACCESSIBLITY

The proposed Karbi Langpi Middle -II HPP is located near the village Morinto, in Karbi Anglong district of Assam. The project will be located upstream of existing Lower Langpi HEP (100MW) and is one of the four identified upstream projects. The village Morinto can be approached by motorable road from Amsoi which is connected by NH-37. The project road will be required to approach barrage and powerhouse sites from village Morinto. The powerhouse site will be located on the opposite bank of the exiting road. To approach barrage site about 3.6 km of access road will be required from village Morinto. The same road will be extended from downstream of barrage site to approach powerhouse site. A bridge and a road of about 3.4km along the right bank of river will be required to approach the powerhouse site. Presently, barrage and powerhouse sites are approachable with the help of footpaths.

The village Morinto is about 22km from the nearest town called Langeri. Most of this stretch of road is blacktopped with the exception of about 5km of katchha road. Langeri town is connected by NH-37 with Guwahati and is at a distance of about 117km. Guwahati is well connected by air, rail and road networks with other parts of the country. The project site is about 139kms from Guwahati. The nearest broad-gauge rail head is Jagiroad and is about 94kms from the powerhouse site.

1.8. TOPOGRAPHY AND PHYSIOGRAPHY OF THE BASIN

Umkhem/Borpani River is a left bank tributary of River Kopili. It originates near the village Laitker in the District East Khasi Hills of the State of Meghalaya with the name of Umkhen and finally meets River Kopli in Assam after flowing for a total distance of about 139 kilometres. Total catchment area of Borpani River up to its confluence with kopli is 2326 km^2 and up to the proposed barrage site is 1090. 0km^2.The entire catchment is rain fed and lies below permanent snowline, considered at El 4500m. The highest elevation in the catchment is 1891m and most part of the catchment area is under mild to moderate slope, leaving aside small patches near the ridge area towards the southwest which has extremely steep slopes of 50% or larger. The major portion of the basin is under forest cover. The elevation in the project area varies from 600 to 300m.

1.9. GEOLOGY

The project area falls in the Archean basement terrain of Mikir hill. The Archean group of rocks mainly consists of prophyritic granite, granites, granite gneiss with its variants like biotite gneiss, biotite-hornblende gneiss and quartzosegneiss. There are few rock exposures in the project area which are presentnear the river while the slopes are mostly covered with scree/ slopewash material covered with dense vegetation cover.

Based on available geological data including the surface geological mapping and geotechnical investigations completed for the project structures, the site may be considered suitable for construction of project components. No adverse geological features have been observed and noted during the geological mapping and investigations. The project area may be categorized to the extent of having satisfactory geological conditions.

Similar to Lower Kopili HEP (120 MW), the Karbi Langpi HPP area lies in the Seismic zone 'V' of India as incorporated in the Indian Standard Criteria for Earthquake Resistant Design of Structures (IS: 1893 Part 1-2002). According to "Seismotectonic Atlas of India and its Environ (SEISET-14)" the Dhansiri-Kopili Fault trending NW-SE passes along the Kopili river for a distance of approximately 40 km from the project area.

1.10. CLIMATIC CONDITION

The project catchment experiences moderate summers & winters and are in sub-tropical agro climatic zone. The region experiences four seasons viz., the winter (starting from late November and continuing up to March), the Pre- Monsoon (April and May), South-West Monsoon (end of May to September) and Post Monsoon (October to beginning of November). Temperature in the region varies generally from a maximum of 23°C to 32°C in summer to a minimum of 6°C to 12°C in winter. Summer in Karbi Anglong is hot, humid and sultry. During winter the area experiences fog and mist. The average relative humidity varies between 73% and 84%.

The average annual rainfall in the catchment is 2484.8mm. June to October has been considered as monsoon period and November to May has been considered as non- monsoon period.

1.11. EXISTING INFRASTRUCTURE FACILITIES

NH37 is a stable road well maintained by NHAI. This road follows flat land up Amsoi with vegetation and habitation on both sides of the road. After Amsoi the 41 kms long motorable road is leading the way to APGCL guest house atLangeri. The road enters hilly terrain after crossing Langeri. There is a stretch of 22 kms from Langeri to Moriontо. It is assumed and expected that this stretch of road shall be improved by various operational schemes by various State/Central Govt. agencies e.g. National Rural Employment Guarantee Scheme (NREGS) or Pradhan Mantri Gram Sadak Yogna (PMGSY) etc. There is a Govt. dispensary with basic facilities of health care, primary Govt. school & banks are available at nearest town Langeri, which is about 22 kms from Morinto village. There is an existing petrol pumping station near Baithalangso, which is about 25 km from the Morinto village.

1.12. SURVEY & INVESTIGATION

The following topographical surveys were carried out for project layout, geological mapping & planning of infrastructure and construction facilities etc.

i) Survey of India Topo sheet (Scale 1:50,000)

Survey of India topo sheet no. 83-C/5 which covers all the components of the project area while other topo-sheets 83-C/1, 83-C/2, 83-C/3, 83-C/6 and 83-C/9 were used for the catchment area.

ii) Topographical Maps 1:2,000 of the entire Project Area with a contour interval of 2.0m.

iii) L-Section of Borpani river covering 500 m downstream of powerhouse area to 500mupstream of the weir axis.

iv) River cross section at Barrage axis was prepared on 1:1000 at 25m interval for 100mupstream of the weir axis.

v) River cross section at Barrage axis was prepared on 1:1000 at 25m interval for 50mdownstream of the weir axis.

vi) River cross section at powerhouse axis was prepared on 1:1000m for 50m upstreamof the powerhouse location.

vii) River cross section at powerhouse axis was prepared on 1:1000m for 50m downstream of the powerhouse location.

A total of 12 drill holes have been drilled for the different project components to assess the geotechnical competence.

1.13. CIVIL ENGINEERING STRUCTURES

The following are the main civil engineering structures of the project (Refer Tender drawings for sizes and dimensions):

- The River Diversion Scheme comprises a Single Stage Diversion Channel designed for managing non-monsoon floods, specifically handling a 360 Cumec flow with a 25-year return period, and involves the use of Rockfill Dams as coffer dams, featuring specific dimensions for effective water control. The Barrage Complex, situated on the River Borpani in the West Karbi Anglong district of Assam, is a Conventional Barrage with a crest level at EL 375.00 m, designed to handle a flood of 4740 Cumec; it features 4 Radial Gates (10.0 m W x 10.50 m H) operated by a Hydraulic Hoist and employs a Sloping Stilling Basin for energy dissipation. The Power Intake is situated on the right bank and incorporates a Trash Rack with 3 bays featuring specific dimensions and design features; it also includes a Vertical wheel type Intake Gate. The Water Conductor System for the main plant features a 3065.0m long, D-shaped Head Race Tunnel with a 5.2m diameter, starting downstream of the Intake and terminating at the Surge Shaft, with proposed shotcrete lining; access to the Head Race Tunnel is facilitated through two adits. An open-to-air Surge Shaft with a diameter of 15.00m and a height of 30m (Approx.), designed as a Restricted Orifice Type, is proposed upstream of the powerhouse to manage surge waves and water hammer pressure, featuring a reinforced concrete lining. The Pressure Shaft system consists of one main pressure shaft with specific dimensions and features, trifurcating into three-unit pressure shafts,

each with a diameter of 3.7m. An adit is proposed for access to the Surge Shaft, facilitating transportation and erection of steel liner/bifurcation manifolds in the system The Main Power House, located on the right bank and of surface type, features Vertical Francis turbines with a combined installed capacity of 24 MW, operating at a rated gross head of 65.10 m and a net head of 57.10 m, with a rated discharge of 15.87 Cumec per unit, and specified dimensions and elevation levels. The Tailrace for the Main Powerhouse comprises a tailrace with a width of 33.5m, featuring three separate ducts that converge into a single common duct, necessary for maintaining the required tail water levels Switch yard.

To support the construction and operation of the project components, access roads have been proposed for the Switchyard, which operates at a voltage level of 33.0 kV, with dimensions of 33.0m x 40.10m, following an outdoor scheme, and located at a finished ground level of EL 335.00m.

1.14. INFRASTRUCTURE & CONSTRUCTION FACILITIES

The main infrastructure works envisaged are as follows:

i) About 2708m of Project Road (PR-1) from bifurcation from PWD road to Powerhouse at right bank

ii) About 379m of Project Road (PR-2) from junction point on PR-1 to surge shaft at right bank

iii) About 2971m of Project Road (PR-3) from Morianto village to Barrage axis at left bank

iv) One temporary bailey bridge (span of 35m to 45m) at 100m d/s of Barrage site to provide access from left bank to right bank and also to access the Adit-1 Portal.

v) About 400m of Temporary Project Road (TR-1) from Powerhouse to Adit-2 at right bank

vi) About 488m of Temporary Road (TR-2) from Bailey Bridge to Barrage at right bank

vii) About 177m of Temporary Road (TR-3) from Bailey Bridge Adit-1 at left bank

viii) Temporary roads to quarry site locations, Crusher plant, Concrete batchingplants, Muck Disposal Area, Explosive Magazine site

ix) All temporary buildings for site offices for the contractors including their labour etc. Arrangements etc. have been planned on left bank. Limited muck disposal has also been planned on the right bank.

x) Construction power may be drawn from nearest substation by laying 3 kms of 11kV transmission line. The dependability of construction power shall always be the key concern and hence adequate back-up arrangement estimated as 1.5MW shall have to be made for providing construction power to carry out uninterrupted construction activities.

xi) The boulders and pebbles transported by the river shall be used as a construction material at Barrage and powerhouse sites, in situ rock at Barrage site can also be advantageously used as construction material after due processing.

Technical Specifications of Hydro Mechanical Works

Gates, Hoists and Cranes

1) Intent of Technical Specifications and Scope of Work
2) Description and Design Criteria
3) Materials
4) Manufacture
5) Quality Assurance, Inspection and Workshop Testing
6) Erection, Site Testing, Commissioning and final Acceptance
7) Work and Safety Regulations
8) Pressure Shaft

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1. INTENT OF TECHNICAL SPECIFICATIONS AND SCOPE OF WORK

1.1. Intent of Technical Specifications

1.1.1. General

a) These specifications are part of the requirement for various items related to the work, which are to be provided according to the stipulations of the Contract. Hence, the instructions given herein form an integral part of and are applicable to the Bidding Documents issued for the Works. Addenda to these Specifications may be issued, as required, during bidding and construction phases.

b) These specifications shall be read in conjunction with the Conditions of Contract, the Tender Drawings and the Schedule of Prices and the Contractor shall comply with all provisions contained within the Bidding Documents and instructions of the Engineer-in-Charge.

c) Certain performance requirements, materials, features and design requirements are specified herein. It is not the intention in these specifications to specify in complete detail of the various components of the equipment. This is left to the experience and practice of Manufacturer who shall furnish equipment, which shall meet, in all respects, the specified requirement in regard to performance, durability and satisfactory operation. However, certain features, materials and design requirements are specified and intended to establish minimum standards for the work and to enable the bidder to submit a well-planned bid.

d) It is the intent of these specifications to establish acceptable standards of quality. Deviations from these specifications shall be considered for acceptance provided that, in the opinion of the Engineer-in-Charge, the proposed substitutions are equal or superior in quality to those specified therein and no extra cost shall be claimed by the contractor.

e) All works shall be executed according to the Technical Specifications, Specification Drawings and requirements issued for construction, in a professional and diligent manner and all supplies and works shall comply with the quality requirements as defined in the relevant Chapters of these Specifications and other Bidding Documents. The Contractor shall endeavour to provide all such necessary efforts to comply with the intent of these Specifications to the satisfaction of the Engineer-in-Charge.

1.1.2. Submittals

a) The Contractor shall provide to the Engineer-in-Charge atleast four copies or as otherwise specified, of all submittals as requested for in these Specifications and other Bidding Documents. Although their extent shall be to the discretion of the Contractor, these shall be complete enough to illustrate adequately the problem of the aspect concerned for the understanding of the Engineer-in-Charge.

b) At any time, the Engineer-in-Charge may call either for additional information, completion of the submittals or may request the Contractor not to submit some of them.
c) The Contractor shall submit these documents to the Engineer-in-Charge, so that, even if not specifically expressed, reasonable time will be given to the Engineer-in-Charge to comment or approve the submittals.

1.1.3. Standards and Codes

1.1.3.1. GENERAL

a) All works and supplies shall conform to the Indian Standards (IS). Authoritative Standards and Codes other than IS or those specified in the Bidding Documents, which ensure an equal or higher quality, may also be acceptable.
b) All Standards and Codes referred therein shall be the latest current issues.
c) In case of the discrepancies between these specifications and National or International Standards and Codes, these Specifications being part of Bidding Documents shall govern, unless otherwise directed by the Engineer-in-Charge in each particular case.
d) The contractor shall submit a copy of all applicable Indian/International Standard Codes, Laws, and Regulations, which find mention in the design/drawing submission by the contractor in the first instance.

1.1.3.2. NATIONAL STANDARDS, CODES, LAWS AND REGULATIONS

a) Throughout duration of the contract, the materials, equipment, services, design and workmanship shall conform to the applicable National Codes, Standards, Laws and Regulations in force in India, if not otherwise specified.
b) It is the Contractor's duty to acquaint himself with all National Codes, Standards, Laws and Regulations related to the works in any way and he shall procure and keep at his works at the site a copy of each of such applicable documents.

1.1.3.3. INTERNATIONAL STANDARDS AND CODES.

a) The International Standards/Codes may be adopted provided that:
   - The Standards/Codes proposed are at least as stringent as the equivalent National ones relevant to the works, or if there is no applicable National Standard/Code for the specific item concerned.
   - The Contractor shall state, prior to starting the works, the International Standard/Codes he proposes to apply, giving full identification of each of them. These proposals are subject to the approval by the Engineer-in-Charge.
   - The contractor shall clearly mention the equivalent Indian standard (if exists) for the international standard which the contractor proposes to refer in the design stage in the first instance and shall supply the copy of same.
b) Where reference is made in the Bidding Documents to the Standards/Codes of the country of origin for a supply item, it shall be a recognized National Standard/Code of the country where the specific supply item is manufactured. To be acceptable under these Specifications, such Standards/Codes must comply in all respects with the quality requirements of above-mentioned International Standards/Codes and must be approved by the Employer.

1.1.4. System of Units

The SI system of Units has been used throughout these specifications and this system of units shall be used consequently throughout the duration of contract for all technical or contractual purposes.

1.2. Scope of Work

These specifications cover the requirement of design, procurement, fabrication, shop assembly, painting, testing, transportation, supply, erection, site testing and commissioning of the following equipment at site complete in all respects, for Karbi-Langpi Middle-II Hydro Power Project, in accordance with these Technical Specifications and Tender Drawings. The materials, workmanship, technical requirements, equipment, accessories, supplies and services required, shall be as set forth in these Technical Specifications.

It shall also include the spares required for satisfactory operation and maintenance of Gates/stoplogs/cranes/trashracks/ Hoists and their associated equipment for a period of five years from the date of commissioning of the equipment as set forth in these Technical Specifications and Specification Drawings. The description and quantity of spares required for various Gates, Hoists and their associate equipment have been appended with the Bidding Documents.

The scope of work also covers supervision of unloading, stacking, operation, storage and preservation of components of Gates/stoplogs /cranes/ trashracks/ / Hoists and their accessories in the stockyards of the Contractor at the project site before they are transported, installed, tested and commissioned at their respective sites.

1.2.1. Barrage Radial Gates and Hydraulic Hoists

a) 4 sets of 1st stage inserts such as J-anchors, U-anchors, suitable anchorages system for trunnion bracket etc., complete in all respects.
b) *4* sets of 2nd stage embedded parts such as sill beam with bottom seal seat, side seal seat cum wall plate with base, anchor bolts/studs, double nuts & washers, embedments for anchorage system and dogging arrangement etc., complete in all respects.
c) 4 sets of barrage radial gates of clear vent opening of size 10000 mm x 10500 mm (w x h) along with all accessories such as skin plate, horizontal girder, stiffener, seals, seal clamps, stainless steel fasteners for seals, ferrules, guide rollers, lifting lugs, trunnion hubs, trunnion pins, trunnion brackets, trunnion ties/thrust blocks, dogging/latching arrangement etc.
d) 4 sets of single acting twin cylinder hydraulic hoist of min 30T capacity per cylinder for operation of above gate including all the accessories such as hoist suspension, cylinder shell, piston rod and their mountings on gate, seals, connected piping etc., complete in all respect.
e). 4 pairs of cylinder assembly mountings and support structure complete with structural components and embedded parts complete with all accessories.

f). 4 sets of independent hydraulic power unit (HPU) assembly such as hydraulic reservoir, electric motor driven pumps, pressure relief valves, check valves, flow control valves, directional control valves, pressure and temperature gauges, fluid level switches, filters, strainers, automatic control, hydraulic oil, hydraulic piping, in-built in the hydraulic circuit oil dehydration and particle cleaning system for removal of moisture, humidity and oil impurities in the oil reservoir of power pack units ,electrical control panel, gate position indicator (both digital and analogue) limit switches etc. for operation of above gate etc., battery operated water level alarm along with batteries and trickle charger with provision for automatic lifting of gate by no float control or level relays/sensors (control through float will not be permitted), Provision for suitable terminals in the electrical control cabinet shall also be kept for its connection to the remote control panel as well as from centralized/computerized automatic control for operation of these gates. Also, the hydraulic & electric control and its related power components shall be suitably interconnected to enable the operation of the hoist cylinders of one gate with the hydraulic power unit of other gate. The gates shall be designed to close under their own weight for all operating conditions. In case, the gate is not able to lower under its own weight, the contractor shall provide the double acting hoist without any extra cost. etc., complete in all respects.

g) Mandatory spares for Radial gate & Hydraulic Hoists .

h) Additional spares as recommended by bidder for 5 years trouble free operation of Radial Gates and Hydraulic Hoist.

1.2.2. Barrage Stoplog for Radial Gates, Lifting Beam and Gantry Crane

a) 4 set of 1st stage inserts such as J-anchors, U-anchors and Kerb angles etc. complete in all respects.

b) 4 set of 2nd stage embedded parts such as slide track with track base, sideseal seats with base, sill beam with bottom seal seat, side guide etc., with anchorbolts and double nut & washers etc., complete in all respects.

c) One (1) set of stoplog suitable for 04 Nos. clear vent opening of size 10000 mm x 10500 (w x h) consisting of 4 units as interchangeable with skin plate, main horizontal girders, end vertical girders, stiffeners, Aluminum Bronze slide/thrust pads with base, rubber seals with seal bases for side and bottom, ferrules, seal clamp plates with stainless steel fixing nuts and bolts, release probe, guide shoes, lifting arrangement, latching arrangement etc., complete in all respects.

d) 4 sets of instrumentation pipe of suitable size including all fixtures, clamps, embedment's etc., complete in all respects.

e) 4 sets of latching arrangement with all embedment's complete in all respects.

f) One (1) set of lifting beam with automatic engaging and disengaging type hooks, tie rod, clevis, clevis pin, central pivot arm, counterweight assembly, probe latch mechanism, guide rollers, storing stool etc. complete in all respects.

g) One set of gantry crane of minimum 40T capacity for operation of above stoplogs with supporting legs/columns, hoist platform for engaging and disengaging the lifting beam of stoplogs and complete with all mechanical components such as open gears, gear reduction unit, rope drums, plummer blocks for supporting the rope drum shaft and hold other shafts, wire ropes, brakes (EM as well as EHT), shafts, sheaves, couplings, gate position indicator (both analogue and digital), rope sockets etc., and all the electrical items such as motors, switches, cables, control panel, load cells, limit switches, suitable lighting arrangement above and below the crane platform etc., light weight covers for gear assembly, rope drums,

motors, suitable roof cover (polycarbonate) at the top of crane etc., crane rails (minimum CR 100 rails), embedded parts, end stoppers (hydraulic buffer) and related accessories for the complete length of the crane travel etc., complete in all respects.

h) Mandatory spares for stoplogs & gantry crane.
i) Additional spares as recommended by bidder for 5 years trouble free operation of Stoplog & Gantry Crane .

1.2.3. Intake Service gate, Rope Drum Hoist and Hoist Supporting Structure

a) One set (1) of 1st stage inserts such as J-anchors, U-anchors, Kerb angles for gratings, complete in all respects.
b) One (1) set of 2nd stage embedded parts such as wheel track with track base on d/s, top seal seat with base, side seal seats with base, sill beam with bottom seal seat, side guide with anchor bolts with double nut & washers, Latching/dogging arrangement with embedment's in gate groove etc., complete in all respects.
c) One (1) set of wheeled gate suitable for a clear vent opening of size 6200 mm x 4000 mm] (w x h) with skin plate, main horizontal girders, end vertical girders, stiffeners, wheel assemblies with self aligned stainless steel spherical roller bearings, wheel cut-out arrangement, wheel axle/pins, ferrules, rubber seals with both sides sealing arrangement with seal bases for top, side and bottom, seal clamp plates with stainless steel fixing nuts and bolts, guide shoes, lifting arrangement, latching/dogging arrangement, gratings etc., complete in all respects.
d) One(1) set of Rope Drum Hoist of minimum 25 T capacity for operation of above gates, complete with all the mechanical components such as open gears, gear reduction unit, rope drums, plummer blocks for supporting the rope drum shaft and for all other shafts, wire ropes, brakes (EM as well as EHT), shafts, sheaves, couplings, gate position indicator (both analogue and digital), rope sockets etc., and all the electrical items such as motors, switches, cables, control panel (with a provision of 1 no. 15A and 1 no. 5A switch and socket), load cell, limit switches, suitable lighting arrangement (minimum 500W) above and below the hoist platform etc., covers (light weight) for gear assembly, rope drum, motors,polycarbonate roof for hoist platform etc. complete in all respects.
e) One(1) set of hoist supporting structure to support the hoist consisting of horizontal girders, cross girders, columns/trestles , bracings on all sides, chequered plates for flooring, hand railing, platforms for latching arrangement, , ladders, embedded parts such as base plates, foundation bolts etc., complete in all respects.
f) One (1) set of Local control panel (LCP including all instruments, digital gate position indicator, enclosures, ducts, cabling between LCP to HPU, limit switches, etc. (LCP to be installed adjacent to HPU) complete in all respects.
g) Mandatory spares for gate & hoist.
h) Additional spares as recommended by bidder for 5 years trouble free operation of gate & hoist.

1.2.4. Intake Emergency Gate and Rope Drum Hoist and Hoist Supporting Structure

a) One(1) sets of 1st stage inserts such as J-anchors, U-anchors, Kerb angles for gratings complete in all respects.
b) One (1) set of 2nd stage embedded parts such as wheel track with track base , top seal seat with base, side seal seats with base, sill beam with bottom seal seat,

side guide etc., anchor bolts/studs and double nut & washers, dogging arrangement with embedment's in gate groove etc., complete in all respects

c) One (1) set of fixed wheel intake emergency gate suitable for a clear vent opening of size 6200 mm x 4000 mm (w x h) with skin plate, main horizontal girders, end vertical girders, stiffeners, wheel assemblies with self-aligned stainless steel spherical roller bearings, wheel axle/pins, ferrules, rubber seals with seal bases for top, side and bottom, seal clamp plates with stainless steel fixing nuts and bolts, guide shoes, lifting arrangement, latching/dogging arrangement, ballast (if required), gratings etc., complete in all respects
d) One(1) set of Rope Drum Hoist of minimum 25 T capacity for operation of above gates, complete with all the mechanical components such as open gears, gear reduction unit, rope drums, plummer blocks for supporting the rope drum shaft and for all other shafts, wire ropes, brakes (EM as well as EHT), shafts, sheaves, couplings, gate position indicator (both analogue and digital), rope sockets etc., and all the electrical items such as motors, switches, cables, control panel (with a provision of 1 no. 15A and 1 no. 5A switch and socket), load cell, limit switches, suitable lighting arrangement (minimum 500W) above and below the hoist platform etc., covers (light weight) for gear assembly, rope drum, motors, polycarbonate roof for hoist platform etc. complete in all respects.
e) One(1) set of hoist supporting structure to support the hoist consisting of horizontal girders, cross girders, columns/trestles , bracings on all sides, chequered plates for flooring, hand railing, platforms for latching arrangement, , ladders, embedded parts such as base plates, foundation bolts etc., complete in all respects.
f) One (1) set of Local control panel (LCP including all instruments, digital gate position indicator, enclosures, ducts, cabling between LCP to HPU, limit switches, etc. (LCP to be installed adjacent to HPU) complete in all respects.
g) Mandatory spares for gate & hoist.
h) Additional spares as recommended by bidder for 5 years trouble free operation of gate & hoist.

1.2.5. Intake Trashracks

a) One (1) set (consisting 3 bays) of Embedded Parts for trash racks consisting of channels with anchors, complete in all respects.
b) One (1) set (consisting 3 bays), each consisting of Six panels in a bay of size 4200 mm x 12000 mm (Vertical) (w x h) consisting of channels, trash bars, I-section, angles, lifting arrangement, dowel bars etc. complete in all respects.
c) 1 set monorail hoist with supporting structure and lifting beam for trash rack lifting

1.2.6. Surge Shaft Gate, Rope Drum Hoist and Hoist Supporting Structure

a) One(1) set of 1st stage inserts such as J-anchors, U-anchors, Kerb angles for grating complete in all respects.
b) One(1) set of 2nd stage embedded parts such as Roller track with base, side seal seats with base, top seal seat with base, sill beam with bottom seal seat, side guide , embedments for dogging beam for gate maintenance, anchor bolts/studs and double nut & washers etc., complete in all respects.
c) One(1) set of Wheel gate suitable for a clear vent opening of size 5200 mm x 5200 mm (wxh) with skin plate, main horizontal girders, end vertical girders, stiffeners, Wheel assembly, rubber seals with seal bases for top, side and bottom,ferrules, seal clamp plates with stainless steel fixing nuts and bolts, guide shoes,lifting arrangement, latching arrangement, 2nos. filling valves, grating with wire mesh etc., complete in all respects.

d) One (1) set of Rope Drum Hoists of minimum 40 T capacity for operation of above gates, complete with all the mechanical components such as open gears , gear reduction unit, rope drums, plummer blocks for supporting the rope drum shaft and for all other shafts, wire ropes, brakes (EM as well as EHT), shafts, sheaves, couplings, gate position indicator (both analogue and digital), rope sockets etc., and all the electrical items such as motors, switches, cables, control panel (with a provision of 1 no. 15A and 1 no. 5A switch and socket), load cell, limit switches, suitable lighting arrangement (minimum 500W) above and below the hoist platform etc., covers (light weight) for gear assembly, rope drum, motors, polycarbonate roof for hoist platform etc. complete in all respects.
e) One(1) set of hoist supporting structure to support the hoist consisting of horizontal girders, cross girders, columns/trestles, bracings on all sides , chequered plates for flooring, hand railing, ladder, embedded parts such as base plates, foundation bolts etc., complete in all respects
f) Mandatory spares for gate & hoist.
g) Additional spares as recommended by bidder for 5 years trouble free operation of gate & hoist.

1.2.7. Draft Tube Gates, Rope Drum Hoists and Hoist Supporting Structures

a) Three (3) set of 1st stage inserts such as J-anchors, U-anchors, Kerb angles for grating complete in all respects.
b) Three (3) set of 2nd stage embedded parts such as Roller track with base, side seal seats with base, top seal seat with base, sill beam with bottom seal seat, side guide, embedments for dogging beam for gate maintenance, anchor bolts/studs and double nut & washers etc., complete in all respects.
c) Three (3) of Wheel gate suitable for a clear vent opening of size 3200 mm x 4000 mm (wxh) with skin plate, main horizontal girders, end vertical girders, stiffeners, Wheel assembly, rubber seals with seal bases for top, side and bottom, ferrules, seal clamp plates with stainless steel fixing nuts and bolts, guide shoes, lifting arrangement, latching arrangement, 2nos. filling valves, grating with wire mesh etc., complete in all respects.
d) Three (3) set of Rope Drum Hoists of minimum 25 T capacity for operation of above gates, complete with all the mechanical components such as open gears , gear reduction unit, rope drums, plummer blocks for supporting the rope drum shaft and for all other shafts, wire ropes, brakes (EM as well as EHT), shafts, sheaves, couplings, gate position indicator (both analogue and digital), rope sockets etc., and all the electrical items such as motors, switches, cables, control panel (with a provision of 1 no. 15A and 1 no. 5A switch and socket), load cell, limit switches, suitable lighting arrangement (minimum 500W) above and below the hoist platform etc., covers (light weight) for gear assembly, rope drum, motors, polycarbonate roof for hoist platform etc. complete in all respects.
e) Three (3) set of hoist supporting structure to support the hoist consisting of horizontal girders, cross girders, columns/trestles, bracings on all sides , chequered plates for flooring, hand railing, ladder, embedded parts such as base plates, foundation bolts etc., complete in all respects
f) Mandatory spares for gate & hoist.
g) Additional spares as recommended by bidder for 5 years trouble free operation of gate and hoist.

1.2.8. Fish Pass Gate, Screw Hoists and Hoist Supporting Structures

a) One (1) set of 1st stage inserts such as J-anchors, U-anchors, Kerb angles for grating complete in all respects.
b) One (1) set of 2nd stage embedded parts such as Slide track with base, side seal

seats with base, top seal seat with base, sill beam with bottom seal seat, side guide, embedment for latching beam for gate maintenance, anchor bolts/studs and double nut & washers etc., complete in all respects.

c) One (1) no of Slide type gate suitable for a clear vent opening of size 1500 mm x 1500 mm (wxh) with skin plate, main horizontal girders, end vertical girders, stiffeners, slide pad, rubber seals with seal bases for top, side and bottom, ferrules,seal clamp plates with stainless steel fixing nuts and bolts, guide shoes, lifting arrangement, latching arrangement etc., complete in all respects.
d) One (1) set of manual screw hoist of minimum 5 T capacity for operation of above gates, complete with all the mechanical components with connecting stems with suitable lighting arrangement below the hoist platform etc complete in all respects.
e) One (1) set of hoist supporting structure to support the hoist consisting of horizontal girders, cross girders, columns/trestles, bracings on all sides , chequered plates for flooring, hand railing, ladder, embedded parts such as base plates, foundation bolts etc., complete in all respects
f) Mandatory spares for gate & hoist.
g) Additional spares as recommended by bidder for 5 years trouble free operation of gate and hoist.

1.2.9. Instruments and Remote-Control System

PLC based Remote Control System including cabling shall be provided by the Bidder along with provision for picking up signal from “Local control panels”.

One uninterruptible power supply (battery backup) to provide minimum 30 minutes back-up shall be provided.

Two sets of water level measuring and indication equipment at dam area along with necessary alarms shall be provided.

Differential pressure measurement and indication equipment across intake trash racks

Water level measuring system to indicate balance head condition of spillway stoplogs, Intake gate, surge shaft gate and draft tube gates.

Main distribution board & feeder pillar for all HM equipment

Main distribution board shall be provided by the Bidder at Barrage Control Room for supply to spillway and intake gate hoisting equipments. Power supply to main distribution board will be taken from owner’s distribution board. Two feeders will be available in owners’ distribution board for power supply to main distribution board of bidder. The Cabling between above two panel shall be in the scope of this specification.

Feeder pillars shall be provided in the vicinity of respective local control panels of above hoisting equipment.

Cabling between main distribution board and above feeder pillars shall be in the scope of the Bidder.

Feeder pillars shall be provided for surge shaft gate and Draft Tube gates in the vicinity of respective local control panels. Cabling to feeder pillars from respective distribution board of owner shall be in the scope of HM contractor.

One (1) set of MIV interlock switches for Draft Tube Gates.

The works shall be complete with all necessary auxiliaries such as primary elements (position transmitters, limit switches etc.), hardware, software, modules, transducers, cabling etc. as well as frames, built-in and embedded parts including all spare parts and special tools required. All the equipment shall be standard-type of well-known manufacturers.

Automatic Reservoir Measuring and Control System (ARMAC)

The ARMAC computing and control system shall be situated in the Dam control room (DCR) and shall be provided by the Bidder.

Diesel Generating Set

Supply of one set of 250KVA, 415V, 50 Hz AC output three-phase synchronous type Diesel generating set complete with all accessories, equipment, instrument wiring and acoustic enclosures for making the equipment complete and for warranting a trouble-free safe operation including its design, manufacturing, testing and commissioning. The diesel generating set shall be located in the dam area near barrage control room to provide back-up supply to HM main distribution board for hoisting equipment and instrumentation and control system etc.

1.2.10. Tools and Tackles

The bidder shall provide the tools and tackles as mentioned in the mandatory tool and tackle list for gates and hoists maintenance. Additionally, the bidder may propose additional tools and tackles which is not mentioned mandatory tool and tackle list but required for maintenance work of gates and hoists shall include in the recommended tools and tackles list."

1.2.11. Installation, Operation and Maintenance Manuals

Five(7) sets (5 hard copies and 2 soft copies) of installation, operation and maintenance manuals containing drawings, catalogues and brochures, service manuals for each bought out item, handling procedure for assembly & subassemblies of all Gates, Hoists, Cranes and associated equipment etc. covered under the scope of work.

1.2.12. Manufacture History Record (MHR)

6 sets (5 hard copies and 2 soft copies) of abridged manufacture history records and inspection & test records for all equipment to be supplied under the scope of work.

1.2.13. Erection & Commissioning Documents

7 sets (5 hard copies and 2 soft copies) of erection & commissioning documents for gates, hoists and their allied equipment.

1.2.14. Instruction Plates

Suitable instruction plates indicating main technical data, important operating and maintenance instructions along with warning instructions for each gate, hoist and associated equipment.

1.2.15. Notes

a) The responsibility of the correctness and accuracy of alignment of embedded parts would rest with the contractor for this work.
b) The works, materials and services not called for explicitly in these specifications or in the drawings, but which are necessary for the complete manufacturing, installation, testing and operation of the Gates, Hoists and other associated equipment covered in these specifications shall be furnished by the contractor at no extra cost to the Employer.
c) Shop as well as field painting is included in the scope of supply.
d) Dry as well as wet tests are to be carried out by the contractor. Any defect noticed during testing or during the guarantee period (not less than 24 months) is to be removed/rectified by the contractor free of cost.
e) The contractor shall provide all tools, tackles and equipment to be used for erection, testing and commisioning of the equipment covered in these specifications.
f) In general, the contractor for Gates and Hoists shall design the shear reinforcement for Gates blockouts wherever required and supply the relevant drawings, on the basis of which the main civil contractor shall provide the same.
g) All the submissions and documents shall be submitted in plastic coated hard board index folder. Loose, spiral/spico folders shall not be accepted

1.3. Inspection & Quality Assurance Plans

All supplies shall be subject to inspection and tests by the Employer. Shop tests shall also be subject to inspection and tests by the Employer and the Employer shall depute his Engineers for witnessing shop tests. Inspection shall be carried out in accordance with relevant Indian Standards or equivalent International Standards where Indian Standards are not available or as described elsewhere in these specifications. The cost of carrying out tests/inspection shall be borne bythe contractor and shall be inbuilt in the price bid.

1.4. General Requirements

a) The Bidder shall carefully study the Technical Specifications and Specification Drawings and shall intimate the Employer in case any error/omission is noticed. As a result of such interaction, if some corrections/modifications are required, the Employer shall bring the same to the notice of all the Bidders before the date of submission of the Bids.The contractor shall cooperate with other contractors in the exchange of drawings, dimensions, data and all other information required to ensure proper co-ordination of the work. All documents to be supplied shall be submitted in accordance with the agreed programme so that any comment and change requested by the Employer can be taken into account before starting of the manufacture in the workshop and/or erection or installation at the site.If the contractor fails to submit such documents, then the later execution of changes requested by the Employer and the resulting additional cost and/or delays shall be the contractor’s liability. The contractor shall not be relieved of his responsibility and guarantee for satisfactory operation of the equipment after drawings and computations have been approved by the Employer
b) The contractor without the written authorization of the Employer shall not subcontract the preparation of drawings, computations or other technical

documents. In such a case of subcontracting, the contractor shall be fully responsible for such drawings, computations and other technical documents as if they were done by him.

c) Each item appearing on any document (Drawing, diagram, list etc.) shall clearly be designated. The abbreviation mark used for an individual item shall be identical throughout the complete documentation so as to avoid confusion. All documents shall have a uniform title-block as outlined in the specification. Beginning with the very first submittal to the Employer, the contractor's drawingsshall bear a serial number.
d) Revised technical documents replacing previously submitted documents should be marked accordingly. Also, the revised part in the Documents and drawings itself shall be marked clearly.
e) All parts of works shall be suitable in every respect for continuous operation at maximum output under the climatic conditions and operating conditions prevailing at the site.
f) Special attention shall be given to works, parts of which are delivered by different manufacturers. Problems arising in this conjunction shall be solved by the contractor and be defined in writing.
g) All live, moving and rotating parts shall be adequately secured in order to avoid danger to the operating staff. All electrical components shall be electrically earthed as per the latest practice.
h) Manufacturer shall take appropriate measure to prevent the ingress of dust, silt etc. into any works/components (such as bearings, relays, controls and measuring equipment etc.), which may be endangered thereby.
i) Suitable lifting eyes and backing out bolts shall be provided wherever required or where they will be useful while erection and dismantling.
j) Pockets and depressions likely to hold water shall be avoided, and if not avoidable, they shall be properly drained. Parts of works principally intended for standby purposes shall be protected from corrosion by careful choice of material and if necessary by additional means these should not reduce their continuous readiness.

1.4.1. Drawings and Data to be Furnished along with the Technical Bid by the Bidder

a) Estimated weight, Hoist capacity calculation for each of the equipment covered under the scope of thework. List of Documents to be submitted along with Bid as per the Annex.-I appended with the Technical Specifications.
b) Gate wise Schedule of submission of design calculations, drawings, fabrications, erection, testing and commissioning for the Gates, Hoists and their associated equipments covered in the scope of the work to match with the delivery period (As per Annex.-III) appended with technical specification.
c) The contractor shall also submit along with his Bid a detailed program based on the dates indicated in the tender document or alternatively his own time schedule giving shorter delivery/ erection period. The schedule will be in the form of a detailed PERT network on Primavera software program within the time frame agreed above, consisting of adequate number of activities covering various key phases of the works such as designs, drawings, procurement, manufacturing, shop assembly, painting, transportation, field erection and testing activities. This network shall also indicate the interface facilities to be provided by the Employer, if any, and the dates by which such facilities are needed. It shall also indicate the details of resources like manpower/ machinery envisaged in the activity and to be mobilized by the contractor for all stages of erection.
d) In case the Bidder proposes to make major changes in the design arrangement

of the equipment to be furnished under these specifications, then he shall also submit along with his Bid, the drawings and the design calculations of his alternate arrangements/ proposals (as per Annex-IV as appended with the technical specifications). Such drawings shall be complete and give all proposed changes in details. Acceptance of the alternate arrangements/ proposals of the Bidder shall not be binding on the part of Employer.

e) Erection methodology including dry and wet testing of the equipment giving minimum time period of each activity.
f) List of erection equipment including material handling machines/cranes at site along with their capacities, make, year of manufacture and personnel etc.
g) Quality Assurance system and detailed Quality Assurance Plans both at the time of manufacture and during erection along with relevant standards/reference document/plant standard/accepted norms/tests and inspection procedures etc.

Note: Non-compliance of the above stipulations and specified elsewhere in these specifications by the Bidder will be considered unresponsive and liable for rejection.

1.4.2. While furnishing the data, the bidder may keep in mind the following

a) Any item not specifically mentioned or shown in the bid documents but necessary to complete the job, shall be considered included in the scope of work by the contractor.
b) The manufacturer shall include in their bid any other drawings, catalogues, descriptions and photographs necessary to present clear picture of the type and class of the equipment proposed to be supplied.
c) The drawings, data and information shall be elaborate enough to enable the Employer to comprehend and assess the vital details, features, capabilities and functioning of the equipment and their arrangements.
d) Any item or services, which the Bidder desires to be supplied/ provided by the Employer, shall be specifically mentioned, failing which it shall be presumed that such items/ services are included in the scope of supplies/ work by the Bidder. However, the supply of these services or other items shall be at the discretion of the Employer and in case the same are not arranged/ supplied by the Employer, the contractor shall have to make his own arrangement.
e) It is entirely the responsibility of the Bidder to see that the designs and drawings are got approved in time. To ensure timely approval of the design and drawings these should be submitted strictly as per schedule as envisaged above, in proper sequence and in accordance with the requirements of the technical specifications duly supported by technical documents, literature etc., as required in three lots viz. 1st and 2nd stage drawings and complete Gates design along with general arrangement and end assemblies drawings in first lot, Gates leaf drawings in 2nd lot, design and drawings relating to Hoists, in 3rd lot after complete scrutiny and checking at his end, so that, the comments from Employer and number of resubmissions are kept to a minimum. Bidder should also ensure that his designers are deputed immediately for discussions wherever there is a request from Employer or his representative. Time period incurred in furnishing comments and resubmission by the manufacturer on account of incomplete submission without supporting data/ documents, supporting computer software program, submission in improper sequence, proposed component details not fulfilling all the requirements of the technical specifications etc. shall not in any way qualify for

delay in approval of drawings, extension of delivery period or any other contractual obligation. However, delay in submission of the above shall be to thecontractor's account and the Employer shall be at liberty to claim liquidated damages for such delays.

f) The technical specifications and specification drawings indicate only the basic arrangement for the Gates, Hoists and their associated equipment.
g) It is manufacturer's responsibility to perform the complete design of all the work/plant, structures and fabrication within the parameters as laid down in these specifications and according to the design procedures therein. Manufacturer may propose changes in design procedure or details of components to suit requirements for fabrication, manufacturing, assembly, and installation or to produce a better or more economical design.
h) All such proposed changes shall be submitted to Employer for approval before being carried out. Manufacturer shall submit full details of changes outlining nature of change and reasons for the same.

1.4.3. Submission of detailed design and drawings by contractor after the award of contract

a) All drawings shall be drawn in accordance with the Indian Standards to scale, and shall be legible. Wording on drawings shall be in English and shall be at least 3 mm high in block capitals. All drawings shall bear the mutually agreed title block, and drawing number as per the coding and pattern available with the Employer. All symbols shall be in accordance with Indian Standards. The contractor shall submit to the Employer for approval, not less than four sets of detailed computations and drawings, which shall have sufficient details to show. The contractor shall also submit two soft copies of the design and drawings and other documents on computer CD's which shall be used for checking of design and drawings along with the first submission. The contractor shall also provide training to Employer's design engineers in respect of gates and hoists along with the use of various engineering software packages and programs.
b) Qualified designers who are engineers or other professionals and have experience and capability necessary for the design shall prepare design. The Contractor undertakes that the designers shall be available to attend discussions with the Engineers at all reasonable times until the date of relevant Defect notification period.
c) Design calculations in **workable excel format** for all components and parts in accordance with design criteria and specifications to prove their adequacy supported by catalogues/technical literature of all bought out components with selection criteria and characteristics. The contractor shall have to supply the documents for the approval of employer.
d) The drawings shall broadly cover following items and it is essential that independent drawings drawn as per best drawing practice prevailing shall be supplied. Drawings should be conveniently sized as per relevant Indian Standards
e) Detailed dimensions, block out details, location of 1st stage anchors, 2nd stage anchors/studs, concrete outline of 1st stage & 2nd stage concrete, bill of materials covering item no., description of item, sizes, quantities, weight, material with relevant standard, remarks (if any) etc
f) Weld details, surface finishes, assembly tolerances/fits, machinery imposed on load on concrete structure etc.
g) Handling attachments for handling, site assembly/erection etc.
h) Painting system
i) The Design, Drawings, software's, programs, pen drive/DVD's etc. submitted by the contractor will form a part of contract and shall become the property of

Employer at no extra cost. The Employer shall be free to refer them to other agencies for advice.

j) All drawings shall be carefully checked by contractor for accuracy, completeness and clarity before submission to Engineer for approval

k) Minor changes involved in the layout plans of Gates, Hoists and associated equipment shall not involve any extra cost whatsoever not withstanding the particular of equipments furnished in the bid.

l) Approval by the Employer for the contractor's design and drawings shall not be held to relieve the contractor from any part of the contractor's obligation to meet all the requirements of the specifications or of the responsibility for the correctness of the contractor's drawings and designs.

m) The requirements of any alterations requested by Engineer shall not be construed to mean that the drawings have been checked in detail, accepted as justification for an extension of time and shall not relieve the contractor from responsibility for the adequacy of the designs and correctness of the drawings.

n) The design of all equipment shall be such that installation, replacements and general maintenance may be undertaken with the minimum time and expense.

o) The thickness and section to be adopted for various components of Gates, Hoists and their associated equipments etc. shall not be less than the minimum requirement specified in the technical specifications and shall be subjected to the approval of Employer. Any increase in Hoist capacity or increase in weight of Gate component to match with the requirement set out in the technical specifications and drawings shall be carried out at no extra cost to Employer and shall be subject to approval of Employer.

p) The contractor shall also submit the method statements and techniques of manufacture, painting, transportation, testing and commissioning of Gates, Hoists and their associated equipments immediately within 30 days after approval of design and drawings.

q) The Employer will return a copy of each drawing to the contractor marked either 'Approved' or 'Approved as noted' or 'Returned for corrections/modifications'. The notation 'Approved' or 'approved as noted' shall authorize the contractor to proceed with the manufacture of the equipment covered by such drawings subject to the corrections, if any, noted thereon. When the design computation/ prints of drawings have been returned for corrections/ modifications, the contractor shall revise/modify the design/drawings as necessary and shall resubmit fresh design computation/drawings for approval in the same routine as before. Any fabrication work performed prior to the approval of drawings, will be at the contractor's risk. The Employer shall have the right to ask the contractor to make changes in the design, which may be necessary in the opinion of the Employer to make the equipment to conform to the stated provisions and intent of the specifications, without any additional cost. After designs and drawings are completed and approved, the contractor shall supply to the Employer 4 no. prints of each of the approved drawings, out of which 2no. prints shall be duly laminated whereas in respect of finally approved design computations only four sets shall be supplied. However, prior to completion of contract, contractor shall supply 2no. prints of all approved as built drawings.

r) Drawings shall be submitted to the Employer for approval 20 days prior to the date on which they will require such drawings to ensure that the work is carried out in accordance with approved schedule of work.

s) The contractor shall submit the manufacturing methodology , painting procedure, erection methodology of Gates, Hoists and their associated equipment’s immediately within 15 days after approval of design and drawings.

t) All design details and layout matters shall be discussed in periodic meetings with the Employer’s Design Engineers. The first design meeting between Contractor

and the Employer's Design Engineers shall take place within 15 days after the award of the contract. Further design meetings shall take place as advised by the Employer until the design work is completed.

u) For all larger parts of equipment which, due to their dimensions and/or weight and transport limitations, will require special means for their transportation, the contractor shall submit loading drawings indicating dimensions, weight etc. of the respective item of equipment and the necessary trailer for its transportation to the site.

v) Provide the actual size 3D model of the product in the format of Revit Software or STEP format

1.4.4. Approval/Review of Technical Documents (design & drawings, Quality/inspection plans, erection methodology etc.) by the Employee

Within 30 days after the receipt of complete submission along with supporting documents, data literature, codes etc., the Employer shall return one copy thereof to the contractor, duly “approved” or “approved as noted” or “returned for modification/corrections”. The contractor shall resubmit the documents within fifteen days after receipt of the comments/observations of the Employer. The number of submissions shall be kept to the minimum.

1.4.5. Installation, Operation & Maintenance Manual

For guidance during the installation of the work and subsequently for guidance of the plant operating and maintenance staff, contractor shall prepare manuals. The manuals shall include a separate and complete section describing the following:-

- Safety at Work
- Technical data
- Description of work & equipment.
- Operating principles & characteristics.
- Installation Procedures
- Operating instructions (for normal and emergency operation).
- Testing & adjustments.
- Maintenance instructions.
- As build drawings.
- List of spare parts with their vendors/manufacturers and their contact numbers/email ids.
- Catalogues of bought out items.

The manuals shall describe and illustrate the procedure for assembling, adjusting, operating and dismantling of each component and control system. The maintenance of each component shall be described, including the recommended frequency of inspection and lubrication.

Manuals shall also describe and illustrate procedures for installation, storage, handling, unloading, reloading, unpacking and upkeeping of each component of the equipment. Four (4) copies of the manuals shall be submitted in English in draft form for approval of Employer within one months after the final approval of the equipment. 4sets (2 set of hard copies and 2 set of soft copies) shall be provided to Employer not later than 30 days after receipt of approval.

If revision of the manuals becomes necessary, as a result of information gained during installation and initial operation, contractor shall make the necessary revisions and furnish 4 copies of the revised sections.

The manuals shall include a complete list of all drawings prepared by contractor, a list of spare parts and a list of parts for each component or item of equipment. The parts list shall include manufacturers name and their contact numbers/email-ids.

Contractor shall ensure that his installation supervisor has a copy of all approved drawings and the manuals at his site office.

1.5. Schedule and Progress

a) Immediately after the receipt of approval of drawings, the contractor shall submit to the Employer for his approval the schedule of fabrication and transportation of the equipment so as to ensure its delivery within the specified period. The schedule shall clearly state all the stages of fabrication to enable the Employer to plan his inspection accordingly as stated in these specifications.

b) The contractor shall, before the 7th day of each calendar month, (during the course of design & fabrication) submit 4 copies of monthly progress report in a format acceptable to the Employer, detailing the progress of the work during the preceding month along with photographs of fabrications done, to the Employer apprising him of the progress of equipment. The report shall contain (but not limited to) the following information: -

- A general description of works performed during the reporting period on each main activity.
- Overall percentages of the work completed, with reference to the CPM programme.
- The percentage of each main work activity completed during the reported month with reference versus the scheduled programme.
- A list of all activities of scheduled and actual progress during the reporting period including actual starting dates versus scheduled starting dates and actual completion dates versus scheduled completion dates for each activity.
- A list of activities scheduled to be started within the next period of two (2) months, with expected starting and completion dates. Any notable problems, differences, comments with reference to the schedule may be supported with appropriate documents.

c) During erection, the Contractor shall, before the 7th day of each calendar month, submit 4 copies of the monthly progress reports in a format acceptable to the Employer, detailing the progress of the work during the preceding month. The report shall contain (but not limited to) the following information:-

- A general description of erection works performed during the reporting period on each main activity.
- Overall percentages of the erection work completed, with reference to the CPM programme.
- The percentage of each main erection work activity completed during the reported month with reference versus the scheduled programme.
- A list of all activities of scheduled and actual progress during the reporting period including actual starting dates versus scheduled starting dates and actual completion dates versus scheduled completion dates for each activity.
- A list of activities scheduled to be started within the next period of 2 months, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the CPM program, an explanation shall be given.
- Contractor shall briefly report the manpower strength and expatriate personnel employed (if any), equipment etc. deployed during the reporting period.
- A statement concerning potential problems and recommendations on how they could be resolved.

d) The time and the date of completion of works as stipulated in the bid document shall be the essence of the contract. However, the bidder, keeping in view the programme of the erection front availability but without effecting the completion date, can suggest certain alterations.

e) The contractor shall so organize his resources and perform his work as to complete it not later than the date agreed to by him. The time for completion of the works contracted for shall be reckoned from the date of issue of the letter of award by the Employer. During the performance of the contract, if in the opinion of the Engineer, proper progress is not maintained; suitable changes shall be made in the contractor's operation to ensure proper progress.

1.6. Delivery Period

The period of completion for the entire contract will be as given in the conditions of the contract. Delivery schedule for items/sub-items in respect of hydro-mechanical works shall be agreed during the pre-award discussions.

1.7. Responsibilities of Contractor

The contractor shall be responsible for:

a) The quality of materials and workmanship in all the items of work.
b) Strict adherence to the dimensions of parts shown on approved drawings unless deviations are specifically authorized in writing by the Engineer or Employer.
c) Strength of all parts of Gates and Hoists when operated under the worst conditions of load and under conditions of closure during periods of maximum flow discharge as applicable.
d) It is contractor's responsibility to ensure that all components supplied in accordance with these specifications shall fit correctly to each other. In the event of any field modifications being required due to errors in shop fabrication, contractor shall bear the full cost of such modifications. Any such changes shall be shown on the drawings and approved by Engineer, before being made by Contractor.
e) Satisfactory performance of the entire work under all operating conditions without signs of undue strain, and without damage, breakdown or deterioration of any of the parts due to faulty or incorrect or unallowable material, workmanship or design.
f) Freedom from vibrations of any part or parts under the most severe operating conditions beyond permissible limits.
g) The water tightness of the Gates seals, bearings and controls.
h) The contract documents and specifications do not specify in complete detail the various components of the equipment. The contractor shall supply and erect all equipment in a complete shape, which will meet the requirements regarding performance, durability and satisfactory operation.
i) The contractor shall be fully and finally responsible for adequacy, stability and safety of all the site operations and methods of executions of various activities to be performed under the scope of contract.

Technical Specifications of Hydro Mechanical Works

Gates, Hoists and Cranes

1) Intent of Technical Specifications and Scope of Work
2) Description and Design Criteria
3) Materials
4) Manufacture
5) Quality Assurance, Inspection and Workshop Testing
6) Erection, Site Testing, Commissioning and final Acceptance
7) Work and Safety Regulations
8) Pressure Shaft

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2. DESCRIPTION AND DESIGN CRITERIA

2.1. Barrage Radial Gates , Embedded Parts and Hydraulic Hoists

2.1.1. Barrage Radial Gates

Karbi- Langpi Middle-II comprises of Four sets of barrage radial gates of clear vent opening of size 10000 mm x 10500 mm (w x h) . The Full Reservoir Level (F.R.L.) is at El. 385.50 m.

The radial gate shall be used to pass the flood and periodically flushing of the sediment out of the reservoir. The radial gate shall be independently raised or lowered bytwin cylinder hydraulic hoist installed at piers. The provision shall also be made for operation of gate by an independent petrol engine driven hydraulic pump of suitable capacity at a reduced speed, which shall not be less than one half of the normal speed in case of failure of electric power/control circuit.

The radial gate shall be capable of being opened, closed or stopped and regulate flow in any intermediate position. The radial gate shall be designed to close under maximum flow conditions and throttling flow at any intermediate position and to open under unbalanced condition. The gate shall be designed to close under their own weight for all operating conditions. The gate when dropped against design head shall, therefore be able to go down under its own weight (self-closing). For meeting this requirement the weight of the gate shall be at least 20% more than the forces opposing the closure of the gate. In case the gate is not able to lower under its own weight,the contractor shall provide the double acting hoist without any extra cost.

The gates shall be designed to eliminate vibrations and gate lateral movements during the closing / opening process and at any partial opening position.

a) Gate Leave

The gate shall be fabricated out of structural steel with skin plate forming the upstream curved surface. The skin plate shall be stiffened in the rear by vertical stiffeners. They shall transmit the load to horizontal girders, which shall be supported by inclined radial arms, so that the water load is transmitted to the trunnion girder through radial arms and trunnion bracket. Finally, the trunnion girder transmit the load to concrete pier through anchorage system. Suitable rubber sealing arrangement shall be provided on sides and bottom. The seals shall be fixed with the help of seal clamp plates and stainless steel socket head screws so as to ensure positive pressure between seal and gate and to bear tightly on the seals to prevent leakage.

The radial gate is proposed to be operated by hydraulic hoist connected to downstream of gate. The hydraulic hoist cylinder is to be connected to hoist supporting structure at the top through gimble suspension assembly. The hoist support structure shall be located such that all the parts are sufficiently clear from civil structure and arms. The hydraulic hoist stem shall be connected to the bottom horizontal girder and shall be sufficiently rigid. The pin connecting the hydraulic cylinder with gate shall be of stainless steel and fitted with

suitable bearing provided/ recommended by the Hydraulic cylinder manufacturer.

b) Horizontal girders and Vertical Stiffeners

The horizontal girders shall have built up plate girders suitably welded in shop. Minimum number of girders shall be provided as per IS 4623 (latest revision). The spacing and design of bearing and intermediate stiffeners shall be governed by relevant portions of IS 800 (Latest revision).The vertical stiffeners shall be designed as continuous beams resting on horizontal girders. The horizontal girders shall be checked for shear at the points where they are supported by the arms.

c) Arms and Bracings

As many pairs of arms as the number of horizontal girders, shall be used, unless vertical end girders are provided. The radial arms shall be fabricated out of rolled steel sections or structural steel plates. The arms shall be rigidly connected to the trunnions hubs by welding and shall be suitably braced in between arms to withstand buckling. The bracings connecting the arms shall be so spaced, that the slenderness ratio of arms in both the longitudinal and transverse directions are nearly equal.

The arms shall be designed as columns for axial loads and bending moments from horizontal girders considering their fixity.

d) Guide Rollers

Guide rollers shall be provided on each side of the gate leaf to limit lateral movement in either direction. Enough rollers must be engaged, even if the gate is in the fully open position it has to be guided. These rollers shall be provided with self-lubricating bushings and thrust washers. Pins shall be of stainless steel in a quality compatible with bushing's manufacturer recommendations. Each roller and pin as well as the necessary built-in parts shall be designed to resist the imposed load due to the gate becoming jammed.

The guide rollers shall be spring loaded, to compensate destabilizing influences such as deformations by temperature and load.

e) Trunnion Hub

The trunnion hub shall rotate about the trunnion pin. The arms of the gate shallbe connected to the hubs to ensure full transfer of loads. The hubs shall be sufficiently long so as to allow arms of the gate to be fixed to the respectivelimbs of the hub without cut and shape the flanges of the arms. The thickness ofthe webs and flanges of each of the limbs of hub shall be greater to the extent so as to provide adequate space for the weld. Sufficient ribs and stiffeners shall be provided in between its webs and flanges to ensure rigidity of the trunnion hubs.

f) Trunnion pin

The trunnion pin shall normally be supported at both ends on the trunnion bracket which is fixed to the trunnion girder. The trunnion pins shall be designed for bending for the total load transferred through the trunnion hubs. The load shall be taken as uniformly distributed over the length of the pin bearing against the hub. The pin shall be checked for shearing and bearing also for the same load. The trunnion pins shall be corrosion resistant steel conforming to IS 1570 Part V (latest revision) and suitably locked against rotation.

g) Trunnion Bush

The bearing shall be self lubricating, completely maintenance free for life time. They should consist of bronze with solid deposits of special lubricants (white). The lubricant shall be free from graphite and molybdenumto avoid electrolysis. It should be distributed on the whole sliding surface, covering more than 25% of the area. The sliding surface shall be covered with a running in film containing the same lubricant (fluorocarbon with about 0.02 mm of thickness). The bearing shall have high static and dynamic load capacity, consistent low coefficient of friction (<0.01), without "stick – slip" and shall be consistent over all load ranges.

h) Trunnion Bracket

The trunnion brackets shall be rigidly fixed to the Cantilever beam by bolts/welds and shall transfer the total load from the trunnion to the anchorage system. Ribs and stiffeners shall be provided on the trunnion bracket to ensure sufficient structural rigidity.

i) Thrust Block

The thrust block is fixed to the trunnion bracket and is designed to withstand the bending and shear force caused by the side thrust on the trunnion due to the inclined arms. A thrust washer should be used between the trunnion hub and trunnion bracket to transfer the thrust.

j) Seals

i). Radial gate

The gate shall be sealed at the bottom with a flat rubber seal attached to the gate so that the bottom edge of the seal seals tightly against the seating face of the bottom seal seat. The side seals shall be angle shaped fluorocarbon coated, bolted to the skin plate with full or partial length stainless steel clamps, with stainless steel nuts, washers, ferrules and stainless steel socket head screws.

2.1.2. Embedded Parts

Embedded parts shall consist of: -

a) Side seal cum wall plates of stainless steel with base.
b) Sill beam with stainless steel bottom seal seat.
c) Anchors/studs with double nuts and washers for aligning the 2nd stage embedded parts.
d) First stage inserts (anchors with plates to be embedded in first stage concrete for providing suitable reference surface for erection of 2nd stage embedded parts.
e) Embedements for dogging arrangement.

Anchor bolts with plates shall be embedded in first stage concrete at a spacing not exceeding 500 mm centre to centre, leaving suitable blockout opening for 2nd stage embedments. The size of the first stage anchors/studs shall not be less than 16 mm in dia and 300 mm in length. The 2nd stage anchors with double nuts and washers attached to 2nd stage embedded parts shall then be welded to these inserts and shall be used for proper alignment of these embedded parts. The

surface of the bottom sill beam shall be made flush with the surrounding concrete/ liner.

Anchorage System

The trunnions shall be located on an in-situ cast concrete beam in between the piers transferring the load directly in bearing.

Design Criteria

	Radial Gate	
i)	Type	Radial gates
ii)	Clear width of opening	10000 mm
iii)	Clear height of opening	10500 mm
iv)	Number of span	4 No.
v)	Width of pier	4.0 m
vi)	Full reservoir level (FRL)	El. 385.50m
vii)	Maximum water level (MWL)	El. 389.00m
viii)	El. of C/L of trunnion	El. 387m (Tentetive)
ix)	Sill elevation	El. 375.00m
x)	Design head	10.5 m
xi)	Design loading conditions	Full Hydrostatic load on upstream side of the gate with FRL at El. 385.50m
xii)	Inside radius of skin plate	13.50m
xiii)	Level of bottom of the gate in fully raised position	El. 386.00m

xiv)	Operation	The gate is of regulating nature and required to be operated to pass flood discharge as well as reservoir flushing as and when required. It shall be operated by single acting twin cylinder hydraulic hoist. However, if gate is not seating under its own weight, the contractor shall provide double acting hydraulic hoist at no extra cost.
xv)	Type of arms	Inclined arms
xvi)	Type of hoist suspension	Downstream
xvii)	Type of side seal	Angle shaped Fluorocarbon cladded seal for sides
xviii)	Type of bottom seal	Flat type
xix)	Governing Indian Standard	IS:4623 & IS:800 (latest revision))
xx)	Permissible stresses :	Permissible stresses in structural components for gate and embedded parts shall be in accordance with Annexure B of IS 4623 (latest revision). The stresses in various parts of the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress.
xxi)	Skin plate	Wet and inaccessible
xxii)	All other structural components which are not direct contact with water	Dry and inaccessible
xxiii)	Seismic coefficients of the project are:	
	a) Seismic Horizontal coefficient	• h=0.24g
	b) Seismic Vertical Coefficient	• v=0.16g

xxiv)	Permissible bearing and shearing stresses in concrete	As per IS:456(latest edition).
xxv)	Grades of concrete to be used 1st stage concrete 2nd stage concrete	 M 20/M25 One Grade higher than that of 1st Stage Concrete and shall not be less than M-25 Grade
xxvi)	Lubrication of trunnion	Self lubricated bronze bushing. However, suitable lubrication arrangement shall also be provided as additional measure.

Note:- The arrangement of seals at the bottom and sides of the gate shallbe such that there is no leakage past the gate & special attention shall be given to the leakage at the bottom where gate rests on the sill and at the corner points of the side seals with bottom seals.

2.2. Hydraulic Hoists for Radial Gates

2.2.1. General

a) Barrage Radial gates shall be equipped with Hydraulic hoists (single acting) and shall be designed in accordance with IS:10210 (latest revision).
b) All aspects of hydraulic hoists, which are not covered in the specifications, shall conform to the applicable requirements of Indian Standard or any equivalent national/international standards (latest revision) for industrial hydraulics.
c) All hydraulic hoists components, such as seals, gaskets, pumps, valves and hoses that are normally in contact with hydraulic fluid shall be compatible. All hydraulic hoists parts and components that are permanently or occasionally submerges in water shall be adequate to resist without damage. It shall be ensured that cylinders and piping are permanently and completely full of hydraulic fluid under normal working conditions at all times, to avoid internal corrosion effects of moisture.
d) All the hydraulic power units shall be interconnected to facilitate operation of hydraulic cylinders of any one gate with the hydraulic power unit of other gates. The Hydraulic piping, valves etc. and other hydraulic circuit shall be designed keeping this aspect in mind.

2.2.2. Description of Hydraulic Hoist

All parts, components, and accessories that are specified herein, or that are required for the intended function of the hoists except those which are specifically indicated to be supplied by others, shall be furnished by the contractor, even if they are not described herein. The items to be supplied by thecontractor shall

include all pipe hangers and supports to the terminal box of the hoist components installed for remote control and indication. Each hydraulic hoist shall include one or more of the following major subassemblies, materials, equipment etc. described in the subsequent paragraphs of this section:

- hydraulic cylinder assemblies.
- cylinder assemblies mountings and support structures.
- connecting piping.
- hoist control module, including hydraulic power unit, electrical control cabinet, frame, housing, accessories, and appurtenances; and
- Electrical Connections.
- Hydraulic fluids.
- Petrol Engine

2.2.3. Hydraulic Cylinder Assembly

i). General

A hydraulic cylinder assembly shall include a cylinder tube, cylinder heads, piston, piston rod, seals, accessories, and appurtenances.

ii). Design Stroke

Hydraulic cylinder assemblies shall be designed so that when the gate and hoist assembly are erected exactly to the nominal design geometry, the piston rod shall have an available over-stroke in addition to the stroke required for complete rod extension to lower the gate fully. The overstroke measured along the piston rod travel be not less than 40mm. Similarly when the gate is completely raised (to the dogging position, where applicable), the hoist will have an available over-stroke of 25mm minimum. Actual extent of over-stroke shall take into consideration, all manufacturing and erection tolerances and other factors like bottom seal compression for gates and gate travel beyond the opening.

iii). Cylinder Body

Construction: All cylinders shall be of standard mill type construction. Cylinder body (cylinder tube) shall be manufactured from a single piece of material and then machined in one piece. The cylinder shall be straight and true and shall be of sufficient wall thickness to resist the maximum operating pressure and bending forces that could be imposed upon it.

a) Interior surface finish: Interior surface of the cylinder tube that comes in contact with piston seal shall be continuous and without detectable offsets. Surface shall be uniformly honed to a surface finish commensurate with the specified maximum leakage limit and long life of the seal. In any case, the finish shall not be coarser than 0.33 microns.

(the honing of inside surface of cylinder has to be achieved in onedirection)

b) Exterior surface finish: Outer surface of cylinder shall be sand blasted and preserved in accordance with standard practice for surface protection.

c) Ports: Ports shall preferably be located in the cylinder heads. If located on the cylinder tube, their edges shall be kept at least 6mm away from the piston seal contact line in all positions of the piston.

iv). Cylinder Heads

a) Each cylinder assembly shall have a blind end cap and a rod end head, each fastened to the cylinder tube by bolted connection. Cylinder head shall have machined contact surfaces for resisting the thrust of the piston and rod assembly without exceeding the normal allowable stresses, in the event of a failure of limit switch or other malfunction.

b) A gland shall be provided in the rod-end head. The gland shall include a piston rod guide bushing, piston rod seal, and a heavy duty scrapper/wiper ring, which shall prevent the entry of foreign material into the cylinder. Guide bushing shall be fiber-reinforced phenolic material.

c) Design of the rod end head shall permit the servicing of the piston rod seal (s) without disassembling the cylinder, while the cylinder shall remain in its normal working position.

d) Water exclusion seals shall be provided as necessary to prevent the entry of water into the cylinder.

v). Piston

Piston shall be of steel, forged or cast in one piece and shall be equipped with seals and guide rings. Guide rings shall be of bronze and/fiber-reinforced phenolic material. Design of the piston shall permit easy replacement of seals and guide rings. The seals and rings shall not be less than two each. The piston shall be designed for operating pressure.

vi). Piston Rod

a) The material for piston rod shall be selected from one of the following:

1) Solid bar of corrosion-resistant steel of IS: 1570 (latest Revision) or DIN 17440, Type X20 Cr 13(15) or ASTM A 276, Type 316 or seamless tube of corrosion resistant steel of IS: 1570 (latest revision) or DIN 17100 (St 52-3 (N) or ASTM A-276, Type 316, with a hard chrome plated outer surface.

2) Solid carbon steel of IS: 1570 (latest revision) or ASTM A 572, and shall be given ceramic coating. Carbon steel other than ASTM A 572 with which the seller has experience may be used subject to approval.

3) The Stem shall be straight and be of uniform diameter and surface shall be polished.

b) Outer surface of the piston rod shall be hard chromium plated with the minimum plating thickness of microns after machining, if manufactured from the material as under para a(1) above. The chrome plating shall be done in atleast two stages. The thickness for each stage shall not exceed 0.05mm.

c) Outer surface of the piston rod, which contacts the piston rod guide bushing and seals shall be ground and polished to a uniformly concentric finish having surface finish equal to, or better than 0.2 microns.

d) Connection of the piston rod to the piston shall be rigid attachment and shall permit disassembly for maintenance.

e) Piston rod eye, when used, shall be in one piece and shall have a bushed hole for pin connection to the gate. The eye shall be of rolled or forged steel, rigidly attached to the piston rod by threaded or bolted connection. Guide surfaces

and shoulder shall be provided for proper alignment of the eye with the rod.

f) Connecting pin where used, shall be of corrosion-resistant steel conforming to IS: 1570 (latest revision) or ASTM A 276 Type 316 or ASTM A 564 Type 630. The pin shall be positively secured against axial movement by either a shoulder on one end and washer and retaining pin on the other end, or by a washer and retaining pin on both ends, or by bolted retaining plates. Use of snap-type retaining rings will not be permitted.

vii). Seals

Piston seals and piston rod shall be of the chevron type packing seals for piston and for piston rod, mechanically locked in place. Seals shall resist roll, turn and extrusion. On hoist cylinders designed for fluid pressure acting from either side, a separate set of piston seals shall be provided on each side.

viii). Packings

Packings or static seals such as rings shall be provided between all connected parts where leak-tight joints are required, such as between cylinder tube and heads or between piston and piston rod.

viii). Speed limiting orifice

Cylinder shall have a permanently mounted speed limiting orifice to limit the downward speed of the gate to 3m/min in case of rupture in the connectingpipes.

ix). Bosses, Drains, Vents and Test Connection

- Bosses: If bosses are provided at the hydraulic cylinder ports, they shall be welded.
- Drains: All necessary drains shall be provided.
- Air Bleed Valves: Cylinder shall be furnished with at least 2 air bleed valves for complete removal of trapped air. All air bleed valves shall be of stainless steel.
- Test Connections: Cylinder shall be furnished with one test connection in each of the fluid ports for attaching a pressure gauge or transducer. Additional test connections shall be provided with corrosion resistant steel connectors equipped with check valves; no shut off valves shall be used.

x). Cylinder Mounted Components

Except for pipe connectors, pipe supports, air bleed valves, test connections, plugs and the necessary pressure piping, no other components shall be mounted on the hydraulic cylinder.

However, from safety consideration, a control plate with at least one shut off valve, lock valve and pressure release valve may be flanged on to the cylinder directly.

xi). Handling Eyes

Each cylinder shall be equipped with handling eyes to facilitate easy handling during transportation and erection.

xii). Proximity Switches

Each cylinder shall be equipped with proximity switches, one at each end to switch

off the power unit at the end positions of the gate. Connection between the proximity switches and control wiring shall be weatherproof. Also the conduit supplied by the seller (including flexible conduit) up to the terminal board shall be weatherproof.

xiii). Position Transducer

Each gate cylinder shall be equipped with an electronic position transducer to measure the position of the gate. The transducer shall be suitable for accurately measuring 50-Hz quantities. Transducer outputs shall be a D.C. current signal ranging from 4 to 20mA full scale suitable for termination in a load, resistance up to 500 ohms. The piston rod shall be drilled as necessary to accommodate the lower transducer body. Unless specified otherwise, the maximum allowable error shall not exceed plus/minus 0.25% of full scale at 25 degree C, and the error resulting from a temperature variation between - 20 degree C. and 60 degree C. shall not exceed plus/minus 0.5% of full scale. AC output ripple shall not exceed 1%. The units shall be provided with a 10% full scale calibration adjustment, and the response timeshall be 400ms or better from 0 to 99%. There shall be electrical isolation between input, output, external power supply, if used, and the case ground connection. The transducers shall satisfy the requirements of ANSI C37.90a andshall have a dielectric test voltage rating of 1500 V AC rms for one minute

Transducer components shall be totally enclosed in steel cases with integral brackets for surface panel mounting. External electrical connections shall be made using screw type barrier terminal blocks. A separate terminal connection shall be provided for grounding the output cable shield.

xiv). Synchronization

If the gates are operated by a twin cylinder hydraulic hoist, a, synchronization of the two hydraulic cylinders shall be planned and designed accordingly. The equipment necessary for the synchronization of the hydraulic cylinder shall be provided by the contractor and is included in the scope of work.

xv). Standards

In addition to other required specifications, hydraulic cylinder assemblies shall conform to all applicable requirements of IS:2825 (Latest Revision), IS: 10210 (Latest Revision), DIN 19704 or section VIII, Division I of ASME code.

2.2.4. Connecting Piping

i). General

a) All piping on the hoist control module and between the control module and the hydraulic cylinder as well as on the hoist cylinder shall be of the stainless steel and conform to the requirements specified in subsequent paragraphs. Insulators shall be used to isolate all dissimilar metals at the connection points.
b) The piping and appurtenances shall conform to the applicable requirements of ANSI-B31.1 or equivalent standard.
c) All piping in the hoist control module shall be completely installed in the shop before shop testing and shipping. The piping between the hoist control module and hoist cylinder shall be finished in the shop to obtaintransportable (in no case longer than 6m) lengths with all bolting flanges or couplings welded to the sections. Piping sections where dimensions may require adjustment at

field installations shall be prepared in the shop without welding the flange or coupling on one or both ends of the piping section and cutting the pipe to 200mm overlength at each of these ends.

d) All pipe sections to be connected in the field shall be flanged using shop or field welded flanges or shall be designed for connection in the field with the socket welded couplings. Pipe section shall not be design for butt welding in the field.

ii). Piping Arrangement

a) The general arrangement of all piping shall be in accordance with the space and clearances available from gate and operation chamber.

b) The piping shall allow easy removal and reinstallation of the hydraulic cylinders and hoist control module. For this purpose, all hydraulic lines connecting the hydraulic cylinders to the hoist control modules shall be provided with flexible connections at the cylinders and if necessary at the control modules. Both ends of all flexible connections shall be connected with corrosion resistant steel shut off valves so that the piping, cylinder, and hydraulic power unit can be shut off when the connections are removed.

c) Manual vent valves shall be provided at all high points and wherever else required in the system for the complete removal of trapped air. The valves shall have threaded female ends and shall be of corrosion resistant steel or bronze. The outlet ports of all vent valves shall be plugged with threaded bronze plugs.

d) Rigid piping installed on the cylinders shall be kept to an absolute minimum and shall be of stainless steel and shall not be welded to the cylinder. Also no compression fitting shall be used. All connections shall be screwed connections.

e) Piping shall not be designed for embedment in concrete.

f) Piping in the hoist control module shall be laid out such that it shall not obstruct access to, or removal of hydraulic components for maintenance or inspection.

g) Piping shall be adequately sized to permit fluid flow and functioning of the system without significant pressure drop between the power unit and the farthest cylinder. The minimum size of the piping for pressure and return piping shall be 16mm inside diameter.

iii). Fittings and Flanges

a) All pipe fittings shall be of the socket welding type conforming to the applicable requirements of ANSI B 16.11 or equivalent.

b) All pipe flanges shall be of the weld neck type conforming to the applicable requirements of ANSI B 16.5 or equivalent.

iv). Flexible Connections

a) General

The flexible connections shall allow reconnection of the hydraulic power unit or hoist cylinder without realignment and shall also permit the necessary freedom of movement of the hoist cylinder in its mounting.

b) Flexible Hoses

1) All flexible hoses shall be corrugated flexible metal hoses.

2) All flexible hoses shall be furnished with factory installed fittings which shall be of corrosion resistant materials.

v). Pipe Supports

All pipe supports such as pipe hangers, anchors, guides, clamps etc. shallconform to the applicable requirements of ANSI B31.1 MSS SP-58 and MSS SP-69.

2.2.5. Hoist Control Module

i). General

a) The hoist control module shall be furnished complete in all appurtenances to provide pressurized hydraulic fluid for the operation and control of the hydraulic hoist cylinders.

b) The hoist control module shall include a hydraulic power unit and an electric control cabinet. These parts shall form a single integrated equipment package mounted on a common frame and installed in a single housing. Thehoist control module shall also include all interconnecting wiring between these two sub-assemblies, the required housing and all other appurtenances.

c) The hoist control module shall be provided with separate sets of hydraulic control and power components for each gate arranged on a common hydraulic fluid reservoir and separate sets of electric components for each built in a common electric control cabinet. The hydraulic and electrical control and power components shall be suitably interconnected to enable the operation of the hoist cylinders of one gate by the pump of other gate.

d) Sufficient space at least 1000mm shall be provided all around the control module to facilitate operation and maintenance. The location of control module shall not interfere with the free movement of the men and material through operation chamber.

ii). Hydraulic Power Unit

The hydraulic power unit shall include a hydraulic fluid reservoir, electric motor driven pump, automatic controls, pressure relief, check, flow control and directional control valves, pressure and temperature gauges, fluid level switch, filters and strainers, in-line dehydration and oil particle cleaning machines, piping, and all accessories, appurtenances and wiring required to provide an operational fluid power system for the operation of the hoist according to the requirement of these specifications. All of the components shall be mounted on the hydraulic fluid reservoir. Manhole of dia. 700mm min. shall be provided for the maintenance of HPU.

iii). Hydraulic System Layout

a) Motor driven Pumps: Independent electric motor driven pump for each hydraulic hoist shall be provided.

b) Independent petrol engine driven pump for each hydraulic hoist shall be provided.

c) Pressure Filters: All hydraulic fluid being discharged from each pump shall pass through its own pressure filter before entering.

d) Return Line Filters: All hydraulic fluid returning from the system to the hydraulic reservoir shall pass through a return line filter shall be provided for each gate.

e) Check Valves: One check valve shall be provided in the pressure line ofeach pump between the pressure line filter and the rest of the system to prevent back pressure on the pumps when they are not in operation. Other check valves shall be arranged in the hydraulic system as required.

f) Pressure Relief Valves:

1) One pressure relief valve, sized to pass the full discharge of one motor- driven pump, shall be arranged in the pressure line of each motor driven pump.

2) Pressure relief valves to limit pressure due to heat expansion or to limit hoist capacity in one direction shall be provided as required.

g) Surge Suppressors: Surge suppressors (hydraulic accumulators used as shock dampers) shall be provided in the cylinder pressure line(s) and elsewhere as required to dampen pulsations, surges, and pressure shocks in the hydraulic system resulting from valve operation and from hydrodynamic forces on the gate.

h) Pressure Gauges: One pressure gauge shall be provided on the common pressure line of one or more pumps and on the hoist cylinder pressure and return line between the hoist cylinder and hydraulic control components within the hydraulic power unit. Additional pressure gauges shall be provided as per standard practice or as otherwise required.

i) Test connections: Test connections shall be provided suitably.

j) Pressure Switches: All pressure switches shall be heavy duty piston type.

iv). Fluid Reservoir

The reservoir serves primarily as a storage space and supply point for the hydraulic system fluid and its structure shall be used for mounting the control devices. The oil tank is constructed in carbon steel plates with welded joints with a drain plug at the lowest point for easy and complete draining of the tank and anchored. The oil tank should be properly cleaned and painted to ensure cleanliness and to avoid rusting. The capacity of the tank shall be not less than 120% of the volume of cylinders. The tank shall be fitted with moisture absorber. All pipelines shall have suitable bleeding arrangement. The minimum oil level must be such that the pump suction remains submerged about 100 mm so that air cannot be drawn in. Also, it is recommended locating the pump suction 50 mm far from the tank bottom so that sludge or any solid matter cannot be picked up. All return lines to the tank are always located below the minimum oil level and separated from the suction pipes by vertical bafflers to prevent the fluid coming back to the tank from returning immediately to the circuit without having performed effective heat dissipation. Generally, the maximum oil temperature should be limited to 55°C and 80°C inside the tank and piping, respectively. Tanks are also provided with oil filling cap (combination of air vent, dust screen and air filter), oil level gauges, breather openings, drain plugs and two large removable

maintenance covers are provided on each end for medium and large size tanks to

permit easy access for cleaning. There shall be no escape of oil from the breather cap when the gate is closing at the maximum speed. The reservoirshall be provided with lifting and jacking lugs for its handling.

v). Motor driven pumps

The motor driven hydraulic pumps shall be of the self priming positive and constant displacement type. The pumps shall be driven by direct coupled electric motors and shall be equipped with individual “Manual auto” switches and“Start Stop” push buttons for operating the pump in the manual mode.

vi). Petrol engine driven pump

Petrol engine driven pump shall be provided to serve as an alternative to electric motor driven pumping unit for each hydraulic hoist. The petrol engine shall be a standard product of reputed manufacturer. It shall be of rugged construction suitable for outdoor duty and quick start without any electric appliance under cold and tropical weather. The Petrol engine shall be self start type (push button start as well as manual arrangement) and shall be operated by independent battery. The petrol tank shall have sufficient capacity for continuous running of 3 hours. The oil tank shall be fitted with a suitable oil filter, oil level gauge and breather.

vii). Hydraulic control panel

The hydraulic control panel shall be mounted on the top of the hydraulic fluid reservoir in the plane of the front face of the reservoir. All hydraulic components which need to be accessible for manual operation and all gauges shall bemounted on the hydraulic control panel. Strainers and filters shall also be easily accessible for maintenance; their location shall be such that the draining oil during change of the filter elements shall not spoil the instrumentation including pressure gauges and pressure switches and other critical items. All components shall be removable without removing the surrounding components and piping.

viii). Hydraulic valves

a) General

All valves shall have JIC (Joint Industrial Council) or equivalent pressure ratings not less than the maximum system pressure. All pressure relief and flow control valves shall be preset in the shop to their operational setting. All electrically operated valves shall be furnished with suitable provision for standby manual operation. Each valve shall be furnished with a corrosion resistant tag suitably engraved or stamped with reference number to identify the valve according to its designation on the hydraulic circuit drawing and according to its function in the system.

b) Shut-off valves

All shut-off valves shall be ball valves. 2 way ball valves are units which serve to shut-off the flow of an operating medium in both directions. Ball valves are not designed to be used as flow control valves; therefore they should always be either fully open or fully closed to avoid damaging the sealing cups.

c) Check valves

The check valves, which are also directional valves, permit free flow in one direction and prevent flow in the reverse direction. The check valve shall be of spring closed construction with threaded ends and shall be rated for working

pressure up to 250 kg/sq.cm. One check valve shall be provided in the pressure line of each pump between the pressure line filter and the rest of the system to prevent back pressure on the pumps when they are not in operation. Pilot-controlled check valves are used to permit flow in the reverse direction beyond a determined point in the working cycle.

d) Directional control valves

The four way valve for the control system for operating the gates shall be a double solenoid controlled, spring centered, 3 position (to control start, stop and direction) spool type and shall have suitable rated capacity and suitable for atest pressure for the control system. The valve shall be equipped with a mounting sub-plate suitably tapped to permit mounting or removal of valve without disconnecting the pipes and shall be furnished with threaded external drain and shall be suitable for operating pressure on the tank port. Electrical contacts shall be provided with each solenoid of each valve which shall operate during the period, the solenoid remains energized. Two contacts shall be normally closed and other two contacts open. The above electrical contacts and the operating solenoids of the four way shall be rated for 5A, 230V, 50 Hzs, AC supply. The valve shall be equipped with pushpins for manual operation in case of power supply is not available. All directional control valves shall be of standard manufacture and nominally rated for zero leakage.

e) Pressure relief valves

The system pressure relief valve (safety device) shall be included in the circuit to protect the hydraulic system against overpressure and consist of relief valves installed in the pump discharge line. The relief valve causes the oil to return to the tank when the pressure exceeds a preset value. It shall be balanced piston type with internal drain, having sufficient capacity and shall have an adjustable pressure range of approximately 20 to 250 kg/sq.cm. The valves shall have independent outside adjustment for setting the pressure and shall maintain the pressure within 5% of the preset value. In the event of power failure, it should be possible to operate the valve manually.

f) Flow control valves

All flow control valves shall be of the adjustable pressure and temperature compensated type within a integral check valve for free return. All valves shall be shop tested to pass the required flow within +5%.

ix). Filters and strainers

i. Filter shall be of the disposable, replaceable element type. Strainers shall be of the cleanable, replaceable element type. Elements of all filters and strainers shall be stainless steel of Monel woven or wound wire.

ii. All filters shall be constructed and installed to permit servicing of the filter elements without disturbing the piping and without draining the hydraulic system and the fluid reservoir. Shut off valves shall be provided where necessary.

iii. Each filters shall be furnished with a bypass valve which shall open to pass the flow when the pressure drop across the filter element exceeds the allowable limit.

iv. Each filter shall be provided with means to indicate the condition of the filter element by visual inspection.

v. Each filter and strainer shall be furnished with a differential pressure or

minimum pressure switch to energize a warning light when the pressure drop across the filter or strainer reaches a predetermined value.

vi. Filter elements shall be screw-on type and shall be furnished with the following absolute ratings.

Low pressure line strainers	:	160 microns
Pressure filters	:	10 microns
Return line filters	:	40 microns

vii. Pressure drop requirements: The maximum pressure drop across any clean filter or strainer at normal flow shall not exceed the flowing values in the normal operating temperature range; 0.0703kg/cm2 (1 PSI) for low pressure line strainers. 0.3515 kg/cm2 (5 PSI) for pressure filters.

viii. By-pass valves: The filters shall be provided with by-pass valves which shall be set to open when the pressure drop across the filter element exceeds 1.0545 kg/cm2 (15 PSI).

x). Pressure Gauges

All pressure gauges shall be of the Bourdon tube type with glycerin filled housing. The accuracy of pressure gauges shall conform to Grade A of ANSI B40.1. All pressure gauge dials shall have dial graduation equal to their accuracy. The total measuring range of the gauge shall be between 110 and 200% of the maximum pressure expected. All pressure gauges shall be provided with corrosion resistant shut off valves and snubbers.

xi). Test Connections The power unit shall be furnished with test connection at appropriate locations for attaching a pressure gauge or transducer. Each test connection shall be provided with a corrosion resistant steel connector equipped with check valves; no shut off valves shall be used.

xii). Flexible coupling

The flexible coupling between the motor and the pump shall be an all-metal type suitable for accommodating radial and angular misalignment. The coupling shall be of adequate capacity to drive the pump and shall be accurately bored. Suitable keyway shall be provided to ensure proper fitment on motor and pump shaft and permit minor adjustments for alignment purpose.

2.2.6. Electrical Connections

a) All internal wiring required for the electrical equipment of the hydraulic power unit shall be provided. All wiring shall be installed in conduits. Wiring and conduits shall be installed so as not to interfere with access and maintenance of any part of the power unit.

b) The hydraulic power unit and the electrical control cabinet shall be completely wired to terminals in the shop for field interconnection to other.

c) Automatic operation

Provision shall be made for automatic operation of the gates by no-float control or level relay system when the control switch is set on Auto

d) Electric Motor

The electric motor shall be directly coupled to the oil pump and shall be of sufficient capacity to carry continuously the maximum load likely to develop under all conditions of operation of gates and shall have nominal speed tomatch the requirements of the oil pump.

The motor shall be of totally enclosed fan cooled squirrel cage induction motor continuous type duty with insulation B Type and suitable for 400/440 V, 3 phase 50 cycles AC, non-reversing type with high starting torque characteristics, and shall conform to IS: 325 (latest revision). The electric insulation shall be moisture resistant for use with motors which may either continuous running or may be idle for long periods under highly humid atmospheric condition. All the motor bearings shall be self lubricating and shall be either ball or roller type, properly sealed against loss of lubricant or entrance of dust.

The motor shall be suitable for outdoor type duty and breakdown torque shall not be less than 200% of normal running torque. The motor shall be of standard make approved by the employer.

e) Wiring

All wiring of all power control cabinets shall be single conductor, tinned annealed copper wire with PVC insulation and shall be neatly installed, connected and securely anchored in plates in a workman like manner. Electric connection shall be mechanically tight and secure and shall be made at appropriate terminal blocks. Terminal for field connection shall be accessible easily the insulation of control wiring shall be polyvinyl chloride or similar synthetic insulation of 650 V grade and oil vapour proof. All wiring shall be water-proof and suitable for tropical climate and highly humid atmosphere. Wherever necessary the wiring shall be carried in a heavy gauge hot dip galvanized metal conduits. Conduits shall conform to Indian Standard ' Rigid Steel Conduits (With amendment No. 1)' IS: 9537 (Part II, latest revision) and Indian Standard ' Rigid Plane Conduits of Insulating Materials' IS: 9537 (Part III, latest revision)

f) Circuit breaker

One air insulated triple pole breaker shall be provided for the control of each oil pump motor. It shall be suitable for use as back up protection against short circuit current and in accordance with Indian Standard Specifications for Alternating Current Circuit Breakers, Requirements and Tests, Section-I, Voltages not exceeding 1000 V AC or 1200 V DC (First Revision) (With Amendment No.1) IS:2516(Part-I & II/See-I, Latest Revision.

The circuit breaker shall be provided with thermal overload release. The breaker interrupting capacity shall not be less than 50-0 amperes. Provision shall exist on the circuit breaker for the adjustment of triple setting to suit the requirements of electric motor.

g) Motor Starter

For each oil pump motor, one magnetic motor starter of suitable capacity rated for 400/440 volts, 3 phase, 50 cycles, AC and direct on line starting service shall be provided. The starter shall be suitable for working in conjunction with the control relay for thermal overload and single phasing protection and shall have ano volt release coil.

h) Control Switch

For raising and lowering a gate spring loaded control switch of self resetting type shall be provided. The switch shall provide momentary contact when its handle is operated to positions corresponding to raising and lowering the gate. The control switch shall be of heavy duty type having silver plated contacts and suitable for flush mounting on a panel. The rating shall be 5 amperes, 230/250 volts and 50 hertz. AC.

i) Push Button

The gate moves with the independent push buttons for stop and start. The push buttons shall be of spring loaded oil tight, heavy duty type, having silver plated contacts and suitable for flush mounting on the panel. The push button shall have normally closed contacts. The rating shall be 5A, 230V/250V, 50Hz, AC supply.

j) Indicating Lamps

To indicate the gate at extreme positions and other positions, indicating lamps shall be provided as under:

i). Gate fully opened Green Indicating Lamp

ii). Gate fully closed Red Indicating Lamp

iii). Gate in intermediate position Blue Indicating Lamp

iv). Gate in moving position Amber indicating Lamp

In addition to above, suitable indications shall also be provided for the following:

i. Low oil level/High oil temperature

ii. Gate drift fault

iii. High oil temperature

iv. Pressure Filter Clogged

v. Return filter clogged

vi. Gate jam

vii. Power On

viii. Motor Operation

ix. Emergency stop

x. Local Operation

xi. Dam Control Room Operation

xii. Remote Operation

xiii. Gate latched/unlatched

The indicating lamps shall be water tight, heavy duty type rated for 230/250 volts, AC and suitable for flush mounting on a control panel. While the gate starts opening or closing, the amber lamp will be lighted and shall remain lighted during gate movement. Provision shall also be made for red lamp or green lamp to flicker to indicate the direction of movement of the gates. Once the gate is moved to fully open or closed position the red or green light as the case may be, shall become stable and stop flickering and amber light shall switch off automatically.

k) Heater Switch

Single pole disconnecting heater switch rated for 5 amperes, 230/250 volts, 50 cycles, AC supply shall be provided for the heater in each electric motor and in the control cabinet. The switch shall be oil tight and suitable for flush mounting on a panel.

l) Control relay

For overload and single phasing protection of the motor, a 3 phase control relay shall be provided. The overload device shall be set or adjusted to trip the starter between 115 to 120% of the rated normal, full load running current of the motor. The relays shall be capable of resetting manually.

m) Limit Switches

Limit switches are to be provided to take the gate to its position in the event of its creeping down. When the gate is left in any position for a long time and creeps up to 150mm under the weight of parts due to oil from the rod end side of piston leaking past the piston to the top, one of the limit switches shall be operated to move the gate up and restore to the original position. If it is not possible to restore the original position and the gate creeps to an extent of 175mm and more another limit switches shall be operated to sound an alarm.

It should be arranged that the gate moves up only when the relevant push button is pressed & will be left in an intermediate position when once the push button is not pressed.

2.2.7. Hoist Electric Control Cabinet

i). One control cabinet shall serve each gate. The electrical control cabinet shall contain all relays, time delay relays, motor starters, disconnecting switches, control transformer contactors convenience outlet and lighting receptacles, and any additional electrical equipment required to provide proper and safe operation of the hoists. The convenience outlet shall be installed outside the cabinet, on the side wall. All other electrical control components shall be mounted inside the control cabinet. A main disconnect switch shall be mounted in each control cabinet. The controls may be conventional (hard wiring), or an electronic programmable controller may be used.

ii). The gates shall be controlled by means of momentary push buttons. Gates shall operate in the opening or closing direction continuously until stopped by either the stop push button or applicable limit switch.

iii). The control cabinet shall be fully wired in the shop. The only wiring required in the field shall be the wiring between the cabinet terminal blocks and the components located outside the cabinet.

iv). The enclosure of the local control cabinet shall be as per National Electrical Manufacturers Association i.e. NEMA type 4 IP66 or equivalent cabinet constructed of heavy gauge steel not less than 3mm. thick. This cabinet shall be provided with hinged and gasketed doors on the front for full access to the equipment. Tamperproof locks shall be provided on the doors of the enclosure. The control cabinets shall be provided with spaces for conduits entering from below as required.

2.2.8. Contactors

a) Contactors for the control system of each of the gates shall be provided in each control cabinet.

b) Contactors shall be of 1,2,3 or 4 poles and of appropriate current and voltage rating for the application. The contactors shall be of the open, magnetically held type.

c) The contactors shall be rated in amperes for all classes of loads. Interrupting capacity shall be 6 times of rated current. No derating shall be necessary when used on high inrush current loads. Each pole of the contactors shall be furnished with magnetic blowouts.

d) The Contactors shall be Asco Bulletin 1035, or equal.

2.2.9. Control Panel

The control panel shall contain all the Push buttons, indicating lights, selector and transfer switches, meters, and other indicating devices required for proper and complete operational control of the hoist. All control items shall be functionally in appropriate locations.

2.2.10. Control Cabinet Lighting and Outlets

i). Lighting: The control cabinet shall be provided with lighting to facilitate operation and maintenance. The lighting circuit shall include an ON-OFF switch.

ii). Outlets: One duplex convenience outlet with 'ON' 'OFF' switch shall be provided with each control cabinet for maintenance tools. They shall be rated 15A, 2 pole, 3 wire. The outlet shall be installed, completely outside the cabinet, mounted on the side wall of the cabinet.

iii). Lighting and outlet circuits shall be obtained from separately fused circuits derived from the common control transformer.

iv). Common Control Transformer: A control transformer shall be provided in each of the control modules. The control transformer shall have sufficient volt-ampere capacity to continuously carry the control circuit load required for the control module plus the load for space heaters lighting and outlets. A fuse shall be provided in each ungrounded leg of the control transformer secondary and primary. The minimum control transformer rating shall of 2500 VA.

v). Grounding: Control assemblies shall include a 6mm x 50mm (wxh) copper ground bus. The housing framework and other noncurrent-carrying metallic parts of all equipment shall be securely connected to the ground bus. Holesshall be drilled at each end of the bus to accommodate equivalent standard 2- bolt lugs furnished by others

vi). Instruments: Instruments shall be calibrated in the SI customary system of units.

2.2.11. Transducers

i). General:

Transducers shall be suitable for accurately measuring 50- Hz quantities. Transducer outputs shall be a D.C. current signal ranging from 4 to 20 mA full scale, suitable for termination in a load, resistance up to 500 ohms. If thestandard transducer has an output different from 4 to 20 mA, suitable instrumentation shall be provided to achieve an output of 4 to 20mA.

ii). Unless specified otherwise, the maximum allowable error shall not exceed plus/minus 0.25% of full scale at 25 degree C,. and the error resulting from a temperature variation between - 20 degree C. and 60 degree C. shall not exceed plus/minus 0.5% of full scale. AC output ripple shall not exceed 1%. The units shall be provided with a 10% full scale calibration adjustment, and the response time shall be 400ms or better from 0 to 99%. There shall be electrical isolation between input , output, external power supply, if used, and the case ground connection All transducers shall satisfy the requirements of ANSI C37.90a and shall have a dielectric test voltage rating of 1500 V AC rms for one minute.

iii). Transducer components shall be totally enclosed in steel cases with integral brackets for surface panel mounting. External electrical connections shall be made using screw type barrier terminal blocks. A separate terminal connection shall be provided for grounding the output cable shield.

2.2.12. Hydraulic Fluids

i). Hydraulic working fluid

Petroleum based hydraulic oil may be used in the system. Oil shall be clean and free from contamination. In order to insure peak performance and extended operating life of the equipment, it is recommended that an ISO cleanliness code of 16/14/11, be maintained regardless of system pressure. System operating temperature of oil shall be restricted to below 65°C for satisfactory performance. Oil used in flushing should not be used to fill the hydraulic system.

ii). Flushing fluids

Flushing fluid shall be supplied separate from the hydraulic working fluid to flush and clean the complete hydraulic system of each hoist. The flushing fluid shall be compatible with the hydraulic working fluid.

System Cleanliness

a) General

Before filling the system with hydraulic fluid the system cleanliness shall conform to National Aerospace Standard i.e. NAS 1638, class 8 or equivalent.

b) Piping

The piping supplied for field installation shall be free of all scale, dirt, grit and other foreign matter. The piping shall be cleaned at the source of its fabrication and then sealed to prevent accumulation of foreign matter during transportation to the site. The suppliers installation instruction shall state that the piping shall remain sealed during storage at the site, that the seal shall be removed just prior to installation, and that after installation has been completed, the entire system shall be free of chips of wood, dirt, grit, waste and other foreign matter.

c) Others

The cylinders, hydraulic power units, and manifold shall be clean and free of all foreign matter which occurs as a result of manufacture, assembly and transportation and storage at site.

2.2.13. Flushing

i). General

Procedure for flushing the hydraulic system (including the list of equipment to be supplied for this purpose and method to ensure cleanliness) shall be submitted as part of the installation instructions. The instruction shall conform to ASME LOS-5CI (cleaning and flushing of oil system for lubrication) and shall include the criteria specified below.

ii). Flushing Hydraulic Cylinders

Hydraulic cylinders need not to be flushed at site. They shall be delivered to job site filled with hydraulic oil in a faultless and clean condition. Oil shall be new and conform to the requirement of relevant specifications to be approved by employer. The cylinders must not be connected to the hydraulic system until the employer is satisfied that the cylinders have been cleaned of foreign matter. Oil used in flushing must not be used to fill the hydraulic system.

iii). Flushing Piping

Before installation of hydraulic power unit, cylinders and manifolds, all hydraulic piping must be flushed. By-pass loops of piping must be installed in place of cylinders, manifolds and the power units. Hydraulic oil must be circulated through each and every pipe until returning oil meets NAS 1638, Class 8 requirements or equivalent.

iv). Flushing Hydraulic Power Unit

After cleaning and prior to shipment, each hydraulic power unit shall be flushed in the supplier shops. The hydraulic tank shall be filled with hydraulic oil as specified and the oil filtration system actuated with 10 micron element in filter. The oil shall be circulated and filters changed as they become clogged. The power unit shall be flushed until the filter stays clean. After flushing of the fluid in the tank is complete, a by-pass loop with filter shall be installed on the pressure and tank lines of unit and the pump shall be run alternatively until the return oil line has no foreign particles greater than 10 microns in size.

v). Flushing Valve Manifolds

After cleaning and prior to installation, each valve manifolds must be flushed by circulating hydraulic oil through all ports until the cleanliness of the return meets NAS 1638, class 8 requirements.

2.2.14. Cylinder Mounting Structure

Each cylinder assembly shall be provided with two mountings, a cylinder trunnion (or cylinder end) along with a support structure and rod-end mounting. The hydraulic cylinder should be suspended from the cylinder support frame through a suitable hoist trunnion. Trunnions should be designed to safely takethe load of the entire gate and the hoist assembly including oil.

i). Cylinder Trunnion & Rod end mounting

Cylinder shall be trunnion mounted. It shall connect the cylinder tube to the support structure which will transfer the loads to the concrete pier. For cylinder end suspensions, the pin cantilevers from the pier hall be supported and firmly secured with concrete through properly designed steel work. For maintaining accuracy of suspension, suitable blockouts at the level of hoist support pin shall be provided as necessary. The concrete in block outs shall be well bonded with first stage concrete by providing a rough surface and adequate no. of dowel bars. For filling up any gaps between first and second stage concrete, suitable grouting shall also be done. Manufacturer shall supply the loading details of hydraulic hoist for incorporation in civil design.

The cylinder shall pivot freely as the gate moves along its radial path. Pivoting angle allowed by the mounting shall not be less than the maximum angle required for gate operation, maintenance or erection plus 75mm in each direction.

Bearings for cylinder mountings shall include permanent self-lubricating bushings on corrosion-resistant pins. The pin materials shall be IS: 1570 (PartV) or ASTM A 564 Type 630.

Counter balancing weights shall be provided or the pivoting point on the hoist cylinder shall be arranged so as to minimize bearings pressure on the piston and piston guide rings caused by the weight of the hoist assembly and contained hydraulic fluid.

The piston rod also has mounting attachment (single clevis with a spherical ball bearing) to connect the cylinder to the gate bracket at the bottom horizontal girder ends (LH & RH) through a stainless steel pins with lock plates.

ii). Cylinder support structure

The cylinders will be suspended on a tubular cantilever supporting beams (LH & RH) by means of axles mounted on thick plates extending perpendicular from the outside diameter of the tube. The support beams shall be anchored to the piers concrete.

The suspension support assembly will be held in specified position by a suitable numbers of load bearing anchors embedded in the first stage concrete, to transfer the imposed cylinder effect.

At each end of the cylinder will be equipped with maintenance –free Radial Spherical plain bearing (particularly suitable for arrangement where alignment, oscillating recurrent tilting or slewing movements have to be accommodated),

working on stainless steel axles.

Cylinder support structure shall be designed to allow adjustment and leveling during erection.

2.2.15. Design data for Hydraulic hoists

Type of hoist cylinder	single acting hydraulic cylinder
No. of Hoists	4 Set
Capacity of hoist	Min. 120T (min. 60T capacity per cylinder)
Number of cylinders per gate	Two
Operation of hoist	Independent HPU
Design Stroke	6.0m (approx.)
Operating criteria	Unbalanced water head conditions (Regulating type)

2.3. Slide Stoplogs for Radial Gates, Lifting Beam and Gantry Crane

2.3.1. Slide Stoplogs for Radial Gates

One set of slide type stoplogs suitable for clear vent opening of size 10000 mm x 10500 mm (w x h) is proposed on upstream side of radial gates for their maintenance. Placement of the stoplog units in vertical slots is carried out by a gantry crane together with automatic engaging/disengaging type lifting beam.

Stoplogs shall be fabricated from structural steel comprising of skin plate, horizontal girders, vertical stiffeners and end vertical girders, seals, guide shoes, lifting arrangement etc. The skin plate shall be supported by horizontal girders at suitable intervals, which shall be supported by end vertical girders, which in turn shall support Aluminium Bronze slide pad/thrust pad. The total water load shall be transmitted to concrete structure through the slide/thrust pad mounted on end vertical girders to the stainless steel track fixed on M.S. track base embedded in concrete. Stoplogs shall consist of 4 units shall be interchangeable type. These stoplogs shall be operated under balanced water head conditions by operating top unit in unbalanced head condition then remaining in balanced head condition by Gantry crane (with a provision ofautomatic disengaging and engaging type lifting beam). Each unit shall consist of an Downstream skin plate and downstream sealing. The seals shall be fixed by means of seal clamps, ferrules and stainless steel allen key headed counter sunk screws. Each unit shall be fitted with guide shoes, two on eachside to limit the lateral movement of stoplog unit not more than 6 mm in each direction. Drain holes shall be provided on all horizontal girder webs.

Suitable lifting attachments shall be provided on the stoplog units. Suitable

latching arrangement shall be provided at the top of the bays for the same. The stoplogs and its components shall conform to IS: 5620 (Latest revision).

2.3.2. Embedded Parts

i). First stage inserts (J or U anchors with plates) to be embedded in first stage concrete at a spacing not exceeding 500 mm centre to centre leaving suitable blockout openings for second stage embedments. The size of the 1st stage anchors shall not be less than 16mm in dia. and 300mm in length. The 2nd stage anchors/studs with double nut and washers attached to 2nd stage embedded parts shall than be welded all around to 1st stage anchor plates for providing suitable reference for proper alignment for erection of 2nd stage embeddedparts.

ii). Design of all embedments shall conform to IS: 5620 (latest revision). Minimum sizes and tolerances of all components as specified in IS: 5620 (latest revision) shall be adhered to. The concreting in the blockouts shall be done after erecting the embedded parts, aligning and checking them and ensuring their correct position. Suitable struts, supports etc. as required shall be provided by the contractor to prevent disturbance in the parts during concreting.

2.3.3. Design Criteria of Slide Stoplogs for Radial Gates

Design Criteria for Stoplogs

The design requirements for the stoplogs are mentioned as here under:	
Type of stoplogs	Slide type with D/s skin plate and downstream sealing
Clear width of opening	10000 mm
Clear height of opening	10500mm
Number of spans	4 Nos.
Number of stoplog units	1 set (4 units)
Full Reservoir Level (FRL)	El. 385.50m
Maximum Water Level (MWL)	El. 389.00m
Centre to centre of side seals	10100mm ± 2
Centre to centre of tracks	10500mm ± 2
Sill Elevation	El. 375.00m
Design head	10.5m
Type of rubber seals	Wedge type rubber seal at bottom and music note solid bulb fluorocarbon claddedtype for sides
Type of hoisting arrangement	Gantry crane (min. 40T capacity) & lifting beam
No. of sets of embedded parts	4 sets

Operation – raising and Lowering.	Balanced head No flow water condition created by lifting top unit in un- balanced head condition.
Storage arrangement	4 units shall be stored in the respective grooves after their use
Governing Indian Standard	IS:5620 (Latest Revision)
Permissible stresses	Permissible stresses in structural components for stoplog and embedded parts shall be in accordance with Appendix B of IS: 5620 (latest revision). The stresses in various parts of the stoplog under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress.
Permissible stresses for stoplog units	Dry & accessible conditions
Permissible stresses for embedded parts	Wet & inaccessible conditions
Permissible deflection	Span/800
Permissible bearing & shearing stresses in concrete	As per IS: 456 (Latest Revision)
Seismic Coefficients (horizontal & vertical)	αh= 0.24 g & αv= 0.16 g
Grade of 1st stage concrete to be used	M 20/M25
Grade of 2nd stage concrete to be used	One Grade higher than that of 1st Stage Concrete and shall not be less than M-25 Grade

2.4. Gantry Crane for Operating Barrage Stoplogs

2.4.1. General

All the components of the gantry crane shall conform to the requirement and intent of these specifications.

i) Frame

The gantry shall be fabricated from structural steel sections and plates and shall be of either riveted or welded construction. The legs shall be of box type/rolled, with all angles on the inside of the leg. Field welding will not be accepted. Diaphragms shall be provided to distribute the loads properly to the two sides of

the legs and plate stiffeners shall be provided where necessary. Bearing surfaces of joints designed to transmit stress by bearing shall be machine finished to provide full contact. Shop connection in the frame shall be riveted or welded so that the surface of the crane including the outside of the frame cabin and hoist housing when viewed along the runway, will be a plane surface, except for the projection of rivet heads if any. The structures shall be designed adequately safe for each of the following load combinations.

- Dead and live loads with 50 Kg /sq.m. wind load on the crane and impact loads
- Dead and live loads with 50 kg/sq.m wind loads on the crane and tractive forces.
- Dead loads with no load on lifting blocks and 150 Kg/sq.m. storm loads.
- Breakdown torque of motor.
- Collision of buffers and track stops.

ii) Legs

The gantry legs shall be connected to the crane members by heavy gussets in a manner that will prevent skewing and ensure rigidity and strength. Diaphragms shall be provided to distribute properly the loads from the cross members to the side of the legs. If the centre lines of the legs are not matching with the centre lines of the crane runway rails, the eccentricity shall be considered in determining the stresses.

iii) Machinery Housing

A weather tight housing shall be provided. The floor shall be constructed of reinforced chequered steel plates not less than 8mm thick and shall be welded or riveted to the framework. Clearance between the machinery floor and the roof framing shall not be less than 2 metres.

iv) Operator's Cabin

The cabin shall be of closed type for outdoor services made of structural steel and shall be provided with sufficient ventilating type window to allow the operator to have a clear view of all operations and the cabin shall have ample space for the operation and maintenance of the equipment located in it. The floor of the cabin shall be made of steel plates fastened securely to the frame of the cabin and covered with 'TRANSITE' having not less than 12mm thickness.Provision shall be made for access to the cabin by means of walkway from the ladders.

v) Walkways, Ladders and Railings

All ladders, platforms, and walkways necessary to provide access to the crane drive machines, shall be provided. The platform and walkways shall be designed for a live load of at least 500 kg/sq.m. and shall consist of suitable non-slip steel plates riveted or welded together and riveted or bolted to the steel framework except that the walkway on the top deck of the gantry shall be constructed of floor grating. The ladders shall not be less than 400mm width between side parts and shall have round rungs 20mm in dia. spaced at 300mm centre to centre. The walkways shall provide clearance of not less than 600mm between machinery and/or the structure and the railings. Clips shall be provided on all open edges of the walkways and platforms. Standard pipe railings with three horizontal pipe rails shall completely enclose all walkways. The railings and ladder rungs on the

outside of the crane shall be made of steel having fittings of the flush jointed type. Railings shall be provided along the open sides of the walkways, platform, stairs and other locations where required. The platforms are required to be proportioned for a moving single load of 300 kg. Railings are tobe proportioned for a travelling horizontal single load of 30kg acting on the rail iron.

vi) Buffers

The hydraulic buffers shall be provided at either end of the travel of gantry crane and movable trolley and shall be capable of bringing the crane to a gradual stop in a distance of not more than 200mm when travelling in either direction at rated speed while power off and brakes not applied, without producing excessive stress or damage in the structure. The buffers stops shall be of cast or structural steel, accurately mounted to meet the buffer squarely. The centre line of contact shall not be more than the centre line of wheel base. The design of the buffers shall provide minimum factor of safety of six.

2.4.2. Mechanical Equipment

The hoist shall be designed in accordance with the Latest Revision of IS: 6938 & IS: 3177. All mechanical equipment's shall be simple and substantial in design and capable of being easily erected, inspected, painted and taken apart. The hoist shall be single motor twin drum type connected through gearing and shafting. The capacity of motor shall be such that the specific performance ofthe hoist at rated load will not demand more than full load torque. The shaft connecting the end gear train shall be provided with flexible coupling of the geared type, or any other approved arrangement which will permit one drum to be rotated with respect to the other drum and keeps the lifting beam in a level position. All shaft loads shall be transmitted by suitable keys, splines or pins. The transmission of loads by press fit only will not be permitted. A factor of safety of 5 (five) over UTS based on the rated capacity of the crane (exclusive of duty factor, impact factor, acceleration and retardation) shall be used in design of all mechanical parts provided that all parts of the equipment shall have sufficient strength to resist the forces produced by the rated breakdown torqueof the motor without exceeding 80% of the yield point strength of the material used. Duty factor shall also be considered in breakdown torque condition or the stresses limited to those under breakdown torque condition as per IS: 3177 (Latest Revision). The hoist shall be so designed as to limit the maximum rope fleet angles to one in twelve, unless otherwise approved. The grooving on the main hoist drum shall be such as to allow the lifting beam to travel vertically. Thehoist shall be provided with an electromagnetic brake as well as EHT brake and means for position control of the loading movements of the hooks.

i) Wheels and Axles

The crane shall be carried on not less than eight wheels, four wheels in tandem, fully equalized and provided for each crane travel base. The wheels shall beheat treated properly and certified copies of the test of the heat treatment, shall be furnished by the wheel manufacturer. The tread width shall have the proper clearance for the rail head and shall be of Sufficient size to withstand satisfactorily maximum standing and rolling loads. In no case shall the diameter of the crane wheels be less than that given in IS: 3177. The wheels shall be turned or ground to true and uniform diameter concentric with the bore. The wheel axles shall be made of forged carbon or alloy steel and shall be accurately turned, ground and polished at journals.The wheel assemblies shall be designed to facilitate removal

of wheels, bearings and journals from the frames. This shall be arranged such that wear may be compensated in order to maintain the drive gears in proper mesh. The size of the journal shall be ampleto carry the load at the specified speed without excessive heating during continuous operation. Track sweeps on each end shall be provided and shall extend below the top of the rail on both sides. Wheels shall be interchangeable.

ii) Gantry Drive

The gantry drive motion shall be effected by means of motors and shall be designed to move the crane at a rated speed while supporting the maximum load for operating the stoplogs. Not less than 50% of the wheels on each track shall be connected for driving. Each motor mounted at one end of the gantry crane shall be arranged to drive one track on each side of the crane through gears. The general arrangement is shown in the drawing. The drive shall be free from vibrations while moving and in no case, there shall be any tendency for gantry crane structure to get misaligned.

iii) Brakes

Following brakes shall be provided on the gantry crane:

Hoist brake

The hoist shall be provided with an automatic electro hydraulic thruster brake and EM brake of suitable capacity. The brake will arrest the motion and hold at rest any load upto and including overload test load at any position of the lift. The electro-hydraulic thrust brake shall be applied automatically by springs or weights when the power supply to the brake is interrupted or when the circuit breaker is opened or when the controller is brought to off position. The electro- hydraulic thrust brake shall be mounted on the same base as the hoist motorand shall be equally effective in both directions of motor rotation. The brakes shall be capable of overcoming at least one and half times the rated full load torque exerted by the motor.The brake shall be equipped with manual release, which must be held by hand and cannot be left in the released position or one which will automatically reset at all times when the power is disconnected. The provision shall be made to enable any load capable of overcoming the friction in the system up to and including the test load to be lowered safely in controlled manner in the event of power failure. The brake shall be designed to exert a restraining torque of minimum 50% greater than the maximum torque transmitted to the brake from the suspended load under the loading conditions.
Gantry motion and parking brakes

iv) Wire rope

The wire rope shall be made of special improved plough steel of 6 x37 or 36 construction, ordinary lay, fiber or steel main core and shall conform to IS: 2266 (Latest Revision)). While calculating the dia. of wire rope, the efficiency of pulleys, sheaves and drums shall be considered.

v) Rope drum

The drum design, shape of grooves etc. shall conform to the Latest Revision of IS: 6938 & IS: 3177.

vi) Gears and Pinions

Spur gears of 20 degrees pressure angle full depth involute system conforming

to IS: 3681 (Latest Revision) shall be provided in end reduction gear unit. While designing the gears and pinions, in accordance with the Latest Revision of IS:6938 and IS:4460, the correction factor for peripheral speeds and the efficiency shall also be considered. The teeth of gears and pinions shall be cut from solid metal and shall be free from chatter marks and other imperfections. The pitch line shall be scribed on all gears and pinions to facilitate erection, suchthat gears & pinions shall have a common tangent to Pitch Circle Diameter (P.C.D).The materials for pinions shall be harder than that of gears by at least 50 B.H.N.

vii) Reduction Gear box

It shall consist of worm & worm wheel and whole assembly housed in a dust proof steel casing with suitable lubrication facility. The gear box shall have self locking characteristic. The shaft shall extend through housing for a sufficient length to permit the attachment of flexible couplings in proper alignment and shall be designed and rated in accordance with the accepted Indian Standard Code of Practice. Gear Boxes shall conform to Indian Standard.

viii) Shafts for Gears and Pinions

The shafts shall be designed for combined torsion and bending and the angle of twist shall be taken into account, as detailed in the IS:6938 (Latest Revision). The shaft for drum shall preferably be stationary.

ix) Sheaves

The rope sheaves shall conform to IS: 6938 (Latest Revision). All sheaves shall be in true running balance and shall be provided with antifriction bearing with pressure greasing arrangement.

x) Bearings

All the running shafts shall be provided with ball, roller or self lubricating bush bearings. The selection of bearings shall be done on considerations of duty, load and speed of the shafts as recommended by the manufacturer. All bearingsshall be weather proof, drip proof and shall be protected against the entrance of rain, dust or any other foreign matter. Bearings shall conform to Indian Standard or equivalent International Standard. Plummer block housing shall be provided for the same.

xi) Flexible Couplings

Flexible couplings shall be all metallic, fully enclosed, dust proof, self oiling type and shall be bored for tight fits on the shafts. Straight square keys shall be provided for fitting the couplings on shafts. All couplings shall fit true on shafts and shall be fitted accurately on shafts. The flange couplings between motors and worm gear reducers shall be provided for both angular and offset misalignment of the coupled shafts. Flexible couplings shall conform to Indian Standard .

xii) Lifting Pulley Block

The block shall be arranged to lift the stoplogs without twisting. The hook shallbe mounted on thrust bearing. The blocks shall be so designed and constructed as to guide the hoisting ropes fully and prevent them from leaving the sheaves under any operating conditions. A locking arrangement shall be provided to the hook to prevent the rope from leaving the hook due to any jerk.

xiii) Gear Box Covers

Gear box covers shall be of light weight construction fitted with inspection covers and lifting handles. The covers shall be so shaped that the gears can be easily removed or replaced. Facilities for lubrication, oil draining, oil level indication etc. shall be provided where necessary.

xiv) Counter Weight

Suitable counter weight shall be provided to make the crane stable under conditions laid down in para of stability.

xv) Keys and Keyways

The size of the keys shall be such as to be within safe bearing and shear limits for the materials in contact and, in general shall conform to the relevant Indian Standard for square and flat keys. Where round end keys are used, the total cross sectional area may be considered in effective shear. But in calculating bearing stresses in keys and keyways, the projected area of the rounded ends shall not be included in the effective bearing area. If two keys are used, they shall be placed 120 degree apart. The design shall be such as to hold all keys effectively in place. Further, keys and keyways shall have rounded ends having tight fits in the seats. Keyways shall not be extended into the bearings.

xvi) Wrenches And Tools

A suitable grease gun and a complete set of wrenches and tools in a pressed tool box shall be furnished for the crane. Sufficient quantity and variety of tools shall be furnished to cover all ordinary maintenance work of the crane. Operating instructions in a suitable metal frame covered with glass shall be mounted at a convenient location in operator's cabin

2.4.3. Electrical Equipment

GENERAL

All electrical equipment furnished under these specifications will be subjected to severe moisture condition and shall be designed to prevent deterioration from corrosion and shall be insulated accordingly. All wiring of the electrical equipment shall be in accordance with the Indian Electricity Act in force and the relevant B.I.S. Code. The wiring shall be in hot dipped galvanized metal conduits. Conductors having nominal equivalent copper area of cross section of 9.5mm sq. shall be used for power wiring and those having1. 5mm.sq.for control circuits and auxiliary wiring. Conductors shall normally be insulated for not less than 600 volts and shall have standard moisture resisting, double braided insulation cover.

i) Electric Motors

Motors shall be of totally enclosed with or without fan cooling slip ring type design for operation on 3 phase, 400/440 volts, 50 cycles per sec., A.C., conforming to IS:12615 (I.S: 325 stands withdrawn), of rated capacity. Each motor shall be equipped with heater to prevent condensation of moisture drawn into the motor during shut down periods.

The contractor shall clearly specify in his bid the breakdown torque of the motor. All hoist components shall be checked for their stress value under these conditions Selection of motor shall be as per IS:3177 (Latest Revision). Service factor of 1.15 shall be accounted in deciding the capacity of motor. Motor shall

be of Indian Standard or equivalent international standard marked.

ii) Master Control Equipment

Master control equipment shall be so placed in the operator's cabin that the operator may control all the functions of the crane from there. The operator's stand shall be placed in such a convenient position that enough room is available for various operations of gantry crane and operator may have unrestricted view of the load. All motor controls shall be fully magnetic, reversing with definite time limit and equipped with frequency controlled acceleration devices, instantaneousover current, over loads and low voltage protections. They shall be designed so that it will be possible to limit the vertical movement of the hook, with full rated load, when starting from complete stand still to within 10mm from main hook. All hoist motor controls shall have at least six speed control points in each direction of operation. The contact of protection relays of any motor shall be so wired that the operation of the relay will trip the motor primary conductor, thus making it necessary to return all control to the 'OFF' position before the motor can be started. The control shall be so interlocked that only one operation can be performed at a time. The instantaneous relays shall be adjustable between 200% to 300% of motor full load current. The power supply from the main connections, shall be protected by three pole 400/440 V.A.C totally enclosed air circuit breaker equipped with three time relays, direct acting overload tripping element and one shunt trip coil located in the operator's cabin for emergency tripping. A circuit breaker shall be provided to control and protect the control circuit for each motor and all control circuits shall be fused properly. Indicating lamps shall be provided to show that the control circuit is healthy. All switches, contactors and relays shall be enclosed in suitable cabinets and placed in accessible location to facilitate inspection and maintenance. All motor controls shall have master switches with vertical handles. Changes in speed while lowering the load shall be under the direct control of the operator and shall permit him to stop the motor without time delay from any position by the master switches. All resistors shall be non-breakable, corrosion resisting type and shall have a low temperature coefficient. Where practicable, controller handle should move into the direction of the resultant movement. Each controller shall be marked in a permanent manner to show the motion concluded and wherever practicable of the direction of the movement. The notching for the controller handle in 'off' position shall be more positive than the notching in other position. The control lever shall be provided with stop and/or latches, to ensure safetyand facility of operation. The resistor shall be placed in accessible places outside the cabin and in a well-ventilated non-combustible cabinets which will not emit flame. Each main supply circuit breaker shall have interrupted capacity of not less than 10000 amps. All switches, conductors, primary relays and preliminary circuits on controllers shall have a thermal capacity of 10000 amps, for one second without injury. The resistor shall preferably be intermittently rated and their rating will be as per IS:3177 (Latest Revision). Allowable temperature rise during operation of the crane under service condition shall not exceed and limits specified in relevant Indian Standards. The contractor shall state in his tender the make and types of all electrical equipment, which he proposes to furnish. All switches, controller levers and other operating mechanism and electrical devices shall be subject to the approval of the employer. A provision shall be kept for a multi socket with switch 5A & 15A for future operation & maintenance.

iii) Cables and Cable Reel

The rubber insulated cable or polyvinyl chloride insulated cables used for crane

wiring should comply with the relevant Indian Standard. The gantry crane shall be equipped with an automatic spring actuated device to take up cable reel. Power will be obtained from plug receptacles placed at convenient intervals of the runway. The cable reels shall be provided with sufficient length of flexible cable and with limit switches arranged to cut off the power supply to the cable of the motors, when all but two turns of the cable are unreeled. The attachment plug for the receptacle end of the cable shall be furnished by the contractor.

iv) Wiring

All wiring shall be in the hot dipped galvanized metal conduits. All conductors for primary power lighting and control circuit shall be insulated for not less than 600 volts and shall have standard moist resisting double braided covering. All conductors between the secondaries of the motor conductor and resistors shall have sufficient current carrying capacity in accordance with Indian standard and shall be insulated with 600 volts class asbestos. The primary conductor to the motor shall have standard continuous current carrying capacity of not less than 100% of the rated full load primary current of the motor. Cables having conductors smaller than 2.5mm2 nominal equivalent copper areas of the cross section shall not be used for the power wiring for any of the motor. For control circuits and auxiliary wiring, cables having a sectional area smaller than 1.5mm2 nominal equivalent copper area shall not be used. All cables shall be adequately protected

against mechanical damage and metal trunking may be used if desired. Electrical conduit shall comply with the relevant Indian Standard. For outdoor cranes except where flexible unarmoured cables are essential, cables shall be either armoured or enclosed throughout their length in galvanized trunking or conduit, either flexible or rigid. A flexible metallic tube or duct may not form an effective earth connection and shall not be used for that purpose. Tapped and braided varnished cambric insulated cables shall not be used for outdoor crane.

v) Limit switches

The limit switches shall be of the totally enclosed type. All limit switches shall be capable of being reset by reversing the controllers. The limit switches shall have water proof coverings and shall be suitably designed and tested for normal lift. and satisfactory operation under the humid climatic conditions. They shall be of approved and standard type and shall be suitable for service under extreme position in either direction. The design shall be such as to facilitate easy servicing and replacement when worn-out.

Limit switches shall be provided for following operations:

- To limit the travel of gantry crane at both ends of the travel and to stop the crane at centre of each bay.
- To limit the hoisting travel of the hook block/lifting beam.
- To limit the travel of cross travel trolley of hoist

vi) Isolating Switches

The manufacturer shall fit a main isolating switch in the cabin or adjacent to it, capable of disconnecting the supply for power driven and associated equipment on the crane but not the auxiliary loads such as lighting and heating circuit. In the case of main isolating switches being combined with the crane protective panel, it shall be mechanically interlocked with the door giving access to the panel, and the terminal shall be screwed to prevent accidental contact when the door is opened.

When so combined a suitably worded red warning plate shall be attached to the cover of the protective gear and all other panels and controllers, not fitted with interlocked isolators. The main isolating switch and the additional isolating switches should be so situated that it will be possible to carry out any maintenance work or functional testing on them without danger.

vii) Protective Equipment

Iron clad electric protective gear in accordance with IS:3177 (Latest Revision) shall be provided except that if the aggregate power of the two largest motors is less than 30 kW and their aggregate current rating is less than 60 amps., a manually operated equipment as per IS:3177 (Latest Revision) may be used.

viii) Emergency Push Button

A push button emergency stop shall be so located as to be readily accessible for prompt use by the operator in case of emergency. This emergency push button shall be connected in the operating coil circuit in case of contactor and in the under voltage release circuit in the case of a circuit breaker.

ix) Lighting at Convenient Outlets

The permanent 220 volt lighting system on the crane shall consist of four five hundred watts high bay lighting units to illuminate the area under the crane, one five hundred watt high bay lighting unit to illuminate the area under the cantilever and two 80W fluorescent tubes in the operator's cabin. The system shall be supplied from 400/440 V crane power system through a 400/440V circuit breaker with a convenient outlet in the operator's cabin. One branchcircuit system shall be connected for lighting hoist mechanism through flexible conduit with four 100W lighting units. Each of the two 500W high bay lights and another branch circuit shall be connected to give convenient outlets. The wiring shall be done in accordance with the Indian Electricity Rules. The 400/440V circuit breakers shall be of enclosed, two pole type with an over load tripping element for each pole.

x) Interlocking and Earthing

'Off' position interlocking, earthing and other electrical equipments shall be provided as per IS:3177 (Latest Revision).

2.4.4. Design Criteria

The crane shall be class II as per IS:807 of the Outdoor Travelling type with rope drum hoist mounted at the top of the crane structure. The operation of the crane shall be completely electrical with 400/440 volts, 3 phase, 50 Hertz and the power supply shall be made available from the plug receptacles located at suitable intervals along with the crane runway. To facilitate a better control of thecrane, a operator's cabin shall be provided with the crane. All the controls required for the electrical equipment on the crane shall be provided in theoperator's cabin along with the control panel having indicating lights for the various operations. The crane should be made to stop at the centre of each bay of stoplogs with the help of limit switches provided along the travels.

i) Loading

All structural loads shall be computed as follows:

a) The dead load shall include the weights of the legs and horizontal members of the crane, crane drive, hoist mechanism and operating cabin. The effect

of the eccentricity of the location of the crane drive mechanism, hoisting mechanism and operator's cabin shall be included in the design

b) The tractive force on each wheel shall be considered as 5% on the resultant maximum wheel load considering the weight of the crane and live load equal to hoist capacity.

c) The live load shall include the weight of hooks, blocks, ropes and attachments. The live load shall be multiplied by the impact factor as per IS:807 (Latest Revision).

d) The wind load on the crane shall be taken as 50 Kg./sq.m and also in accordance with the Latest Revision of IS:875 & IS:807. The wind area of the crane shall be taken as the vertical projection of the structure, normal to the direction of the wind. While applying wind pressure, appropriate form factors in accordance with IS:807 (Latest Revision) shall be accounted.

ii) Permissible stresses

The crane and the structural members shall be proportioned in such a way that the actual calculated stresses for the combination of loading causing most adverse effect on the members, arrived at by any of the accepted methods of calculations, shall not exceed the permissible stresses specified in IS:807 (Latest Revision).

The design of the component parts of the mechanism relating to crane motion shall include due allowance for the effects of the duty which the mechanism will perform in service.

In all cases the mechanism shall be classified in accordance with the provision of IS:807 (latest revision) on the basis of the duty and the design of the component parts shall be in accordance with the provision given in this section.

The overall design and fabrication of gantry crane shall conform to the Latest Revision of IS:3177, IS:807, IS:800,IS:806, IS:816, IS:822 & IS:9595.

iii) Stability

a) Considering load under breakdown conditions of motor and steady wind pressure 50 kg./sq.m., the stability factor must be greater or equal to 1.3

b) Considering live load under service conditions with stable wind pressure of 50 Kg./sq.m. and acceleration and retarding forces the stability factor mustbe greater or equal to 1.8.

c) In case of crane without load and not operating and considering storm wind pressure of 150 kg/m2 , the stability factor must be greater or equal to 1.5.

iv) Limiting Length of Members

The L/r ratio shall not exceed 180 for main compression members and 240 for bracing and subsidiary members. The ratio of the unsupported length of the horizontal projection of any riveted tension members to the least radius of gyration shall not exceed 150. The ratio of l/b for any beam or girder shall not exceed the following limits:

Welded box plate girder: l/b < or = 60

v) Rolled section

All rolled sections used as beams shall have a depth of not less than one sixteenth of the span and where used in pair shall have full depth separators spaced not more than 1.5m centre to centre. Stiffeners shall be provided on the webs of the rolled steel beams at the ends and at points of concentrated loadsto resist buckling.

2.4.5. Design data for Gantry crane

The design requirements for the Gantry Crane are mentioned as here under:

Type and class	Outdoor type, class II
Number of gantry	One
Capacity (safe working load)	Min. 40T
Centre to centre distance between Runway rails	2.50 m
wheel base of crane	6.50 m
Total Lift	16.5 m (Tentative)
Speed of hoisting	1.5 m /min
Gantry travel speed	6 to 8 m/min
Total length of travel	70m (Tentative)
Governing Indian Standard	IS:3177 (Latest revision), IS:6938 (Latest revision), IS:800 (Latest revision)

2.5. Intake Emergency Gate, Rope Drum Hoist, and Hoist Supporting Structure

2.5.1. Intake Emergency Gate

One (1) set of fixed wheel type gate suitable for clear vent opening of size 6200 mm x 4000 mm (w x h) are proposed on upstream of the intake service gates to permit repair and maintenance of the intake gates and during malfunctioning of intake gate.

The operation of intake emergency gate is carried out by a Rope Drum Hoist. The general arrangement of the gate with Rope Drum Hoist is shown in the tender drawing.

Intake Emergency Gate shall be fabricated from structural steel comprising of skin plate, stiffened by horizontal girders, vertical stiffeners, wheels and end vertical girders and all other accessories required for proper functioning of the gate complete in all respects as per these specifications and tender drawings. The gates shall have upstream skin plate w.r.t reservoir and sealing upstream sides to isolate HRT . The skin plate shall be supported by horizontal girders at suitable intervals. The horizontal girders shall be supported by end verticalgirders, which in turn shall support the wheels at downstream side as shown on the general arrangement drawing. Wheels shall transfer the load to concrete through an embedded stainless steel bearing track fixed on mild steel trackbase. The Intake Emergency Gate shall be operated under unbalanced water head conditions. Gate maintenance is proposed at deck. Suitable latching/dogging arrangement shall be provided to facilitate this requirement. Suitable lifting attachments shall be provided at the top of each gate. Suitable grating with supporting angles etc., complete in all respects shall be provided at top of gate shaft. The Gate and their components shall conform to IS: 4622 (latest revision).

Drain holes shall be provided on all the horizontal girder webs and horizontal stiffeners.

Two numbers of guide shoe assembly on each side of gate shall be provided to check the side and lateral movement of the gate and to restrain the same within specified limits.

The intake emergency gate shall have wedge type rubber bottom seal and solid bulb fluorocarbon cladded side & top seals respectively. The thickness of bottom seals shall not be less than 20 mm. Care should be taken that side seals bear evenly and with uniform pressure throughout the length on the side seal seats. The bottom seal should also bear uniformly on the bottom seal seat. Seals should have perfect leak proof joint. The seal bases shall be machined after welding to the gate leaf. The seal clamps shall be shaped suitably to prevent any cutting or damage to the seals.

2.5.2. Embedded Parts

First stage inserts (J or U anchors with plates) to be embedded in first stage concrete at a spacing not exceeding 500 mm centre to centre leaving suitable blockout openings for second stage embedments. The size of the 1st stage anchors shall not be less than 16mm in dia. and 300mm in length. The 2nd stage anchors/studs with double nut and washers attached to 2nd stage embedded parts shall than be welded all around to 1st stage anchor plates for providing suitable reference for proper alignment for erection of 2nd stage embedded parts.

Design of all embedments shall conform to IS: 9349 (latest revision) & IS: 4622 (latest revision). Minimum sizes and tolerances of all components as specified in IS: 9349 (latest revision) & IS: 4622 (latest revision) shall be adhered to. The concreting in the blockouts shall be done after erecting the embedded parts, aligning and checking them and ensuring their correct position. Suitable struts, supports etc. as required shall be provided by the contractor to prevent disturbance in the parts during concreting. The contractor shall be responsible for correctness of erection of the embedded parts in position and maintaining the dimensional accuracies as per approved drawings.

2.5.3. Design Criteria for Intake Emergency Gate

Design Criteria for Intake Emergency Gate

The design requirements for the Intake Emergency Gate is mentioned as here under:

Type of stoplogs	Wheel type with Upstream skin plate and Upstream sealing
Clear width of opening	6200 mm
Clear height of opening	4000mm
Number of spans	1 No.
Number of gate	1 No.
Full Reservoir Level (FRL)	El. 385.50m
Maximum Water Level (MWL)	El. 389.00m
Centre to centre of side seals	6350mm ± 3
Centre to centre of tracks	6800mm ± 3
Sill Elevation	El. 377.00m
Design head	8.5m
Type of rubber seals	Wedge type rubber seal at bottom and music note solid bulb fluorocarbon claddedtype for sides

Type of hoisting arrangement	Rope Drum Hoist (min. 25T capacity) & lifting beam
No. of sets of embedded parts	1 set
Operation – raising and Lowering.	Lowering: under balanced water head conditions. Raising: under balanced water head conditions achieved through crack opening
Governing Indian Standard	IS:4622 (Latest Revision)
Permissible stresses	Permissible stresses in structural components for stoplog and embedded parts shall be in accordance with Appendix B of IS: 4622 (latest revision). The stresses in various parts of the stoplog under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress.
Permissible stresses for Gate	Dry & accessible conditions
Permissible stresses for embedded parts	Wet & inaccessible conditions
Permissible deflection	• L/800 (L = C/C of wheels) • Maximum deflection of gate at the top seal shall not be more than 80% of the initial interference of theseal
Permissible bearing & shearing stresses in concrete	As per IS: 456 (Latest Revision)
Seismic Coefficients (horizontal & vertical)	αh= 0.24 g & αv= 0.16 g
Grade of 1st stage concrete to be used	M 20/M25
Grade of 2nd stage concrete to be used	One Grade higher than that of 1st Stage Concrete and shall not be less than M-25 Grade

2.6. Intake Service Gate, Rope Drum Hoist, and Hoist Supporting Structure

2.6.1. Intake Gates

One (1) set of wheeled Type Gate suitable for clear vent opening of size 6200 mm x 4000 mm (w x h) are proposed at Intake. Intake gate shall be used for initial filling of water conductor system through crack opening and to avoid back flow from water conductor system to reservoir during reservoir flushing or when power station is not in operation. Intake gate is required to suit the design criteria specified in the subsequent paras. These shall be fabricated from structural steel comprising of skin plate, stiffened by horizontal girders, vertical stiffeners, end vertical girders, wheels, seals, guide shoes etc. and all other accessories required for proper functioning of the gate complete in all respects as per these specifications and Tender drawings. The gates shall have Downstream skin plate w.r.t reservoir and Downstream sealing to isolate HRT. The skin plate shall be supported by horizontal girders at suitable intervals. The horizontal girders shall be supported by end vertical girders, which in turn shall support the wheels at downstream side shown on the general arrangement drawing. Wheels shall transfer the load to concrete through an embedded stainless steel bearing track fixed on mild steel track base. The intake service gate shall be operated under unbalanced water head conditions. The intake service gates shall be able to be crack opened by 100mm for initial filling of water conductor system. The gate shall be operated by individual rope drum hoists mounted on hoist supporting structures supported by steel trestles. Gate maintenance is proposed at deck. Suitable latching/dogging arrangement along with ladder, platform etc. shall be provided to facilitate this requirement. Suitable lifting attachments shall be provided at the top of each gate. Suitable grating with supporting angles etc., complete in all respects shall be provided at top of gate shaft. The Gate and their components shall conform to IS: 4622 (latest revision).

Suitable drain holes shall be provided on all horizontal girder webs and horizontal stiffeners. Ballast if required shall be provided to achieve the required seating pressure. The gate units will be assembled at site by using bolts. The bottom of the gates shall be shaped so as to have the best hydraulic performance.

Two numbers of guide shoe assembly on each side of each gate shall be provided to check the side and lateral movement of the gate and to restrain the same within specified limits. They shall travel on side guide track embedded in piers.

All the gates shall have wedge type rubber bottom seal and fluorocarbon cladded music note rubber seals shall be provided on sides and top. The thickness of bottom seals shall not be less than 20 mm. The seal clamps shall be shaped suitably to prevent any cutting or damage to the seals.

2.6.2. Embedded Parts

First stage inserts (J or U anchors with plates) to be embedded in first stage concrete at a spacing not exceeding 500 mm centre to centre leaving suitable blockout openings for second stage embedments. The size of the 1st stage anchors shall not be less than 16mm in dia. and 300mm in length. The 2nd stage anchors/studs with double nut and washers attached to 2nd stage embedded parts shall than be welded all around to 1st stage anchor plates for providing suitable reference for proper alignment for erection of 2nd stage embedded parts.

Design of all embedments shall conform to IS: 4622 (latest revision). Minimum sizes and tolerances of all components as specified in IS: 4622 (latest revision) shall be adhered to. The concreting in the blockouts shall be done after erecting the embedded parts, aligning and checking them and ensuring their correct position. Suitable struts, supports etc. as required shall be provided by the contractor to prevent disturbance in the parts during concreting. The contractor shall be responsible for correctness of erection of the embedded parts in position and maintaining the dimensional accuracies as per approved drawings.

2.6.3. Design Criteria for Intake Service Gate

Intake gates shall be normally operated under unbalanced water head conditions. However, the gates shall be able to be crack opened by 100mm for initial filling of water conductor system and to avoid back flow from HRT to reservoir during reservoir flushing or when power station is not in operation. The gates shall have Downstream skin plate and Downstream sealing .

Design Criteria for Intake Service Gate

The design requirements for the Intake Service Gate is mentioned as here under:

Type of stoplogs	Wheel type with Downstream skin plate and Downstream sealing
Clear width of opening	6200 mm
Clear height of opening	4000mm
Number of spans	1 No.
Number of gate	1 No.
Full Reservoir Level (FRL)	El. 385.50m
Maximum Water Level (MWL)	El. 389.00m
Centre to centre of side seals	6350mm ± 3
Centre to centre of tracks	6800mm ± 3
Sill Elevation	El. 377.00m
Design head	8.5m

Type of rubber seals	Wedge type rubber seal at bottom and music note solid bulb fluorocarbon claddedtype for sides
Type of hoisting arrangement	Rope Drum Hoist (min. 30T capacity) & lifting beam
No. of sets of embedded parts	1 set
Operation – raising and Lowering.	Lowering: under balanced water head conditions. Raising: under balanced water head conditions achieved through crack opening
Governing Indian Standard	IS:4622 (Latest Revision)
Permissible stresses	Permissible stresses in structural components for stoplog and embedded parts shall be in accordance with Appendix B of IS: 4622 (latest revision). The stresses in various parts of the stoplog under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress.
Permissible stresses for Gate	Dry & accessible conditions
Permissible stresses for embedded parts	Wet & inaccessible conditions
Permissible deflection	• L/800 (L = C/C of wheels) • Maximum deflection of gate at the top seal shall not be more than 80% of the initial interference of theseal
Permissible bearing & shearing stresses in concrete	As per IS: 456 (Latest Revision)
Seismic Coefficients (horizontal & vertical)	αh= 0.24 g & αv= 0.16 g
Grade of 1st stage concrete to be used	M 20/M25
Grade of 2nd stage concrete to be used	One Grade higher than that of 1st Stage Concrete and shall not be less than M-25 Grade

2.6.4. Rope Drum Hoist for Intake Emergency Gate and Intake Service Gate

The hoist equipment to be furnished by the contractor will be used to operate the Intake Emergency and Service gate. The Hoist mechanism shall include a driving motor, a gear reducer, rope drums, Plummer blocks for supporting the rope drum shaft and all other shafts, ropes, shafts, gears, couplings, brakes, emergency manual arrangements, limit switches, gate position indicator (both analogue and digital), covers etc., all mounted on a fabricated steel frame including anchor bolts, plates and base plate etc. Electrical controls and all necessary electrical and mechanical accessories shall be provided for the satisfactory operation of the hoist. The hoist shall be capable of fully opening/closing the gate and shall conform to design criteria mentioned in subsequent paras. Sufficient space shall be provided around the hoist components for repair/maintenance. Roof over the hoist platform shall also be provided.

i) Central Drive Unit

a) Motor:

Totally Enclosed Fan Cooling (T.E.F.C) reversible squirrel cage, IP-66, operating on 415 V +/- 6% , 3 phase, 50 Hz A.C. power supply with a provision of inbuilt heater of reputed make such as Siemens, Kirloskar, Crompton Greaves, Marathon, Bharat Bijlee. The shaft of the motor shall be of extended type on both sides to accommodate arrangements for manual drive. The rated speed of motor shall not be more that 1000 rpm. The motor shall conform to Indian Standard. The motor shall have high starting torque, low starting current and shall be suitable for operation in highly humid atmosphere. The breakdown torque shall not be less than 200% of the rated torque of the motor. The central drive unit shall be mounted on portable frame.

b) Brake

Three phase, shoe type, Electro-magnetic as well as Electro-Hydraulic Thruster operated brakes (having rated torque of 1.5 times the output torque of motor) of reputed make such as Electromag, Stromkraft or of any other Indian standard make. The brakes shall be of robust construction. The shoes and base shall be made of close grained cast iron of ample strength for the duties specified. Fulcrum pins shall be of manganese bronze. Allsteel parts shall be plated to prevent rusting.

c) Worm reducer

Reversible, self-locking, of reputed make such as Radicon, Allennoyd, Allen Berry, Elecon, premium or of any other Indian standard make. The reducer shall match with rating of motor. The reduction assembly shall be totally enclosed type. The reduction unit shall comprise of worm and wheel set. A provision shall be kept for lubrication with oil by gears dipping in the sumps. The reduction unit shall be provided with oil level dip stick, sight glass, drain plugs and oil filter/ ventilator.

d) Manual drive

The equipment shall comprise of a gear box with a handle and a two-way ratchet fitted to the input shaft. A manually operated claw coupling shall connect the gearbox to the non-drive end of the worm box input shaft. A limit

switch shall be fitted to provide electrical interlock to prevent operation by electrical power when the manual drive is engaged. Efforts per person shall not be more than 10Kgf. at a crank radius of 400mm operating at a speed of 24 rpm. The high-speed brake and motor brake shall need to be released via the manual levers to enable the manual drive to be operated. Pawl and ratchet arrangement shall also be provided to prevent the lowering of the gate by its own weight.

ii) Drum Assembly

Each drum shall be fabricated in one piece from mild steel or machined caststeel and shall be spiral grooved to suite right hand (RH) and left hand (LH) coiling. The loose ends of the rope shall be secured to the gear wheels by rope clamps (min. 4 nos. per side). The spur wheels shall be manufactured in one piece and shall be secured to the drums with screws and drive dowels. Thedrum shaft shall be manufactured from high tensile steel and is keyed to the drum.

iii) Bearings

All the running shafts shall be provided with ball or roller bearings. The selection of the bearings shall be done on considerations of duty, load and speed of the shafts as recommended by the manufacturer. All bearings shall be weather proof drip proof and shall be protected against the entrance of rain, dust or any other foreign matter. The bearings shall be of reputed and standard make like SKF or equivalent. Bush bearings are not to be provided for any shaft, exceptfor the drum. their static and dynamic capacities should be minimum 1.5 times the load. Bearings should also be safe against any axial loading.

iv) Bed Frame

The hoist main frame shall be manufactured from rolled steel sections and plates with a chequered plate to form a composite support structure. The various components of the hoist equipments shall be mounted on mild steel sub-frames which shall be bolted/welded to the upper faces of the main frame. Shimming allowance shall be included at critical positions for final alignment of couplings and gears etc.

v) Coupling

All couplings shall be of Forged or Cast steel and shall be designed to transmit the maximum torque that may be developed. Solid couplings shall be aligned in such a way that these meet accurately. Flexible couplings shall be initially aligned with the same accuracy as in case of solid couplings. Flexible couplings shall be fitted between the motor shaft and extension shafts..

vi) Rope & Sockets

The ropes of the hoist shall be galvanized fiber core conforming to IS:2266(latest revision), 6x36 or 6 x 37 construction. The ropes shall be supplied permanent markings at suitable distances from centreline of the socket pin to provide alignment facility with the drum. The fused and taper ends of the rope shall be clamped to the spur gear wheels with minimum four clamps.

vii) Hoist Pulleys

Hoist pulley shall be provided to ensure equal rope loads and shall be provided with straps to retain the ropes in the groove. The pulleys shall be supported by non rotating stainless steel pins and shall be fitted with high tensile strength aluminium bronze bushing for grease lubrication.

viii) Gear Coupling

Half Geared semi flexible coupling shall be fitted between output shaft of the worm reduction unit and the pinion shaft. Coupling shall be protected with a special surface treatment or coating to improve corrosion resistance.

ix) Dial Indicator

The gate position indicators shall be provided to show the position of the gates, when these are being raised or being lowered. The indicator dial shall be made of non - rusting metal or enameled Plates. The markings on the dial in operating range shall have minimum readability of 1/20th. of meter. The meter markings shall be very bold. The words 'CLOSED', 'OPEN' and 'FULLY RAISED' shall also be engraved or permanently marked. The dial shall be located at a convenient place from where it can be read easily. The indicator points shall be made of non -rusting metal. Electro- plated or digital type indicator may also be provided

x) Covers

All hoist machinery covers shall be of light weight construction with handles.

xi) Control panel and protective devices

Circuit breakers, fuses, thermal protected relays etc., of suitable rating shall be provided in the motor circuit and circuit breaker, limit switches (for lowest and highest positions of gate) of suitable ratings compatible with the equipment shall be provided in the control circuit. All the contactors relays, push buttons etc., shall be of adequate ratings of standard make and of tested quality and shall be provided for brake contactor, slack rope, maintenance position , gate open limit , gate close limit , rope overload, brake overload, emergency stop etc. etc. Sufficient spare relays shall also be provided. Limit switches shall also be provided to ensure that the motors do not start while the gates are being operated manually. A provision shall be made in the control panel for thermostatically controlled heater of suitable capacity. A provision shall be kept for a multi socket with switch 5A & 15A for future operation & maintenance. All the components of hoists shall be checked for the breakdown torque of motor selected. Actual breakdown torque (BDT) or pull out torque (POT) as indicated in the motor catalogue has to be adopted. Limiting of BDT/POT of motor by using a torque limiter or by effecting any local change in the motor circuit will not be permitted.

2.6.5. Design data for Rope Drum Hoist for Intake Emergency and Service Gate

The design requirements for the rope drum hoist for Intake Emergency Gate and Intake Service Gate are mentioned as here under:

Capacity of Hoist	30T minimum. However, theContractor may examine for the adequacy of Hoist capacity intended for the above-mentioned job. In case the higher Hoist capacity is required,he will indicate the same in his Bid.
No. of hoists and hoists supporting structures	1 (One) for Intake Emergency Gate and 1 (One) for Intake Service Gate with common Supporting Structure.
Lift of Gate	15.0m (Tentative)
Operating Speed	0.5m/min. ± 10%
Number of Drums	2 (Two) with single layer of rope (for each hoist) with L.H. and R.H. groove on drum for two points lifting of gate
EL of bottom of trestles	391.50m
Governing Indian Standard	IS:6938 (Latest revision)

2.6.6. Head loss measurement value

The hoist supporting structure shall be designed for the worst combinations of the following:-

i) Load on the structure:

a) Load transmitted through the hoist under normal operating conditions.

b) Impact load

c) Live load of 500Kg./sq.m.area

d) Dead weight of the members

e) Seismic load

f) Wind load

ii) Permissible stresses : As per IS:800 (latest revision)

As per IS:807 (latest revision)

iii) Breakdown condition: for Hoist supporting structure shall be checked

actual breakdown torque of motor selected.

iv) Limiting deflection: L/800

v) Flooring: Reinforced chequered plate of minimum 8mm thickness shall be provided.

2.7. Surge Shaft Gate, Rope Drum Hoist and Hoist Supporting Structure

2.7.1. Surge Shaft Gate

One (1) set of Wheel type gate suitable for a clear vent opening of size 5200 mm x 5200 mm (w x h) is proposed to facilitate inspection, repair & maintenance of butterfly valves. The gate are required to suit the design criteria specified inthe subsequent paras. The gate shall be fabricated from structural steel comprising of skin plate, horizontal girders, vertical stiffeners, end vertical girder,seals, guide shoes, thrust pads, lifting arrangement etc and all other accessoriesrequired for proper functioning of the gates complete in all respects as per these specifications and drawings. The skin plate and sealing shall be provided on the d/s side w.r.t. the flow from HRT. The skin plate shall be supported by horizontal girders at suitable intervals. The horizontal girders shall be supported by end vertical girders which in turn shall support the wheels at downstream side shownon the general arrangement drawing. Wheels shall transfer the load to concrete through an embedded stainless steel bearing track fixed on mild steel track base. The gate shall be raised under balanced water head conditions achieved through 2 no. filling valves provided as an integral part of the gate. The gate shall be capable of lowering under differential water head of [...]m. The gateshall be operated by the rope drum hoist mounted on hoist supporting structure supported by steel trestle and bracings. Suitable air vent pipe shall also be provided for this gate to meet the air demand when d/s portion of the pressure shaft shall be filled to create balance head conditions and dewatering of the d/s portion of pressure shaft between the gate and the butterfly valve. Suitable liftingattachments shall be provided at the top of the gate. Suitable grating with wire mesh and supporting angles etc., complete in all respects shall be provided at top of gate shaft. Gate maintenance is proposed at El. 396.5m. Suitable doggingbeams shall be provided for the same. The gate shall be stored in the gate groove. Suitable latching arrangement viz. ladder, platform along with necessary attachments shall be provided to facilitate this requirement. The Gate and their components shall conform to IS: 4622 (latest revision).

Suitable drain holes shall be provided on all horizontal girder webs and horizontal stiffeners.

Two nos. of guide shoe assembly on each side of the gate shall be provided to check the side and lateral movement of the gate and to restrain the same within specified limits. They shall travel on side guides embedded in gate groove.

Solid bulb double stem fluorocarbon cladded seals for top and sides and wedge type plain rubber seal at the bottom shall be provided. The thickness of bottom seals shall not be less than 20 mm. Care should be taken that side seals bear evenly and with uniform pressure throughout the length on the side seal seats. The bottom seal should also bear uniformly on the bottom seal seat. All the seal should have perfect leak proof jointing. The seal bases shall be machined after welding to the gate leaf. The seal clamps shall be shaped suitably to prevent any cutting or damage to the seals.

The gate shall satisfy the following requirements:

In closed position, the gates must be completely watertight with full water pressure acting from upstream side and sealing must be reliable. The gates shall have

downstream sealing and skin plate as shown in the specifications drawing.

The gates and accessories shall be so designed that the stresses in the different members due to dynamic loads in closing and opening operations and static load in the closed position do not exceed the permissible stresses specified.

The hoist capacity shall be calculated for the worst conditions.

2.7.2. Embedded Parts

First stage inserts (J or U anchors with plates) to be embedded in first stage concrete at a spacing not exceeding 500 mm centre to centre leaving suitable blockout openings for second stage embedments. The size of the 1st stage anchors shall not be less than 16mm in dia. and 300mm in length. The 2nd stage anchors/studs with double nut and washers attached to 2nd stage embedded parts shall than be welded all around to 1st stage anchor plates for providing suitable reference for proper alignment for erection of 2nd stage embedded parts. They shall be designed to suit the as per IS: 4622 (latest revision).

Minimum sizes and tolerances of all components as specified in IS: 4622 shall be adhered to. The concreting in the blockouts shall be done after erecting the embedded parts, aligning and checking them and ensuring their correct position. Suitable struts, supports etc. as required shall be provided by the contractor to prevent disturbance in the parts during concreting. The contractor shall be responsible for correctness of erection of the embedded parts in position and maintaining the dimensional accuracies as per approved drawings.

2.7.3. Design Criteria for Surge Shaft Gate

The gate shall be lowered during the maintenance of the Butterfly valves. The gate shall have downstream skin plate & sealing. The gate shall be raised under balanced water head conditions achieved through 2 no. filling valves provided as an integral part of the gate.

Design Criteria for Surge Shaft Gate

The design requirements for the Surge Shaft Gate are mentioned as here under:

Type of stoplogs	Wheel type with Downstream skin plate and Downstream sealing
Clear width of opening	5200 mm
Clear height of opening	5200mm
Number of bay	1 No.
Number of gate	1 No.
Maximum Surge Level	El. 395.50m
Minimum Surge Level	El. 373.00m
Centre to centre of side seals	5350mm ± 3
Centre to centre of tracks	6000mm ± 3

Sill Elevation	El. 363.20m
Design head	32.3m
Type of rubber seals	Solid bulb double stem fluorocarbon cladded seals for top and sides and Wedge type rubber seal for bottom corresponding to IS:11855(Latest revision).
Type of hoisting arrangement	Rope Drum Hoist (min. 40T capacity) & lifting beam
No. of sets of embedded parts	1 set
Operation – raising and Lowering.	Lowering: under balanced water head conditions. Raising: under balanced water head conditions achieved through filling valve
Governing Indian Standard	IS:4622 (Latest Revision)
Permissible stresses	Permissible stresses in structural components for stoplog and embedded parts shall be in accordance with Appendix B of IS: 4622 (latest
	revision). The stresses in various parts of the stoplog under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress.
Permissible stresses for Gate	Dry & accessible conditions
Permissible stresses for embedded parts	Wet & inaccessible conditions
Permissible deflection	• L/800 (L = C/C of wheels) • Maximum deflection of gate at the top seal shall not be more than 80% of the initial interference of theseal
Permissible bearing & shearing stresses in concrete	As per IS: 456 (Latest Revision)
Seismic Coefficients (horizontal & vertical)	αh= 0.24 g & αv= 0.16 g
Grade of 1st stage concrete to be used	M 20/M25

Grade of 2nd stage concrete to be used	One Grade higher than that of 1st Stage Concrete and shall not be less than M-25 Grade

2.7.4. Rope Drum Hoist for Surge shaft Gate

The hoist equipment to be furnished by the contractor will be used to operate the surge shaft gate. The Hoist mechanism shall include a driving motor, a gear reducer, rope drums, Plummer blocks for supporting the rope drum shaft and all other shafts, ropes, shafts, gears, couplings, brakes, emergency manual arrangements, limit switches, gate position indicator (both analogue and digital), covers etc., all mounted on a fabricated steel frame including anchor bolts, plates and base plate etc. Electrical controls and all necessary electrical and mechanical accessories shall be provided for the satisfactory operation of the hoist. The hoist shall be capable of fully opening/closing the gate and shall conform to design criteria mentioned in subsequent paras. Sufficient space shall be provided around the hoist components for repair/maintenance. Roof over the hoist platform shall also be provided.

i) Central Drive Unit

a) Motor:

Totally Enclosed Fan Cooling (T.E.F.C) reversible squirrel cage, IP-66, operating on 415 V +/- 6% , 3 phase, 50 Hz A.C. power supply with a provision of inbuilt heater of reputed make such as Siemens, Kirloskar, Crompton Greaves, Marathon, Bharat Bijlee. The shaft of the motor shall be of extended type on both sides to accommodate arrangements for manual drive. The rated speed of motor shall not be more that 1000 rpm. The motor shall conform to Indian Standard.

The motor shall have high starting torque, low starting current and shall be suitable for operation in highly humid atmosphere. The breakdown torque shall not be less than 200% of the rated torque of the motor. The central drive unit shall be mounted on portable frame.

b) Brake

Three phase, shoe type, Electro-magnetic as well as Electro-Hydraulic Thruster operated brakes (having rated torque of 1.5 times the output torque of motor) of reputed make such as Electromag, Stromkraft or of any other Indian standard make. The brakes shall be of robust construction. The shoes and base shall be made of close grained cast iron of ample strength for the duties specified. Fulcrum pins shall be of manganese bronze. Allsteel parts shall be plated to prevent rusting.

c) Worm reducer

Reversible, self-locking, of reputed make such as Radicon, Allennoyd, Allen Berry, Elecon, premium . The reducer shall match with rating of motor. The reduction assembly shall be totally enclosed type. The reduction unit shall comprise of worm and wheel set. A provision shall be kept for lubrication with oil by gears dipping in the sumps. The reduction unit shall be provided with oil level dip stick, sight glass, drain plugs and oil filter/ ventilator.

d) Manual drive

The equipment shall comprise of a gear box with a handle and a two-way ratchet fitted to the input shaft. A manually operated claw coupling shall connect the gearbox to the non-drive end of the worm box input shaft. A limit switch shall be fitted to provide electrical interlock to prevent operation by electrical power when the manual drive is engaged. Efforts per person shall not be more than 10Kgf. at a crank radius of 400mm operating at a speed of 24 rpm. The high-speed brake and motor brake shall need to be released via the manual levers to enable the manual drive to be operated. Pawl and ratchet arrangement shall also be provided to prevent the lowering of the gate by its own weight.

ii) Drum Assembly

Each drum shall be fabricated in one piece from mild steel or machined caststeel and shall be spiral grooved to suite right hand (RH) and left hand (LH) coiling. The loose ends of the rope shall be secured to the gear wheels by rope clamps (min. 4 nos. per side). The spur wheels shall be manufactured in one piece and shall be secured to the drums with screws and drive dowels. Thedrum shaft shall be manufactured from high tensile steel and is keyed to the drum.

iii) Bearings

All the running shafts shall be provided with ball or roller bearings. The selection of the bearings shall be done on considerations of duty, load and speed of the shafts as recommended by the manufacturer. All bearings shall be weather proof drip proof and shall be protected against the entrance of rain, dust or any other foreign matter. The bearings shall be of reputed and standard make like SKF or equivalent. Bush bearings are not to be provided for any shaft, exceptfor the drum. their static and dynamic capacities should be minimum 1.5 times the load. Bearings should also be safe against any axial loading.

iv) Bed Frame

The hoist main frame shall be manufactured from rolled steel sections and plates with a chequered plate to form a composite support structure. The various components of the hoist equipments shall be mounted on mild steel sub-frames which shall be bolted/welded to the upper faces of the main frame. Shimming allowance shall be included at critical positions for final alignment of couplings and gears etc.

v) Coupling

All couplings shall be of Forged or Cast steel and shall be designed to transmit the maximum torque that may be developed. Solid couplings shall be aligned in such a way that these meet accurately. Flexible couplings shall be initially aligned with the same accuracy as in case of solid couplings. Flexible couplings shall be fitted between the motor shaft and extension shafts..

vi) Rope & Sockets

The ropes of the hoist shall be galvanized fiber core conforming to IS:2266(latest revision), 6x36 or 6 x 37 construction. The ropes shall be supplied permanent markings at suitable distances from centreline of the socket pin to provide alignment facility with the drum. The fused and taper ends of the rope shall be clamped to the spur gear wheels with minimum four clamps.

vii) Hoist Pulleys

Hoist pulley shall be provided to ensure equal rope loads and shall be provided

with straps to retain the ropes in the groove. The pulleys shall be supported by non rotating stainless steel pins and shall be fitted with high tensile strength aluminium bronze bushing for grease lubrication.

viii) Gear Coupling

Half Geared semi flexible coupling shall be fitted between output shaft of the worm reduction unit and the pinion shaft. Coupling shall be protected with a special surface treatment or coating to improve corrosion resistance.

ix) Dial Indicator

The gate position indicators shall be provided to show the position of the gates, when these are being raised or being lowered. The indicator dial shall be made of non - rusting metal or enameled Plates. The markings on the dial in operating range shall have minimum readability of 1/20th. of meter. The meter markings shall be very bold. The words 'CLOSED', 'OPEN' and 'FULLY RAISED' shall also be engraved or permanently marked. The dial shall be located at a convenient place from where it can be read easily. The indicator points shall be made of non -rusting metal. Electro- plated or digital type indicator may also be provided

x) Covers

All hoist machinery covers shall be of light weight construction with handles.

xi) Control panel and protective devices

Circuit breakers, fuses, thermal protected relays etc., of suitable rating shall be provided in the motor circuit and circuit breaker, limit switches (for lowest and highest positions of gate) of suitable ratings compatible with the equipment shall be provided in the control circuit. All the contactors relays, push buttons etc., shall be of adequate ratings of standard make and of tested quality and shall be provided for brake contactor, slack rope, maintenance position , gate open limit , gate close limit , rope overload, brake overload, emergency stop etc. etc. Sufficient spare relays shall also be provided. Limit switches shall also be provided to ensure that the motors do not start while the gates are being operated manually. A provision shall be made in the control panel for thermostatically controlled heater of suitable capacity. A provision shall be kept for a multi socket with switch 5A & 15A for future operation & maintenance. All the components of hoists shall be checked for the breakdown torque of motor selected. Actual breakdown torque (BDT) or pull out torque (POT) as indicatedin the motor catalogue has to be adopted. Limiting of BDT/POT of motor by using a torque limiter or by effecting any local change in the motor circuit will not be permitted.

2.7.5. Design data for Rope Drum Hoist for Surge Shaft Gate

The design requirements for the rope drum hoist for Surge Shaft Gate are mentioned as here under:

Capacity of Hoist	40T minimum. However, theContractor may examine for the adequacy of Hoist capacity intended for the above-mentioned job. In case the higher Hoist capacity is required,he will indicate the same in his Bid.

No. of hoists and hoists supporting structures	1 (One)
Lift of Gate	34.0m (Tentative)
Operating Speed	1.5m/min. ± 10%
Number of Drums	2 (Two) with single layer of rope (for each hoist) with L.H. and R.H. groove on drum for two points lifting of gate
EL of bottom of trestles	396.50m
Governing Indian Standard	IS:6938 (Latest revision)

2.7.6. Hoist Supporting Structure and Platform

The hoist supporting structure shall be designed for the worst combinations of the following: -

i) Load on the structure:

a) Load transmitted through the hoist under normal operating conditions.

b) Impact load

c) Live load of 500Kg./sq.m.area

d) Dead weight of the members

e) Seismic load

f) Wind load

ii) Permissible stresses : As per IS:800 (latest revision)

As per IS:807 (latest revision)

iii) Breakdown condition: Hoist supporting structure shall be checked for actual breakdown torque of motor selected.

iv) Limiting deflection: L/800

v) Flooring: Reinforced chequered plate of minimum 8mm thickness shall be provided.

2.8. Draft Tube Gates, Rope Drum Hoists and Hoist Supporting Structures

2.8.1. Draft Tube Gate

3(Three) sets of fixed wheel type gates each of size 3200 mm x 4000 mm shall be provided to isolate the draft tubes from the Tailrace Tunnel Water for repair & maintenance of generating units and draft tubes. The gates are required to suit the design criteria specified in the subsequent paras. The gates shall be fabricated from structural steel comprising of skin plate, horizontal girders, vertical stiffeners and end vertical girder etc. The skin plate shall be on upstream side i.e. TRT side and sealing on the downstream side i.e. power house side. The skin plate shall be supported by

horizontal girders at suitable intervals. The horizontal girders shall be supported by end vertical girders, which in turn shall support the wheels as shown on the tender arrangement drawing. Wheels shall transfer the load to concrete through an embedded stainless-steel track fixed on mild steel track. The wheels shall be provided with self-aligned stainless steel spherical roller bearings. Solid bulb music note type fluorocarbon Cladded rubber seal for top and sides and wedge type plain rubber seal at the bottom shall be provided. The gate shall be Lowered under flowing water conditionand raised under balanced water head conditions achieved through 2 no. filling valves provided as an integral part of the gate. 20T (minimum) Rope Drum Hoist shall operate the gate. Gate maintenance is proposed at deck level El. 335m in the trestle for which suitable latching arrangement, ladder etc. be provided. suitable lifting arrangement be provided in the gate. The design of the gate and its components shall conform to IS: 4622 (Latest Edition).

In the eventuality of high pressure Penstock water, if admitted inadvertently to the turbine and draft tube, while the draft tube gates are in closed condition, the gate will blow off from its seat, shearing the bolts fastening the lower guide bars provided on both sides of the gate. This arrangement shall prevent damage to the turbine and powerhouse.

As a measure of additional safety, a provision to interlock the draft tube gate with the main inlet valve of the turbine, by means of an interlocking switch installed at appropriate place in the gate groove in the maintenance chamber shall be made.

The gates shall be stored in the respective gate grooves. A suitable removable wire mesh grating at the top of the gate shaft at El. 335.0m shall also be provided. In addition, suitable air vent pipes shall be provided to meet air requirement during operation of these gates. Pipes for instrumentation shall be provided u/s of the gate.

2.8.2. Embedded Parts

First stage inserts (J or U anchors with plates) to be embedded in first stage concrete at a spacing not exceeding 500 mm centre to centre leaving suitable blockout openings for second stage embedments. The size of the 1st stage anchors shall not be less than 16mm in dia. and 300mm in length. The 2nd stage anchors/studs with double nut and washers attached to 2nd stage embedded parts shall than be welded all around to 1st stage anchor plates for providing suitable reference for proper alignment for erection of 2nd stage embedded parts.

Design of all embedments shall conform to IS: 4622 (latest edition). Minimum sizes and tolerances of all components as specified in IS: 4622 shall be adhered to. The concreting in the blockouts shall be done after erecting the embedded parts, aligning and checking them and ensuring their correct position. Suitable struts, supports etc. as required shall be provided by the contractor to prevent disturbance in the parts during concreting. The contractor shall be responsible for correctness of erection of the embedded parts in position and maintaining the dimensional accuracies as per approved drawings.

2.8.3. Design Criteria

The gates shall be pressed into operation during the maintenance of generating units/draft tubes. The gates shall be lowered under unbalanced water head condition and raised under balanced head conditions achieved through 2 nos. filling valves. The guide bars shall be designed such that fixing bolts of guide bars shall shear off in the event of pressurization of turbine side of Draft Tube due to unintentional opening of Inlet

Turbine Valve or leakage past their sealing surfaces. However, a provision of the interlock switch between the draft tube gates and the main inlet valve has also been kept which shall prevent the opening of the MIV when the gate will be in closed position.

The design requirements for the Gates are mentioned as here under:

Design Criteria for Draft Tube Gate

The design requirements for the Draft Tube Gate are mentioned as here under:

Type of stoplogs	Fixed wheel vertical lift gate with skin plate and sealing on the downstream side w.r.t Tailrace tunnel side.
Clear width of opening	3200 mm
Clear height of opening	4000mm
Number of bay	3 No.
Number of gate	3 No.
Maximum Tail Water Level	El. 333.40m
Minimum Tail Water Level	El. 323.40m
Centre to centre of side seals	3350mm ± 3
Centre to centre of tracks	3800mm ± 3
Sill Elevation	El. 313.95m
Design head	19.45m
Type of rubber seals	Solid bulb double stem fluorocarbon cladded seals for top and sides and Wedge type rubber seal for bottom corresponding to IS:11855(Latest revision).
Type of hoisting arrangement	Rope Drum Hoist (min. 25T capacity)
No. of sets of embedded parts	3 set
Operation – raising and Lowering.	The gate shall be raised under balanced water head conditionsachieved through 2 no. filling valves provided as an integral part of the gate and lowered under unbalance water head conditions.
Governing Indian Standard	IS:4622 (Latest Revision)

Permissible stresses	Permissible stresses in structural components for stoplog and embedded parts shall be in accordance with Appendix B of IS: 4622 (latest revision). The stresses in various parts of the stoplog under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress.
Permissible stresses for Gate	Dry & accessible conditions
Permissible stresses for embedded parts	Wet & inaccessible conditions
Permissible deflection	L/800 (L = C/C of wheels)
Permissible bearing & shearing stresses in concrete	As per IS: 456 (Latest Revision)
Seismic Coefficients (horizontal & vertical)	αh= 0.24 g & αv= 0.16 g
Grade of 1st stage concrete to be used	M 20/M25
Grade of 2nd stage concrete to be used	One Grade higher than that of 1st Stage Concrete and shall not be less than M-25 Grade

2.8.4. Rope Drum Hoist for Draft Tube Gate

The hoist equipment to be furnished by the contractor will be used to operate the Draft Tube gate. The Hoist mechanism shall include a driving motor, a gear reducer, rope drums, plummer blocks for supporting the rope drum shaft and all other shafts, ropes, shafts, gears, couplings, brakes, emergency manual arrangements, limit switches, gate position indicator (both analogue and digital), covers etc., all mounted on a fabricated steel frame including anchor bolts,plates and base plate etc. Electrical controls and all necessary electrical and mechanical accessories shall be provided for the satisfactory operation of the hoist. The hoist shall be capable of fully opening/closing the gate and shall conform to design criteria mentioned in subsequent paras. Sufficient space shall be provided around the hoist components for repair/maintenance. Roof over the hoist platform shall also be provided.

i) Central Drive Unit

a) Motor:

Totally Enclosed Fan Cooling (T.E.F.C) reversible squirrel cage, IP-66,operating on 415 V +/- 6% , 3 phase, 50 Hz A.C. power supply with a provisionof inbuilt heater of reputed make such as Siemens, Kirloskar, Crompton Greaves, Marathon, Bharat Bijlee. The shaft of the motor shall be of extended type on both sides to accommodate arrangements for manual drive. The rated speed of motor shall not be more that 1000 rpm. The motor shall conform to Indian Standard.

The motor shall have high starting torque, low starting current and shall be suitable for operation in highly humid atmosphere. The breakdown torque shall not be less than 200% of the rated torque of the motor. The central drive unit shall be mounted on portable frame.

b) Brake

Three phase, shoe type, Electro-magnetic as well as Electro-Hydraulic Thruster operated brakes (having rated torque of 1.5 times the output torque of motor) of reputed make such as Electromag, Stromkraft or of any other Indian standard make. The brakes shall be of robust construction. The shoes and base shall be made of close grained cast iron of ample strength for the duties specified.Fulcrum pins shall be of manganese bronze. All steel parts shall be plated to prevent rusting.

c) Worm reducer

Reversible, self-locking, of reputed make such as Radicon, Allennoyd, Allen Berry, Elecon, premium . The reducer shall match with rating of motor. The reduction assembly shall be totally enclosed type. The reduction unit shall comprise of worm and wheel set. A provision shall be kept for lubrication with oil by gears dipping in the sumps. The reduction unit shall be provided with oil level dip stick, sight glass, drain plugs and oil filter/ ventilator.

d) Manual drive

The equipment shall comprise of a gear box with a handle and a two-way ratchet fitted to the input shaft. A manually operated claw coupling shall connect the gearbox to the non-drive end of the worm box input shaft. A limit switch shall be fitted to provide electrical interlock to prevent operation by electrical power when the manual drive is engaged. Efforts per person shall not be more than 10Kgf. at a crank radius of 400mm operating at a speed of 24 rpm. The high- speed brake and motor brake shall need to be released via the manual levers to enable the manual drive to be operated. Pawl and ratchet arrangement shall also be provided to prevent the lowering of the gate by its own weight.

ii) Drum Assembly

Each drum shall be fabricated in one piece from mild steel or machined caststeel and shall be spiral grooved to suite right hand (RH) and left hand (LH) coiling. The loose ends of the rope shall be secured to the gear wheels by rope clamps (min. 4 nos. per side). The spur wheels shall be manufactured in one piece and shall be secured to the drums with screws and drive dowels. Thedrum shaft shall be manufactured from high tensile steel and is keyed to the drum.

iii) Bearings

All the running shafts shall be provided with ball or roller bearings. The selection of the bearings shall be done on considerations of duty, load and speed of the shafts as recommended by the manufacturer. All bearings shall be weather proof drip proof and shall be protected against the entrance of rain, dust or any other foreign matter. The bearings shall be of reputed and standard make like SKF or equivalent. Bush bearings are not to be provided for any shaft, exceptfor the drum. their static and dynamic capacities should be minimum 1.5 times the load. Bearings should also be safe against any axial loading.

iv) Bed Frame

The hoist main frame shall be manufactured from rolled steel sections and plates

with a chequered plate to form a composite support structure. The various components of the hoist equipments shall be mounted on mild steel sub-frames which shall be bolted/welded to the upper faces of the main frame. Shimming allowance shall be included at critical positions for final alignment of couplings and gears etc.

v) Coupling

All couplings shall be of Forged or Cast steel and shall be designed to transmit the maximum torque that may be developed. Solid couplings shall be aligned in such a way that these meet accurately. Flexible couplings shall be initially aligned with the same accuracy as in case of solid couplings. Flexible couplings shall be fitted between the motor shaft and extension shafts..

vi) Rope & Sockets

The ropes of the hoist shall be galvanized fiber core conforming to IS:2266(latest revision), 6x36 or 6 x 37 construction. The ropes shall be supplied permanent markings at suitable distances from centreline of the socket pin to provide alignment facility with the drum. The fused and taper ends of the rope shall be clamped to the spur gear wheels with minimum four clamps.

vii) Hoist Pulleys

Hoist pulley shall be provided to ensure equal rope loads and shall be provided with straps to retain the ropes in the groove. The pulleys shall be supported by non rotating stainless steel pins and shall be fitted with high tensile strength aluminium bronze bushing for grease lubrication.

viii) Gear Coupling

Half Geared semi flexible coupling shall be fitted between output shaft of the worm reduction unit and the pinion shaft. Coupling shall be protected with a special surface treatment or coating to improve corrosion resistance.

ix) Dial Indicator

The gate position indicators shall be provided to show the position of the gates, when these are being raised or being lowered. The indicator dial shall be made of non - rusting metal or enameled Plates. The markings on the dial in operating range shall have minimum readability of 1/20th. of meter. The meter markings shall be very bold. The words 'CLOSED', 'OPEN' and 'FULLY RAISED' shall also be engraved or permanently marked. The dial shall be located at a convenient place from where it can be read easily. The indicator points shall be made of non -rusting metal. Electro- plated or digital type indicator may also be provided

x) Covers

All hoist machinery covers shall be of light weight construction with handles.

xi) Control panel and protective devices

Circuit breakers, fuses, thermal protected relays etc., of suitable rating shall be provided in the motor circuit and circuit breaker, limit switches (for lowest and highest positions of gate) of suitable ratings compatible with the equipment shall be provided in the control circuit. All the contactors relays, push buttons etc., shall be of adequate ratings of standard make and of tested quality and shall be

provided for brake contactor, slack rope, maintenance position , gate open limit , gate close limit , rope overload, brake overload, emergency stop etc. etc. Sufficient spare relays shall also be provided. Limit switches shall also be provided to ensure that the motors do not start while the gates are being operated manually. A provision shall be made in the control panel for thermostatically controlled heater of suitable capacity. A provision shall be kept for a multi socket with switch 5A & 15A for future operation & maintenance. All the components of hoists shall be checked for the breakdown torque of motor selected. Actual breakdown torque (BDT) or pull out torque (POT) as indicatedin the motor catalogue has to be adopted. Limiting of BDT/POT of motor by using a torque limiter or by effecting any local change in the motor circuit will not be permitted.

2.8.5. Design data for Rope Drum Hoist for Draft Tube Gate

The design requirements for the rope drum hoist for Draft Tube Gate are mentioned as here under:

Capacity of Hoist	15T minimum. However, the Contractor may examine for the adequacy of Hoist capacity intended for the above-mentioned job. In case the higher Hoist capacity is required,he will indicate the same in his Bid.
No. of hoists and hoists supporting structures	3 (Three)
Lift of Gate	22.0m (Tentative)
Operating Speed	1.0m/min. ± 10%
Number of Drums	2 (Two) with single layer of rope (for each hoist) with L.H. and R.H. groove on drum for two points lifting of gate
EL of bottom of trestles	335.00m
Governing Indian Standard	IS:6938 (Latest revision)

2.8.6. Hoist Supporting Structure and Platform

The hoist supporting structure shall be designed for the worst combinations of the following: -

ii) Load on the structure:

g) Load transmitted through the hoist under normal operating conditions.

h) Impact load

i) Live load of 500Kg./sq.m.area

j) Dead weight of the members

k) Seismic load

l) Wind load

iii)	Permissible stresses :	As per IS:800 (latest revision) As per IS:807 (latest revision)
iv)	Breakdown condition:	Hoist supporting structure shall be checked for actual breakdown torque of motor selected.
vi)	Limiting deflection:	L/800
vii)	Flooring:	Reinforced chequered plate of minimum 8mm thickness shall be provided.

2.9. Fish Pass Gate, Manual Screw Hoist and Hoist Supporting Structure

2.9.1. Fish Pass Gate

1 (One) no of slide type gates each of size 1500 mm x 1500 mm shall be provided to isolate the fish pass channel from the upstream side Water for repair & maintenance of fish pass and isolate during flood time. The gate are required to suit the design criteria specified in the subsequent paras. The gates shall be fabricated from structural steel comprising of skin plate, horizontal girders, vertical stiffeners and end vertical girder etc. The skin plate and sealing shall be on the upstream side. The skin plate shall be supported by horizontal girders at suitable intervals. The horizontal girders shall be supported by end vertical girders, which in turn shall support the slide pad as shown on the tender arrangement drawing. Slide pad shall transfer the load to concrete through an embedded stainless-steel track fixed on mild steel track. Solid bulb music note type rubber seal for top and sides and wedge type plain rubber seal at the bottom shall be provided. The gate shall be Lowered under flowing water conditionand raised under unbalanced water head conditions. 5T (minimum) manual screw Hoist shall operate the gate. Gate maintenance is proposed at deck level El. 392m with suitable latching arrangement to be provided. A suitable lifting arrangement be provided in the gate. The design of the gate and its components shall conform to IS: 5620 (Latest Edition).

2.9.2. Embedded Parts

First stage inserts (J or U anchors with plates) to be embedded in first stage concrete at a spacing not exceeding 500 mm centre to centre leaving suitable blockout openings for second stage embedments. The size of the 1st stage anchors shall not be less than 16mm in dia. and 300mm in length. The 2nd stage anchors/studs with double nut and washers attached to 2nd stage embedded parts shall than be welded all around to 1st stage anchor plates for providing suitable reference for proper alignment for erection of 2nd stage embedded parts.

Design of all embedments shall conform to IS: 5620 (latest edition). Minimum sizes and tolerances of all components as specified in IS: 5620 shall be adhered to. The concreting in the blockouts shall be done after erecting the embedded parts, aligning and checking them and ensuring their correct position. Suitable struts, supports etc. as required shall be provided by the contractor to prevent disturbance in the parts during concreting. The contractor shall be responsible for correctness of erection of the embedded parts in position and maintaining the dimensional accuracies as per approved drawings.

2.9.3. Design Criteria

The slide type shall be designed in accordance with IS: 5620. The gate shall be designed for water head corresponding to FRL and check for HFL condition with increase allowable stresses. The hydrodynamic forces due to horizontal earthquake acceleration at the top of opening and at sill shall be worked out as per Para 7.2 of IS 1893 and considered in the design.The Gate shall be designed for operation under unbalanced head condition and shall be operated by screw hoist.

The design requirements for the Gates are mentioned as here under:

Design Criteria for Fish Pass Gate

The design requirements for the Fish Pass Gate are mentioned as here under:

Type of stoplogs	Slide type vertical lift gate with skin plate and sealing on the upstream side.
Clear width of opening	1500 mm
Clear height of opening	1500mm
Number of bay	1 No.
Number of gate	1 No.
Maximum Water Level	El. 390.40m
FRL	El. 385.50m
Centre to centre of side seals	1600mm ± 3
Centre to centre of tracks	1800mm ± 3
Sill Elevation	El. 383.00m
Design head (HFL)	7.4m
Gate operation head (FRL)	2.5m
Type of rubber seals	Music note type rubber seal for top and sides and Wedge type rubber seal for bottom corresponding to IS:11855(Latest revision).
Type of hoisting arrangement	Screw Hoist (min. 5T capacity)
No. of sets of embedded parts	1 set
Operation – raising and Lowering.	The gate shall be raised under un unbalanced water head condition and lowered under unbalance water head conditions.
Governing Indian Standard	IS:5620 (Latest Revision)

Permissible stresses	Permissible stresses in structural components for gate and embedded parts shall be in accordance with Appendix B of IS: 5620 (latest revision). The stresses in various partsof the gate under the action of occasional forces shall not exceed 133% of the permissible stresses specified in Annexure B subject to the maximum of 85% of the yield stress.
Permissible stresses for Gate	Dry & inaccessible conditions
Permissible stresses for embedded parts	Wet & inaccessible conditions
Permissible deflection	L/800 (L = C/C of wheels)
Permissible bearing & shearing stresses in concrete	As per IS: 456 (Latest Revision)
Seismic Coefficients (horizontal & vertical)	αh= 0.24 g & αv= 0.16 g
Grade of 1st stage concrete to be used	M 20/M25
Grade of 2nd stage concrete to be used	One Grade higher than that of 1st Stage Concrete and shall not be less than M-25 Grade

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1. MATERIALS

All the materials shall be of tested quality, new, unused, free from defects and of the grade/ classification envisaged in the designs and shall conform to latest relevant Indian Standards or equivalent standard/make. The contractor shall furnish the test certificates for each lot of material, if so required by the Employer. Plates with laminations discovered during welding or during inspection shall be rejected. Materials not supplied according to the approved designs/drawings shall be rejected and replaced. Approval of Employer shall not relieve the manufacturer from the responsibility of supply of suitable materials.

Recommended materials for the components of different Gates/Stoplogs/Hoists / Cranes/Lifting Beams/Trashracks are given below :-

1.1. Slide Gate & Stoplog

Sr. No.	Component/Part	Recommended Materials	Reference
`1.	Skin plate, horizontal girders, vertical stiffeners, end vertical girders, lifting brackets, track bases, seal seat bases, guide, seal clamps, thrust pad bases, guide shoe/roller , latching arrangement, etc.	Structural Steel	IS:2062
2.	Anchor plates/ anchor bolts/studs etc.	Structural Steel	---do----
3.	Slide track and seal seats	Corrosion and abrasion resistant stainless steel	IS: 1570 Part V
4.	Thrust /bearing pad	Aluminium bronze	IS: 305
5.	Side & Top Seals	Fluorocarbon cladded rubber seals	IS: 11855
6.	Bottom Seal	Wedge type natural or synthetic rubber	---do----
7.	Fasteners for seals	Stainless Steel	IS: 1570

			Part V
8.	CSK Screws for Thrust/bearing pads	Stainless steel	IS:1570 Part V
9.	Filling valves (if required)		
	Spring	Spring steel (Stainless steel)	IS: 1570
	Seal	Bronze/rubber seating on Stainless steel	IS: 1570
	Stem	Stainless Steel	IS: 1570
	Piping	Structural Steel	IS: 2062
10.	Air vent /instrumentation pipes and their embedements	Structural steel	IS:2062

1.2. Radial & Wheeled Gate

Sr. No.	Component/Part	Recommended Materials	Reference
1.	Skin plate, horizontal girders, vertical stiffeners, end vertical girders, lifting brackets, track bases, seal seat bases, guide track, seal clamps, guide shoe/roller , latching arrangement, etc.	Structural Steel	IS:2062
2.	Anchor plates/ anchor bolts/studs etc.	Structural Steel	---do----
3.	Wheel / Trunnion hub	Cast steel/ forged steel	IS: 1030 IS: 2004
4.	Bearings in wheels	Stainless steel self aligned spherical roller bearing	Standard make
5.	Wheel pin/Lifting pins/guide roller pin	Corrosion resistant stainless steel	IS: 1570
6.	Wheel track and seal seats	Corrosion and abrasion	IS: 1570

		resistant stainless steel	
7.	Side & Top Seals	fluorocarbon cladded rubber seals	IS: 11855
8.	Bottom Seal	Wedge type natural or synthetic rubber	---do----
9.	Fasteners for seals	Stainless Steel	IS: 1570
10.	CSK Screws	Stainless Steel	IS: 1570
11.	Filling valves (if required)		
	Spring	Spring steel (Stainless steel)	IS: 1570
	Seal	Bronze/rubber seating on Stainless steel	IS: 1570
	Stem	Stainless Steel	IS: 1570
12.	Piping	Structural Steel	IS: 2062
13.	Trunnion pin	Corrosion Resistant Steel	IS:1570(v)Gr.20Cr13/30Cr13
14.	Trunnion Bush	Self Lubricating	Deva/GGB/ eqv. make
14.	Guide Roller	Self Lubricating	Deva/GGB/ eqv. make

1.3. Automatic Lifting Beam

Sr. No.	Component/Part	Recommended Materials	Reference
1.	Structural components of lifting beam, guide bars/rollers etc.	Structural steel	IS: 2062
2.	Pins	Corrosion resistant stainless steel	IS: 1570 (Part-V)
3.	Hooks	Forged steel, structural steel	IS: 2004, IS: 2062
4.	Bush for hooks	Aluminium bronze	IS: 305
5.	Sheaves and guide rollers	Cast steel	IS: 1030

1.4. Gantry Crane/ EOT Crane /Rope Drum Hoists

Sr. No.	Component/Part	Recommended Materials	Reference
1.	Wire Ropes	6x37 construction un-galvanized improved plough steel, with fiber core or steel core ; extra flexible	IS: 2266
2.	Wire rope sockets	Structural steel	IS:2062
3.	Base plates, anchors, beams, columns, stiffeners, bracings, lifting lugs, gantry girders etc.	Structural steel	IS: 2062
4.	Lifting hooks	Forged steel	IS:2004
5.	Rope drum	Cast steel structural steel	IS:1030 IS:2062
6.	Gears	Cast steel	IS:1030
7.	Pinion	Cast steel forged steel	IS:1030 IS:2004
8.	Sheaves, pulleys	Cast steel	IS:1030
9.	Shafts	Carbon steel Forged steel	IS:1570 IS: 2004
10.	Threaded fasteners	Stainless steel	IS:1363 IS:1364 IS:1365 IS:1367 IS:2389 IS: 1570
11.	Bush bearings	Aluminium bronze	IS:305
12.	Turn buckles	Forged steel	IS:2004
13.	Hoist supporting structure	Structural steel	IS:2062 (Grade B)

		Rolled steel	IS:808
14.	Wheels	Forged steel Cast steel	IS:2004 IS:1030
15.	Keys, Keyways	Forged Steel	1S:2048 IS:2291 IS:2292
16.	Ball and Roller bearings	Standard	SKF or equivalent
17.	Electric Motors		IS:900
18.	Cables and conductors		IS:9968 IS:8130
19.	Switch gear		IS:1822, IS:2147
20.	Electrical bought out items.		Reputed Make
21.	Rail track for Gantry/E.O.T.Crane		Rail of suitable size but not less than 45 Kg/m.

1.5. Hydraulic Hoist

Sr. No.	Component/Part	Recommended Materials	Reference
1.	Hoist cylinder	Boiler quality plate forged steel	IS: 2002 Gr. 2A, IS: 2004
2.	Upper & Lower cylinder head	Boiler quality plate cast steel	IS: 2002 Gr. 2A, IS: 1030
3.	Piston	Forged steel/cast steel	IS: 2004, IS: 1030

4.	Piston rod	Solid bar of corrosion resistant steel with ceramic coated Stainless steel with chrome plating	IS: 1570 or DIN 17440 TYPE X20 Cr 13(15) or ASTM A 276 Type 316
5	Piston rings	Lead Tin Bronze	IS: 318
6.	Piston glands	Cast Manganese bronze	
7.	Clevis Pin	Corrosion resistant steel	IS: 1570 or ASTM A-276 Type 316 or ASTM A-564 Type 630
8	Piston seals & Piston rod seals	Cheveron Type packing seals	
9	Bearings for cylinder mountings	Self lubricating bushing on corrosion resistant pins	Reputed make
10	Bush bearings	Lead Tin Bronze/Al Bronze	IS: 318/IS:305
11	Shafts	Carbon Steel	IS: 1570
12.	Studs/threaded fasteners	Carbon steel	IS: 1367 IS: 1570
13.	Support frame	Structural steel	IS: 2062,
14.	Pipe flanges & fittings	Stainless steel	DIN-17440/8 DIN-17458 BS-3604
15.	Seals	Synthetic	Buna-N (NITRILE)

16.	Piping	Seamless stainless-steel tubes	DIN-17440/8, DIN-17458, DIN-2462, BS-3604
17.	Epoxy Grout		Reputed make
18.	Seal washers		Seal washers of cadmium-plated steel with nitrile sealing element
19.	Lubricating Grease		Reputed make
20.	Lubricating Oil		Reputed make
21	Hydraulic Oil		VG-32

1.6. Trash rack panels

Sr. No.	Component/Part	Recommended Materials	Reference
1.	All structural members of the trash rack panels etc.	Structural Steel	IS:2062

Notes: The details covered in above Paras shall be read in conjunction with the following notes: -

1) In all the references cited above, the latest revised revision of Indian Standards or equivalent shall be followed. In case the contractor proposes to use material different from those mentioned above, he should mention the same in his tender and indicate the exact extent to which he proposes to use, furnishing necessary details for approval of the Employer. Materials conforming to International Standards like ASTM, DIN which are equivalent to those mentioned above can be used with the approval of the Employer.
2) The sizes, ratings, capacities, and dimensions of the various standard equipment items listed in the Contract Documents are based on currently available standard products. Reasonable deviations will be allowed to permit supply of standard equipment. In no case shall the capacity furnished be less than that specified, unless approved.
3) All bolts, nuts, screws, rivets, threads, pipes, ball and roller bearing, gauges and gears shall conform to US/BIS/DIN standards. Screw threads for screws, bolts, nuts and other threaded hardware shall conform to relevant Indian Standards.

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1. MANUFACTURE

All the works shall be performed and completed in a thorough workman like manner as per the best modern practice in the manufacture and fabrication of materials of the types covered by these specifications. The work shall in all cases be of high grade and carefully performed to the satisfaction of the authorized representative of the Employer. The contractor shall warrant all materials and workmanship furnished by him to be free from injurious and defective materials or defective workmanship and shall bear all cost of the repairin case of any error for which he is responsible. Workmanship shall conform to the relevant standards laid down by the Bureau of Indian Standards. All sharp corners, which can damage the matching parts, shall be rounded and chamfered.

1.1. Tolerances

Where tolerance or fits are not specified on the drawings, the contractor shall follow the best modern shop practice for apparatus of the type covered by these specifications and drawings, due considerations being given to the special nature of function of the parts and to the corresponding accuracy required to secure proper operation.

1.2. Machine Finish

Where finished surfaces are not specified on the drawing, the type of finish, shall be that most suitable for the part to which it applies and shall be as per IS: 3073. A smooth finish (two deltas, i.e., 1.6 to 6.3 microns) will be required for all surfaces in sliding or rolling contact and for surfaces in permanent contact,where a tight joint is required. A finish (single delta, i.e., 6. 3 microns) shall be given to all other machined surfaces where selective assembly for matching parts is specified on the drawings or otherwise required. The parts shall be ground, if necessary, to obtain the limiting tolerances.

1.3. Casting

While making patterns for the castings, care shall be taken to avoid sharpcorners or abrupt changes in cross section and ample fillets shall be used. All castings shall be 139 true to patterns and the thickness of the metal shall notvary at any point by more than 5 mm from that shown in the drawings. Care shall be taken in the foundry to cool the castings properly so that they will not warp or twist. No casting will be accepted if it is warped or twisted to such an extent that machined surfaces cannot be properly finished to the dimensions shown on the drawings. All castings shall be sound, clean, and free from cracks, holes or sand holes and other defects. These shall have a workman like finish. Castings shall not be repaired, plugged, or welded without the permission of the Employer. Such permission shall be given only when the defects are small and do not affect the strength, use or machinability of the castings. No welding shall be done after the castings are finally annealed. No defect shall be removed, and paint or oil applied to the surface of any casting until it has been inspected by the Employer or his authorized representative. The treatment for casting involves heating slowly up

to a temperature of about 40°centigrade above its upper critical temperature, holding it at the temperature just only long enough for a uniform temperature to be attained throughout the casting and then allowing it to cool slowly in furnace. During the process the requisite annealing temperatureshall not exceed and overheating shall be avoided. End products shall conform to the requirements of relevant Indian Standards. All castings shall be ultrasonically tested to ascertain their soundness.

1.4. Forging

All forging shall be done in accordance with the latest practice and shall exhibit physical and chemical properties envisaged in the corresponding Indian Standards. Only those forging shall be used whose working is well known without doubt

All important forging for Gates like Wheels, Wheel pins, Gears, Hoist/Crane Wheels etc. shall be ultrasonically tested. The acceptance limit of ultrasonic testing of forging shall be as per SA 388 of ASME Section -5.

1.5. Fabrication Of Structural Steel

The contractor is supposed to perform fabrication in the best possible manner to meet the requirements of design and drawing. However, some specific guide lines are given below:-

1.5.1. Straightening of members

Before being laid off or worked in any manner, structural steel shall be straight, without twists, bends or kinks, and if straightening is necessary, it shall be done by a method which shall not injure the metal to ensure good welding and fittings of members. All steel shall be cleaned of dirt, mill scale and rust prior to fabrication.

1.5.2. Shearing, Chipping and Gas Cutting

Shearing, chipping, and gas cutting shall be performed carefully and all portions of the work which will be exposed to view shall present a neat appearance. Finishing of sheared or cut edges of plates or shapes will not be required except as noted in these specifications.

1.5.3. Edges to be welded.

The edges of plates and shapes to be joined by welding shall be properly formed to suit the type of welding selected. Where plates and shapes have been sheared, edges to be joined by welding shall be machined or chipped to sound metal. Plates and shapes to be field welded shall have their edges prepared in the shop for the type of weld selected.

1.5.4. Bent Plates and Shapes

Where bending or forming of plates or shapes is required, the plates or shapes shall be bent by cold forming. Heating and hammering to correct bends will not be permitted

1.6. Welding

1.6.1. Welding Technique

Care shall be taken in designs so that the welds when being made are well accessible. Overhead welding is to be avoided, if possible and flat position is to be strived for. Drawings should clearly indicate the joint position, shop or field welding, kind of welding, method of welding, welding sizes and other relevant details. Symbols to be shown on the drawing should conform to relevant Indian Standards. All welding shall be done by the electric arc method by a process which will exclude the atmosphere from the molten metal, except where otherwise specifically permitted. All welding electrodes required shall be furnished by the contractor. Correct selection of electrodes shall be done taking due care of welding method and base metals of components. The weldingelectrodes shall be of the heavily coated type designed for all position welding. The make, type and size of all welding electrodes shall be subjected to the approval of the Employer in assembling and during welding the component partsof built up members shall be held in place by sufficient clamps or other adequatemeans to keep all parts in proper position. The surface to be welded shall be cleaned of scale, slag, rust, paint and other foreign matter, except that thin coat of linseed oil need not bere moved before welding. Where weld metal is deposited in two or more layers, each layer shall be brushed with a wire brush or otherwise cleaned before the subsequent layer is deposited. In welding, precautions shall be taken to minimize stresses due to heat by using the proper sequence in welding. Upon completion, the welds shall be brushed with wire brush and shall show uniform section smoothness of weld metal. Edges andends of fillets and butt joint welds shall indicate good fusion and penetration into base metals.

Specific requirements for butt joints and fillet joints are given below.

i) Butt Joints
In principle, butt joints should be made with back run. Should it be not possible to do the back-run, either a backing strip should be placed and welding should be so made that the melted metal fully penetrates to the backing strip or the side butt welding should be executed so that the melted metal reaches the back of the groove and a full penetration is achieved and radiography is possible. Die-penetration test shall be carried out after each pass of the weld.

ii) Fillet Joints
All fillet welds shall be continuous. For the main members, no fillet welding should be made on members whose thickness differs substantially. Fillet weld at
`T' Joints should be made, as a rule, on each side of the joint, unless it is otherwise agreed due to some practical reasons. All fillet welds shall be tested ultrasonically for soundness Radiographic tests shall be carried out for all criticalfull strength butt welds. Welded joints requiring radiographic testing shall be decided by the Employer Welding methodologies and sequences should be suitable for

temperatures during welding as well as during service life of weldments. All the surfaces required to be welded shall be prepared and all welding shall be either manually or by the shielded arc method or by submerged arc method in accordance with I.S: 816 and I.S: 9595. Welds shall be made as indicated on the drawings and identified there on by conventional welding symbols as per I.S: 813. Procedure qualification test shall be required when welding is done by automatic machine. For such tests, the required material, equipment, and labour, shall be made available by the contractor at no extra cost to the employer However, the cost thereof including transportation charges may be included in lump-sum price bid in the schedule by the contractor at time of bidding. All welded parts requiring machining shall be completely welded and stress relieved before machining. For welding dis-similar methods appropriate type of weld consumables should be used in accordance with various BIS codal provisions and Americans Welding Standards (AWS)

a) Test for Soundness of Welds

All testing for soundness of welds shall be carried out as per I.S: 822 (latest edition) and as per other I.S codes listed in appendix 'A' of code. Following procedure should be followed for selection of various tests to be carried out by contractor.

i) 20 % to 30 % of fillet welds may be checked by Dye Penetration tester Fluorescent Penetration test & rest by ultrasonic tests.

ii) Butt welds shall be checked as under: Butt welds in the webs and flanges of all the girders of gantry, all fabricated girders, legs and other load carrying member's etc. shall be 100% checked for soundness radio- graphically

b) Qualification of Welding Process

A specification of the welding process, that is proposed to be used, shall be established & recorded and a copy of such specification together with a certified copy of report of results of tests made in accordance with the process and specifications shall be furnished.

The qualification of the welding process shall be at least equal to that required by 'Standard Qualification Procedure' of the Indian Standards and the minimum requirement of the tests shall be at least as stated in the said 'Standard Qualification Procedure'. The Contractor shall submit the WATR (Welder approval test Record), WPS (Weld procedure specifications) and WPR(Weld procedure records) to the Employer for approval before the start of the activity, complete in all respects along with relevant standards, supporting documents etc.

The contractor shall be responsible for the quality of the work performed by his welding staff. All welders assigned to the work shall have passed qualification tests for welders. If at any time the work of any welder appears questionable, the welder shall be required to pass additional qualification tests to determine his ability to perform the type of work on which he is engaged.

1.7. Stress Relieving

Stress relieving of welded parts shall be done, where required, after all the welding is completed. Machined surfaces of parts requiring stress relief shall be machined to final dimensions after the parts have been stress relieved. Localized stress relieving will not be permitted for shop welded parts. The procedure for stress

relief shall conform to IS: 10801, IS: 10234, IS: 2825. All plates to be welded above the thickness of 25 mm shall be stress relieved.

1.8. Electrical Works

1.8.1. General

The electrical items of works of any electrical or mechanical installation to be provided under this contract shall be according to the Technical Specifications and if not stated otherwise shall fulfill the complete requirements of the work. All components shall be of reputed and reliable design. The maximum extent of uniformity and interchangeability shall be considered while designing the equipment. The design shall facilitate easy maintenance and repair of the components. The works shall be pre-assembled to the maximum possible extent in the Contractor or Sub-contractor workshop, complete with all devices and wired up to common terminal blocks. Unless otherwise agreed, rating of main electric works as selected or proposed by the Contractor, whether originally specified or not, shall generally include a safety margin of 10% under consideration of the worst case to be met in service. Prior to approval of such basic characteristics, the Contractor shall submit all relevant information such asconsumer lists, short circuit calculations, de-rating factors etc. Short-circuit calculations shall be evaluated giving full evidence that every electric componentcan withstand the maximum stresses under fault conditions, for fault levels and durations obtained under the worst conditions, e.g. upon failure of the corresponding main protection device and time delayed fault clearing by the back-up protection device. All works shall be suitable for the prevailing climatic conditions at site. Outdoor installations shall be protected against solar radiations by means of adequate covers, where required. The Contractor shall ensure that all the supplied works is insensitive to any signals by wirelesscommunication equipment.

1.8.2. Object and Limits of Supply

The Bidder shall supply and install all apparatus, terminal boxes, etc. necessary to make the distribution services to complete and ready for operation.

The main items of control & equipment to be supplied and installed under this section comprise the following:

A. PLC based Remote Control System complete in all respects consisting of one operating station located in Dam control room (DCR) to be supplied, installed and commissioned shall envisage the following control functions and indications:

- Individual control and operation of spillway radial gates.
- Individual gate opening height indications of spillway radial gates.
- Auto / manual operation indication.
- Gate opening / flash lamp indication with suitable alarm for spillway radial gates.
- Gate closing and flash lamp indication with suitable audible alarm for spillway radial gates.

- Reservoir water level indication on continuous display mode in digital form with alarm where water level starts exceeding FRL and when water level starts receding. (Levels shall be decided during detail design).
- One uninterruptible power supply (battery backup) to provide back up (minimum 30 minutes) to the system in case of failure of main power supply to equipment.
- Two (2) sets of water level measuring and indication Equipment at dam area along with necessary alarms.

B. Instruments not part of PLC system shall also be provided at their respective locations complete in all respect: -

Differential pressure measurement and indication equipment across intake trash rack-One (1) sets

Electronic measuring system to indicate achieving of balance head condition across:

Spillway stoplogs	: Six (6) sets
Intake gate	: One (1) set
Surge shaft gates	: One (1) set
Draft tube gates	: Three (3) sets

C. Main distribution board & feeder pillar for all HM equipment

- Main distribution board shall be provided at dam site for 415/230V AC power supply for Spillway gates, Automatic remote control system, Intake gates. Feeder pillars shall be provided in the vicinity of respective local control panels of above gates. Cables between main distribution board and feeder pillar shall be in the scope of the Bidder.
- Feeder pillars shall also be provided for surge shaft gates and draft tube gates in the vicinity of respective local control panels. Additional contacts including necessary interface shall be provided.
- Additional contacts shall be provided in Dam control room for communication of status of gates (position indication) for spillway radial gates.

1.8.3. Design Criteria

The specified measuring system shall provide the data (reservoir level, gate position and spillway discharge) to determine the three above mentioned parameters by the main computer in the DCR (Dam Control Room).

Design data:

Rated voltage	230 V AV/110V DC
Maximum ambient temperature	37 degree
Degree of protection for panels	IP 54
Degree of protection for transducers	IP 67
Special treatment	Tropicalized
Transmitter output signal analog	4-20 mA (2 wire)

1.8.4. Water level control and Measuring Equipment

This function shall control the water level Radar Type in the barrage in order to maintain the water level at a given set point. The function shall start and stop the radial gate according to water level set points. Alarm will be generated when the water level falls/rise beyond the set point or the probe signal is lost.

In the event of a fault in the level transducer or its data transmission channel, the level control feature shall be switched off and a fault signal shall be issued at all panels. The gate shall maintain its last position till further action is initiated by the operator. The system shall support redundant level transducers assessing the plausibility of the level signals and disconnecting the defective transducer from the control loop.

Automatic water level control activation shall be enabled/disabled from the operator workstation in the Dam control room. The level monitoring system shall issue alarms at the programmed sequence water level.

The controller is required to maintain the water level at FRL throughout the year.

The following levels are indicated for designing the water level control system.

1	Full reservoir level (FRL)	385.50m
2	Crest level	375.00m

The Bidder shall supply and install best quality Level sensors/pressure transmitter at the following points.

a) Two sets of water level measuring equipment at upstream of barrage area with water level transmitter shall be provided. Sensors shall be multiple types to evaluate the water level from sill level to maximum reservoir level, housed in a weatherproof enclosure.

b) One (1) set each of water level/pressure measuring system suitable for measuring water head from gate sill level to FRL/Maximum water level shall be provided at respective gate areas to indicate balance head condition of intake gates, barrage stoplog ,Surge Shaft and draft tube gates.

c) One (1) set each of head loss measuring system shall be supplied to detect head difference at the intake trash rack.

d) One (1) set each for measuring and transferring gate position status (open, close, in transit as required) for all gates as per specification details.

For measuring and control, redundancy shall be provided for signal transmission and gate control system. The transmitters shall be properly mounted with embedded metal tubing and suspended from the upstream pier. Mounting location for the level transmitters shall be so chosen that level measurement is not affected by the silt and water profile.

The all signals shall be made available at remote operation panel at Control Room, at operator stations and local controls. The sensor shall be continuous monitoring type and very sensitive with accuracy level ± 1cm or less. Thesensors shall also be capable to transmit the continuous signal under silt laden water with same accuracy. All necessary instruments, interconnecting wire, pipe work, housing, cable, panel etc shall be provided according to the type of equipment.

1.8.5. Automatic Reservoir Measuring and Control System (ARMAC)

General

The ARMAC computing and control system shall be situated in the Dam control room (DCR) and shall be provided by the Bidder.

The local control and computing system for the spillway shall be able to calculate the actual spillway discharge depending from reservoir water level and gate opening. The system is to be mounted in the equipment control cabinet (ECC).

The local computing system shall be interconnected with the latest industrial grade computer with monitor not less than 51 cm sizes in the DCR, from which the command for the necessary discharge on the spillway shall be provided. All signals shall be sent and received to/from the DCR. Operating system shall be Windows 2013 or latest.

A PID-master controller shall define the required total gate opening. Indication of actual discharge passing through various gates (spillway radial gate) in cumecs, formula for single gate opening and the number of gates open shall be indicated for calibration. This indication shall be available on demand as well as at regular intervals for login. However to prevent hunting of hoist the deviation should be beyond the preselected tolerance band.

In a selection circuit the ‘open’ - instruction shall be transferred to the gate, which at the time of the comparison controls the smallest opening. Similarly, a ‘close’ - instruction shall be given to the gate controlling the largest opening.

For the gate selection, only the gates shall be considered, of which the manual switches are in the 'Automatic' position, and where no alarm signal has been received from, the 'open' or 'close'- instruction shall remain with the selected gate, unless any of the following conditions is met:

- The required and actual openings agree and the positioner cancels the instruction, or
- The gate had previously reached its limit position, or,
- The max. Permissible deviation (pre-set difference in position between controlled gate and average of all gates available) has been reached previously.
- The selected gate is not in operating condition.

In the event of major changes in required size of opening, the gates shall be moved successively one step each, i.e. after re-setting all gates again agree within the pre-set margin in size of opening. After all available gates havereached their limit positions a corresponding signal shall be given. At any individual gates shall be allowed to be switched over from the automatic mode tomanual mode of operation, and vice versa, however the operation from the local panel cannot be overruled by the remote / automatic operation stage. Adjustments made manually are to be automatically compensated for with the other gates by the automatic control system.

Manually adjusted gates shall, when returned to automatic mode of operation, be adapted to their normal functioning in the automatic mode. The automatic system shall work independent of the number of available gates with the same characteristic. If all gates have been changed over to MANUAL, the master controller shall be reset so as to permit a smooth switching-over to AUTO operation. The system is to be designed to monitor the duration of the instruction. The monitoring is to prevent, that an instruction is maintained over a period, that is longer than a pre-selected time, e.g. in the event of a malfunction of gate selected by the controller, if the monitoring system is actuated, the particular gate is to be cancelled from the group of the gates available for selection.

1.8.6. Trash Rack head loss detection system

Head loss across trash racks will be determined by measuring the head difference between upstream and downstream of the trash rack. Trash rack chocking/head loss shall be measured by the pressure difference between the upstream and downstream sides of the intake trash rack. The indication and alarm shall be provided at a remote panel/operator station mounted in Dam control room and shall indicate from 0 to 2m head loss.

1.8.7. Gate Position Measuring System

Suitable encoders, shaft couplings and transducers with position Indicators shall be provided for gate position measuring & indication of all gates. Each hoist shall be equipped with sensor giving 4-20mA output over its range of operation. The gate position indicators shall be supplied with necessary cabling/wiring connected to local controls.

Each radial gate shall be provided with suitable sensor/transducer as per specification and located at a suitable location on the radial gate to sense its position for complete opening range, provide feedback to DCS, and indicate its position in real time. Signal from sensor will also be used for close loop control of the gate during automatic operation.

The sensor shall be of reputed and standard make, robust in construction and suitable for outdoor and harsh operating conditions. The sensor shall work on 24 V supply fed from DCS and will provide analogue output which shall be made compatible with the requirement of DCS I/O cards.

1.8.8. Level /Pressure transmitters

The level/pressure transmitters shall be of reputed make, efficient, high accuracy, compensated for ambient influence, suitable for PID control and based on microprocessor technology. The hydrostatic pressure acting on the pressure transmitter corresponding to the water level is converted into an electrical signal (4-20mA) and fed to the gate controller for level indication and gate control.

The transmitters shall be two wire system capable of operating from 24V DC obtained from the gate controller. The transmitter shall be capable of performing standard tasks of self-test and self-diagnostics. Parameter adjustment and configuration shall be possible through a laptop computer. The level transmitters shall be adequately protected against lightening surges. The standard communication protocol for the pressure transmitters shall be “HART”5.1.

1.8.9. Proximity sensors

Proximity sensors shall be of reputed standard make and provided on each gate to indicate its full open and full close status. The Sensors shall be mounted at suitable location to sense its true status. The sensors should be appropriate to capable under water as per requirement.

The sensors shall be robust in construction, weather proof, suitable for outdoor harsh conditions. The sensors shall operate on 24V supply supplied from the DCS system and provide two NO and two NC potential free contact.

1.8.10. Discharge Warning System

Whenever any of the radial gates are operated for release of water, an alarm is required to be sounded as a warning to downstream areas. The warning system shall comprise of DC operated horns, speakers and flashing lights. The alarm system will also give alarm whenever water level reaches full reservoir level and overtopping of barrage crest is possible.

The alarms will be generated by the gate controller. Provision for manual operation of warning system shall be provided with appropriate interlocks to avoid false alarms.

The warning system shall consist of 3 horns. One horn shall face down stream of the barrage and other two along the barrage in opposite direction. Strobe light will be mounted on the control building.

1.8.11. Remote Control Panel

The panel shall be an Indoor type (degree of protection of enclosure type IP-55) made of steel sheet of thickness not less than 2.0mm, containing all necessary equipment for the control, protection/safety and supervisory elements as required and shall be completely painted and wired. The panel frame structure shall be self-supporting, free standing on floor or suitable for wall/vertical post mounting. For outdoor enclosure necessary shelter arrangement shall be provided and shall be located on raised platform.

Cubicles and panels shall be vermin proof. Removable gland plates shall be supplied and located to provide adequate working clearance for the termination of cables. Under no circumstances shall the floor/ roof plate be used as a gland plate. The cables and wiring shall enter from bottom or top as approved by Employer's representative.

The cubicles and panels shall be adequately ventilated, if required, by vents or louvers and shall be so placed as not to detract from the appearance. All ventilating openings shall be provided with corrosion resistant metal screens or a suitable filter to prevent entrance of insects or vermin. Space heating elements with thermostatic control shall be included in each panel.

Cubical/panel will be of sufficient size so as to neatly and methodically accommodate all the electrical power and control equipment. Indicating lamps, push buttons, all the necessary relays, starters, fuses, limit switches, selector switches, terminal blocks, circuit breakers, contactors, current transformers, protection gears, Interlocks, alarms, measuring instruments including all wiring and all other accessories necessary for safety, control and operation of the hoist.

The controls, indicating lamps, push button, selector switches etc. will be installed flush mounted on the outside door of the control panel so as to give clear view of all the indicating lights, measuring instruments, position indicator. The remaining equipment will be installed inside the cabinet being accessible when the door is opened.

The panel door shall have close fitting, gasketed, hinged and swing off construction capable of being opened through 180 degree. The doors shall be provided with integral lock and master key. A mechanical interlock shall be provided so as to ensure de-energization of the panel as soon as the door is opened. Suitable provision may, however, be made to bypass the above interlock under extraordinary requirements when manual energization of panel isnecessary under open condition. Panel shall be provided with door switch operated illumination.

All terminals will be of block type. Wiring inside the control panel is made at least with 650 Volt insulation grade, 1.0mm², 1.5mm² and 2.5mm² Control cable and required size of power cable. All cables shall be brought at terminal blocks mounted inside the control panels to facilitate connection with the external cables. All the metallic parts of the switch- boards and all the earth wires of the circuits shall be connected with the Earthing bus of not less than 25 sq. mm copper conductors. All control cables and components will be marked in asystematic manner on drawings on the accordingly tagged cables and components in the control panel. All necessary auxiliary devices for connection to limit switch shall also be provided. The control equipment shall generally meetthe requirements of IS: 6938.

Important operating instructions of the equipment in a metal frame covered with glass shall be kept at appropriate locations in the operator cabin.

All electrical equipment shall be designed for use under the prevailing climatic condition to avoid any operational error and accident. All the electrical equipment rating shall be de-rated as per the site elevation. Complete wiring of the electrical equipment and the control device with all cables shall be included, under the scope of Supplier. Supplier shall provide the necessary connections including hard wirings/cables between local control, remote control and other instruments.

The control cabinet shall be PLC type and house the following equipment:

- A main selector switch (key operated) for the different modes of operation (local/remote and automatic).
- Controls comprising push buttons and relays (including overload and under voltage relays and single phase preventer for motors) for manual/remote and automatic as the case may be.
- A position indicator showing the exact position of the gate (in case of hoist).
- Various alarms to indicate the operating faults.
- Potential free contacts for all indications and alarms shall be wired to a separate terminal box inside the panel for interface control room.

In addition to above, necessary instrument required for control and measurement shall be provided by the Supplier. The following instruments but not be limited to, shall be mounted on or within the control cabinet:

- Incoming supply moulded case circuit breaker.
- Source voltmeter.
- Source pilot light.
- Load ampere meters.

- 230V-13A convenience outlets, from transformer 400/230 V supply.
- “Gate fully raised” indicating light.
- “Gate fully lowered” indicating light.
- “Gate stopped at intermediate position” indicating light.
- “Raising” indicating light.
- “Lowering” indicating light.
- “Light test” push button for inspection of all indicating lights.
- Gate position indicator.
- Space heater to prevent moisture condensation.
- Emergency Stop Push button
- All other necessary transformers, relays, contactors, switches, push buttons and miscellaneous wiring components.

1.8.12. Local Control Panel

The local control panel shall be an indoor/outdoor type (degree of protection of enclosure type IP-55) made of steel sheet of thickness not less than 2.5 mm, containing all necessary Equipment for the control, protection/safety and supervisory elements as required and shall be completely painted and wired. The panel frame structure shall be self-supporting, free standing on floor or suitable for wall/vertical post mounting. Cubicles and panels shall be vermin proof. Removable gland plates shall be supplied and located to provide adequate working clearance for the terminals of the cables. Under no circumstances shall the floor/roof plate be used as a gland plate. The cables andwiring shall enter from bottom or top as approved by Employer. The cubicles and panels shall be adequately ventilated, if required, by vents or louvers and shall be so placed as not to detract from the appearance. All ventilating openings shall be provided with corrosion resistance metal screens or a suitable filter to prevent entrance of insects or vermin. Space heating elements with thermostatic control shall be included in each panel. Cubical/panel will be of sufficient size so as to neatly and methodically accommodate all the electrical power and control equipment, indicating lamps, push buttons, all the necessary relays, starters, fuses, limit switches, selector switches, terminal blocks, circuit breakers, contactors, current transformers, protection gears, interlocks, alarms, measuring instruments including all wiring and all other accessories necessary for safety, control and operation for the hoists/cranes. The controls, indicating lamps, push buttons, selector switches, etc. shall be installed flush mounted on the outside door of the control panel so as to give clear view of all the indicating lights, measuring instruments, position indicators so that the gate and hoist can be operated with the cabinet door closed. The remaining equipment will be installed inside the cabinet being accessible when door is opened. The panel door shall have close fitting, gasketed, hinged, swing off construction, capable ofbeing opened through 180º. The doors shall be provided with integral lock and master key. A mechanical interlock shall be provided so as to ensure de- energisation of the panel as soon

as the door is opened. Suitable provision may, however, be made to bypass the above interlock under extraordinary requirements when manual energisation of panel is necessary under open condition. Panel shall be provided with door switch operated illumination. All terminals will be of block type. Wiring inside the control panel is made at least with 650 Volts insulation grade, 1.0 mm², 1.5mm² and 2.5mm² Control cable and required size of power cable. All cable shall be brought at terminal blocks mounted inside the control panels to facilitate connection with the external cables. All the metallic parts of the switch-boards and all earth wires of the circuits shall be connected with the Earthing bus of not less than 25 mm² copper conductors. All control cables and components will be marked in a systematic manner on the drawings accordingly tagged cables and components in thecontrol panel. All necessary auxiliary devices for connection to limit switch shall also be provided. The control equipment shall generally meet the requirement of Clause 6.6 of IS: 6938 (Latest Revision).

1.8.13. Standards

The design, manufacture and testing of all works and installations shall strictly comply with the latest revision of the relevant IEC standards (International Electrotechnical Commission Standards).

1.8.14. Colour Code

The manufacturer's painting systems shall be used to the maximum possible extent but shall by all means be subject to the approval of the Employer. Final coats of paint shall be matched with adjacent installation, where required.

1.8.15. Electrical Motors

All motors shall be of reputed make and shall comply with the requirements of the work. Motors of the same type and size shall be fully interchangeable and shall comply with Indian Standard and to IEC Standard motor dimensions.

The general construction shall be stiff and rigid, no light metal alloy casings will be accepted. All precautions shall be taken to avoid any type of corrosion.

All motors shall be fitted with approved types of lifting hooks or eye bolts as suitable.

a) Rating

The rating of the motors shall be adequate to meet with the requirements of the works. The service factor, being the ratio of the installed motor output to the required power at the shaft of the driven machine at its expected maximum power demand, shall be applied as follows:

Power Demand of Driven Machine:	Service Factor
Up to 5kW	1.2
More than 5kw	1.1

AC motors shall be capable of operating continuously under rated output conditions at any frequency between 95% and 105% of the rated frequency and or with any voltage variation between 90% and 110% of the normal voltage. A transient over voltage of 130% of the normal voltage shall as well be sustained. Further, the motors shall be capable of maintaining stable operation when running at 70% nominal voltage for a period of 10 second. The pull-out torque for motors shall not be less than 200% of the rated torque.

b) Starting

AC motors shall be designed for direct on-line starting. They shall be capable of being switched on without damage to an infinite bus bar at 110% of the nominal voltage with an inherent residual voltage of 100% even in phase opposition. For starting the motors from the individual main and auxiliary bus bars, a momentary voltage drop of 20% referred to nominal voltage should be taken into consideration. With 85% of the nominal voltage applied to the motors terminals, each motor shall be capable of accelerating its associated load to full speed with a minimum accelerating torque of 5% of full load torque.

The maximum starting currents (without any tolerance) shall not exceed value 5 times of rated current for motors.

Motors for frequent automatic starting shall have an adequate rating.

c) Windings and Insulation Class

The insulation of motors shall be of class F but maintain in operation the temperature limits of class B materials. It shall be suitable for operation in damp and humid atmosphere, for occasional contact with corrosive gases and vapours and for considerable fluctuations in temperature.

The stator winding shall be suitably braced to withstand the forces due to direct-on-line starting and transfer conditions as mentioned before. The winding envelopment and tails shall be non-hygroscopic. The stator winding shall withstand the maximum fault current for the period determined by the associated protective devices.

The rotor winding (if applicable) shall be designed to give trouble-free continuous service including repeated directon-line starting. The rotor shall be subjected to a 120% over speed test for 2 minutes without showing any winding dislocation.

d) Ventilation and Type of Enclosure

All motors shall be of the totally enclosed fan-cooled type, protection class IP 54 according to IEC Recommendation 144. Cable terminal boxes shall be of class IP 55.

They shall have a closed internal cooling air circuit recooled by an external cooling air circuit drawn from the opposite side of the driving end.

Where motors are installed outdoors, a weather-proof design shall be chosen. Above shall be equipped with automatically controlled space heating elements for protection against internal condensation of moisture during stand-still period.

Motors installed outdoors and directly subjected to solar radiation shall be rated such as not to exceed a maximum metal temperature of 85ºC. Where necessary, such motors shall be provided with sun shields.

Vertical motors shall be provided with a top cover to prevent the ingress of dirt etc.

e) Bearings

As far as possible, the motors shall have sealed ball or roller bearings lubricated for life. All other motors with ratings of about 1kW and above shall be equipped with lubricators permitting greasing while the motors is running and preventing over-lubrication. Additionally, the bearings shall be fitted with grease nipples permitting the use of a universal grease gun. Vertical motors shall have approved thrust bearings.

All bearings shall be easily controllable during operation or stand-still without dismantling the bearings. The bearings shall further be protected and sealed against dust penetration and oil leakage.

In case of independent bearings, motor and bearing pedestals shall be fitted on a common base plate.

For the transport of motors equipped with ball or roller bearings, special bearing inserts shall be provided to prevent transport damage.

f) Shafts and Couplings

The motors shall be provided with a free shaft extension of cylindrical shape with key and keyway according to IEC Recommendation 72-1 and with the motor side-coupling which shall be pressed on the motor shaft and be balanced together with it. A coupling guard shall be provided.

g) Terminal Boxes and Earthing

The terminal leads, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables as specified in these Technical Specifications.

The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable.

The terminal boxes with the cables installed shall be suitable for connection to supply systems with the shortcircuit current and the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be clearly indicated.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust. All joints shall be flanged with gaskets of neoprene or similar material. For motors above 1kW, the terminal box shall be sealed from the internal air circuit of the motor.

Depending on the size, the terminal box of L.V. motors shall be fitted either with an approved cable sealing-end or with a gland plate drilled as required and provided with suitable fittings for cable fixing and sealing. Such openings shall be temporarily plugged or sealed during transportation.

Terminal boxes of M.V. motors shall be fitted with an approved cable sealing end and a pressure relief diaphragm suitably located. For plastic insulated and sheathed cables filling with compound is not required.

The three neutral end of the windings of M.V. motors shall be brought out to a separate terminal box.

For Earthing purposes, each motor shall have adequately sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one Earthing screw.

h) Noise-Level and Vibrations

Under all operating conditions, the noise level of motors shall not exceed 80

dB(A). In order to prevent undue and harmful vibrations, all motors shall be statically and dynamically balanced. Vibration displacements or velocity shall be measured in accordance with DIN 45 665 for IEC motor sizes 80 to 315. The results for all motors shall be within the "R" (reduced) limits.

1.8.16. Cables

The Contractor shall provide the relevant design of the relevant cable systems, prepare the cable installation schedules, drawings with cable routing, connection diagrams and cable lists, details etc and submitted to the Employer for approval. The power cable and control cables shall be of copper as per Indian Standards or IEC publications and the power cables shall be of minimum size of 16mm2 and control cables shall be of minimum size 1.5mm^2 .
All cables and accessories shall be suitable for installation under site conditions.

The contractor shall select the cable routes and raceways ensuring a minimum of interference with other installations.

a) Colour Code
Live parts of electrical connections shall be colour coded as follows: -

Conductor Designation	**Coding Alphanumeric**	**Symbol**	**Colour**
A.C Network	Phase – 1	L1	Red
	Phase – 2	L2	Yellow
	Phase – 3	L3	Blue
	Neutral	N	Black
D.C. Network	Positive	L+	+White
	Negative	L-	-Black
	Neutral	M	Blue
Protective earthed	Neutral	PE/N	Green/yellow
Earth		E	Grey
Colour Coding for Mimic Diagrams			
Mimic diagrams to be arranged on switchgear cubicles, control panels/desks etc. shall be colour coded as below			
380V D.C.		White	
110V D.C.		Violet	

b) Earthing System
All electrical system shall be properly earthed as per the latest ruling practice for the safety of the equipment, operating staff as well as the system. All protection devices for the control equipment's including grounding system/pit wherever required shall be provided by the Contractor.

1.8.17. Labels and Plates

Labels and data plates shall be provided in accordance with applicable standards and as detailed hereunder.

The proposed material of the labels, size, exact label lettering and proposals for the arrangement of the labels shall be submitted to the Employer for approval.

Designations in the Hindi shall appear above or to the right of the designation in the Contract language. The translations into and writings in the local language shall be submitted for approval.

a) Equipment Labels and Instruction Plates

Labels written in the Contract language shall be provided for all instruments, relays, control switches, pushbuttons, indication lights, breakers etc. In case of instruments, instrument switches and control switches, where the function is indicated on the device, no label is required.

The label shall be fixed close to the devices in such a way that easy identification is possible. Fixing on the dial glass of instruments will not be accepted. The wording shall conform to the wording used in engineering documents.

Easy separate construction unit (cubicle, panel, desk, box etc.) shall be identified by its Works identification number. Cubicles and similar units shall also bear this identification number on the rear side if rear access is possible. The overall designation of each unit shall be given in the Contract language and - if required – also in Hindi. These labels shall be made of anodized aluminium with black engraved inscriptions, arranged at the top section of the units. Manufacturer's trade labels shall – if desired – appear in the bottom section of the units.

All works inside cubicles, panels, boxes etc. shall be properly labelled with their item number. This number shall be the same as indicated in the pertaining documents (wiring diagrams, works list etc.).

Instruction plates sequence diagrams or instructions for maintenance shall be fitted on the inside of the front door of the electrical switchboards. These shall be in the contract language and in Hindi.

b) Warning Labels

Warning labels shall be made of synthetic resin with letters engraved in the Contract language and in Hindi.

For indoor circuit-breakers, starters etc. transparent plastic material with suitably contrasting colours and engraved lettering would be acceptable.

c) Labels for Conduits etc.

The material shall be non-corrosive and the description be done with 4mm high letters / figures.

d) Labels for Cables

Each cable when completely installed shall have permanently attached to each end and at intermediate positions as may be considered necessary by the Employer, non-corrosive labels detailing identification number of the cable, voltage and conductor size.

The cables identification numbers shall comply with those of the cable list.

All cables in cable pits and at the entry to buildings shall be labeled utilizing the aforementioned type of label.

e) Rating Plates

Works (hoists, machines, transformers etc.) rating plates and other technical data/ informative plates shall either be of the enameled type or be of stainless steel suitably protected after engraving with a transparent paint resistant to aggressive atmosphere and solar radiation.

Key System for Electric Boards

The locks or padlocks shall be coordinated for the different applications and shall

be supplied with three keys. A key cabinet at the end of each board (distribution board, MCC, control cubicles etc.) shall be provided for storing the keys of that board.

For all locks supplied there shall be six master keys to open any lock or padlock supplied. Each key shall have only identification label fixed above the key hanging hook inside the cabinet.

The cabinet door keys shall be similar and shall be six (6) in number.

1.9. Painting and Surface Coating

1.9.1. General

All paints, painting materials and accessories for painting shall be supplied by the contractor and shall be included in the price bid. The paints proposed by the contractor must be approved by the Employer or his Authorized representative before application of the same. The analysis in respect of paint properties, paint composition and performance requirements of the paints shall be submitted by the contractor for examination and approval. The painting and surface preparation shall also conform to IS:14177(Guidelines for Painting system for Hydraulic Gate and Hoists) or any other relevant Indian Standards. Decision of Employer for the recommendation of such standard shall be final and binding on the contractor.

1.9.2. Preparation of Surfaces

The preparation of surfaces prior to painting or coating shall be done as outlined below :

a) Weld spatter or any surface irregularities shall be removed by suitable means before cleaning.
b) All oils, grease and dirt shall be removed from the surfaces by the use of clean mineral spirits, xylol, white gasoline (lead free) and clean wiping materials.
c) Following solvent cleaning, the surfaces to be painted shall be cleaned of all rust, mill scale or other lightly adhering foreign objectionable substances by sand blasting or grit blasting to uniform bright base metal. Size & type of the short blasting gun should be such that it can reach intricate & inaccessible locations. Any grit or dust remaining after the cleaning operation shall be completely removed from the surface by wire brushing, air blowing, suction or other effective means.
d) Surfaces of stainless steel, bronze, nickel and machined surfaces adjacent to the metal work being painted or cleaned shall be protected by masking or other suitable means during the cleaning and painting operation.
e) Primer shall be applied as soon as surface preparation is completed and prior to the development of surface rust. The time gap between the application of primer and surface preparation shall normally not exceed six hours. In case there is considerable time gap, the surface should be reblasted prior to priming.

1.9.3. Shop Painting

a) Stainless steel and bronze surfaces should only be cleaned and not painted.
b) All surfaces of the embedded parts which are to come in contact with concrete shall be cleaned as mentioned above and given two coats of cement latex to prevent rusting during shipment/transportation and while awaiting installation.

c) Two coats of zinc rich primer shall be applied to all unfinished surfaces of the embedded parts and Gate to be exposed to atmosphere or water to obtain a dry film thickness of 75 microns, which shall be followed by two coats of coal tar blend epoxy resin paint to get dry film thickness of 150 microns in each coat. Total dry film thickness of paint shall not be less than 350 microns. Over and above aluminum epoxy paint of dry film thickness of 30 microns shall be provided for surfaces of the leaf exposed to sun. Time interval between thecoats shall be 24 hours.

d) All finished surfaces of ferrous metal including bolts, screws, threads etc., that will be exposed during shipment or while awaiting installation shall be cleaned and given a heavy uniform coating of gasoline soluble rust preventive compoundor equivalent.

e) The structural components of Hoists, Gantry Crane, EOT Crane, Lifting beam shall be given two coats of zinc phosphate primer to obtain a dry film thickness of 45 micron per coat followed by one finishing coat of alkeyd based micaccous iron oxide paint to obtain a dry film thickness of 70 microns followed by two coats of synthetic enamel paint conforming to IS: 2932 to give dry film thickness of 25 microns per coat of synthetic enamel paint. The total dry film thickness ofall the coats shall not be less than 175 microns.

f) Except machined surfaces all the surfaces of the machinery of the Hoists including gearing housing, shafting, bearing pedestal etc. etc. shall be given onecoat of zinc phosphate priming paint to give a minimum dry film thickness of 50 microns. Motors and other bought out items shall also be painted. This will be followed by three coats of aluminum paint conforming to IS:2339 or synthetic enamel conforming to IS: 2932 to give a dry film thickness of 25 microns per coat.

1.9.4. Field Painting

The painted metal work shall be handled with care so as to preserve the shop coats. The area of the shop paint, which has been damaged during transportation shall be cleared to base metal and repainted. Paint applied to such areas shall be of the same type as used originally in shop painting. All exposed unfinished surface of embedded parts and Gate shall be given a finishing paint of Aluminium epoxy paint so as to obtain shining surface of pleasing colour. This finishing coat should be able to reflect light and limit the heat absorption when exposed to sun.

1.9.5. Painting for Electrical equipment

Rust and scale shall be removed by sprinkling with dilute acid followed by the washing in running water followed by rinsing in slightly alkaline hot water and drying.

Oil, grease and dirt shall be thoroughly cleaned by emulsion cleaning.

All steel sheets shall be phosphated in accordance with IS 6005 ‘code of practice for Phosphating iron and steel”.

After Phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.

The Phosphate coating shall be sealed with application of two coats of ready mixed stoving type Zinc chromate Primer. The first coat may be flushed dried, while the second coat shall be stoved.

Adequate thickness of powder coating with high voltage electrostatic appliance shall be applied. Final colour of the panels shall be pebble grey as per RAL – 7032 or equivalent as per the colour code IS –5.

Relay and instruments: EGG Shell/Bright Black Circuit Level: White letter on Black level.

1.9.6. Measures during Painting

a) Any bare spots or holidays shall be recoated with additional application of primer.
b) All runs, sags, floods or dips shall be removed by scrapping and cleaning. The cleaned area should be retouched or all such defects shall be remedied by reblasting or repriming.
c) Special attention should be given to good coverage on rivets, welds, sharp edges and covers.
d) Suitable measures shall be taken to protect the applied primer from contact with rain, fog, mist, dust or other foreign matter until completely hardened and next coat being applied.
e) The air temperature at the time of application must not be below 100C and relative humidity must not be above 90%.

The components during or after painting shall be handled carefully so that no damage to the paint occurs.

1.9.7. Application Procedure

All paints and coating materials shall be in a homogeneously mixed condition at the time of application and shall not be thinned except as hereinafter specifically provided. Warming of the paint shall be performed by means of hot water bath.

All surface to which paint shall be applied immediately after cleaning, and except otherwise specifically provided, shall be applied by either brushing or by airless spray. When paint is applied by spraying, a mechanical agitator type of paint pot shall be used. Means shall be provided for removing all free oil and moisture from the air supply line of all spraying equipment. Each coat of paint shall completely cover the surfaces and shall be free from runs, sags, pinholes and holidays. Each coat of paint shall be allowed to dry or harden thoroughly before the succeeding coat is applied.

All paints shall be applied by skilled workers in a workman like manner. Paint shall not be applied during damp weather and on the surfaces which are not entirely free from moisture. Rust preventive compound shall be applied by any convenient method to ensure complete coverage of heavy coating. After the finalapplication, the paint film shall be allowed to cure atleast for 7 days.

1.10. Transport and Storage

Shipping, transportation,insurance, loading and storage shall be done under the supervision of the Contractor. An appropriate period for transportation shall be considered.

The general co-ordination of storage and erection work as well as the civil engineering work on site will be done by the Employer to the possible extent.

The delivery dates, transportation and erection periods indicated in the Contract Documents shall be strictly adhered to.

From the time of manufacturing until commissioning, all parts of the plant shall be protected against damage of any kind. Parts, which are damaged during transport shall be fully replaced at the Contractor's expense.

The contractor shall provide the Employer with complete packing lists of each performed shipment.

1.10.1. Packing

After the workshop assembly and shop inspection and tests including witness inspection by the Employer or his authorized representative wherever specified and prior to dismantling for shipment to the Site, all items shall be carefully marked to facilitate site erection. Wherever applicable, these markings shall be punched or painted so they are clearly visible.

Dismantling shall be done into convenient sections, so that the weights and sizes are suitable for transport to site and for handling on the site under the site conditions of the Project.

All individual pieces shall be marked with the correct designation shown on the Contractor's detailed drawings and other documents (packing lists, spare part list, in Operating & maintenance Instruction etc.)

Marking shall be done preferably by punching the marks into the metal before painting, galvanizing etc. and shall be clearly legible after painting, galvanizing etc. In labeling, the Contractor shall endeavor to use as few designations as possible and each part of identical size and detail shall have the same designation, regardless of its final position in the plant.

All parts of the Works shall be packed at the place of manufacture. The packing shall be suitable for shipment by sea and for all special requirements/ limitations of the transportation to Site. Where necessary, double packing shall be used in order to prevent damage and corrosion during transportation, unloading, reloading or during intermediate storage.

All parts of the Works shall be packed at the place of manufacture. The packing shall be suitable for shipment by sea and for all special requirements/ limitations of the transportation to Site. Where necessary, double packing shall be used in order to prevent damage and corrosion during transportation, unloading, reloading or during intermediate storage.

All parts including electrical parts shall be suitably protected against corrosion, water, sand, heat, atmospheric conditions, shocks, impact, vibrations etc. by packing them into high pressure polyethylene foil.

The Employer reserves the right to inspect and approve the packing before the items are dispatched but the Contractor shall be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not exonerate the Contractor from any loss of damage due to faulty packing.

All packing costs shall be included in the scope of Work.

The packing shall be provided with suitable handles so that slings for handling may be attached readily while these are to be moved. Where it is unsafe toattach slings to the box, parts shall be packed with slings attached to the part and slings shall project through the box or crate so that attachment can be madeeasily. All parts shall be properly secured and packed to withstand handling during transportation. All packing shall allow for easy removal and checking at sites. Special precautions shall be taken to prevent rusting of steel and iron parts during transit.

Suitable methods proposed to be adopted for protection against moisture shall be subject to the prior approval of the Employer. Each bale or package is to contain packing note quoting number and date of contractor's order and the name of office placing the order.

After delivery of material at site, all packing material shall become property of the Employer. Notwithstanding anything stated in this clause, the contractorshall be entirely responsible for loss, damage or depreciation to the stores dueto faulty and insecure packing. The Works/Plant shall be insured for loss or damage during transit at the cost of the contractor.

1.10.2. Storage

The Contractor shall inform himself fully as to all relevant transport facilities and requirements, loading gauges and other limitations, road, bridge limitations up to the site and shall ensure that the Works/Plant as prepared for transport shall conform to such limitations. The Contractor shall also be responsible for obtaining from the railway or highway authorities any permit that may be required for the transport of loads exceeding the normal gauges.

The contractor shall be responsible for all Custom clearance of the consignments from the Indian port if by sea and or from airport if shipped as air cargo, local storage and further transportation to site.

The contractor shall provide means for all unloading and reloading for all consignments of the plant, during transport to Site. Unloading on the Site will be provided by the Contractor. Consignments shall be unloaded immediately on arrival at Site and the Employer shall be immediately informed about the arrival of the consignment. The contractor is required to take the necessary steps in order to provide the carriage, special supporting structures for heavy loads etc.

The contractor shall develop necessary storage facility for proper and safe storage of all the materials. The warehouses shall be waterproof, well ventilatedand of designated floor etc.

If large parts are stored in the open air, they shall be provided with weather resistant and fire-resistant covers. Electrical parts which are not packed in heavy duty polyethylene foil and those so packed but whose packing has been damaged shall be kept in suitable places from the moment of storage to the moment of installation.

All insulation materials which will be taken from the warehouse for installation and which are stored temporarily in the station shall be protected from weatheror humidity.

1.11. Handling Works/Plant

Handling Works/Plant for maintenance of the following components shall also be supplied by the manufacturer.

i) Gates and embedded parts

ii) Gates seals

iii) Gates wheels and bearings

iv) Hoists

Manufacturer shall supply a list of all special tools required for gates assembly, dismantling and alignment.

Handling Works/Plant required for installation of gates and embedded parts shall also be arranged by the manufacturer.

Technical Specifications of Hydro Mechanical Works

Gates, Hoists and Cranes

1) Intent of Technical Specifications and Scope of Work
2) Description and Design Criteria
3) Materials
4) Manufacture
5) Quality Assurance, Inspection and Workshop Testing
6) Erection, Site Testing, Commissioning and final Acceptance
7) Work and Safety Regulations
8) Pressure Shaft

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(GATE, HOIST AND CRANES)

1. QUALITY ASSURANCE, INSPECTION AND WORKSHOP TESTING

1.1. Quality Assurance Programme

The Contractor shall submit and finalize manufacturing Quality Plans for all the major components and equipment. These Quality Plans will detail out various tests/inspections to be carried out as per the requirement of these Specifications and standards mentioned therein and quality practices and procedures followed by Contractor's Quality Control Organization, the relevant reference documents and standards and acceptance norms etc., during all stages of material procurement, manufacture, assembly and final testing/performance testing.

The Contractor shall also furnish copies of the reference documents/plant standards/acceptance norms/test and inspection procedure etc., as referred in Quality/reference documents/standard etc., will be subjected to Employer approval without which manufacturer shall not proceed. Purchaser shall reserve the right to add any inspection or test which is felt necessary for completion of the work. These approved documents shall form a part of the Contract. In these approved Quality Plans, purchaser shall identify Customer Hold Points (CHP's) i.e. testing checks which shall be carried out in the presence of the 52 purchaser's Engineer or his authorized representative in writing. All deviations to these Specifications, approved Quality Plans and applicable standards must be documented and referred to purchaser along with technical justification for approval and dis-positioning.

The Contractor shall also submit and finalize field quality plans which will detail out for all the equipment, the quality practices and procedures etc., to be followed by the Contractor's site Quality Control Organization during various stages activities from receipt of material/equipment at site. The field Quality Plans shall also be approved by the purchaser.

No material shall be dispatched from the manufacturer's works before the same is accepted subsequent to pre-dispatch/final inspection including verification of records of all previous tests/inspection by purchaser's Engineer of his authorized representative and duly authorized for dispatch.

All the vendors/sub-vendors proposed by the Contractor for procurement of major brought out items including casting, forging, semi-finished and finished components/equipment, list of which shall be drawn up by the Contractor and finalized with the purchaser shall be subject to purchaser's approval. The Contractor's proposal shall include vendor/sub-vendor's facilities established at the respective works, the process capability, process stabilization, Quality Control System followed, experience list etc. along with his own technical evaluation of vendor/sub-vendors and shall be submitted to the owner for approval and shall not relieve the Contractor from any obligation, duty or responsibility under the Contract. This action would, however, not involve purchaser in any complications arising between the Contractor and his sub- contractor(s)/vendor/sub-vendors or any other liabilities. The Contractor shall also obtain Quality Plans from approved vendor/ sub-vendors from whom he proposes to procure the material and submit these Quality Plans for purchaser's approval.

Normally, no request for change of vendors/sub-vendors shall be entertained by purchaser. But in the peculiar circumstances if the request for change of vendor/ sub-vendors is found reasonable and justified then the same shall be entertained and the decision of purchaser in this respect shall be final and binding. The time 53 consumed for the change of vendor/sub-vendors shall not be excluded from the stipulated time of the completion of the Contract. This change shall not relieve the Contractor from the responsibility to complete the Work within the stipulated time in any manner.

Purchaser reserves the right to carry out quality audit and quality surveillance of the system and procedures of the Contractor. The Contractor shall provide all necessary assistance to enable the purchaser to carry out such details and surveillance including Quality Manuals.

For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.

Repair/rectification procedures to be adopted to make the job acceptable shall be subjected to the approval of purchaser.

Before sub-contracting any portion of work, the Contractor will take prior approval of purchaser.

All materials used or supplied shall be accompanied by valid and approved material certificates and tests and inspection reports. These certificates and reports shall indicate the heat numbers or other such acceptable identification numbers of the material. The material certified shall also have the identification details stamped on it.

1.2. QA Documentation

The contractor shall be required to submit copies of the following quality assurance documents in original duly reviewed and accepted by contractor along with the request letter for issuance of MDCC (Material Dispatch Clearance Certificate):

a) Material mill test reports on components as specified in Quality Plan.

b) Sketches and drawings used for indicating the method of traceability of the radiographs to the location on the equipment.

c) Non-destructive examination results reports including radiography interpretation reports.

d) Factory test result for testing required as per applicable codes and standards referred in the Specifications.

e) Inspection reports duly signed by the authorized Engineer representative of the purchaser and Contractor for the agreed inspection hold points.

f) All the accepted deviations shall be included with complete technical details.

g) Copy of all reference drawings and reference technical document.

1.3. Inspection, Testing & Maintenance

The guidelines/recommendations for inspection, testing and maintenance of Gates, Rope Drum Hoists/cranes/ hydraulic hoist as contained in the relevant Indian Standards viz. IS-7718, IS-10096, IS-3177 and IS- 13053 (Latest Revision) etc. but not limited to, shall be applicable at different stages of the work viz. at the manufacturing stage, at the time of erection as well as after the erection.

1.4. Inspection and Tests

The inspection and test by the Employer of any supplies or lots thereof does not relieve the contractor from any responsibility regarding defects or other failure to meet the contract requirements which may be discovered prior to the acceptance. Except as otherwise provided in the contract, acceptance shall be conclusive except as regards latent defects, fraud or such gross mistakes as amounting to fraud.

1.4.1. Workshop Assembly, Inspection and Tests

The sub-assemblies and parts shall be assembled and tested in shop to ensure that parts are correctly fabricated and properly aligned. Prior to shop assembly and testing, the contractor shall submit for review an outline of the procedures and tests which are planned to be performed to demonstrate the fulfillment of the requirement of these specifications. The cost of carrying out the test (including the cost of inspection by the Employer's personnel) shall be borne by the contractor and shall be included in the lump sum price bid in the price schedule. However, shop assembly testing and test of bought out items would be carried out at the instruction and discretion of the Employer or his authorised representative without any extra cost.

In the event it is not possible to complete the assembly of Gate leaf or such other components in the shop, they will be accurately assembled in the shop using temporary connections and various critical dimensions shall be verified.

1.4.1.1. CHECKING OF DIMENSIONS

The dimensions, especially clearances and fit, (ISO 286), which are essential for operation and efficiency shall be carefully checked in an approved manner, as for example:-

- Run out and roundness tolerances of shafts, etc. to be measured on single parts as well as (wherever possible) on the assembled components.
- Fits and clearances of gates, bearings, guiding, etc.
- Accuracy, surface roughness and shape of sliding and guiding surfaces of seals, bearings, etc.
- Dimensions of couplings or connections for assembly with other deliveries from the Contractor, Sub contractors or other contractors.

1.4.2. Gates/Stoplogs (Wheeled/Slide)

Each Gate shall be completely assembled in the shop for inspection and to ensure

that all parts fit properly and that dimensions, clearances and tolerances required in the specifications and drawings have been achieved. The Gates/Stoplogs shall be assembled in a vertical position and holes for field connections carefully drilled or reamed. Connections which have to be disassembled for shipment/transportation shall be made by the use of erection pins, one size less in diameter than the designed size or temporary machine bolts. The shop assembly must also be checked for correctness in all respect, such as quality or workmanship, freedom from defects, free rotation of roller etc. The surfaces of seals on sides and top shall be in same vertical plane.

1.4.2.1. EMBEDDED PARTS

The assembly of each wheel/slide tracks, side guide tracks, seal seat and sill beam assemblies should be made for full length to the extent possible. The dimensions, finish and accuracy of machining shall be checked in the shops. The side seal seat assemblies and top seal seat assembly shall be assembledto ensure that the seal seats are in plane as required and conforms to the designed dimensions, fits, tolerances, surface finishes, clearances etc.

1.4.3. Radial Gates

All gates, frames, and appurtances shall be assembled in the shops to assure accurate fit and proper alignment of all parts and that the over-all dimensions and clearance are as covered by these specifications. While the units are assembled, the holes for field connections shall be reamed to full size.

1.4.3.1. EMBEDDED PARTS

The embedded metal work to be furnished under these specifications shall be shop assembled to the extent possible. Special care shall be taken in all phases of work affecting the strength and rigidity of anchorage system, since the correct operation and stability of gates are largely dependent upon the strength and accuracy of these parts.

The anchorages with bearing plates shall be completely fabricated in the shop. Special care shall be taken in all phases of work affecting the strength and rigidity of the anchorage.

The anchors shall be load tested equivalent to 1.5 times the design load.

Assembly of wall plates and sill beams shall be done at shop to the extent possible.

Soundness of Welds

The welds shall be inspected for soundness by dyepenetrant test and shall be locally stress relieved and if necessary shall be tested to the satisfaction of inspecting officer of the employer.

Test of Butt Welds

Minimum requirement of radiographic testing of butt joints shall be as under:

Skin Plate a) 10 % Radiographic test

b) 40% Dye - penetrant/ Magnetic particle test.

Horizontal girders	100% Radiographic test
Arms	100% Radiographic test
In-situ Anchorages system	100% Radiographic test
Hoist Support Structure	100% Radiographic test

1.4.4. Rope Drum Hoists

The contractor shall assemble the Hoist completely and shall conduct tests in his workshops to ensure that all parts fit and function properly and the dimensions and tolerances are as per the approved drawings for the parts and assemblies for its proper performance . The Hoist shall be completely assembled and run under no load in shop to ensure that all parts fit accurately atsite when erected. The Hoist under such tests shall run smoothly, without vibration, noise, chatter or undue friction.

1.4.5. Hydraulic Hoist

The contractor shall assemble the hoist completely and shall conduct tests in his workshops to ensure that all parts fit and function properly and the dimensions and tolerances are as per the approved drawings for the parts and assemblies for its proper performance. The hoist shall be tested for a pressure 150% of the design pressure, by applying the oil pressure to move the piston.

1.4.6. Hydraulic Testing of Components

Each hoist cylinder before it is machined finally and appurtenant piping, all valves and other parts subjected to oil pressure shall be subjected to a hydrostatic pressure test, for a pressure equal to at least 1.5 times the design pressure. The pressure shall be applied gradually and maintained for sufficiently long time to permit inspection of all parts and joints. A leakage through the joints in the cylinder can be repaired by rewelding, at the discretion of and in a manner acceptable to the employer based on standard practices and specifications as mentioned in IS: 2825 (Standard for unfired pressure vessels). The contractor shall carry out stress relieving and radiographic examination of the cylinder after it is repaired as per the instructions of the employer. Other parts found to be defective or not functioning satisfactorily during the test are to be replaced

All equipment required for testing shall be furnished by the contractor and these will remain his property after completion of the tests.

1.4.7. Gantry Cranes

The cranes shall be completely assembled, inspected, operated and tested in shop. The gantry tracks shall be centered & supported by two parallel & level rails to form the run way after accurately aligning all shaft couplings, bearing & gears. They shall be dowelled with pin & straightened by shear blocks if necessary. The hoist and gantry drive shall be operated by power to check the operation of the gearing. The hoist shall be operated for 15 to 30 min. in slowest speed to demonstrate that the equipment has been designed for continuous

duty. The gantry shall be made to travel for a distance of about 20 meters, if space permits. Alternatively, driving wheel shall be rotated under power to demonstrate satisfactory operation. Concentricity of each wheel of gantry shallbe checked by dial gauge.

- Overall inspection of crane, dimensions, spans.
- All motions of the crane.
- The deflection test shall be carried out with the safe working load at rest. The measurement shall not be taken on the first application of the load.

1.4.8. Overload Test in Shop

After the above tests but before the Rope Drum Hoists/Hydraulic hoist/Gantry crane are put into service, these shall, with overload relays appropriately set, be tested to lift and sustain a minimum tests load of 125 percent of the working load. In case of cranes, during overload test each motion in turn shall be maneuvered in both directions and the crane shall sustain the load under full control. The specified speeds need not be attained but the crane shall show itself capable of dealing with the overload without difficulty.

1.4.9. Test for Lifting Beam

During load testing following should apply:

- Proof load certificate needs to be issued.
- The lifting beam assembly shall be load tested.
- The load shall be 1.25 times of the working load.
- A string line should be put across the top of lifting beam (across the top of guide up stands at either end of the beam) and the distance from string to the top of beam itself measured before, during and after the lift to determine any deflection during the load test and any permanent set. These figures should be recorded.
- The measurement shall not be taken on the first application of the load.
- The load should be lifted and held for minimum of ten minutes.
- After the load test, all load bearing welds should be 100% examined by using Magnetic Particle Inspection.

1.4.10. Hydrostatic Testing

Hydrostatic shop testing shall be conducted in shop. Details of the testing procedures and test beds to be used shall be furnished.

Cylinder assembly, hydraulic pipes and valves etc. shall be in general subjected to the test pressure equal to 150% of the design pressure or a test pressure producing stress not exceeding 90% of yield stress in shell.

In case of extra high tensile steel liner using ASTM-517 Gr. 'F' or equivalent, a test pressure shall be equal to ½ the minimum UTS of the materials or ¾ yield point of the materials, whichever is less, shall be adopted.

During testing, each piece item shall be subjected to a test pressure.

The test pressure shall not be applied until the items being subjected to test and its contents reach the same temperature which shall preferably, be not less than 15 degree C.

Before applying pressure, the equipment shall be inspected to see that all joints are leak proof and to ensure that all low pressure filling lines and other appurtenances that shall not be subjected to the test pressure, are disconnected.

Times successively increasing and decreasing at uniform rate but not lowering the pressure below 0.75 times the operating pressure and shall then be held at the specified test pressure for such a time as is considered sufficient for inspection of plates, all welded joints and connections and all regions around openings but the period shall in no case be less than ten minutes.

All deflective welded seams and all defects in steel plates discovered during the hydrostatic pressure test shall be marked and after draining out the water they shall be satisfactorily repaired.

After repair and radiography, all sections shall again be subjected to a hydrostatic pressure test. This procedure shall be repeated till satisfactory results are obtained throughout.

1.5. Witnessing Shop Tests, Inspection and Training

The Employer will depute his representative(s) for witnessing tests and carrying out inspection during manufacturing stage and final complete assembly/ testing of Gates/ Hoists/cranes/lifting beams etc.

The Employer will depute Engineers for the following purposes:

i) Witnessing Shop Inspection & Tests	Min 6 Engineers for 4 weeks (Total 24 Engineers week with 24 round trips)
ii) Training in works & Design office	Minimum 8 Engineers for 1 week (total 8 Engineers week with 8 round trips)

Contractor shall make necessary arrangement of stay and local transport for Employer's Inspectors/ Engineers at or near the place of work, if so requested by Employer.

The Employer or his representative shall have free access to the software(s) used or being utilized by the contractor for Planning and Design of Gates, Hoists, cranes and lifting beam etc., both at his office premises and also at his shop premises. The Employer or his representative shall be free to check the design and drawings etc. on his software at any time.

The contractor shall have to impart training to Employer's Engineers and workmen to familiarize them with the operation and maintenance of the Equipment covered in these specification to the extent that thereafter, the duties can be assigned to the Employer's trained personnel and the certificate in this regard shall be given by the contractor and shall be appended in the commissioning documents. The period and training manual shall be approvedby the Employer. The cost on account of this training shall be in-built in the price bid.

1.6. Non-Destructive Tests Destructive Tests

The non-destructive tests shall be carried out as specified in SNT-TC-IA "Recommended practice for non-destructive testing, personnel qualifications and certification" of the American Society for non-destructive Tests or other similar International Standards.

1.6.1. Radiographic and Ultrasonic Inspection

1.6.1.1. RADIOGRAPHIC EXAMINATION

i. The radiographic examination of atleast 10 percent of total length of butt welds for plates of thickness greater than 6mm but not exceeding 20mm for the Gates and structural components of hoist shall be carried out by the contractor. The selection of the 10 percent of total length of butt welds for radiographic examination shall be done at random and shall represent each welder's work. The radiographic examination of 100 percent length of all butt welds for plates exceeding 20mm in thickness for the Gates shall be carried out by the contractor. The radiographic examination shall also be done for all castings. All radiographic examination shall be carried out by the contractor as directed by and to the satisfaction of the Employer at no extra cost. The radiographic examination shall conform to Indian Standards "Code of practice for Radiographic Testing (Latest Revision)" IS:2595 (Latest Revision), "Code for Unfired Pressure Vessels (with Amendments No. 1 to 4)" and IS:2825 (Latest Revision). The quality of butt welds brought out by the radiographic examination shall obtain a minimum of 5 marks corresponding to International Institute of Welding (IIW), Black Colour in accordance with IS: 2825 (Latest Revision). Isolated films getting lower marks may however, be accepted with the approval of the Employer in each individual case. In addition, the Employer may demand radiographic test checking of any of the important butt weld joints to check the soundness of joint of weld. This shall be carried out by the contractor without any extra cost to the Employer. Any retake of radiography after rectification of defects, shall also be free of charge to the Employer

ii. Whenever dissimilar materials are butt welded together, atleast one X-ray radiographic examination for each component of sub-assembly shall be carried out at the selected points. The number of points to be taken shall depend upon the results obtained after the first series of test are carried out. Prior to making radiographs of butt welds, the contractor shall place suitable identification markers adjacent to the welds. Each marker shall be so designed and located that the image will appear in the radiographs. The markers shall be painted, stamped or fastened as directed by the Employer and shall not be removed until all welds have been accepted. The radiographic test shall be carried out by the qualified technician and at such time as decided by the Employer. The technician's interpretation reports on the radiographic examination shall be furnished by the contractor to the Employer. All precautions shall be taken to minimize radiation hazards.

iii. All radiographs of welded joints shall become property of the Employer.

1.6.1.2. ULTRASONIC EXAMINATION

I. Ultrasonic examination shall be performed in accordance with the Article -5 of ASME code on Boiler and Pressure Vessels, Section- V. The relevant references from ASTM specification E164-74 shall also be taken. The ultrasonic examination

shall be performed and supervised by experienced and qualified personnel. If found necessary special type of transducers and/or higher test frequency etc. shall be adopted to improve the reliability of the test. The Equipment with recording facility shall be used for ultrasonic examination. The records in such case shall be furnished and the same shall become the property of Employer.

II. All indications which produce a response greater than 20 % of the reference level shall be investigated to the extent that the operator can determine the shape, identity and location of all such reflectors and evaluate them in terms of the acceptance standard given below:-

- Discontinuities shall be unacceptable if the amplitude exceeds the reference level and also the discontinuities having length which exceeds 1/3 t where 't' is the thickness of the weld being examined.
- Where discontinuities are interpreted to be crack, lack of fusion or incomplete penetration, they shall be unacceptable regardless of discontinuity or signal amplitude.

The marker shall not be removed until all the welds have been accepted.

Defective welds shall be air gouged or chipped out, rewelded, re-X-rayed and the cycle repeated until satisfactory results are obtained.

Ultrasonic /Radiographic tests in respect of steel liners subjected to internal pressure shall be conducted as give below:-

S.No.	Type of joints	Shop Testing
a)	All longitudinal joints	100% x-ray
b)	Circumferential joints of ASTM-537 Class-1 or 517 Gr. F	100% x-ray

Butt joints in antipercolation and stiffener rings shall be examined ultrasonically as directed by the employer. Atleast one joint shall be examined for each ring.

1.6.1.3. MAGNETIC PARTICLE INSPECTION

All fillet welds joining diaphragm plates, rings, lugs, etc. shall have smooth transitions into the sides of plates with toes of the welds, made before depositing the major bead. The surfaces shall be ground to merge smoothly into the plate surfaces. The fillet joints shall be subjected to magnetic particle testing. The procedure of carrying out the above test shall be as per relevant Indian or equivalent Standards. Where magnetic particle testing is not possible, dye penetration test shall be undertaken as per appendix-8 of ASME code section- VIII with the approval of the Employer.

1.6.1.4. ADDITIONAL EXAMINATION

i. The Employer may direct the use of visual, dye penetrant, magnetic flux and ultrasonic methods and Equipment to supplement the radiographic examination. The additional methods will be used to ensure that welds do not contain unacceptable defects. The same shall be at no extra cost to the Employer.

ii. The contractor shall make available continuously throughout the contract, the technicians and all necessary Equipments for ultrasonic examination of thewelds.

Technical Specifications of Hydro Mechanical Works

Gates, Hoists and Cranes

1) Intent of Technical Specifications and Scope of Work
2) Description and Design Criteria
3) Materials
4) Manufacture
5) Quality Assurance, Inspection and Workshop Testing
6) Erection, Site Testing, Commissioning and final Acceptance
7) Work and Safety Regulations
8) Pressure Shaft

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(GATE, HOIST AND CRANES)

1. ERECTION, SITE TESTING, COMMISSIONING AND FINAL ACCEPTANCE

The Works/Plant covered by these Specifications and Specification Drawings shall be furnished and erected by the contractor completely at the project site. The contractor shall be required to furnish all erection drawings. The contractor shall prepare a complete erection procedure, which shall describe the sequence of operations to be carried out, the method to be used, the measurements to be taken and the tolerances to be met within the erection and alignment of the Works/Plant. Such procedure shall have the approval of the Employer, prior to the commencement of erection, when approved shall form a part of the specifications furnished by the contractor.

1.1. Installation of 1st Stage Embedded Parts

The extreme care shall be taken to ensure that their surfaces be in a true plane and within the tolerance limits throughout their entire length.

1.2. Installation of 2nd Stage Embedded Parts

Gates frames, guides, tracks and seal seats, stoplogs frames, radial gate anchorages etc. as applicable shall be assembled and installed, brought to line, grade and plumb within the erection tolerances and secured in place by anchorages as shown on the drawings or otherwise according to the best method in practice and as may be necessary for successful functioning of these units. The erection tolerances for the frames and guides shall be as indicated on the drawings or as per latest revision of relevant Indian Standards. Extreme careshall be taken to ensure that their surfaces be in a true plane and within the tolerance limits throughout their entire length. The 2nd stage anchorages shallbe strong enough to hold the frames and guides securely in position while the concrete is being placed.

After the erection/installation of the second stage embedded parts, there is time gap during which the embedded parts remain un-concreted and have a tendency to get displaced/misaligned due to some of the work activities going onin the vicinity of the embedded parts. It is, therefore, the responsibility of the contractor to ensure that the alignment of the embedded parts remain intact and does not get dislodged/displaced due to any activity in the surroundings. To ensure this, the contractor may suitably brace the embedded parts by providing additional steel members, if necessary. The cost of all labour, materials and use of tools and Works/Plant for ensuring the same shall be included in the item rates of second stage embedded parts in the price schedule.

Before placing the concrete in any one lift and between placement of successive lifts, alignment and tolerances shall be checked and remedial action taken bythe contractor, if any displacement has occurred.

1.3. Installation of Gates, Stoplogs, Rope Drum Hoists, Hydraulic Hoist, Gantry Cranes, EOT cranes and Lifting Beam

All the components of the Gates/Stoplogs and their operating equipment shall be erected perfectly giving due cognizance to the units and match marks on the components. All components shall be designed and assembled to fit snugly and shall be made watertight. In case these Gates/stoplogs are exposed to floods, it is desirable to avoid the flood period to perform erection of Gates/hoists. Should it be necessary to do so, due precautions should be taken for measures against floods, since the Gates may be submerged in water sustaining damages or the half-erected Gates/stoplogs may disturb the water flow causing damages to the civil structure. One of the measures may be that the Hoists should be erected first and when the flood forecast is made, the half-executed Gates/stoplogs should be hoisted above the flooding water.

1.4. Guidelines for Site Erection

a) The Equipment shall be erected by the contractor in accordance with these specifications to the satisfaction of the Employer using most modern techniques under the directions of the supervisory erection personnel to be provided by the contractor and agreed to by the Employer.
b) Any required tool or Equipment which is not normally available at the work site as well as any jigs and fixtures required for proper erection shall be furnished by the contractor. A list of such tools shall be supplied by the contractor.
c) Erection tolerances shall conform to Indian Standards and as per approved drawings.
d) Erection bolts, nuts, washers and other fasteners shall be furnished to theamount of 15 percent or ten bolts, nuts, washers and other fasteners whichever is greater, in excess of the nominal numbers of each size and length required forcomplete installation of the Equipment.
e) Bolts in tension shall have a net section at root of thread 15 percent in excess of the net section required in tension.

1.5. Erection Personnel

Skilled as well as unskilled personnel shall be arranged by the contractor for erection of the Equipment covered in these specifications.

1.6. Erection Limitation

The contractor should visualize the accessibility for erection from civil data/drawings provided in these Technical Specifications/ Specification Drawings and should ensure that all Gates/stoplogs/Hoists/cranes and associated equipment can be transported through the access tunnels availableat various locations. The contractor shall be responsible for provision of site jointing to suit access restrictions and provide for all requirements of transportation through the access tunnels.

1.7. Notification

The Employer will notify the contractor within thirty (30) days prior to date on which erection and installation of the Equipment is to commence.

1.8. Site Tests and Commissioning

1.8.1. Functional Tests

During erection, commissioning & trial operation, the Contractor shall organize at suitable intervals all inspections and tests in the presence of the employer in order to provide the orderly execution of the works in accordance with the Contract and approved field quality plans. Unless otherwise specified, all costs for testing at site and of the works and charges associated with it shall be borne by the Contractor. This includes the measuring devices (properly calibrated) and any pertinent accessories, which shall be made available by the contractor for the entire duration of the tests. The Contractor shall delegate his experts to supervise the test at site.

The test, checks, examinations at site shall comprise but not be limited to: -

a) Checks and examinations of site welds.
b) Hydrostatic Pressure Test (if any).
c) Dielectric Tests.
d) Functional Checks (on all operating mechanism, on protective devices, automatic and manual controls, monitoring, supervisory equipment etc.)
e) Running Tests (gates/stoplogs/hoists/crane/lifting beam).
f) Performance tests & determination of characteristic data.

All such tests and checks shall be performed in the presence of the Employer's Representative. If not satisfied with the performance of the tests and checks, the Employer's Representative shall have the liberty to ask for additional tests or repetition of same.

The testing at Site shall be complete in every respect to prove the successful performance and operation of all the works and Works supplied and erected under the Contract.

1.8.2. Pre-Commissioning Tests

Pre-commissioning Tests shall include the appropriate inspections and functional tests to demonstrate that each item of Equipment can safely undertake the next stage.

1.8.2.1. INSPECTION AT SITE

a) Requirements of IS: 7718, IS:3177, IS: 13053 & IS: 10096 shall be covered. Inspection of embedded parts duly assembled/erected at site, fully aligned and adjusted including installation of sill beam, side guide members, lintel members, side seal seats/sill seats/tracks/ thrust/bearing pads and hoist/cranes supporting structure, rails etc. This inspection involves measurement of critical dimensions, verticality, co-planerness of sealing/bearing surfaces and dimensional accuracy within permissible erection tolerances.
b) Prior to concreting, it shall be ensured that the embedded parts, which have been erected/aligned and inspected are supported by additional bracing etc. so that they do not get disturbed during concreting.
c) After concreting, critical dimensions of embedded parts shall again be inspected for clearance of any excess concreting requiring chipping etc.
d) Inspection of Gate/stoplogs at site after its complete assembly and checking of dimensional accuracy, critical dimensions, co-planerness of skin plate and bearing/sealing faces.
e) Inspection of structural components of hoist/crane support, their dimensional accuracy, correct location and rigidity.
f) Inspection of Hoist/crane for exact location of hook/ pulley block over the lifting point of the Gate/stoplogs and for proper matching and connections.

1.8.2.2. GATES/STOPLOGS

i) Dry Test

Operational tests in dry conditions shall be carried out as soon as possible after completion of erection when all controls and permanent power supply have been connected. The tests shall include at least two complete traverses from the maximum raised position to the full closed/ seating position and it shall be ensured that there is no obstruction during the operation, the movements are smooth without any jerks and no undue effort is required for operation. Contact between gate/stoplogs seal and seal seats shall be checked and precompression ensured by viewing the contact surface against the light source. The operation of the hoist/crane shall be smooth without any undue noise/excessive friction and without excessive vibration in the gate/stoplog and supporting structure. Any dry testing movements should have rubber seal and seal faces lubricated with water (Do not use grease/oil). For metal-to-metalsealing/ bearing faces grease to be used. All adjustments, clearances, brakes etc. shall be checked for proper operation of the equipment's.

1.8.2.3. TEST FOR ROPE DRUM HOISTS AND CRANES

a) After the Hoist/crane has been erected, adjusted, lubricated and otherwise made ready for operation, it will be operated through cycles of placing and removing of the gate/stoplogs. The hoist/crane shall raise, lower, held in any position the Gate/stoplogs at rated speed. Before conducting any field trial or tests, complete procedure for the tests shall be drawn and submitted by the contractor to the Employer for his approval.

b) Insulation Tests:
After erection but before the hoists/cranes are connected to the supply, the insulation of the electrical equipment shall be tested by a suitable instrumentand any defects revealed shall be rectified. The voltage required for the insulation resistance test shall be D.C. voltage not less than twice the rated voltage. Any reading less than 0.5 megaohm obtained with an insulation resistance tester of the unregulated type shall be disregarded and the wiring under test shall be subdivided until a reading higher than 0.5 megaohm is obtained . Failure to obtain a higher reading shows an unsatisfactory state of insulation. If an installation has been sub-divided for test purposes, each sub- division shall meet the requirement. The insulation resistance of each wiring circuit exclusive of connected apparatus shall be not less than 2 megaohm, if necessary, it shall be permissible to disconnect individual item of equipment while making this test.

1.8.3. Commissioning Tests

These tests shall include the specified operational tests to demonstrate that the work or section can be operated safely and as specified under all available operating conditions and shall include:

i) Satisfactory operation of all Equipment after erection.
ii) Vibration & noise shall not exceed permissible limit during entire cycle of operation.
iii) The testing of Gates/stoplogs and Hoists/cranes shall be performed with water pressure against the gate/stoplogs (preferable up to design head).

1.8.3.1. OPERATIONAL TESTS FOR GATES/VALVES

i) The contractor shall carry out in the presence of project authorities such tests on the gate/stoplogs/valves to determine that the gate/stoplogs/valves will fulfill the functions for which it has been designed. Tests shall be repeated, if necessary, until successfully carried out to the satisfaction of the employer. The tests shall be carried out at the convenience of the employer after completion of the other portions of the work and when the reservoir is at its full level. The employer shall have the right to carry out such tests also when the reservoir is at level other than the full reservoir level.
ii) Wet Test
These tests should simulate the actual operating conditions. Atleast two complete traverses will be made from the fully closed position to the normal raised position as follows:
   a) When Gates/stoplogs/valve is closed, Gates/ stoplogs/valve is raised to their normally open position in steps and observe the performance including vibration etc.

b) Lower the Gates/stoplogs/valve to the fully closed position in steps and observe the performance of the Gates/stoplogs including vibrations etc.

c) Check for proper operation of the filling valves.

d) Check up of proper operation of limit switches.

iii) Leakage Tests

Leakage tests shall be carried out with the Gates/stoplogs/valve closed. Before measuring the leakage, the Gates/stoplogs/valve shall be raised and lowered several times by a few inches or so in order to dislodge any debris that may have lodged in the seal seats. The leakage shall then be measured and recorded. The maximum permissible leakage shall not exceed 5 liters per min. per metre length of periphery of sealing surface.

1.8.3.2. OPERATIONAL TEST FOR ROPE DRUM HOISTS AND CRANES

i) After the supply has been connected and before the complete hoist/crane installation is put to commercial service, tests shall be carried out to prove the following:

a) The satisfactory operation of each control switch, contactor, relay and other control devices and in particular the correct operation of all limit switches under the most unfavourable conditions.

b) The correctness of all circuits and interlocks and sequence of operation.

c) Satisfactory operation of all protective devices.

d) The satisfactory operation of each motion of the hoist/crane.

e) The compliance of the hoist/crane with the specified performance requirement.

f) Tolerances on specified speeds on full load shall be within 10%.

ii) Deflection Test

The deflection test shall be carried out with the safe working load at rest. The measurement shall not be taken on the first application of the load.

iv) Overload Tests

After the above tests but before the crane/hoist is put into service, it shall, with overload relays appropriately set, be tested to lift and sustain a minimum test load of 125 percent of the working load.

During overload test each motion in turn shall be maneuvered in both direction and the crane/hoist shall sustain the load under full control. The specified speeds need not be attained but the crane shall show itself capable of dealing with the overload without difficulty.

v) Field Test and Acceptance of Gantry Crane

After the gantry crane has been erected, adjusted, lubricated and otherwise made ready for operation, it will be operated through cycles of placing and removing the stoplog units. The crane shall raise, lower, held in any position andtransport the stoplogs unit at rated speed.

1.9. Field Tests For Lifting Beam

After installation and prior to putting lifting beam in use, the assembly of lifting beam and gate/stoplogs together shall be subjected to field test in the presence of the employer and/or his authorized representative. The assembly shall be initially tested under dry condition for proper clearances and operations. The assembly shall be operated several times under each control mode to verify proper operation. The assembly of lifting beam and gate/stoplogs shall be further tested for the actual conditions. In this condition, the functions of all attachments like hooks, counterweight, guide rollers etc. shall be verified for the satisfactory operation. (If gate/stoplogs is not ready or its manufacture is deferred, then the decision regarding the suitability of lifting beam in regard to compatibility of gate/stoplogs shall be taken by the Engineer and that shall be binding on the contractor).

Before conducting any field trial or test, complete procedure for this test shall be drawn and submitted by the contractor to the employer for his approval.

Entire testing shall be conducted as per approved test procedure.

During the shop and field tests, all the data needed for proper evaluation of the performance of equipment shall be recorded. All test data shall be submitted for approval. If the test data do not demonstrate compliance with the specified requirements, all remedial actions shall be repeated until complete compliance is demonstrated to the satisfaction of the employer and/or his authorized represtantive(s).

The functioning of gate/stoplogs for proper operations has to be demonstrated for water level conditions as stipulated in design criteria. However, water levels, duration of test and timing thereof shall be decided by the employer and shall be binding on the contractor. It should be noted by the contractor that all testing specified in the above paras may have to be carried out while the Power House is functional and water is discharged through tail race.

1.10. Final Checking and Testing at Site

After completion of various phases of works final checking of the entire workshall be done by the contractor to ensure that all the Equipment erection and wiring etc. have been done strictly according to the specification drawings and approved by the Employer. All the works shall be thoroughly inspected keepingin view the following various points:

i) Checking for completion of all works in accordance with specifications and drawings.
ii) Checking of alignments of all mating parts.
iii) Checks for correctness of connections, continuity check, insulation resistance test.
iv) Checks, adjustment and characteristics tests of all control/ protective equipment in accordance with contractors instructions.
v) Setting and calibration of components e.g. relays, etc.

vi) Checking of Equipment for proper mechanical adjustment and proper adjustment and proper operation
vii) All routine and pre-commissioning tests and any other special tests required to be conducted at site on each and every Equipment as per the relevant standards and instructions/recommendations.
viii) All other tests as specified under relevant standards and codes of practice but not mentioned here.
ix) Tests and commissioning of control panels.

Proper record shall be maintained for all visual inspection, settings and checks carried out and be submitted by the contractor to the Employer.

1.11. Operational Acceptance

The operational acceptance of the Equipment shall be based on the following:

i) Quality and Workmanship of the Equipment.
ii) Satisfactory operation of the Equipment after erection as required under these specifications.
iii) Acceptance of various tests by the Employer as mentioned above.
iv) All tests may be witnessed by the contractor/ Employer or his authorized representative(s). On successful completion of all tests, the Equipment shall be accepted but all the responsibility shall remain with the supplier within the guarantee period/ defect liability period.
v) The taking-over of any part or section of the Permanent Works, which can operate as an independent unit, shall be performed in accordance with the standards and regulations laid down in the Specifications and the test procedure.
vi) Immediately upon termination of any such testing of a part or section of the Permanent Works a “Protocol of Acceptance”, which shall be deemed to be the Test certificate, shall be issued by the Employer.
vii) This document shall be signed by an authorized representative of the Employer and the Contractor and shall form an integral part of the later “Operational Acceptance Certificate”.

The acceptance of the equipment will be based upon:

- Mutual acceptance of results of test between the contractor and the Employer.
- Acceptance of Inspection and test records/Test Certificates carried out at “Site”.

This “Protocol of Acceptance” shall state:

- The date of testing.
- The Confirmation that the guaranteed data have been proven.
- Confirmation that all contractual documents have been submitted.
- Confirmation that the Employer’s personnel have been familiarized with the works and that they will be able to operate and maintain the works properly.

If any test for the verification of the guaranteed data could not be performed for operational reasons beyond the Contractor’s responsibility, this part of the acceptance shall be stated in the “protocol of Acceptance” and be postponed for a mutually agreed period.

1.12. Defective Equipment

In case any part of the Equipment is found to be defective in materials or workmanship or develops defects or does not otherwise meet the requirements of the specifications including errors or omissions on the part of the contractor, the following shall apply.

a) Defects disclosed prior to Operational Acceptance Any defects in materials or workmanship or other failure to meet the requirements of these specifications including errors or omissions on the part of contractor, which are disclosed prior to final payment or prior to operational acceptance tests, whichever occurs at a later date, shall, if so directed by the Employer, be corrected entirely at the expense of the contractor.

b) Defects disclosed after Operational Acceptance

Any latent defect not disclosed before the date of operational acceptance shall be corrected promptly by the contractor entirely at his expense provided that the total period during which the contractor is liable for replacement due to latent defects shall not exceed 365 days after the date of operational acceptance ofthe Equipment.

Technical Specifications of Hydro Mechanical Works

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1.1. Safety Engineering

Accident prevention shall be an essential part of the programme of the Contractor for the Work under this Contract, in order to reduce the cost of construction, measured in terms of:

i. Human life sacrificed.

ii. Temporary and Permanent injuries to workers.

iii. Loss of materials resulting from accident.

iv. Loss or damage to equipment.

v. The cost of Workmen's Compensation Insurance.

vi. Loss of time due to accident

a) The Safety programme should be so developed, so as to cope up with particular hazards for each operation (blasting, drilling, excavation, transport, cutting of metals, welding, fabricating, handling, erecting, testing and commissioning).

b) The Contractor shall ensure proper safety of all the workmen, materials, plant and equipment belonging to him or to Employer or to others, working at or near the site. The Contractor shall also be responsible for provisions of all safety notices and safety equipment, firefighting equipment, first aid etc. required both by the relevant legislations and the Employer as he may deem necessary.

c) The Contractor will notify well in advance to the Employer of his intention tobring to the Site any Container filled with liquid or gaseous fuel or explosive or petroleum substance or such chemicals which may involve hazards. The Employer shall have the right to prescribe the conditions, under which such container is to be stored, handled and used during the performance of the works and the Contractor shall strictly adhere to and comply with such instructions.The Employer shall have the right at his sole discretion to inspect any such container or such construction plant/equipment for which material in the container is required to be used and if in his opinion, its use is not safe, he may forbid its use. No claim due to such prohibition shall be entertained by the Employer. Nor the Employer shall entertain any claim of the Contractor towards additional safety provisions/ conditions to be provided for/constructed as per Employer's instructions.

d) Further any such decision of Employer shall not, in any way, absolve the Contractor of his responsibilities, and in case, use of such a container or entry thereof into the site area is forbidden by Employer, the Contractor shall use alternative methods with the approval of Employer without any cost implication to Employer or extension of work schedule.

e) Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosives, the Contractor shall be responsible for carrying out such provision and/storage in accordance with the rules and regulations laid down in Petroleum Act 1934, Explosives Act 1948, and Petroleum and Carbideof Calcium Manual Published by the Chief Inspector of Explosives of India. All such storage shall have prior approval of the Employer. In case, any approvals are necessary from the Chief Inspector (Explosives) or any statutory authorities, the Contractor shall be responsible for obtaining the same.

f) All equipments used in construction and erection by Contractor shall meet Indian, International Standards and where such standards do not exist, the Contractor shall ensure these to be absolutely safe. All equipments shall be strictly operated and maintained by the Contractor in accordance withmanufacturer's operation manual and safety instructions and as per Guidelines/Rules of Employer in this regard.

g) Periodical Examinations and all tests for all lifting/hoisting equipment & tackles shall be carried out in accordance with the relevant provisions of Factories Act 1948, Indian Electricity Act 1910 and associated laws/ Rules in force from time to time. A register of such examinations and tests shall be properly maintainedby the contractor and will be promptly produced as and when desired by Employer or by the person authorized by him.

h) The Contractor shall be fully responsible for the safe storage of his and his sub-contractors radio-active sources in accordance with BARC/DAE Rules and other applicable provisions. All precautionary measures stipulated by BARC/DAE in connection with use, storage and handling of such material will be taken by Contractor.

i) The Contractor shall provide suitable safety equipment of prescribed standard to all employee and workmen according to the need or as may be directed by Employer who will also have right to examine these safety equipments to determine their suitability, reliability, acceptability and adaptability.

j) Where explosives are to be used, the same shall be used under the direct control and supervision of an expert, experienced, qualified and competent person strictly in accordance with the Code Practices/Rules framed under IndianExplosives Act pertaining to handling, storage and use of the explosives.

k) The Contractor shall provide safe working conditions to all workmen and employees at the Site including safe means of access, railings, stairs, ladders, scaffoldings etc. The Scaffoldings shall be erected under the control and supervisions of an experienced and. competent person. For erection, good and standard quality of material only shall be used by the Contractor.

l) The Contractor shall not interfere or disturb electric fuses, wiring and other electrical equipment belonging to the Employer or other contractors under any circumstances, whatsoever, unless expressesly permitted in writing by Employer to handle such fuses, wiring or electrical equipment.

m) Before the Contractor connects any electrical appliances to any plug or socket belonging to the other Employer or Contractor, he shall:

    i. Satisfy the Employer that the appliance is in good working condition.

ii. Inform the Employer of the maximum current rating, voltage and phases of the appliances.

iii. Obtain permission of the Employer detailing the sockets to which the appliances may be connected.

n) The Employer will not grant permission to connect until he is satisfied that:

i. The appliance is in good condition and is fitted with a suitable plug.

ii. The appliance is fitted with a suitable cable having two earth conductors, one of which shall be an earthed metal sheath surrounding the cores.

o) No electric cables in use by the Employer/Contractor will be disturbed without prior permission. No weight of any description will be imposed on any cable and no ladder or similar equipment will rest against or attached to it.

p) No repair work shall be carried out on any live equipment. The equipment must be declared safe by Employer and a permit to work shall be issued by Employer before any repair work is carried out by the Contractor. While working on electric lines/equipments whether live or dead, suitable type and sufficient quantity of tools will have to be provided by contractor to electricians/workmen/ officers.

q) The contractor shall employ necessary number of qualified, full time Electricians/Electrical Supervisors to maintain his temporary electrical installations.

r) In case any accident occurs during the construction/erection or other associated activities undertaken by the Contractor thereby causing any minor or major or fatal injury to his employees due to any reason, whatsoever, it shall be the responsibility of the Contractor to promptly inform the same to Employer in prescribed form and also to all the authorities envisaged under the applicable laws.

s) The Employer shall have the right at his sole discretion to stop the work, if in his opinion the work is being done in such a way that it may cause accidents and endanger the safety of the persons and/or property, and/or equipments. In such cases, the Contractor shall be informed in writing about the nature of hazards and possible injury/accident and he shall comply to remove short comings promptly. The Contractor after stopping the specific work, can, if felt necessary, appeal against the order of stoppage of work to the General Manager of Project within 3 days of such stoppage of work and decision of Project GM in this respect shall be conclusive and binding on the Contractor.

t) The Contractor shall not be entitled for any damages/compensation for stoppage of work due to safety reasons as provided in above and the period of such stoppage of work will not be taken as an extension of time for completionof work and will not be the ground for waiver of levy of liquidated damages.

u) The Contractor shall follow and comply with all Employer Safety Rules relevant provisions of applicable laws pertaining to the safety of workmen, employees, plant and equipment as may be prescribed from time to time without any demur, protest or content or reservation. In case of any inconformity between statutory requirement and Employer Safety Rules, if any, referred above, the statutory requirement/provisions shall be binding on the Contractor.

1.2. Scaffolding and Ladders

Suitable scaffolding should be provided for workmen for all works that cannot be done from the ground, or from solid construction, except such short period work as can be done safely from ladders. When a ladder is used, an extra mazdoor shall be engaged for holding the ladder and if the ladder is used for carrying materials, suitable footholds and hand holds shall be provided on the ladder and the ladder shall be given an inclination not steeper than 1/4 to 1.

1.3. Scaffolding and Staging Guards

Scaffolding or staging more than 3.5 m above the ground and floor swung or suspended from an overhead support or connected with stationary support shall have a guard-rail properly attached, bolted, braced and otherwise secured at least 90 cms. high above the floor or platform or such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such openings as may be necessary for the delivery of materials. Such scaffolding or staging is so fastened as to prevent it swaying from the building or structure.

1.4. Platform, Gangways and Stairways

Working platform, gangways and stairways should be so constructed that they should not unequally erected. If the height of the platform of the gangway or the stairway is more than 3.5 metre above ground level or floor level, they should be closely boarded, should have adequate width and should be suitably fenced.

1.5. Protection for Opening in Floor

Every opening in the floor of a building, bridge or in a working platform shall be provided with suitable means to prevent the fall of a person or materials by providing suitable fencing or railing whose minimum height shall be 90 cms. In case, it may be necessary to cover the opening temporarily.

1.6. Safe Access to Working Places

Safe and easy means of access shall be provided to all working platforms and other working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9 metres in length, while the width between side rails in rung ladder shall, in no case, be less than 30 cms length. Uniform step spacing shall not exceed 30 cms.

Adequate precaution shall be taken to prevent danger from electrical equipment. No materials in any of the sites of work shall be so stacked or placed to cause danger or inconvenience to any worker or the public. The Contractor shall also provide all necessary fencing and lights to protect the public from accident and shall be bound to bear the expenses of defence or every suit, action or other proceedings at law that may be brought by any person for injury sustained, owing to neglect of the above precautions and to pay the damage and costs which may be awarded in any such suit, action or proceedings to any such persons or which may, with the consent of the Contractor be have to be to paidto compromise any claim of any such person.

1.7. Drowning Rescue and First Aid

When the work is done near any place where there is risk of drowning, all necessary equipment should be provided and kept ready for use and all necessary steps taken for prompt rescue of any person in danger and adequate provision should be made for prompt first-aid treatment of all injuries likely to be sustained during the course of work.

1.8. Hoisting Machines and Tackle Like Cranes Cableways etc.

Use of hoisting machines and tackle, including their attachments, anchorage and supports, shall conform to the following standards or conditions.

i.

a) These shall be of good mechanical construction, sound materials and adequate strength and free from latent defects and shall be kept in good repair and good in working order.

b) Every rope used in hoisting or lowering material, as a means of suspension shall be of durable quality and of adequate strength and free from latent defects.

ii. Every crane or cableway operator or hoisting appliance operators shall possess requisite qualifications, and no person under the age of 21 (twenty one) years shall be placed in charge of any hoisting machine, including any scaffold, which will give signal to the operator.

iii. In case of hoisting machines and cabin ring hook shackle, swivel and pulley block used in hoisting or lowering as a means of suspension, the safe working load shall be ascertained by adequate means. Every hoisting machine with the working load shall be used. In case of hoisting machines having a variable safe working load, each safe working load of the conditions under which it is applicable, shall be clearly indicated. No part of any machine referred to abovein this paragraph shall be loaded beyond the safe working load, except for the purpose of testing.

iv. In case of departmental machines, the safe working load shall be notified by the Employer. As regards Contractor's machines, the Contractor shall notify the safe working load of the machine to the Employer whenever he brings any machinery to the site of work, and shall get the same verified by the Employer beforeputting the machine to use.

v. Every precaution shall be taken by the Contractor to ensure that the cableway skips are visible during night.

vi. The cableway skips shall be firmly attached to the hooks.

vii. The travelling and hoisting ropes of the cableway shall be of good quality and shall not break during operation of the cableway,

viii. The limit switches showing the limits of travel of cableways shall function properly at all times and shall be easily visible from the operator's seat.

ix. The rope guides shall be so spaced to prevent any accident due to slippage of carriage from the ropes.

x. Suitable signal men and telephone operator shall be posted on duty whenever cable ways or other hoists are operated

xi. Cableways and ropes shall be inspected frequently to ensure safety of the people and materials or work sites and nearby.

1.9. Motors, Gearings, etc.

Motors, gearing, transmission, electric wiring are other dangerous parts of hoisting appliances shall be provided with efficient safeguards. Hoisting appliances shall be provided with such means as will reduce to the minimum the risk of accidental descent of the load. Adequate precautions should be taken to reduce to the minimum the risk of any part of a suspended load becoming accidentally displaced. When workers are employed on electrical installations which are already energized, insulating material, wearing apron such as gloves, sleeves, and boots, as may be necessary, shall be provided. The workers shall not wear any rings, watches and carry keys or other materials which are good conductors of electricity.

1.10. Maintenance

All scaffolds, ladders and other safety devices mentioned or described herein shall be maintained in safe conditions and no scaffolds, ladder or equipments shall be altered or removed while it is in use. Adequate washing facilities shall be provided at or near places of work.

1.11. Display of Safety Provisions

All Safety provisions shall be brought to the notice of all concerned by display on a Notice Board at a prominent place at work spot. The persons responsible for receiving and processing complaints of safety code shall be named therein by the Contractor.

Technical Specifications of Hydro Mechanical Works

Gates, Hoists and Cranes

1. Intent of Technical Specifications and Scope of Work
2. Description and Design Criteria
3. Materials
4. Manufacture
5. Quality Assurance, Inspection and Workshop Testing
6. Erection, Site Testing, Commissioning and final Acceptance
7. Work and Safety Regulations
8. Pressure Shaft

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8. PRESSURE SHAFT STEEL LINER

8.1. Scope of Work

The specifications described herein-under cover design, procurement, fabrication, shop assembly, painting, testing, transportation, supply, erection,site testing and commissioning of the following equipment at site complete in all respects, for Karbi Langpi Middle II Hydro Power Project, in accordance with these Technical Specifications and Specification Drawings. The materials, workmanship, technical requirements, equipment, accessories, supplies, and services required, shall be as set forth in these Technical Specifications.

It shall also include the spares required for satisfactory operation and maintenance of steel liner and its accessories for a period of five years from the date of commissioning of the equipment as set forth in these Technical Specifications and Specification Drawings. The description and quantity of spares required for steel liner and its accessories have been appended with the Bidding Documents.

The scope of work also covers supervision of unloading, stacking, operation, storage and preservation of components of pressure shaft steel liner and its accessories in the stockyards of the Contractor at the project site before they are transported, installed, tested and commissioned at their respective sites.

i) One (1) set of dia. 3700mm(main), dia. 2200mm (branches) Pressure Shaft Steel Liner and its accessories complete in all respects.

ii) One (1) set of Inspection trolley complete in all respects.

iii) One (1) set of rail track inside the pressure shaft for facilitating erection of steel liner, concreting, inspection etc. complete in all respects.

iv) Measuring Instruments:
The following instruments shall be supplied and installed by contractor for this work:
a) Discharge measuring instrument suitable for a high turbidity water for measuring discharge in pressure shaft.
b) Min. 4 (four) Nos. of pressure taps on each pressure shaft (branch) for measuring pressure.

v) 5 (five) sets (4 hard copies and 1 soft copy) of operation and maintenance (O&M) manuals containing drawings, catalogues and brochures, service manuals for each bought out item, handlingprocedures for assembly & subassemblies of pressure shaft steel liner and accessories.

vi) 4 (four) sets (3 hard copies and 1 soft copy) of abridged manufacturing history records and inspection & test records for all equipment to be supplied under the scope of work

vii) 2 (two) sets (1 hard copy and 1 soft copy) of erection & commissioning documents for pressure shaft steel liner and accessories.

8.2. Description and Design Criteria

8.2.1. Introduction

1. A single pressure shaft of 3.7m diameter takes off from the bottom of surge shaft with its centre line at EL 365.05m. The approximate length ofdia. 3.7m pressure shaft is 90.3m upto centre line elevation of EL315.15m before penstock trifurcates into 3 branches of 2.2m diameter.
2. The total length of the branches and pressure shaft given above may vary and subject to adjustment to suit the final dimensions adopted for the detailed layout.

8.2.2. Design Criteria

The pressure shaft steel liner shall be designed with the following parameters:

1. Internal water pressure corresponding to the Maximum surge level of EL395.5m.
2. Internal dynamic water pressure including water hammer is ~ 90.73 m water head at the powerhouse end.
3. External static water pressure corresponding to NSL while the steel liner is empty.

8.2.3. Design Data

The design data for the pressure shaft steel liner is broadly mentioned below:

S. No.	Parameter	Detail
1	Elevation at the C/L of start of Pressure shaft	365.05m
2	Full reservoir level (static condition)	385.5m
3	Maximum Surge level	395.5m
4	Axis of Main Inlet Valves	315.15m
5	Internal Diameter of Main Pressure shaft	3.7m
6	Internal Diameter of Branches	2.2m
7	Governing Indian Standards	IS:11625(Criteria for hydraulic design of penstocks) IS:11639(Part-II)- Criteria for structural design of penstocks

		(Buried/embedded Penstocks) IS:11639(Part-III)-Criteria for structural design of penstocks (Specials for penstocks) IS:2825(Code of unfired pressure vessels) Boiler and Pressure Vessel Code of American Society of Mechanical Engineers.
8	Seismic coefficients	αh= 0.25g αv= 0.17g

8.3. Submittals

1. Within sixty days from the date of issue of the Letter of acceptance but before procuring and mobilisation of equipment and plants to the Site, the contractor shall submit to the Engineer, complete details of equipment and plants proposed for fabrication, erection, painting and testing of the steel liner shells.
2. The contractor shall specify in his bid and subsequently also, if required by the Engineer, the source(s) from which the contractor shall procure steel plates required for the steel liner. In case the specified source is not acceptable to the Employer, the contractor shall be obliged to substitute the source by an acceptable source. Additional suppliers and change of suppliers shall be subject to the approval of Employer. If the materials are to be arranged from several sources, the estimated quantity to be procured from each source and proposed schedule of supply shall be submitted to the Engineer.
3. Within sixty days from the date of issue of the Letter of Acceptance, the contractor shall furnish to the Engineer, the details of skilled categories of workmen proposed to be engaged on the work.
4. At least 30 days in advance of fabrication, the contractor shall submit to the Engineer the schedule of fabrication of the entire work.
5. Within 90 days from the date of issue of Letter of acceptance, the contractor shall submit, in triplicate, to the Engineer the design calculations, shop and field drawings etc., as under:
   i) Design calculations.
   ii) Fabrication drawings of all the straight shells.
   iii) Development drawings for bends, reducer, cones, bifurcation and bulkheads and their fabrication drawings.
   iv) Drawings exhibiting plate-cutting schedules clearly identifying as to how the contractor intends to utilise each of the steel plates.
   v) Design and drawings of manhole arrangement and drawings for piezometer connections etc.
   vi) Design and drawings of ring girder supports and thrust collars.

vii) Steel liner assembly drawings indicating the shell numbers, position of manholes and other important features and clearly identifying the shop welds and field welds.
viii) Drawings showing edge preparation details (weld groove design)and any other relevant details for the various types of joints involved.
ix) Statement showing weights of the fabricated components intended to be billed duly supported by the computations.
x) Drawings indicating arrangement for hydrostatic shop testing of steel liner components.
xi) Drawings indicating identification markings intended to be made for radiographic inspection of welds.
xii) Drawings showing details of embedment of rail track and other arrangement intended for handling and erection.
xiii) Any other drawings or calculations that may be required for the clarification of the work.
xiv) When submitting duly authenticated drawings for approval, the contractor shall also provide editable soft copy of each drawing.
xv) The contractor shall certify that design & drawings furnished by him have been checked before submission and he shall be responsible for the correct fitting of the parts.
xvi) Drawings indicating arrangement of discharge measurement device, recorder of water level in surge shaft and pressure taps.

1. All design and drawings submitted will form a part of the contract. The sequence of submission of design & drawings will also form a part of the contract. The sequence of submission of all the designs & drawings shall be such that complete information is available for checking of each drawing, when it is received. The contractor shall submit two soft copies of design and drawings on DVDs/ pen drives and one complete set of supporting software packages and programs used in preparation of the designs, drawings, other documents and schedules with his first submission to enable the Employer to properly check the same with the help of the software packages/programs. The design and drawings submitted shall have facility for editing etc. The DVDs/ pen drives and software packages and programs will form a part of contract and shall be the property of the Employer. The Employer will return a copy of each drawing to the contractor marked either 'Approved' or 'Approved as noted' or 'Returned for corrections/modifications'. The notation 'Approved' or 'approved as noted' shall authorize the contractor to proceed with the manufacture of the equipment covered by such drawings subject to the corrections, if any, noted thereon. When the design computation/ prints of drawings have been returned for corrections/ modifications, the contractor shall revise/modify the design& drawings as necessary and shall resubmit fresh design computation/drawings for approval in the same routine as before. Any fabrication work performed prior to the approval of drawings, will be atthe contractor's risk. The Employer shall have the right to ask the contractor to make changes in the design, which may be necessary inthe opinion of the Employer to make the equipment to conform to the stated provisions and intent of the specifications, without any additional cost. After designs and drawings are completed and approved, the manufacturer shall supply to the Employer 4(Four) prints of each of the approved drawings, out of which 2 (Two) prints shall be duly laminated whereas in respect of finally approved design computations only four sets shall be supplied. However, prior to completion of contract, manufacturer shall supply 4 (Four) prints of all approved as built drawings plus one good quality polyester film transparency for each drawing suitable for microfilming.

2. At least 30 days in advance of the transportation of steel liner assemblies to the site of erection, the contractor shall supply the following details to the Engineer for approval.
   i) Method/procedure for handling and transportation of various assemblies, specials and equipment to be used therefore.
   ii) Arrangement/procedure for handling/erection of steel liner assemblies and specials etc. into the tunnel along with details of equipment to be deployed, procedure for alignment and welding in field.
   iii) Detailed procedure for sand blasting and applying necessary primer etc. in shop and coats of paint to be applied in shop/field along with necessary tests, therefore.

iv) The contractor shall submit along with each consignment of assemblies, accessories of steel liner, the parts catalogue and operation instructions in English language especially prepared to cover all the work/items of equipment furnished under these specifications which may be needed or may otherwise be useful in operation, maintenance, painting, repair, and for the repair and identification of parts/materials for ordering replacement. All name plates, instruction plates, warning signs and any marking whatever on the equipment and its parts and accessories shall be in English language.

3. At least 30 days prior to commencing radiographic examination, the contractor shall submit details of all radiographic equipment, processes and procedures for the approval of the Engineer. The type and make of the radiographic films intended to be used shall also be got approved from the Engineer.

4. The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.

8.4. Standards

1. All works and supplies shall conform to the following Indian Standards or where not covered by these standards, to the equivalent International Standards

   i) Steel plates and other Materials

S.No	Material	Standards
1	Steel plates for steelliner (Variable thickness)	i) ASTM-A 537 Class 2or other International equivalent pressure vessel,Carbon-Manganese-Silicon, steel plates. ii) ASTM-A-517 GradeP for thickness higher than 68mm.ASTM-A-517 Gr.F or other international, pressure vesselplates, alloy steel,high strengthquenched andtempered (EHT). iii) The material supplied shall conform to ASTM-A20/A20M. iv) Mechanical testing

		v) Standard specification for through thicknesstension testing ofsteel plate forspecial applicationshall conform toASTM A 770/A770M-86. vi) Standard specification forsteel, sheet andstrip, hot rolled,carbon, structural,high strength low alloy and highstrength low alloywith improved for formability shall conform to ASTM A1011/ A1011M00. vii) Guide forgeneral requirements for Assessment and accreditation of certification/ registration bodies shall conform to ASTM E1905-97. viii) Standard test methods practices and terminology forchemical analysis of steel products shallconform to ASTM A 751-96. ix) Inspection and testing as per IS: 2825-1969 ASME Boilers and Pressure VesselCode.
2	M.S. Bolts, studs, nuts, and washers	IS:1364 Grade S-Semi precisionor equivalent
3	Stainless steel for piezometer plugs	BS: 970-EN-56-A or IS: 1570 (Schedule-V) or equivalent.
4	Gasket or joining materials	BS:1737 or relevant ISSpecifications
5	Welding electrodes	IS: 814
6	Paints • Zinc rich primer • Cold applied coal tar epoxy paint	AWWA Specifications or equivalent IS specifications AWWA Specifications or equivalent IS Specifications

The contractor, while examining the plates, shall ensure that all requirements of the material specifications have been fulfilled by the manufacturer of the steel plates. In the certifications, the contractor shall also state that the necessary certified results of chemical, mineralogical and mechanical tests (e.g., yield strength, tensile strength, minimum elongation, notch-toughness test etc.) and heat treatment etc. have been furnished by the manufacturer and all required inspections have been carried out by the contractor.

ii) Welding:

- IS:2825-1969 (Latest edition) 'Code for Unfired Pressure Vessels'
- ASME 'Boiler and Pressure Vessel Code of American Society of Mechanical Engineers.'

iii) Painting:
- AWWA-C-203-78
  'Coal tar protective coating and lining for steel water pipelines standard of American water works Association.'

iv) Inspection & testing:
- IS:2825-1969 (Latest edition) 'Code for Unfired Pressure Vessels'
- ASME 'Boiler and Pressure Vessel Code of American Society of Mechanical Engineers.'
- AWWE-C-203-78 'Recommended practice for Non-destructive testing, personnel qualification and certification of the American Society.

2. In case of the conflict between the above standards and the specifications given herein the specification shall take precedence.

8.5. Steel Plates

Steel plates required for the fabrication and its specials/accessories shall be arranged/ procured by the contractor, the cost of which shall be deemed to be included in the tendered rates. These steel plates shall be sufficient for the fabrication and erection of straight shell, bends, bifurcation, stiffener rings, manholes, ring girder supports, permanent supports, bulkheads and any other item required for the completion of the work. It should be clearly understood by the bidder that tonnage of steel plates shall be higher than that of finished product on account of:

1. wastage during cutting & grinding.
2. wastage in the form of cut pieces and overweight due to variations/tolerances in length, width and thickness of steel plates.
   It shall be in the interest of the bidder to work out the exact quantity of steel plates required for the fabrication of penstock and its specials/ accessories, based upon the drawings in order to assess the cost of steel plates which he has to take into account while preparing the Price Bid. The bidders, while quoting their rates, shall also take care for the finished product, the weight of which shall be calculated theoretically without considering any variation /tolerance in the dimensions and thickness of steel plates. No extra payment what-so-ever shall be made to contractor on this account including any taxes, duties, octoroi, import duty, insurance etc. paid by the contractor during the process of procurement of steel plates. It may further be noted that all cut pieces and surplus plates, if any, after fabrication shall remain the property of the contractor. However, no compensation for such cut pieces and surplus plates shall be payable to the contractor by Employer.
   The steel plates to be arranged/ procured by the contractor shall confirm to the following specifications:
   Pressure Vessel Plates, Heat Treated, Carbon- Manganese – Silicon steel conforming to ASTM-A-537 class 2 or equivalent (killed quality). Each steel plates shall be ultrasonically tested as per ASTM-A-578.

   Additional requirement for ASTM quality steel plates:

   i) Permissible variation under & above in specified width and length shall be in accordance with ASTM-A-20 M-91a.
   ii) Negative tolerance on thickness shall not be acceptable, whereas

positive tolerance in thickness shall be as per ASTM-A-20 M-91a.

iii) Marking shall be made on each steel plates, indicating thereon name or brand of the manufacturer, heat and slab number, specification number and grade, class dimensions, weight and type etc, in accordance with ASTM –A-20-M-91 a. Marking shall be done bysteel die stamping and/or by stencilling.

iv) Edges of each steel plate shall be sheared from all four sides.

v) Tolerance in squareness shall be ensured to the maximum accuracy. The diagonal difference will not exceed 1% of the nominal width.

vi) Necessary test certificates or photocopies thereof relating to mechanical properties, chemical composition, ultrasonic testing and heat treatment temperature etc. of steel plates supplied shall be furnished by the supplier for each plate/heat before the actual shipment. Various tests shall be carried out in accordance with the requirements of ASTM-A-20-M-91 and other relevant ASTM standards.

Within 180 days after the award of work, the contractor shall precisely work out the quantity of steel plates based upon the construction drawings issued by the Engineer.

The length of the steel plates shall be so selected that there is preferably only one long joint in any shell. However, maximum two long joints shall be permitted. The final quantity of steel plates, worked out by the contractor, along with Technical Specification shall be submitted to Employer for scrutiny and approval. Thereafter, procurement action shall be initiated by the contractor without waiting for final construction/ fabrication drawings to the approved by the Employer. It may be clearly understood by the bidder that the procurement of steel plates has to be initiated and completed without any loss of time.

8.6. Approval of Material and Inspection

8.6.1. Certification of Product by a Third Party

When a third party certifies the product of a steel plant, the third party shall comply with the definition of the ASTM E-1905: Guide for general requirements for assessment and accreditation of certification/registration bodies. In addition, the third party shall do one inspection per year to check the quality organisation of steel plant (in the spirit of the ISO 9001 if possible), including sampling and the testing of the products with an accepted laboratory.

8.6.2. Procedure for Steel Supplier Acceptance

In order to guarantee the quality and the evenness of the steel products, manufacturers shall agree to the following criteria:

If there is a certification of the product by a third party, it shall meet the definition of “Certification of a product by a third party” and only one audit is recommended. If the steel plant product is not certified by a third party, but the steel works is certified ISO 9001, a technical audit about supplied material shall be done as well as factory tests.

If the steel plant product is not certified by a third party and not certified ISO 9001, an audit about organisational and technical aspects, factory tests shall be imposed on site test with a greater frequency than for a steel plant which is certified ISO 9001.

8.6.3. Type of Testing

1. Non-specific test:
   Non-specific testing is the testing done by the manufacturer, using his own method and process, to check the properties of the material to be delivered. Such testing is not necessarily to be done at site.
2. Mill specific testing (specific to the product)
   All testing shall be done in accordance with test methods and in accordance with ASTM A370 or equivalent.

8.6.4. Inspection

Third party inspection shall be carried out on behalf of the contractor subject to the prior approval of third-party inspection agency by the Engineer. The inspector representing the purchaser/contractor shall have entry at all times while working on the supply of the purchaser is being performed to all parts of the manufacturer's works. The manufacturer shall provide all reasonable facilities to satisfy that the material is being furnished in accordance with the specifications. In order to be sure of the steel grade or quality, the contractor and Employer shall have free access in the factory, while tests on the material ordered are performed. The Employer shall also reserve its right to get the material tested independently by deputing its Engineers for the inspection of material at source for each consignment. The shipment of steel plates shall start only after the approval of the Engineer.

8.6.5. Storage/Stacking of Steel Plates

The steel plates procured by the contractor shall be properly stacked. Utmost care shall be taken that steel plates of different specifications and thickness are stacked separately. Sign boards for each stack shall be placed at suitable location indicating stack number, type of steel, size of plates and number ofsteel plates procured etc.

8.7. Measuring Instruments

8.7.1. Discharge Measurement

The contractor shall supply a discharge measurement device that shall be suitable to a high turbidity water. The accuracy of the measurement shall be better than ±0.5%. This device shall be installed at a location decided by Engineer. The cable shall be safely brought to the powerhouse where it shall come out in a connection box.

8.8. Fabrication

8.8.1. General

1. Fabrication of steel liner shall be strictly in accordance with the fabrication drawings approved by the Engineer.
2. The length of the plate will be determined by multiplying internal diameter plus thickness by 'π' (pi). The plate length as far as possible will be close to the required size. However, if more than one plate is required for the Shell, then maximum 2 Nos. longitudinal joints shall be permitted.
3. The concentration of the welded joints shall be such that no two main seams come together under an acute angle or cross each other. Where it is not possible to comply with this requirement, the intersection of these welds shall be radio graphed, 100mm each side of such intersection. The longitudinal joints shall be staggered, wherever possible by introduction of circumferential joints by at least five times the thickness of the thicker plate.
4. Longitudinal seams of steel liner sections with manholes and piezometer connections etc. as incorporated in the drawings shall not intercept such openings. The designs, size and location of these openings shall be selected as required in IS-2825-1969 (latest edition).
5. Manholes shall be provided with suitable handles, flanges and covers, properly machined and shall be complete with bolts, nuts, washers, gaskets, etc.

8.8.2. Cutting of Plates and Preparation of Edges

1. No cutting of plates shall be started without getting relevant drawings approved from the Engineer.
2. The cutting of plates shall be planned in such a way so as to minimize the wastage of steel plates.
3. Where plates to be welded need cutting to size and shape of squaring in shop, following broad guidelines shall be adopted.
   i) Steel conforming to ASTM-A-537 class 2 or equivalent
      Cutting can be done by machining or flame cutting. Where the plate thickness does not exceed 25 mm, cold shearing may be allowed by Engineer provided that the sheared edge is cut back by machining or chipping for a distance of one quarter of the plate thickness but in no case less than 3mm.
   ii) Steel conforming to ASTM-A-517 Grade 'F', 'P' or equivalent:
      Cutting shall be done preferably by machining. In case flame cutting is resorted to in accordance with the recommendations of steel manufacturer/ supplier, which has the approval of the Engineer, a depth of 2mm to 4mm or as recommended by the steel manufacturer shall be removed by grinding. Further heat input in case or flame cutting shall need to be controlled as per the recommendations of the steel manufacturer so as not to affect basic properties and strength of quenched and tempered steel.

4. Plate edges shall be made in conformity with the construction drawings to suit 'V' or 'U' welds as applicable to various thicknesses for all longitudinal and circumferential welds in shop. Edge preparation for all circumferential joints in field shall be to suit single 'U' or joint with backing strip.
   i) Steel conforming to ASTM-A-537 Class 2 or equivalent:
      While marking of plates shall be as per approved fabrication drawings, standard/ accepted procedure for marking, edges of steel plates conforming to the above specifications can be prepared by planning, flame burning, chipping, grinding or arc gauging. Edge preparation details shall be covered in fabrication drawings to be approved by the Engineer.
   ii) Steel conforming to ASTM-517 Gr. 'F' or equivalent:
      Marking shall be conducted with size rulers and templates etc. Punches and chisels shall not normally be used. However, wherethe use of punches is unavoidable, punches with blunt points can be used and whenever possible, plate shall be marked on the side which shall be inside of the pipe after bending.

8.8.3. Bending of Plates

1. Plates for shell section shall be formed to required shape by cold bending process only such that it does not impair the quality of steel.
2. All plates shall be initially pinch type cold formed/bent on plate bending machine which shall ensure a circular shell from the calculated circumferential length of shell of the required internal nominal diameter.
3. Curvature of bent shells shall be checked with the help of necessary templates.
4. Correction of curvature neither by blows nor by hot forming shall be permitted.

8.8.4. Plates of Unequal thickness

1. Steel conforming to ASTM-A-537 Class 2 or equivalent: Where two plates at a welded joint differ in thickness, the thicker plate shall be trimmed to a smooth taper as per IS: 2825.
2. Steel conforming to ASTM-A-517 Gr. 'F' or equivalent: Where lesser thickness of ASTM-A-517 Gr. 'F' is to be joined with higher thickness of steel referred in (i) above, a matching piece of suitable length of higher/suitable thickness of ASTM-A-517 Gr. 'F' machined to smooth taper shall be provided to make the said joint. The matching piece details shall be duly covered in fabrication drawings.

8.8.5. Stiffener Rings and Backing bars.

1. Stiffener Rings
   i) Stiffener Rings, wherever, required, shall be fabricated from minimum number of circumferential sections but welded together and properly fitted, and welded to the pipes/ferrules such that the plates of rings shall be normal to the axis of pipe/ferrules.

ii) b) The butt welds in a stiffener ring shall be so positioned as to have proper staggering with reference to main longitudinal butt welds in the pipe shells.

iii) c) The holes/openings shall be drilled in the stiffener rings as per drawings to permit flow of concrete and the same shall have smooth finish.

2. Backing bars

The contractor shall prepare backing bars out of 12mm thick steel plates ASTM-A-537 Class 2 or equivalent intended to be used for field circumferential joints. The width of the backing bar and method of its attachment to the pipe shells shall be indicated in the drawing to be submitted by contractor for approval to Engineer. The contractor shall carry out all necessary cutting, machining, welding etc. for preparing and attaching the backing bars.

8.8.6. Manholes, Nozzles etc.

All manholes, nozzles, flanges and other accessories as may be required, shall be installed on the steel liner sections. The manhole assemblies shall be fabricated in shop which includes making, cutting of steel plates, edge preparation, pinching, rolling, pre-heating, (wherever required), welding heating during inter-pass, post-heating (wherever required), machining, including supply of other materials like, steel, nuts, bolts, washers, gasket/rubber “O” ring etc.

8.8.7. Bifurcation

The bifurcation shall be fabricated in shop which includes, marking, cutting of steel plates for header, branches, ring girder, flange, sickle plate & stiffeners etc.edge preparation, pinching, rolling, pre-heating, welding heating during inter- pass, post heating. Utmost care shall be taken while marking the steel plates so that the required bifurcation angle is precisely achieved.

8.8.8. Thrust collars and Anti Percolation Rings

Thrust collars shall be installed at entry to powerhouse. Anti percolation rings shall be installed in the initial reach of pressure shaft steel liner. The shape of thrust collars/anti percolation rings is same as the stiffener rings. Thrust collars/anti percolation rings wherever, required, shall be fabricated from minimum number of circumferential section but welded together and properly fitted, and welded to the pipes/ferrules such that the plates of rings shall be normal to the axis of pipe/ferrules. The butt welds in a thrust collar/anti percolation ring shall be so positioned as to have proper staggering with reference to main longitudinal butt weld in the pipe shells. The holes/openings shall be drilled in the thrust collar as per drawings to permit flow of concrete and the same shall have smooth finish.

8.8.9. Bends and Reducers

1. Bends shall be made of short segments of pipe with metered ends as shown on the drawings.

2. Segments of each bend shall be made with equal deflection angles, except for the end ones, which shall be of half the deflection of the other segments.
3. Such segments shall be formed from cut plates, with necessary marking.
4. For change in diameter of steel liner, reducer pipe shall be provided.
5. The contractor shall furnish his proposal for preparing, testing and transporting and erection of bends and reducer cones clearly indicating the extent of work intended to be done at the factory and at the site workshop as well as during erection.
6. The bends shall be so fabricated as to have a staggering of about 60 degrees between the longitudinal welds in the consecutive bend courses when installed.
7. The reducer cones shall have to be fabricated as per the design as may be finalised in consultation with the suppliers of turbine generating sets.

8.8.10. Bulkheads

1. Bulkhead shall be required for hydrostatic testing of bifurcation.
2. The design and fabrication drawings of bulkheads shall be submitted by the contractor well in time to the Engineer for approval.
3. The bulk heads shall be arranged/ fabricated by the contractor for this work.

8.8.11. Alignment and Tolerances

1. Alignment for longitudinal and circumferential joints in shop and circular joints in field for shells made from steel conforming to ASTM-A-537 class 2 or equivalent can be permitted with only minimum number of fit up dogs/cleats which shall be properly welded and neatly removed after alignment to ensure no injury to the parent plates.
2. But while aligning shells made from ASTM-A-517 Gr. 'F', welding of temporary cleats etc. for alignment of shell, shall preferably be avoided as far as possible to ensure that no inadvertent damage occur to parent plate of shell due to welding or removal of cleats later on. The contractor, therefore, shall be required to develop a capsule/man drill fitted with screwed pipe jacks/hydraulic jacks which shall provide perfect alignment of one circular shell with another shell as well as control the gap between them without necessitating welding of fit up cleat/dog etc.
3. Before any welding is commenced, it shall be ensured that the chamfered edges are in alignment and that the displacement of the joints for Class-2 steel is less than:

$$\frac{e}{50} + 1 + \frac{\Delta e}{2} \quad for\ longitudinal\ joints$$

$$and$$

$$e/50+2+\Delta e/2+\ \Delta p/2 \quad for\ circumferential\ joints$$

Where Δe and Δp are the difference between the actual thicknesses (e) of the edges involved and tolerance on the circumference respectively.

4. Other tolerances shall be as specified below or as provided in other acceptable International Standards:

a) The variation from theoretical shape of straight piece of a shell shall be less than

$$\pm\frac{2r}{1000}+2\pi(e_f-e_t+4)\ in\ mm$$

Where,

r = Radius of the shell in mm
e_f = Effective thickness of steel liner plate in mm
e_t = Theoretical thickness of steel liner plate in mm
or
The external circumference of the completed pipe shells shall not depart from the calculated circumference based on the nominal outside diameter by more than 0.25 percent, whichever is less.

b) Individual cylindrical shells shall be reasonably square and straight. The straightness of the generating lines of a shell shall be less than 2L/1000 in mm, where L=Length of a shell in mm.

c) c) The irregularities in profile of a shell (checked by 20° gauge) shall not exceed 3mm plus 5 percent of the minimum plate thickness. The maximum value may be increased by 25 percent if the length of the irregularity does not exceed one quarter of the length of the shell with a maximum of 1000mm.

d) d) The difference between the maximum and the minimum diameters at any cross section of a shell welded longitudinally shall not exceed 0.50 percent of the nominal internal diameter (with a maximum of (D + 1250)/200 in mm).

5.

a) Weld preparations whose cross-sectional dimensions vary from those shown on the approved workshop drawings by more than the following tolerances, shall be corrected prior to welding.

- Root opening of joints ±1.5mm
- Groove angle ±5 degrees
- Size and location of root face ±1.5mm
- Radius of 'J'/'U' grooves ±2mm

b) The maximum offset (or other defect in alignment) between abutting external surfaces at any position along a butt joint shall not exceed 2mm for both the longitudinal joints as well as circumferential joints.

c) The following limit shall apply to the fit-up of joints to be fillet welded and to the fit-up of stiffener rings (as well as anti-percolation rings) to pipe shells.

- Gap at joint to be provided is 2mm maximum. This provision is subject to condition that effective throat thickness of the weld shall be not less than that specified in the approved drawings.

8.9. Grouting and Drainage Holes

1. Holes for grouting and drainage in locations as directed by the Engineer or as shown in the drawings shall be required to be made in the steel liner.

2. Necessary plug for grouting holes shall also be fabricated and supplied by the contractor as per approved drawing and same shall be fitted in position and seal welded after needful operations on site are completed.
3. The grout holes shall be sealed by plugs after grouting is completed.
4. Grouting is not included in the scope of this work as this shall be done by the employer through the contractor for civil works.

8.10. Welding

8.10.1. General

1. After the edges of the plates have been prepared for welding, as aforesaid, these shall be subjected to a thorough visual examination for flaws, cracks, laminations, slag inclusion or other defects, if any, and no plate(s) where such defects are observed, shall be used for fabrication without the approval of the Engineer.
2. The edges of plates shall be free from foreign materials such as rust, scale, paint, oil, slag from the flame cutting or other contaminations of the fusion pieces.
3. The surfaces to be welded shall be free from foreign material such as grease, oil or marking paint. Irregularities, infusion faces which are likely to affect the quality of welding shall be removed by grinding beforewelding is commenced.
4. Welding shall be done by a process which shall exclude the atmosphere from the molten metal viz. by hand welding with shielded arc method and wherever practicable, automatic welding machines using shielded arc or submerged arc method shall be used.
5. The type of joints to be welded shall be either a single or double 'V' or 'U' as shown on the drawings.
6. All welding shall be in accordance with the requirements of relevant standards.
7. Weld metal shall be deposited in successive layers and each layer shall be cleaned of all slags and other deposits before applying the next layer.
8. There shall be at least one layer of metal deposited above the surface. The reinforcement layer shall not exceed [1+(3/100) (e+b)]mm, above the surface of the plate. Where 'b' is the theoretical width between the edges of the chamfer. If transport of sand is to be expected, sill shall be ground flush over 30 degrees.
9. All double 'V' or 'U' joints shall be welded from both sides of joints.
10. The reverse side shall be prepared by chipping, grinding or flat gouging so as to secure sound metal from the reverse side.
11. Where fillet welds are used, the sections to be joined shall be held firmly in position while being welded.
12. To ensure the matching of section at joints, expanding struts or spiders may be used.
13. Temporary welds, where used to hold the sections in position, shall be removed so that they shall not become a part of the permanent welded joints.
14. Whenever possible, joints shall be welded in the flat position.
15. Welded joints shall be free from craters, depressions, and other irregularities/defects.

16. After the welding is completed, all weld splatters shall be removed.
17. The welding of temporary attachments to the steel liner sections for the purpose of handling or aligning of sections with each other shall be limited only to those essentially required, subject to the approval of the Engineer. All such attachments shall be removed by careful chipping or flame cutting and damage if any, to the steel liner shall be repaired.

8.10.2. Welding Procedures

1. Mandatory practice of welding High Tensile Steel ASTM-A537 Class 2 and ASTM A 517 Gr. F or equivalent.
   a) Fitting:
      High tensile steel shells bent to a true circle shall be fitted with sufficient fitting up equipment and finger bars to properly maintain alignment and gap during welding. Tack welds in the joints are allowed to maintain the alignment and gap during the welding operation.
   b) Welding Process:
      Longitudinal and circumferential joints shall be butt welded by either the shielded metal arc (manual) process or the submerged metal arc (automatic welding machine) process.
   c) The Filler Metal:
      For welding High tensile steel with EHT steel, the filler metal shall conform to that of High tensile steel.
   d) Nature of Welding Current:
      The current used for welding shall be direct current, reversed polarity.
   e) Cleaning:
      All slag and flux remaining on any welding shall be removed before laying down the next successive bead.
   f) Defects:
      Any defects that appear on the surface of any bead of welding shall be removed by chipping, grinding or arc gouging before depositing the next successive bead of welding.
   g) Peening:
      In general, light peening shall be done only as an aid to cleaning the weld beads. No peening shall be done on the first or the last passes. However, at points of high concentrated welding stress, each bead after the first may be thoroughly peened to the extent that all the ripple marks shall be smoothened out. The cover or wash pass shall not be peened.
   h) Treatment of Backside of Welding Groove:
      The back side of manual welding grooves shall be back chipped, or arc gouged to sound clean metal sufficiently wide to allow free manipulation of the welding electrodes. The backside of the automatic welding grooves need not be back gouged provide a satisfactory qualified procedure has demonstrated 100 % penetration and fusion can be secured without back gouging.
   i) Stress Relieving:

All weld joints having plate thickness more than 36mm and manhole openings, bifurcation etc. shall be stress relieved as a whole after welding according to section VIII ASME latest edition or IS:2825 (IS Code for unfired vessels), or other acceptable International Standards. However, material over 32mm thickness shall be preheated to a minimum temperature of 200° degree 'F' during welding.

j) Field Welding:
The shop assembled pieces shall be aligned on the site along the alignment. Sufficient finger bars shall be used on circumferential joint to maintain the alignment during the welding.

2. Mandatory Practice for Welding EHT steel ASTM-A-517 Gr F

The welding of EHT steel requires certain mandatory precaution when welding with either the shielded metal arc (manual) or submerged arc welding (Automatic Process). In the fabrication and installation of steel liner, welding shall be performed at two different location viz. at the fabrication shop and the installation site. It shall be noted that the site welding operations are performed under extremely unfavourable conditions. This is particularly significant in the case of manual welding which often involves operation inside the tunnel where the humidity may approach 100 percent. In welding high strength steel plates, close care shall be taken to avoid hydrogen, a direct cause of cracking. When low hydrogen electrodes are used, they shall be baked dry and prevented from absorbing moisture. The preheat temperature shall be strictly controlled as also the welding heat input to prevent embrittlement of heataffected zone.

i) Fitting:
EHT steel bent to a true circle shall be fitted with sufficient fitting up equipment and finger bars to properly maintain alignment and gap during welding. Tack welding of joint shall not be allowed.

ii) Welding Process:
Longitudinal joint shall be of butt-welded type shielded metal are and submerged arc welding process. Suitable electrodes shall be used to ensure proper and satisfactory welding of joints.

iii) Circumferential Welding
When the longitudinal welding is completed, the circumferential joint shall be fitted up with sufficient fitting up equipment and finger bars to maintain alignment during welding.

iv) Welding Material
Welding materials shall be taken as per relevant standard specifications and keeping in view any special recommended for welding material specifications storage instructions etc. of steel manufacturer.

v) Maintenance of Welding Electrodes

One of the most important considerations in welding is to preclude hydrogen from the weld metal as much as possible because hydrogen is a major cause for cracks. The CO2 and MIG process are particularly suited for this purpose. However, most steel liners are fabricated and installed using the covered electrodes and/or the submerged arc welding process. Coated electrodes and the fluxes shall be closely controlled so that they shall not absorb moisture from atmosphere.

Covered electrodes shall be re-baked at the job site to a temperature of 400°C for 3 hours in a baking oven and then removed and transferred immediately to storage ovens maintained at 120°C to 175°C before use. Only the amount of electrode that shall be consumed in one hour period shall be removed at any time. If the rods are exposed to atmosphere for more than one hour, they shall be redried. The redried shall be done once. As in the case of covered electrode for submerged arc welding, flux shall be carefully maintained particularly when it is to be used on EHT steel. The flux shall be dried for 1 to 2 hrs at a temperature of 250°C in thin layer and agitated. The material shall be kept in a container at 150°C. The flux taken out of the container shall be used as promptly as possible and if it is left outside for more than 60 minutes, it must be redried. The redrying can be done as often as necessary. The reclaimed flux used for welding EHT steel usually contains rust and other impurities. All these impurities shall be carefully removed, and the flux shall be redried at a temperature of 400 °C to 500 °C. Redrying must be done only once or twice. The flux that has picked up oil or dirt or which has become fused during previous welding shall be discarded.

vi) Nature of welding current

The current used for manual and automatic welding shall be direct current, straight polarity.

vii) Preheating

Preheat and interpass temperature of 150° C to 200° C (as may be recommended by plate manufacturer) shall be required and maintained. The preheat shall be uniform and continuous. A gas burner or electric strip heater shall be used for heating the tack welds, longitudinal and circumferential joints in the shop as well as in the field. It is necessary to heat each part over a width of 100mm (4x t) or more and to maintain satisfactory temperature control by using automatic thermostats. The manufacturer of steel plates may recommend certain procedure with regard to preheating/post heating of weld joints, which shall be strictly followed by the contractor.

viii) Welding Techniques

- Manual Welding:

When manually welded, the arc length shall be held as short as possible consistent with maintaining satisfactory operation. The straight forward stringer bead method shallbe preferred for welding of EHT steel. Weaving shall be permissible if a steady arc length is maintained, but the widthof the weave shall not exceed three times the diameter of theelectrode used in the vertical position and twice the diameter of the electrode used in the down flat position (diameter of core wire). When welding is performed in the vertical position, all beads shall progress from bottom to top, except that the first pass shall be uphill or downhill and the finish or wash beads shall be run from top to bottom using 3.2mm or 4mm dia electrodes using either 2 of 3 stringer beads to cover the uphill passes.

The tack welding of jigs shall also be welded under the same conditions as for regular welding (welding of the main body). The bead length shall be 80mm minimum.

In periods of high wind, the operator and joint shall be protected to prevent the protective gas blanket of the welding arc from being blown away.

No welding shall be performed when water is falling/ dropping on the surface to be welded unless the work is properly protected.

- Submerged Arc Welding

  In submerged arc welding, penetration is relatively great and the chemical composition of the deposited metal varies widely with dilution of the base metal. For this reason, mechanical properties of crack sensitivity of the deposited metal are easily affected by the speed of cooling. Therefore, in the selection of wire, fluxes, sufficient consideration shall be given to the type of joint, built up method of preheat temperature, interpass temperature welding heat input etc.

- Cleaning

  In making multiple welds, extreme care shall be taken to remove all slag from the weld beads before starting to deposit subsequent beads. Particular attention shall be givento the removal of thin lines of slag which tend to remain inthe crevices along the bead edge.

- Defects:

  Any defects that appear on the surface of any bead of welding shall be removed by chipping, grinding or arc gouging before depositing the next successive bead of welding.

- Peening:

  In general, light peening shall be performed only as an aid to clean weld beads.

- Treatment of Backside of welding Groove:

  The backside of manual welding groove shall be back chipped, or arc gouged to sound clean metal sufficiently wide to allow free manipulation of the welding electrodes. The back side of the automatic welding grooves need not be back gouged provided a satisfactory qualified procedure was demonstrated 100 percent penetration and fusion can be secured without back gouging.

- Flame Gouging:

  Flame gouging shall not be permitted as excessive local heating is possible with resulting detrimental effect to the base metal.

- Field Welding:

  The shop assembled pieces shall be aligned on the site along the alignment. Sufficient finger bars shall be used on circumferential joints to maintain the alignment during the welding. No tack weld in the joints shall be permitted. As there is no access to weld the joint from outside in case of pressure shaft only inside welding is contemplated with back up strip.

- Preheating and Interpass Temperature :

  Preheating and interpass temperature shall be 150° C to 200° C.

- Method of preheating:

  Electric strip heaters with automatic thermostat controls shall be used for recording the temperatures. Alternatively, gas burners shall be used for preheating, if plate can be uniformly heated and to maintain satisfactory temperature control when thermostats are not available, frequent use of crayons is required.

- Welding Technique:

  The field circumferential joints shall be welded manually by covered electrodes. The conditions of maintenance of electrode and the procedure of welding shall be like the manual welding performed at the shop. In the case of embedded type steel liner, where the welding work is liable to be carried out in highly humid tunnels, the chances of delayed cracking of welds is apt to be more easily induced by hydrogen. To prevent weld cracks, stringent control of preheating temperature, heat input and electrode shall be practised.
  Multipass welded joints of this type have a high possibility of cracks occurring in the root pass. Cracks of this type can be removed by the application of continuous welding. This kind of

crack is likely to occur when temperature is under 150° C and when hydrogen contained in heat affected zone is high. In the case of continuous welding, however, it shall take somewhat longer time before the temperature is lowered to 150° C or under. During this period, hydrogen contained is removed and the possibility of crack occurrence shall bethereby eliminated. Welding shall be applied continuously as far as practicable. The heat input and interpass temperaturesshall be followed strictly and no deviation shall be permitted.

8.10.3. Qualification of Welders

All welders assigned to manual welding shall have successfully passed the test conducted by the contractor as prescribed for welder qualification in IS: 2825 or section IX of ASME Boiler and Pressure Vessel Code. If in the opinion of the Engineer, the work of any welder becomes at any time or appears questionable; such welder shall be required to pass another qualification test.

8.10.4. Welding Procedure Qualification

1. When considered necessary by the Engineer, the welding procedure qualification test shall be undertaken. The aim of this qualification is to confirm the choice of the filler metal and of the welding process fora well-defined base material (steel plate) and to make sure that the final features of welded joint reach the guaranteed values to the satisfaction of the Engineer.
2. Qualification of the welding procedure shall take place before manufacture and erection begins. It shall relate to every quality of steel and every welding process provided for. It shall be done under the same conditions as those prevailing during manufacture, such as, for instance shape of chamfers, work preliminary to welding, number of runs, position preheating, annealing etc.
3. As a general rule, a test plate shall consist of two strips (about 400mm x 800 to 1000mm) welded edge to edge in the longitudinal direction. Its thickness shall be approximately equal to the greatest typical wall thickness for the steel or the welding process provided for. This test plate shall be treated in the same manner as the shopor erection welds.
4. Inspection shall be carried out for the following or as directed by the Engineer.
   a) 100 percent radiography or/and ultrasonic test.
   b) One tensile test, test specimen with parallel faces.
   c) One bending test weld ground flush-direct bending.
   d) One bending test weld ground flush-reverse bending.
   e) One tensile test of filler metal (cylindrical test specimen).
   f) One series of test specimens to determine the full impact value on the outer fibres and in the core.
   g) One impact test in the transition zone (3 test pieces).
   h) One test to determine the differences of hardness (base metal, outer fibres transition).
   i) One chemical analysis of the deposited metal.
   j) One microscopic examination.
   k) One micrographic examination (plate, transition weld).

5. If required, for weld ability of base materials and filler metal, additional test like X-Groove Restraint cracking Test, Diffusible Hydrogen Test etc. shall be conducted.

8.10.5. Production Welding Tests

1. During production, the contractor shall when directed by the Engineer carry out production tests on welded joints to:-
   a) Monitor the soundness and properties of welds on a routine basis.
   b) Confirm that new batches of welding consumables produce welds with mechanical properties and soundness in accordance with the specifications.
2. The production test welds may be run-on run-off tabs or separate test plates which simulate as closely as practicable to the production weld being checked. The size of the production test plates shall be as indicated in para iii)-(c) here-in-below. All production test plates shall be welded in the presence of the Engineer or his authorised representative.
3. Production test weld plates shall be welded at approximately the following frequency :
   a) 1 test weld per 100m of longitudinal welds in the steel liner shells welded by automatic processes.
   b) 1 test weld per 200m of circumferential welds in the steel liner shells welded by automatic processes.
   c) 1 test weld per 100m butt welds welded by manual or semi-automatic processes.
4. In general, the frequency shall be greater than average at the commencement of each welding procedure and shall be arranged to test new supplies of consumables, electrodes, welding wire and flux, as their use is commenced in production welding.

5. The production test weld plates shall be radiographically examined to ensure that the standard of welding is at least equal to that required in production. The test plate shall be rejected if rectification is required for more than 5 per cent of the weld length. Production weld test plates shall be sectioned for mechanical testing in the same manner as procedure test plates. Production weld test plates shall provide a minimum of 900mm effective weld test length with the weld centrally placed in a 400mm wide plate. If the mechanical tests or radiographic examination of a production test weld shows that the weld does not comply with the minimum standard required for a procedure weld, then that welding procedure shall be disqualified and further welding with that procedure shall not be permitted. The procedure shall be resubmitted for re- approval when the cause of the failure of the production weld has been determined by the contractor. The failure of the test weld to comply shall not in itself be grounds for the rejection of production welds performed in accordance with the approved weld procedure prior to the failure of the test weld.

8.10.6. Workmanship

1. All steel liner assemblies and specials shall be manufactured and finished

in a thorough workman like manner equal to the best modern Engineering practice in the manufacture and fabrication of steel liner components notwithstanding omissions, if any, in the specifications and the approved drawings. Dimensions shown on the drawings shall be adhered to closely limiting to the maximum tolerance specified in the relevant standards.

2. Where finished surfaces are specified or required for parts or materials, they shall be smooth as specified and almost free from tool marks.
3. Wherein average surface is required, smooth surface shall be produced but slight tool marks shall be allowed.

8.10.7. Repair of Welds

1. Defects in weld such as cracks, pinholes, incomplete fusion penetration or porosity detected as a result of radiographic/ultrasonic inspection shall be removed by chipping or any other mechanical means or by oxygen grooving, gouging, until sound metal is reached on all sides ofthe weld. The resulting cavity shall then be filled solidly with weld metal deposit strictly as per the welding procedure specified in para 6.9 of IS: 2825. Portions of welds that have been repaired shall be radiographed/ ultrasonic tested and repaired till the defects are removed to the satisfaction of the Engineer.
2. All area of welds on which repairs have been made shall be examined 100 percent by the method specified for the original weld.
3. When a weld has been examined for 100 percent of its length and the examination shows many unacceptable defects distributed over its length or when the defects envisage need for rectification of more than25 percent of the weld length, the entire weld length may be rejectedand the weld cut out and re-welded and shall be re-examined by the method specified for the original weld.

8.10.8. Recommendation from Steel Suppliers

1. The contractor shall note that steel supplier may recommend certain procedures/precautions in respect of fabrication and erection of steel liner, which he shall follow. If special type of electrodes and special processes such as preheating and post heating etc. are recommended, such electrodes shall be procured and shall be used according to the instructions of the manufacturer of the steel plates.
2. ii) The latest statistics of welding shall be followed even if the manufacturer of steel plates does not furnish any assistance contemplated in above para.

8.11. Non-Destructive Tests

The non-destructive tests shall be carried out as specified in SNT-TC-IA “Recommended practice for non-destructive testing, personnel qualifications and certification” of the American Society for Non-destructive Tests or other similar International Standards

.

8.11.1. Radiographic and Ultrasonic Inspection

1. Radiographic examination
   a) Radiography shall be performed in accordance with ASME Boiler and Pressure vessel code Section-V Article-2. The image quality indicator shall be of wire type and the sensitivity shall be at least 1.5 percent or better. All radiography shall be conducted using leadintensification screens. The acceptance standard for radiography shall be as stated in para (f) below.
   b) All radiography shall be performed and supervised by the experienced personnel qualified or trained for the job from the institutes such as Bhaba Atomic Research Institute or other reputed Institute of Non-destructive examination.
   c) Prior to making radiography, identification markers shall be placed adjacent to the weld intended to be radiographed. The images of such markers shall clearly appear in the radiographs. It shall be ensured that actual weld and its radiographs are mutually identifiable upto completion and acceptance of the work.
   d) The contractor shall provide at his own expense all materials including radiographic films and all consumables, equipment etc.necessary for radiographic examination and shall perform all radiographic examination in accordance with the requirements of thisspecification and of the Engineer and shall submit all the films duly developed to the Engineer within 8 working hours after taking the exposure. The films will then become the property of the Employer.
   e) Alongwith each radiograph, the contractor shall furnish his interpretation report, in duplicate, in the proper proforma. The Engineer shall be free to make independent interpretation and ask for the repairing of welds, if any necessary.

   f) Sections of welds the radiograph of which show any of the following types of imperfections shall be judged unacceptable.
      - Any type of crack, or zone of incomplete fusion or penetration.
      - Any elongated slag inclusion which has length greater than 1/3 t, where 't' is the thickness of the weld;
      - Any group of slag inclusions in line that have an aggregate length greater than 't' in a length of 12t except when the distance between the successive imperfections exceeds 6L where 'L' is the length of the longest imperfection in the group.
      - Porosity or rounded indications in excess of that specified by the acceptance standards given in Appendix-IV of ASME Boiler and pressure vessels code section-VIII Div.1.
   g) Radiographs shall not be taken until 24 hours after welding has been completed.
2. Ultrasonic examination
   a) Ultrasonic examination shall be performed in accordance with the Article-5 of ASME Boiler and pressures vessels code Section V. The relevant references from ASTM specification E-164-74 shall be also taken. The ultrasonic examination shall be performed and supervised by experienced and qualified personnel. If necessary special type of transducers and/or higher test frequency etc. shall be adopted to improve the reliability of the examination. The equipment with

recording facility shall be used for ultrasonic examination. The records in such case shall be furnished and the same shall be the property of Employer.

b) All indications which produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such reflectors and evaluate them in terms of the acceptance standard given below:
    - Discontinuities shall be unacceptable if the amplitude exceeds the reference level and discontinuities have length which exceeds 1/3t where 't' is the thickness of the weld being examined.
    - Where discontinuities are interpreted to be crack, lack of fusion or incomplete penetration, they shall be unacceptable regardless of discontinuity or signal amplitude.

3. The marker shall not be removed until all the welds have been accepted.

4. Defective welds shall be arc air gouged or chipped out, rewelded, re-X-rayed and the cycle repeated until satisfactory results are obtained.

5. Radiographic/ultrasonic tests shall be conducted as per table given below:

S.No	Type of Joint	Shop Testing	Field Testing
1	All longitudinal joints	100 percent X-ray	-
2	Circumferential Joints, of ASTM-A537 Class 2 or ASTM-A 517 Gr. F	100 percent X-ray	100 percent Ultrasonic testing (accessible field Circumferential joints shall be 100 per centX-ray Examined.)

Butt joints in anti-percolation and stiffener rings shall be examined ultrasonically as directed by the Engineer. Atleast one joint shall be examined for each ring.

8.11.2. Magnetic Particle Inspection

All fillet welds joining diaphragm plates, rings, lugs, etc. shall have smooth transitions into the sides of plates with toes of the welds made before depositing the major bead. The surfaces shall be ground to merge smoothly into the plate surfaces. The fillet joints are subjected to magnetic particle testing. The procedure of carrying out the above test shall be as per relevant standards. Where magnetic particle testing is not possible, dye penetration test shall be undertaken as per appendix-8 of ASME Code Section VIII with the approval of the Engineer.

8.11.3. Additional Examination

1. The Engineer may direct the use of visual, dye-penetrant, magnetic flux and ultrasonic methods and equipment to supplement the radiographic examination. These additional methods will be used to ensure that welds do not contain unacceptable defects as defined in sub-clause 1.11.1(i) herein above.
2. The contractor shall make available continuously throughout the contract technician and all equipment necessary for ultrasonic examination of the welds. The Engineer will direct which welds are to be examined.

8.11.4. Hydrostatic Testing

1. Hydrostatic shop testing shall be conducted in shop. Details of the testing procedures, tests jig etc. and test beds to be used shall be furnished to the Engineer for approval.
2. All the pipe shells, bends, wye pieces, taper pieces etc. shall be in general subjected to test pressure equal to 150 percent of the design pressure producing stress not exceeding 90 percent of yield stress in shell.
3. In the case of extra high tensile steel liner using ASTM-517 Gr. 'F' or equivalent, a test pressure which produces a hoop stress in pipeshall be equal to ½ the minimum UTS of the materials or ¾ yieldpoint of the materials, whichever is less, shall be adopted.
4. During testing, each piece shall be subjected to a test pressure as indicated on the drawings.
5. Suitable vent(s) shall be provided at a high point to vent possible air pocket while the Pressure Shaft shells, bends, bifurcations etc. are being filled.
6. The test pressure shall not be applied until the steel liner section and its contents reach the same temperature which shall preferably be not less than 15° C.
7. Before applying pressure, the equipment shall be inspected to see that all joints are leak proof and to ensure that all low-pressure filling lines and other appurtenances that shall not be subjected to the test pressure, are disconnected.
8. After being completely filled with water, the pressure in steel liner assembly to be tested shall be increased slowly and uniformly until the specified test pressure is reached.

9. The test pressure shall be applied three times successivelyincreasing and decreasing at uniform rate but not lowering the pressure below 0.75 times the operating pressure and shall then be held at the specified test pressure for such a time as is considered sufficient for inspection of plates, all welded joints and connectionand all regions around openings but the period shall in no case be less than ten minutes.
10. All defective welded seams and all defects in steel plates discovered during the hydrostatic pressure test shall be marked and after draining out the water they shall be satisfactorily repaired.
11. After repair and radiography, all sections shall again be subjected to a hydro-static pressure test. This procedure shall be repeated till satisfactory results are obtained throughout.

8.11.5. Inspection Trolley

1. The contractor shall design, manufacture, paint, transport and supply one no. inspection trolley intended for facilitating inspection of completed pressure shaft from within during maintenance needs.
2. The trolley shall be capable of being dismantled and taken through the 600mm dia. manhole and assembled inside the pressure shaft. The trolley shall have a capacity to carry 5 tonne loads. The design shall be with a factor of safety as may be agreeable to the Employer design organisation. The trolley shall be duly equipped with suitable lifting hooks or sheaves. The trolley may have arrangement likebrackets or so for mounting battery-operated flash lamp and for mounting portable radio-intercom. The contractor shall prepare and submit detailed design and drawings of the inspection trolley to the Engineer for necessary approval. The work shall be carried out as per approved design. The contractor shall install and give trial operation test of trolley upon completion of pressure shaft as may be directed by the Engineer. The trolley shall be dismantled after commissioning and stored properly in a safe place in the custody of Employer after repainting.
3. The contractor shall also supply and install necessary winches for penstock, control panels and other accessories for operating the trolley at a suitable place to be proposed by the contractor and approved by Engineer.
4. The trolley may also be used for painting the interior surface of the penstock/pressure shaft after filled welding with the approval of Engineer, in which case the testing and commissioning and dismantling/ storage shall be suitably rescheduled to the satisfaction of Engineer.

8.12. Painting

8.12.1. General

All steel liner assemblies shall be cleaned and painted as hereinafter specified.

1. Machined surfaces and screw threads to be in rolling or sliding contact shall be shop coated with a rust preventive compound before transportation.
2. Outside surface shall be painted in shop with cement solution.
3. Inside surface shall be coated in shop with zinc rich epoxy primer and cold applied, coal tar epoxy paint.
4. Completed coatings shall, in all respects, conform to the detailed requirements of these specifications.

8.12.2. Painting Schedule

Cleaning and painting of steel liner shall be done in accordance with following schedule:

S.No	**Item**	**Paints or coating material**	**Total No. of coats (in shop or field)**	**Dry film thickness of paint coats**
1	External surfaces which are embedded in concrete.	Coat of cement solution mixed with 5% potassium dichromate.	1	-
2	Exposed surface of liner, if any, in adits etc.	a) Zinc rich epoxy primer b) Cold applied, coal tar epoxy paint	2 3	Each coat Minimum of 50 microns but total not more than 150 microns 450 (3x150) microns
3	Interior surfaces	a) Zinc rich epoxy primer. b) Cold applied coal tar epoxy paint	2 3	Each coat minimum of 50 microns but total not more than 150 microns 450 microns

8.12.3. Preparation of Surfaces for Painting

1. Weld spatters, burrs or any other objectionable irregularities shall be carefully removed or repaired by suitable means before cleaning.
2. Any grit or dust remaining from the cleaning operation shall be completely removed from the surfaces by brushing, air blowing, suction or other effective means before the surfaces are accepted for painting.
3. In the event of rust formation or when the surfaces become otherwise contaminated in the interval between cleaning and painting, re-cleaning shall be required to be done.
4. Surfaces preparation shall be in accordance with the method given below: All oil, grease and dirt shall be removed from the surface using clean mineral spirits, xylol or white gasoline followed by wiping with clean wiping materials, except that for surfaces, which require coal tar coatings, the cleaning solvent shall be xylol. Following the solvent cleaning, the surface to be painted shall be cleaned to base metal to remove all rust, mill scale and other tightly adhering objectionable foreign materials by sand blasting or grit blasting. A clean, dry, gypsum and salt free quartz sand having grain size 0.7 to 1.5mm shall be usedfor sand blasting. Blast cleaning shall be accomplished with abrasives of such particle shape, hardness and gradation as to effectively clean the metal and have roughened surface suitable for tenacious adhesion of subsequent coating. The surfaces which have been thus cleaned shallbe primed as soon as practicable after such preparation has been completed, but in any event prior to deterioration of the prepared surface.

8.12.4. Application Procedure and Quality Control of Paints

1. Paint and coating materials to be applied shall be in a thoroughly mixed condition at the time of application and shall not be thinned exceptwhere hereinafter specifically provided.
2. Paint shall not be applied when temperature of the steel surface to be painted is less than 3° C above the dew point or when the weather is frosty/foggy or when the relative humidity is enough to cause condensation on the surfaces to be painted.
3. Paint shall be applied by airless spraying or brushing. The contractor shall make available on-site necessary equipment to measure the thickness of painting coats.
4. Suitable means shall be provided to prevent segregation during the painting operation.
5. Each coat of paint shall cover completely and uniformly the surface being painted and shall be free from runs, sags and blisters.
6. Except as otherwise specifically provided, each coat shall be allowed to dry or harden sufficiently before a succeeding coat is applied.
7. Coverage, application and preparation of various paint materials shall be as follows:

a) Rust Preventive Compound: Rust preventive compound shall be applied by any convenient method which shall ensure coverage of the surface with a heavy uniform coating not less than 0.4mm thick.
b) Cold Applied Coat Tar Epoxy Paint: The contractor shall specifically furnish brand, name of paint and the details of the relevant specifications or accepted standard practice for application procedure. Primer drying time, before first coat of epoxy paint can be given, shall be indicated. Similarly drying time between each successive coat of epoxy paint and its final curing time for a well bonded film as recommended by the manufacturer of paint shall be indicated. Quality/life of this paint after application shall not deteriorate at any ambient temperature from 5°C to 75° C.
c) Zinc Rich Epoxy Primer: Zinc rich epoxy primer shall be applied in two coats by brush or by spray over sand blasted surface. The zinc rich primer shall be stirred properly at regular intervals during applications. Thinning of zinc paste shall be permitted but only with suitable fluid, as directed by the Engineer. The addition of suspension fluid shall not exceed 15 percent. The second and subsequent coats or primer shall not be applied earlier than 24 hours after the application of previous coat.

8.12.5. Cleaning and Repair of Shop Painted Surfaces

Metal works painted in shop or field shall be handled with care so as to preserve the coatings in best practicable condition. Before proceeding with the regular painting or coating operation, the contractor shall clean and repair all areas of shop coat which are defective or damaged areas that are loose, weekly bonded, blistered, abraded, rusted or otherwise defective shall be removed to clean metal by scraping, chipping, power wire brushing or other effective means.Areas thus prepared shall be cleaned of all dust, dirt and other contamination using clean rug and clean solvent. These surfaces shall then be repainted in accordance with the painting schedule and shall be required to pass acceptance tests as specified.

8.13. Transportation

8.13.1. Dispatch and Transportation

1. The transportation of the fabricated shells and accessories from the shop to the site of erection shall be started only after obtaining approval of the Engineer.
2. The safe transport and handling of the steel liner from workshop to the site and from Site store, if any, to the work site shall be done by the contractor. He shall deploy suitable transportation and handling equipment such as lorries, loading and unloading hoists, winches, rails, steel rope, jacks etc.

3. The contractor shall include and provide for spiders, saddles or supports, etc. for securely fastening and protecting the steel liner assemblies in transit so as to avoid any damage to the liner or to thepaint done in shop.
4. The contractor shall be fully responsible for all loss and damage caused by or occasioned by any defect in handling or transportation.
5. All exposed finished surfaces shall be adequately protected against abrasion during transport.
6. Defects, if any, caused to the pipe courses or painting during transportation and handling shall be rectified by the contractor to the satisfaction of the Engineer.

8.13.2. Match Marking and Weight

1. Each part of the steel liner or other auxiliary assemblies shall be legibly marked to show their relative position in the finished marking on each assembly to show top of field/shop vertical, the direction of flow and the serial number shall be made with light steel stamps.
2. The approximate weight of each piece or assembly to be despatched shall be painted as well as indicated in tags attached to the assembly.
3. A list of the weight of assemblies/components despatched by the contractor from shop to the Site of erection shall be submitted to the Engineer simultaneously.
4. In case of high strength quenched and tempered steel, the marking operation which is normally conducted with size rulers, templates, punches and chisels shall not be used.

8.14. Erection

8.14.1. General

1. The steel liners shall be assembled and installed in place inside the tunnel accurately to line and grade as shown on the drawings, and as directed by the Engineer.
2. After successful erection of steel liner assembly/assemblies as per approved drawings, concreting and grouting etc. of steel liner shall be done before erection of next assembly is undertaken.
3. Any timber supports provided for supporting the steel liner shall be removed by the contractor before concreting is undertaken and shall not be permitted to be embedded in concrete.
4. The contractor shall deploy sufficient crews or skilled and unskilled workmen and equipment so that erection of liner and concreting are carried out simultaneously.

8.14.2. Erection Procedure

1. Rail Track:

   The contractor shall install and maintain a rail track to move and to position the pipe sections and leave the rails embedded in secondary concrete with the approval of Engineer, provided the rails are supported on steel pieces. Finger bars and other temporary supports shall be installed in such a way that no deformations are induced on the pipe.

2. Alignment and Welding:
   a) The steel liner shall be installed on Site in correct grade and alignment.
   b) The responsibility for accurate alignment and erection of shells, wyes and bends etc. with reference to the control points rests with the contractor.
   c) Any defects in the alignment of the steel liner shall be rectified by the contractor.
   d) Sufficient finger bars shall be used on circumferential joints to maintain the alignment during the welding operation.
   e) No tack welding shall be allowed in case of pressure vessel quality, high strength quenched and tempered steel.
   f) Field welding inside the steel liner shall be done with back up strip on the outer surface at the joint.

8.15. Tolerances

The tolerances in the alignment and shape of the erected steel liner shall be as mentioned below or specified in other acceptable International Standards.

1. Out of straightness of the shell shall be less than 2L/1000 for the total cylindrical length.
2. The difference between the maximum and the minimum diameter at any cross section of the erected cylindrical length shall be within the limits specified in Para 1.8.12 hereof.
3. iii) For single welded butt joint with backing strip and double welded butt joint with double 'V', the minimum separation of edges of shells to be welded shall not exceed 10mm and 3mm respectively unless otherwise directed by the Engineer.
4. iv) The maximum extra inner and outer thickness of welding shall be less than 3mm.

8.16. Cleaning and Painting in the Field

After erection, concrete back filling and grouting, all temporary fixtures/appurtenances, debris etc. inside the steel liner shall be carefully removed. At least 200mm wide strip of pipe along the field welded joints shall be thoroughly cleaned before painting. The same treatment shall be required at the spots where bars or other temporary steel pieces were installed to facilitate erection of steel liners. The entire interior surfaces of steel liner shall be cleaned and painted as per specifications laid down in para 1.10.0 hereof.

8.17. Drawings Appended to the Bid Documents

The drawings enclosed with the Bid Documents are made a part of the specifications for facilitating the prospective bidders in the preparation of their bids for the work covered under these specifications. These bid drawings are preliminary and not exhaustive and for bidding purpose only subject to improvements/ revisions. Fabrication and erection of steel liner assemblies and accessories shall be done based on fabrication/erection drawings approved by the Engineer. Such fabrication/erection drawings shall be prepared by the contractor and shall be based on the construction drawings issued by the Engineer with additions/alterations and modifications, if any, from time to time during execution of the contract.

8.18. Materials

The materials used in the fabrication and erection of the steel liner shall comply with the specifications as laid down under para 1.4(i)(a) of these specifications. Where materials are not specifically covered by detailed material specifications, the contractor shall furnish the best available commercial grades of materials or articles to the satisfaction of the Engineer.

8.19. Quality Control and Inspection

8.19.1. General

1. The contractor shall maintain a quality control system to the satisfaction of the Engineer which shall establish that all requirements of these specifications including material, fabrication and inspection are fulfilled during fabrication and installation of the steel liner inside the tunnel. This is very important in view of use of Extra High Tensile quenched and tempered steel. The site welding inside the tunnel may have high humidity in addition to difficult working space and ventilation problems. Procedures must be established to thoroughly implement preheating andpost heating, requirement of welds, to facilitate installation work inside the tunnel. The steel liner assemblies need to have required accuracy to reduce defects like circularity, misalignment, angular distortion etc. Procedure of check sheets and inspection records shall be adopted to ensure the quality control as per these specifications. Check sheets and inspection records shall include the following, in addition to any other requirements considered necessary by the Engineer.
    9. At Fabrication shop:
        - Check sheet for gas cutting.
        - Check sheet for bending.
        - Inspection report on shop fabrication.
        - Check sheet for fit-up.
        - Check sheet for material check.
        - Check sheet for dimensions.
        - Check sheet for hydrostatic testing.
        - Radiographic testing records.

10. At Site shop inside the tunnel
    - Check sheet for each pipe assembly.
    - Check sheet for level and alignment.
    - Quality control sheet for welding consumables.
    - Ultrasonic/radiographic testing records.
    - Quality control sheet for repair welding.
    - Inspection report on painting.
    - Inspection report on final dimensions.

2. The contractor shall also follow recommendations, if any, of steel plate manufacturers to ensure quality in welding and erection.
3. Operation of check sheets shall be as follows:

S.No	Site	Sheet	Recorder	Confirmer	Final Confirmer
1	Fabrication shop	Check Sheets	Worker of the contractor	Fabrication staff of contractor	Engineer
		Inspection Recorders	Inspector of the contractor	Q.C. staff of contractor	Engineer
2	Site shop	Check Sheets	Worker of the contractor	Fabrication staff of contractor	Engineer
		Inspection Recorders	Inspector of the contractor	Q.C. staff of contractor	Engineer
3	Installation Site in Tunnel	Check Sheets	Worker of the contractor	Fabrication staff of contractor	Engineer
		Inspection Recorders	Inspector of the contractor	Q.C. staff of contractor	Engineer

8.19.2. Record Retention

The contractor shall have a system for maintenance of radiographs/ultrasonic testing register and manufacturer's data reports to the satisfaction of the Engineer.

8.19.3. Temperature and Humidity Control

Necessary temperature and humidity control shall be maintained during the welding operation in shop as well as in field to the satisfaction of the Engineer. In field, extremely unfavourable conditions like low temperature and high humidity may prevail particularly in case of pressure shaft. Therefore, particular care shall be required to be taken during welding operations in field. For field welding, particularly of extra High Tensile steel liner assemblies inside the tunnel, special care shall be necessary to ensure that absolutely no water is entrapped due to any seepage inside the tunnel, since low hydrogen electrodes are used for welding.

8.19.4. Guarantees and Inspection of Plates

The manufacturer of the pressure vessel steel plates to be used for fabrication of steel liner shells and specials etc., shall be asked by the contractor to furnish necessary mill test certificates etc., in respect of plates to be supplied by them conforming to ASTM-A-537 class-2 and 517 Gr. 'F', 'P' or equivalent international standards etc. and make necessary recommendations with regard to matching filler wire/welding electrodes, pre heat temperature, heat input control and post weld heat treatment etc. The contractor shall examine completely each plate for its soundness in respect of any incipient defects e.g., indentations, roll marks, laminations, and projections etc., and use the same for fabrication only after completely satisfying himself that each plate is suitable for undertaking fabrication and necessary testing thereafter. Overall responsibility for quality control for proper fabrication, erection testing, etc. shall ultimately lie with the contractor.

8.19.5. Inspection/Checking of contractor's work

The contractor shall provide to the Engineer in shop as well as in field, all labour, material instruments and apparatus etc., for checking and testing of work being done or completed by the contractor. Any defects coming to the notice of the Engineer shall be rectified by the contractor till satisfactory results are achieved. Necessary record for such tests or checking of work at various stages of fabrication, erection, and painting and testing shall be maintained by the contractor duly signed by the Engineer. However, this checking of work at various stages, tests tolerances, level etc., by the Engineer, shall not be held to relieve the contractor of any part of contractor's obligation to meet all the requirement of these specifications and drawings, or responsibility for correct fitting and satisfactory operation of the equipment.

8.19.6. Acceptance Tests and Warranty

1. After completion of erection, the steel liner shall be filled with water and its stability and tightness at accessible locations, if any, shall be thoroughly checked to the entire satisfaction of the Engineer.
2. The acceptance, however, shall not in any way absolve the contractor of his responsibility for any damage that may occur to the steel liner or its accessories within the maintenance period.

8.20. Measurements and Payments

8.20.1. Straight Shells, Bends, Wyes and Reducers

1. The measurement for payment and payment for design, supply, fabrication, delivery, hydrostatic testing of the steel liner components namely straight shells, bends, wyes and reducers will be of the length, diameter and thickness of the straight shells, bends, wyes and reducers. The weight of these shall then be computed using weight per m3 of steel as specified in relevant codes.
2. The measurement for payment and payment for installation and erection of the steel liner components namely straight shells, bends, wyes and reducers will be of the length, diameter and thickness of the straight shells, bends, wyes and reducers. The weight of these shall then be computed using weight per m^3 of steel as specified in relevant codes.
3. For the purpose of calculating the weight of the straight reaches of the steel liner, finished lengths of the steel liner including welds will be measured and then weight calculated based on sectional measurements. In such straight reaches where manholes have been provided, deduction will be made for the weight of the plate cut for the manhole opening.
4. For bend, the length along each axis of the curve will be measured and weight calculated there from. Payment for fabrication, delivery, hydrostatic test and erection of the steel liners will be made at the Unit Rates per MT entered in the Bill of Quantities.
5. Unit Rates will include all costs associated with fabrication and delivery to the storage area, erection including the cost of furnishing all paints, equipment, staging, hauling and storage facilities and services, welding of all joints in the pipe shell which makes up the components of the steel liners and corrosion protection of the external surfaces. These unitsrates will also include the cost of all materials, construction facilities, profession and technical services, transport, equipment, labour, assistance in testing and other necessary charges.

8.20.2. Stiffener Rings, Thrust Collars and Backing Strips

For the purpose of calculating the weight of the stiffener rings, thrust collars and backing strips, the thickness, the inner and the outer diameters will be measured.

8.20.3. Manholes

1. The weight of the manholes will be calculated on the basis of the sectional measurement. For purpose of calculating the weight, the heightof the nozzle will be measured at two points, one along the longitudinal axis of the steel liner and the other at right angles to it, and the average of two will be the height of the nozzle. While calculating the weight, no deduction will be made for bolt holes. In case it is not possible to calculate the weight of manhole by sectional measurements, the actual weight of the finished manhole will be taken at the fabrication shop after due calibrations in the presence of the Engineer.

2. ii) The nuts, bolts and gaskets, although to be supplied and fixed by the contractor, will not be paid extra.

8.20.4. Ring Girder Supports

The weight of the ring girder supports will be calculated based on the sectional measurement of each component such as ring girder, spacer plates, columns, flanges, sole plates etc. along with all the accessories. While calculating the weight no deduction will be made for bolt holes. In case it is not possible to calculate the weight of ring girder supports by sectional measurement, the actual weight of the finished ring girder supports along with accessories will be taken at the fabrication shop after due calibrations in the presence of the Engineer. The nuts, bolts, and gaskets etc. although to be supplied and fixed by the contractor will not be paid extra.

8.20.5. Reducers and Matching Pieces

The weight of the reducers will be calculated based on the average of the mean diameters at both sides of the reducers. The weight of the matching pieces between two different thicknesses will be calculated based on average thickness.

8.20.6. Bulkhead

No separate measurement and payment shall be made for design, fabrication, supply, and erection of the bulkhead as these shall be provided to facilitate the hydrostatic testing of bifurcations. The contractor shall include its rates in the Unit Rate per MT of steel liner entered in the Bill of Quantities.

8.20.7. Radiographic & ultrasonic Examination

1. No separate measurement and payment for radiographic and ultrasonic examination will be made. The contractor shall include cost of above examinations in the unit rate per MT of steel liner entered in the Bill of Quantity (Price Schedule).
2. ii) The cost of ultrasonic, dye penetration or magnetic particle inspections of weld, as directed by the Engineer, shall be deemed to be included in the unit rate of steel liner entered in the Bill of Quantities.

8.20.8. Corrosion Protection

The measurement for payment for the supply, surface preparation, application of the interior painting for the steel liner will be made of the surface area painted as specified or directed by the Engineer. The payment for supply and application of the interior coating for the steel liner will be made at the Unit Rate per m^2 entered in the Bill of Quantities. This Unit Rate will include the surface preparation and the cost of the services connected with the work. The cost of de-scaling and supply and application of the cement work will be deemed tohave been included in the cost of the component to which it is applied.

8.20.9. No Measurement for Payment or Payment will be made for the Following:

1. Any Steel liner assembly(s) or components thereof transported without obtaining the approval of the Engineer, shall be at the contractor's own risk and costs.
2. Any steel shells or accessories thereof damaged during transportation, handling or erection in the tunnel shall be replaced or if approved by the Engineer, repaired and re-erected by contractor without any extra cost to Employer.
3. Temporary supports installed by contractor for his convenience and safety of his workmen/equipment during fabrication, transportation and erection of steel liner assemblies and their components.
4. Any type of temporary steel support to be finally embedded in the concrete.
5. The welding operation performance qualification test (i.e., welding, radiographic examination and weld repair etc.) of the welder.
6. Replacement of any defective materials or work.
7. Any fabrication or erection work commenced prior to the approval of the relevant shop/field drawings by the Engineer shall be at the contractor's own risk and cost.
8. The costs of all equipment, labour, materials etc. and all costs of carrying out mechanical testing for production welding tests as per these specifications shall be borne by the contractor and shall be deemed to have been included in the rates tendered for the relevant items in the Bill of Quantities. The record of the production tests shall be furnished in a proper proforma. The radiography of production weld test plates, which meet the requirements, shall be, however, included in the measurement for payment.

8.21. Work and Safety Regulations

Refer work and safety regulations above of Technical Specifications.

1. LIST OF MANDATORY SPARE PARTS

The required Mandatory spare parts for various gates, hoists, cranes and other equipmentas listed below shall be provided. The total price shall be included in the Total ContractPrice.

1.1. Barrage Radial Gates & Hydraulic Hoists

Item	Description/Item	Unit	Qty
1	Rubber seals including fasteners for radial gates.	Set	2
2	Self-lubricating bush and washers for trunnion assembly of radial gate.	Set	1
3	Bush and washers for guide roller assembly of radial gates.	Set	1
4	Set of pump and motor for power pack	Set	1
5	Set of Seals for hydraulic hoist cylinder.	Set	1
6	Bearings for electric motors of hydraulic units.	Set	1
7	Gate connection end bearings & top support bearings of hydraulic hoist.	Set	1
8	Gaskets (O-rings) for hydraulic unit.	Set	1
9	Fuses, auxiliary contactors, push buttons, indication lamps, switches, relays, limit switches, timer/delays for hydraulic hoist	Set	1
10	Filters for hydraulic hoist.	Set	1
11	Control valves, pressure gauge, pressure switches for hydraulic hoist.	Set	1
12	Bearings for electric motors of portable oil filter unit	Set	1

1.2. Barrage Stoplog, lifting beam & Gantry Crane

Item	Description/Item	Unit	Qty
1	Rubber seals including fasteners for complete stoplog set	Set	1
2	Bushes and washers of guide roller assembly of complete stoplog set.	Set	1

3	Brake shoe for different brakes of gantry crane	Set	2
4	Fuses, auxiliary contactors, push buttons, indication lamps, switches and limit switches for gantry crane.	Set	1
5	Bearings for electric motors for gantry crane	Set	1
6	Bearings/bushes for gantry crane	Set	1
7	All types of grease nipples	Set	1
8	Wire rope for Hoist of gantry crane	Set	1

1.3. Electrically operated Lifting Beam

Item	Description/Item	Unit	Qty
1	Bearing/bushes for lifting beam including guide rollers	Set	1
2	All types of grease nipples	Set	1

1.4. Intake Emergency Gate & Rope Drum hoist

Item	Description/Item	Unit	Qty
1	Rubber seals including fasteners for intake emergency gate.	Set	1
2	Complete Wheel assembly for intake emergency gate	No.	1
3	Bearings/bushes for rope drum hoist including motors.	Set	1
4	Brake shoes for rope drum hoist	Set	1
5	Fuses, auxiliary contactors, push buttons, indication lamps, switches, limit switches and relays for rope drum hoist	Set	1
6	Wire Rope for hoist	Set	1

1.5. Intake Service Gate & Rope Drum hoist

Item	Description/Item	Unit	Qty
1	Rubber seals including fasteners for intake service gate.	Set	1
2	Complete Wheel assembly for intake service gate	No.	1
3	Bearings/bushes for rope drum hoist including motors.	Set	1
4	Brake shoes for rope drum hoist	Set	1
5	Fuses, auxiliary contactors, push buttons, indication lamps, switches, limit switches and relays for rope drum hoist	Set	1
6	Wire Rope for hoist	Set	1

1.6. Surge Shaft Gate and Rope Drum Hoist

Item	Description/Item	Unit	Qty
1	Rubber seals including fasteners for Surge Shaft gate.	Set	1
2	Complete Wheel assembly for Surge Shaft gate	No	1
3	Bearings/bushes for rope drum hoist including motors.	Set	1
4	Brake shoes for rope drum hoist	Set	1
5	Fuses, auxiliary contactors, push buttons, indication lamps, switches, limit switches and relays for rope drum hoist	Set	1
6	Wire Rope for hoist	Set	1

1.7. Draft Tube Gate & Rope Drum hoist

Item	Description/Item	Unit	Qty
1	Rubber seals including fasteners for draft tube gate.	Set	1
2	Complete Wheel assembly for draft tube gate	No	1
3	Bearings/bushes for rope drum hoist including motors.	Set	1
4	Brake shoes for rope drum hoist	Set	1
5	Fuses, auxiliary contactors, push buttons, indication lamps, switches, limit switches and relays for rope drum hoist	Set	1
6	Wire Rope for hoist	Set	1

1.8. Fish Pass gate & Screw hoist

Item	Description/Item	Unit	Qty
1	Rubber seals including fasteners for intake emergency gate.	Set	1
2	Bearings/bushes for screw hoist	Set	1

1.9. Instrumentation and Remote Control

Item	Description/Item	Qty
1	Time Synchronizing network cables with connectors	1 set
2	Power supply modules/unit and cards- type/model used	1 sets of each used type
3	Network Interface Cards of type/model used	1 sets of each used type
4	Operator Workstation complete with all accessories	1 set.
5	Data storage drives of each type/model used	1 set.
6	Modem each type	1 set.
7	Repeaters of type/model used	1 set of each type
8	Recorder	1 set each type used
9	Sensors /transducers	1 set of each type
10	Indicating instruments	1 set of each type
11	Sensor/pressure transducer, Limit/proximity sensors, shaft encoder for Rope drum hoist for draft tube gate	
12	Batteries	
12.1	Battery cells	Four (4) nos. for 110 V system
12.2	Vent plugs/ caps/ connectors/ hardware	1 set
12.3	Inter cell connectors	1 set
13	Distribution boards	
13.1	Circuit breaker	1 set of each type
13.2	Indicating lamps	1 set of each type
13.3	Control switch and supervision relays	1 no.
14	Battery charger	
14.1	Ammeters and voltmeters	2 nos each type used
14.2	Shunt resistor	2 nos each type used

14.3	Diode/thyristor module	2 sets of each type used
14.4	Printed circuit cards	2 no. of each type used.
14.5	Semi Conducting fuses	20% of each type used
15	UPS	
15.1	MCCB	2 nos of each type used
15.2	Thyristor Bridge	2 sets
15.3	Printed circuit cards	2 sets of each type used
15.4	Circuit breaker and auxiliary contact	2 set of each type used
15.5	Cooling fan	1 nos
16	Each type of contactors/relays	2 set of each type used .
17	Fuse elements of each type	2 set of each type used .
18	Position indicator and position transducer for Radial gates	1 Set
19	Position indicator and position transducer for Intake Emeregncy gate for intake	1 Set
20	Position indicator and position transducer for intake gates	1 Set
21	Shaft encoder for rope drum hoist of bulkhead gates for intake	1 Set
22	Shaft encoder for rope drum hoist of intake gates	1 Set
23	Complete motor drives of each type	1 No.

2. LIST OF MANDATORY MAINTENANCE & ERECTION TOOLS AND TACKLES

S. No.	Description	Qty.	Unit
1	**Each set comprising of the following items/ instruments/equipment:**		
1.1	Torque wrench (0-150-inch pounds) 3/8-inch square drive.	2.00	
1.2	Pipe wrench 12 inches	2.00	
1.3	3/8 inch to 1/2-inch square drive reducer.	2.00	
1.4	Screwdriver socket 1/2-inch square drive	2.00	
1.5	Sockets 1/2-inch square drive		
i	7/16 inch	2.00	

ii	9/16 inch	2.00	
iii	5/8 inch	2.00	
1.6	Extensions ½ inch square drive		
i	2 inches	2.00	
ii	5 inches	2.00	
1.7	Combination wrench one end ring and one end open		
i	7/16 inch	2.00	
ii	1/2 inch	2.00	
iii	9/16 inch	2.00	
iv	3/4 inch	2.00	
v	7/8 inch	2.00	
vi	15/16 inch	2.00	
1.8	Screw drivers		
i	4 inches	2.00	
ii	6 inches	2.00	
iii	8 inches	2.00	
iv	12 inches	2.00	
v	15 inches	2.00	
1.9	Feeler gauge 4 inches long consisting of many strips	2.00	
1.10	Nose pliers – 150 mm	2.00	
1.11	Circlip removing pliers 200mm	2.00	
1.12	Combination pliers 200 mm	2.00	
1.13	Cutting Pliers	2.00	
1.14	Heavy duty insulated pliers	2.00	
1.15	Tweezers (small)	2.00	
1.16	Plastic hammer	2.00	
1.17	Half-moon spanner 3/8 inch * 5/8 inch	2.00	
1.18	Allen key set	2.00	
1.19	Ball-pein Hammer 2lb	2.00	

1.20	Hammer 5lb	2.00	
1.21	Mallet (Wooden Hammer)	2.00	
1.22	D.E. spanner set 6mm to 32 mm	2.00	
1.23	Ring spanner set 6 mm to 32 mm	2.00	
1.24	Box spanner with handle	2.00	
1.25	Adjustable Spanner 12 inches	2.00	
1.26	Adjustable spanner 6 inches	2.00	
1.27	Socket spanners set 8 mm to 32 mm	2.00	
1.28	Lineman's pliers 8 inch	2.00	
1.29	Spirit level	2.00	
1.30	Soldering iron 15W	2.00	
1.31	Wire stripper cum crimpling tool	2.00	
	All items 1.1 to 1.31, shall be of Taparia / Jhalani / Cuttler hammer/ any other make only if approved by owner.		
2	**One set comprising of following items / instruments / equipment**:		
2.1	Digital clamp meter 500V AC/DC, 20Amp AC/DC including Continuity tester and line tester	2.00	
2.2	D Shackle 1t capacity	2.00	
2.3	D Shackle 2t capacity	2.00	
2.4	Chain Pulley block 2t capacity	2.00	
2.5	Chain Pulley block 5t capacity	2.00	
2.6	Bearing puller	2.00	
	Item 2.1 shall be of Fluke / MECO / any other make only if approved by owner and Items 2.2 to 2. 5 shall be of Indef / any other approved make by owner and Item 2.6 shall be of SKF/ any other make to be approved by owner.		
	Tool boxes for above 1 & 2 (shall be of good quality).		