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Government of Nepal
Ministry of Energy, Water Resources and Irrigation
ALTERNATIVE ENERGY PROMOTION CENTRE

NEP: South Asia Sub regional Economic Cooperation Power System Expansion Project
(SASEC/ADB)

ADB Project No: 44219, Loan No: 3139 NEP (SF), Grant No: 0398NEP (EF)

Bidding Document
for
Procurement
of

Saniveri Uttarganga Mini Hydro Subproject, 998kW

Putha Uttarganga Rural Municipality,

East Rukum District, Nepal

(Package 1- Generation)

PART II Requirements

Section 6 – Employer's Requirements (ERQ)

Section 6 – Employer's Requirements

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I. Specifications

[Attached Separately]

II. Drawings

[Attached Separately]

III. Supplementary Information

(Regarding Works to Be Procured)

[Attached Separately]

IV. Personnel Requirements

Using Form PER-1 and PER-2 in Section 4 (Bidding Forms), the Bidder must demonstrate that it has personnel who meet the following requirements:

No.	Position	Qualification	Total Work Experience [years]	Experience In Similar Work [years]
1	Project Manager	Master's degree in Engineering or Bachelor's in Engineering	5 years 7 years	2 Years
2	Civil Engineer	Bachelor's in Engineering	3 years	1 Year
3	Electrical Engineer	Bachelor's in Engineering	3 years	1 Year
4	Mechanical Engineer	Bachelor's in Engineering	3 years	1 Year

V. Equipment Requirements

Using Form EQU in Section 4 (Bidding Forms), the Bidder must demonstrate that it has the key equipment listed below:

No.	Equipment Type and Characteristics	Minimum Number Required
1	Excavator	1
2	Vibrator	2
3	Concrete Mixture	1
4	Tractor	1
5	Roller	1
6	Tipper	2

Scope of Works

The works to be executed under the Contract which shall include construction, installation, testing, completion and maintenance of such works, but not limited to, are prescribed below:

(1) **Infrastructure Works**

- Employer's Camp, Providing Office Space and equipment to Employer and Facilities including Electrification, Water Supply & Sanitary & Drainage Works, Fencing, Protection Works etc.
- Supply, Installation, Operation & Maintenance of Complete Site Communication System
- Operation & maintenance of Construction Power for the project.

(2) **River Diversion Works and Construction of Headworks Waterway and Powerhouse Structures**

1 Location

Province	:	5
District	:	Rukum East
Gaupalika	:	Putha Uttarganga Rural Municipality (Ward No.11)
Project Boundary	:	28°34' 30" to 28°35'10"N 82°48'50" to 82°49'20" E.

2 General

Name of River	:	Uttarganga River
Nearest Town	:	Rukumkot
Type of Scheme	:	Run of River
Gross Head	:	55.0 m
Installed Capacity	:	998 KW
Beneficiary household (Project Area)	:	5039 HH

3 Hydrology

Catchment Area at Headworks Site	:	420.50 km ²
Mean Monthly Annual Flow	:	16.28 m ³ /s
Design Discharge (Q90%)	:	2.40 m ³ /s
Design Flood (1 in 100 year)	:	477.33 m ³ /s
Compensation flow	:	0.226 m ³ /s

4 Diversion Weir

Type	:	Free Flow Sloping Gravity weir
Length	:	30 m
Crest level	:	El. 2171.0 m
Flood Level at 100 Year Flood at weir	:	El. 2175.0 m
Length of Stilling Basin	:	24.0 m

5 Undersluice

Type	:	Rectangular Orifice
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Size	: 2.5 m x 2.5 m
Invert level	: El. 2168.50 m
6 Intake	
Type	: Side Orifice
No of Orifice	: 2 No.
Size of Opening	: 1.7 m x 1.0 m
Intake Invert Level	: El. 2169.70 m
7 Gravel Trap	
Section	: Rectangular bottom RCC
Size (W x H)	: 4.0 m x 3.6~2.80 m
Length	: 8.0 m
8 Approach Box Culvert	
Section	: Rectangular RCC Box Culvert
Size (W x H)	: 1.5 m x 1.5 m
Length	: 140.2 m
Bed Slope	: 1 in 500
9 Settling Basin	
Type	: Hopper Type, Intermittent flushing, RCC
Size (L x B x H)	: 35 m (effective) x 4.0 m x 2.32~3.22 m
Number of Bay	: 2 No.
Nominal size of trapped particle	: 0.2 mm
Flushing Canal	: 9.6m (L) X 0.5m (B) X 0.6m (H)
10 Headrace Canal	
Type	: Rectangular RCC
Size	: 1.5m (W)X 1.5m (H)
Length	: 492.m long
Bed Slope	: 1 in 500
11 Forbay	
Type	: Rectangula RCC
Size	: 13m (L) X 6m (B) X 4.5m (H)
Headpond size	: 5m (L) X 6m (B) X 5.5m (H)
Flushing Pipe	: 3nos of 44m length and 0.45m dia HDPE pipe
12 Penstock Pipe Alignment	
Type	Mild Steel Pipe
Size	: 1.1.m dia Main pipe and 0.85m dia branch pipe
Thickness (Main Pipe)	5mm thick of 94.15 m Length
	: 6mm thick of 156.86 m Length
	8 mm thick of 41.52 m Length
Thickness of Brach Pipe	10mm thick of 25.5m Length
Total Length of pipe	292.53m Main and 25.5m Branch Pipe

	No. of Anchor Block	: 9 Nos.
13	Powerhouse	
	Type of powerhouse	: Surface Type, Frame Structure
	Size (L x B x H)	: 19.9 m x 9.0 m x 7.25 m
14	Tailrace Conduit	
	Type	: Rectangular RCC Structure
	Size (L x B x H)	: 36.0m x 1.2 m x 1.5 m
16	Turbines	
	Type	: Horizontal Shaft Francis Turbine
	Design Discharge	: 2.4 m ³ /sec
	Rated Output (Mechanical)	: 590 KW X 2 units
	Synchronous Speed	: 750 rpm
	Rated Net Head	: 50.12 m
	Rated Efficiency at 100% Discharge	: 89%
17	Generators	
	Type	: Synchronous AC 3 phase, Horizontal Shaft
	Max Rated Capacity	: 650 kVA
	Rated Efficiency	: 95%
	Rated Voltage	: 0.4 kV
	Number of Poles	: 8
	Speed	: 750 rpm
	No of units	: 2 Nos.
18	Governor	
	Type	: Electronic, PID Oil-hydraulic, self-closing without electric power
	No of units	: 2 Nos.
19	Transformer	
	A. Power Transformer	
	Type	: 3-phase, oil immersed, copper owned Step up
	Rated capacity	: 1500 kVA Three Phase x 1
	Voltage ratio	: 0.4/11 kV
	Efficiency	: 98%
22	Load Center	
	Putha Uttarganga RM (Ward no 1 to 14)	: 5039 HH
23	Power and Energy	
	Installed Capacity	: 998 kW
	Average Annual Deemed Energy	: 7.196 GWh

Dry Energy (Poush to Chaitra) : 2.992 GWh
Wet Energy : 4.204 GWh

(3) Hydro-mechanical Works

The supply shall include, but not limited to design, manufacture, quality assurance and delivery to Site, erection, installation, testing commissioning and guarantee services and remedying of defects for all equipment as specified in the Technical Specifications.

In addition, the Contractor shall provide training to the Employer's personnel as required, to establish a well-trained operation and maintenance crew.

If the specifications and/or drawings of this Bidding Document do not contain particulars of materials or works which are obviously necessary for the proper and safe completion, operation and maintenance of the equipment in question, all such materials and works shall be deemed to be included in the supply.

The following equipment shall be supplied under the contract:

SN	Description	Unit	Qty.	Size (W x H) m	Type
1	Stop log for Undersluice	Set	1	2.5 x 2.5	Vertical lift slide with guide frame hoists and accessories all complete set (2 Nos) with Manual Operated System
2	Intake Gate	set	2	1.7 x1.0	Vertical wheel type with guide frame hoists and accessories all complete set with Electrical Operated System
3	Coarse trash rack Intake Gate with 16 Dia bars @ 100 c/c spcing	set	2	1.7 x 2.5	Trash rack with supporting beam and accessories all complete set.
4	Undersluice Gate	Set	1	2.5 x 2.50	Vertical wheel type with guide frame hoists and accessories all complete set with Electric Operated System
5	Settling Basin Inlet Gate	Set	2	1.2 x 1.5	Vertical wheel slide with guide frame hoists and accessories all Complete set with Electric Operated System.
6	Settling Basin flushing Gate	Set	2	0.5 x 0.5	Vertical wheel slide with guide frame hoists and accessories all complete set with manual operated system
7	Settling basin outlet gate	Set	2	3.5 x 1.5	Vertical wheel slide with guide frame hoists and accessories all Complete with Electric Operated System.
8	Fine Trash Rack at Forebay	Set	1	6.0 x 3.30	Trash rack with supporting beam and accessories all Complete Set
9	Forbay Inlet Gate	Set	1	1.5 x 1.5	Vertical wheel slide with guide frame hoists and accessories all complete set with Electric operated system
10	Stop log for Tailrace	Set	1	1.20 x 1.00	Vertical wheel slide with guide frame hoists and accessories all complete set

11	Butter Fly Gate Valve with 400 Dia.	Set	1	400 Dia.	400 Dia Butter Fly Gate Valve with all complete set.
12	Gravel trap Flushing Sluice Valve of 500 Dia	Set	1	500 Dia	500 Dia Flushing Sluice Valve with all fittings and other accessories all complete set

4. Electro-mechanical Works

The supply shall include, but not limited to design, manufacture, quality assurance and delivery to Site, erection, installation, testing, commissioning and guarantee services and remedying of defects for all equipment as specified in the Technical Specifications.

In addition, the Contractor shall provide training to the Employer's personnel as required, to establish a well-trained operation and maintenance crew.

If the specifications and/or drawings of this Bidding Document do not contain particulars of materials or works which are obviously necessary for the proper and safe completion, operation and maintenance of the equipment in question, all such materials and works shall be deemed to be included in the supply.

The following requirement of equipment shall be supplied under the contract:

- All the equipment shall be new, durable to withstand long time use, and shall satisfy all requirements, which a complete product should generally meet even if such are not expressly provided in the specifications.
- All the equipment shall be of a convenient construction for disassembling, inspection and erection. All surfaces of water passages shall be of even smooth finish turbulence.
- The Contractor shall furnish installation materials as specified in the Technical Specifications.
- Conductors shall not be joint by soldering except where absolutely unavoidable
- Inductions motors shall be of the direct line starting, open guarded type, and when operated, shall not develop trouble under voltage fluctuation of +/-10%. Neither shall they exhibit any trouble at rise in voltage and frequency of power source by 30% and 40% respectively, resulting from the full load rejection of the turbine generator.
- Magnetic contractors used in various switches shall be made of arc resistant metal and have sufficient capacity against inrush current and the contact part shall be free from over-wearing and miscontact for a reasonable period of service.
- AC control circuits shall be designed for operation at 100v. Thereby the Contractor for the relevant control system shall provide 400/110V auxiliary transformer.
- The Contractor shall furnish a complete set of anchor bolts and foundation bolts as necessary for the equipment.
- The relays (Control relays, Protection relays and auxiliary relays) and meters shall be suitable for the control system.
- The cubicles for the Equipment shall be provided with group fault indicator, unless otherwise provided in the specifications. When any trouble is detected, the trouble shall be distinguished on this indicator and contacts shall be provided in the indicator and control on the cubicle.
- Cubicles shall be provided with a fluorescent light (230V AC, 1ph. 50Hz) inside for interior lighting, and shall be provided with a door switch and a moisture-preventing heater (230V AC. 1ph. 50Hz).
- The bushings, insulators and porcelain housing used in the equipment shall have sufficient mechanical and electrical strength and shall meet the requirements of relevant standards.

- The ground terminal of the equipment shall be provided and be suitable for hard drawn copper stranded conductor. All grounding works shall be done with hard drawn copper.

5. Preparatory Works

The Bidder shall visit and examine the project site and its' surrounding to obtain for himself, on his responsibility, all information that may be necessary for preparing the Bidding and entering into a contract. The costs of visiting the site shall be at their own expense.

Likewise, the Contractor shall also construct temporary roads to various sites such as to the quarry sites, camp, storage yards and other project structures and such cost shall not be separately paid to the Contractor and shall be deemed to be included in the respective items of the Bill of Quantities. Temporary access road to the various sites requires frequent repair and maintenance especially at river crossings. These costs shall be deemed included the respective items of the Bill of Quantity.

6. PROGRESS

Progress Report

The Contractor shall, before the seventh (7) day of each calendar month and quarter submit two (2) copies of monthly progress report and quarterly progress report in a format acceptable to the Employer/Engineer detailing the progress of the work accomplished during the preceding month and quarter. The report shall contain but are not limited to the following:

- (a) A general description of the work performed during the reporting period on each maintenance activity to include any notable problems which were encountered.
- (b) The total overall percentages of project works completed as well as scheduled by the CPM network as of the end of the reporting period, with appropriate comments in writing to explain any differences.
- (c) The percentages of each work activity completed as well as scheduled during the month or quarter, with appropriate comments in writing to explain any differences.
- (d) A list of all activities of scheduled progress or actual progress during the reporting period including the Contractor's actual or forecast start date versus scheduled start date, and the actual or forecast completion date versus scheduled completion date for each activity, with appropriate remarks in writing to explain any differences.
- (e) In case of monthly report, a list of activities scheduled to be started within the next 3 months, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the CPM Network, an explanation is to be given.
- (f) A list of local manpower (by trade classification) employed during the reporting period.
- (g) A list of expatriate personnel (by position) employed during the reporting periods.
- (h) A list of the Contractor's Equipment and materials presently located at the Site. Also a list of equipment and material which are arriving at the very near future
- (i) Photographs of the type called for in Sub clause (2) herein under.
- (j) Total quantities of concrete poured, fill materials placed, excavation, etc, during the reporting period.
- (k) Main items of temporary facilities constructed during the reporting period.
- (l) A statement detailing the status of progress on the overall program and how to regain any lost time or set -backs which may have occurred.
- (m) A listing of dead lined (inoperable) equipment, action being taken to get it back in operation and the estimated date for the work to be completed.

- (n) A statement about labor relations and an explanation of any actual or potential problems.
- (o) A listing of each accident involving the hospitalization and/or death of any person.
- (p) A statement concerning the effectiveness of the security program and a listing of any major thefts.
- (q) A listing of the amount and date of each payment received as of the reporting period and the amount of any monthly invoice which has been submitted but not yet paid.
- (r) A list of claims (if any) submitted during the reporting period to include claim amounts on cost and extension of time.
- (s) A statement concerning foreseeable problem areas and recommendations about how they should be resolved.

The cost of the above works shall be deemed to be included in the BoQ (Bidding Price).

Progress Photos

The Contractor shall, throughout the Contractual period, submit to the Employer/Engineer progress color photographs which clearly show the work progress being made. The photographs shall be taken at the start, during and at the completion of each major component of the work and at other times and places as directed by the Employer/Engineer. The photographs to be submitted to the Engineer shall be attached to the monthly progress report specified in this Clause (6) (i) hereinabove.

A brief description of the subject and date taken will be listed for each photograph, the size of post card. If additional prints are required by the Engineer or the Employer, the Contractor shall submit them. The cost of such photographs shall not be paid separately and shall be deemed to be included in the Contract Price.

The Digital copy of the photographs shall be the property of the Employer and no print from these digital copy shall be supplied to any person unless so authorized by the Employer.

Upon completion of the Project, the Contractor shall submit all of the digital Copy to the Employer in a booklet form arranged chronologically and marked for identification. The Contractor shall also submit three (3) sets, of color photographs adequately edited and in a booklet form showing the entire sequence of the work from start to finish.

PART II- I.B: TECHNICAL SPECIFICATION FOR CIVIL WORKS

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CHAPTER - 1

1. GENERAL PROVISIONS

1.1 Scope of Works

The Contractor shall carry out the following works for the construction of **Saniveri Utarganga Mini Hydro Subproject** including all surface civil works viz river diversion & protection works, diversion weir with stilling basin, side intake, gravel trap, approach canal and spillway, settling basin, civil works of Headrace Pipe, Surge pipe and penstock alignment, retaining structures saddle supports, anchor blocks, powerhouse, civil works in switchyard, Tailrace, river training, temporary diversion, employer's camp and associated facilities etc. of the project.

1.2 Cutting Trees in Project Area

Contractor shall not cut any trees on the Site until permission has been given by the Employer.

The Contractor shall submit to the Employer, at least 21 days before the commencement of construction, a written request with a detailed drawing showing the trees to be felled together with the outlines of the relevant temporary or permanent structures.

Along with the drawing, the Contractor shall submit details as to when the trees must be cut to maintain the schedule.

The Employer shall be responsible for liaising with and obtaining all necessary licenses for tree cutting from the GON, Department of Forestry or Community Forest User's committee.

1.3 Tidiness of Site

The Contractor shall be responsible for the proper upkeep and maintenance of the Site and the works and shall remove rubbish garbage and other waste as it accumulates from the Site.

Materials and equipment shall be positioned, stored and stacked in an orderly manner.

1.4 Levels and Reference Points

The datum point for co-ordinates and levels shall be the permanent benchmarks as indicated on the Drawings.

The Contractor shall satisfy himself that the existing ground levels as indicated on the Drawings are correct. Should the Contractor wish to dispute any levels he shall submit to the Engineer a schedule of the position of the levels considered to be an error and a set of revised levels. The existing ground relevant to the disputed levels shall not be disturbed before the Engineer's decision as to the correct levels is given.

1.5 Survey and Setting Out

The Contractor shall install all level and survey stations required. Such stations shall be of robust construction, protected against damage and the influence of movement that may arise from the execution of the works.

The Contractor shall check the condition and re-survey the survey stations at a certain intervals during the progress of the works.

The Contractor shall provide the Engineer with the location and description of all survey stations, the results of surveys and all calculations. Where required, he shall give adequate opportunities for the Engineer to check such stations prior to their use.

The degree of accuracy employed in the survey and setting out shall be such as will allow the alignment, levels and dimensions specified for the works to be achieved.

The Contractor shall ensure that all surveying equipment used for the works is of appropriate accuracy, is properly maintained and that the equipment complies with the manufacturer's specification for accuracy. If requested, he shall give adequate evidence to the Engineer that the calibration of the surveying equipment has been confirmed.

1.6 Standby Equipment

The Contractor shall provide sufficient spares and standby equipment, in particular with respect to concrete mixing and transportation plant and dewatering plant to ensure completion of crucial operations such as continuous pouring of concrete in case of breakdown of duty equipment.

1.7 Works Affecting Watercourses

The Contractor shall notify the Engineer 7 days in advance of his intention to start any part of the works affecting a river course.

Diversions

The Contractor shall plan, design, construct and maintain all necessary diversion works including cofferdams, channels, flumes, drains and sumps and any other temporary diversion and protective works.

The Contractor's plan for the diversion and care of the river shall be subject to the approval for the Engineer, but such approval shall not relieve the Contractor of the full responsibility for the adequacy of the diversion and protective works. Any hydrological data made available to the Contractor is solely for the purpose of guidance, and the Employer does not guarantee the reliability or accuracy of any such data.

After having served their purpose, all cofferdams or other temporary protective works shall be removed or levelled in a manner satisfactory to the Engineer so as not to interfere in any way with the normal flow of the river or with operation or usefulness of the works.

Dewatering

The Contractor shall provide, install, maintain and operate all necessary pumping and other equipment for dewatering the various parts of the works in order to keep the excavations, foundations and other parts of the works free from water as required for constructing each part of the works.

The Contractor shall be responsible for maintaining watercourses within the Site in effective working condition at all times.

1.8 Explosives Handling

The Contractor shall make all arrangements for the procurement, importation, transportation, storage, guarding, and use of all explosives if deemed inevitable for the execution of the project. The Employer shall assist the contractor in getting government approval and liaise with government authorities in acquiring permission to procure, transport, store and use of explosives for the execution of the work.

Transportation to the Site

The Contractor shall pay all costs of purchasing, transporting, storing and using of explosives for the project. However, the Contractor shall not be responsible to pay the Employer or his representative's staff including the Engineer who will assist the Contractor while procuring, transporting, storing and using of explosives.

Explosives Bunkers

The Contractor shall construct a bunker of sufficient space to contain up to one week's use of explosives at the Site. The location of the each explosives magazine on the Site shall be approved in writing by the Engineer.

Accommodation for Security Personnel

The Contractor shall construct temporary accommodation and facilities at the Site for use by the explosives security personnel. Details of required facilities to be agreed by the commander of the security personnel before construction begin.

Records of Explosive

The Contractor shall solely responsible for keeping all records of explosive consumed and stored. Register shall be maintained at bunker and each site showing date, location, amount of explosive and detonator, purpose, name and signature of responsible persons. Where required, the Contractor shall give adequate access for the Engineer to check the records.

1.9 Management Meetings

Site meetings will normally be held weekly but will be called for whenever the progress of the works so requires, or when required by the Engineer. On behalf of the Contractor, the Contractor's Representative who shall be the powers to commit the Contractor in all matters concerning the Contract shall represent all meetings.

Other management meetings will be held in Kathmandu as required.

1.10 Site Diary

The Contractor shall keep a Site diary wherein full details of all work carried out each day (each shift if more than one shift of work) shall be recorded. The diary shall be available for inspection by the Employer or Engineer at any time during normal office hours. At least the following details shall be included:

- location of the various works undertaken
- type and quality of work achieved
- equipment and plant that arrive on site
- number of employees and plant working
- tests carried out and results
- weather conditions
- accidents
- visitors to the Site
- Photographs of major activities and events
- interaction with local people

1.11 Reference to other Sections

Throughout the Specification references are occasionally made to other Sections. All such references are intended solely for the convenience of those using the documents, and the absence of a reference in no manner excludes the application of every other Section in the Specification, which may have any bearing upon the point in question. The intention being that the Contract Documents shall be read and applied as a whole.

CHAPTER - 2

2. EARTHWORKS AND EXCAVATION

2.1 Site Clearance

This work shall consist of clearing, grubbing and stripping the area of the work within the limits of the site as defined in the drawings and ordered by the Engineer for all trees, stumps, bushes, roots, down-timber, rotten wood, rubbish, debris, humus, swamp material and any other vegetation of unacceptable material.

It shall include the removal of buildings, foundations, fences, retaining walls and other obstructions interfering with the proposed work, salvaging such of these material as may be designated by the Engineer, and burning or otherwise disposing of the spoils in a manner satisfactory to the Engineer before work starts and mutually agreed upon in a protocol and layout plan.

Materials suitable for use of any kind may be separated by the contractor, if so approved by the Engineer. All other materials shall be placed or handled as described hereinafter.

The contractor shall perform the work of clearing, grubbing and stripping to remove the material herein specified. If he chooses to remove the waste material suitable for incorporation into or use on the work, the amount of suitable material shall be replaced by the contractor at his expenses. All material removed by the cleaning, grubbing and stripping operation shall be removed from the site or burned or otherwise disposed as directed by the engineer. Care shall be exercised to see that the burning of such material does not destroy or damage public or private property, and the contractor shall be fully responsible for any destruction, damage or nuisance.

Living trees outside of grading limits shall be cut only as specified or directed by the Engineer and all branches of trees extending into the limits shall be trimmed carefully to give a clear height as required over the site.

Within areas where excavation or filling is to be carried out, the ground shall be cleared for all living or dead trees, and stumps and root mats shall be removed to a depth of not less than 0.3 m below the surface or a depth as directed by the Engineer. With the exception of areas to be excavated, all depressions made, below the ground surface by the removal of stumps or roots shall be refilled with suitable material and compacted to the satisfaction of the Engineer. No grubbing and stripping operation will be required in disposal areas and in areas to be excavated, unless the excavated materials shall be used in permanent fills or cofferdam.

Measurement and Payment

Clearing grubbing and stripping executed outside the limits indicated on the drawings without written order from the Engineer will not be paid to the Contractor.

All areas cleared, grubbed and stripped will be paid according to square meter of required area covered by the design and as mentioned in BOQ

Feelings of trees will be paid according to the actual number of trees of different trunks diameter measured 0.30 m or above.

2.2 Open Cut Excavation

2.2.1 General

Excavations shall be executed as specified in the sub chapter and in accordance with the lines and slopes shown on the Drawings, or as indicated by the Engineer. During the progress of the work, it will at times be necessary or advisable to alter the slopes or the dimensions of the excavations shown on the Drawings. Any increase or decrease of the excavated quantities

resulting from the above mentioned alternations will not affect the unit prices of the excavation, which shall be executed by the Contractor at the unit prices of the contract for each one of the excavation items.

Excavations shall be done to the required dimensions and shall be finished according to the specified lines and slopes, in a way acceptable to the Engineer. All necessary precautions shall be taken to cause the minimum possible alternation or disturbance to the material lying under and adjacent to the excavation final lines.

Method

The Contractor shall carry out his operations in such a manner as to avoid damage to, or deterioration of, the Final Surfaces of excavations.

Unless otherwise directed, prior to the work the Contractor shall submit to the Engineer details concerning the methods and equipment proposed for each section or type of open cut excavation, including support methods, drilling and blasting patterns as appropriate.

The sides of excavations shall be adequately supported at all times or may be battered as described in the Contract or permitted by the Engineer.

Final surface

If the Contractor encounters ground in the Final surface which he considers unsuitable, or if the Final surface is damaged or allowed to deteriorate, the Engineer shall be promptly informed.

Excavation shall be carried out to the lines, levels, slopes and dimensions as shown on the Drawings or as directed by the Engineer. Any excavation in excess of such dimensions or instructions shall be made good with suitable, well-compacted material or concrete as directed by the Engineer.

In general excavation tolerance shall be within ± 50 mm unless specified on the Drawings.

When the excavation has reached the lines and grades required, the Contractor shall notify the Engineer. No excavation shall be backfilled or covered in any way until the Engineer has given his approval.

2.2.2 Soil Classification

The classification of excavated material is declared at Bill of Quantities of the concerned are as per design, levels and geographical investigation done at site.

The classification of the excavated material shall be determined by the Engineer. The Contractor shall inform the Engineer when excavation is to take place in material other than prescribed only if there is more than $\pm 20\%$ variation in the classification in total works with proof verified by site engineers.

Soft Rock

It shall mean rock comprising any of the following:

Lime stone, sand stone, late rite, soft conglomerate or other soft or disintegrated rock which can be quarried or split with crowbars or wedges. Unreinforced Portland cement concrete which can be broken up with crowbars or picks; stone or brick masonry in cement mortar below ground level.

Hard Rock

Hard Rock means solid rock which can be removed only by explosives, barring, wedging or other recognized and approved methods of quarrying solid rock, and shall furthermore mean excavation of all existing concrete and masonry blocks in cement mortar.

Boulder Mix Soil

Excavation which can be carried out manually without blasting is categorized in this group which generally forms from the alluvial deposit of the River or formed in the floodplain in shallow depth of deposit above bedrock including boulder which can be removed without using explosives in the field.

Soft Soil

Excavation which can be carried out with simple excavating equipment and there are rare occurrence of boulder is categorized in soft soil group e.g. at the field or abandoned Terrance of cultivated land. Alluvial deposits, weathered rock mass and disposal site or embankment movement shall all be counted as soft soil.

Whatever mentioned in the definition, the site engineer and geologist at site shall determine the type and will be final, only the variation of more than 20% in total excavation price in the complete works shall only be entertained from such changes in rock classification.

2.2.3 Over Excavation

If somewhere, and for any reason, excavations are executed beyond the established lines and without the Engineer's previous approval, the Contractor shall backfill with rubble concrete or other approved materials at his own expense, the volume corresponding to over-excavation. He will not receive any payment for over-excavations not approved or the back-filling thereof.

Cavities or over-excavation at the bottom or at the sides or rock excavations against which concrete is to be placed, whether due to lack of care on the part of the Contractor when making the excavation or due to the removal of materials damaged through and excess or explosives when effecting the blasting or by the use of unsuitable excavation system, with the Engineer's approval, shall be fully backfilled at the Contractor's expense, with concrete of the same quality as the concrete of the structure to be erected in this place.

2.2.4 Backfilling

Foundations and structures shall be backfilled with approved material compacted in layers by suitable equipment until optimum stability has been obtained to the satisfaction of the Engineer. Compacting shall be carried out with special care by means of pneumatic or mechanical tampers or other compactors of a type previously approved by the Engineer to avoid damage structures.

Surfaces receiving fill layers shall, if smooth, be previously prepared to obtain a good key between the new fill layer and the sub grade.

Backfilling of foundation work with rock shall be carried out only after foundations have been inspected by the Engineer and this method has been particularly directed.

If payment is not provided for under a special item in the Bill of Quantities for back filling & compaction, it will be deemed to be included in the unit prices of excavation. Fill shall not be deposited under water without the Engineer's permission. This permission will not normally be granted for cohesive soils or for fill of any kind where the standing water, in the opinion of the Engineer, can be pumped out or diverted. Permission may be granted to place rock fill by random dumping in area where the depth of water is greater than 50 cm but the methods and quality of the fill material shall be subject to approval and when the fill level is 50 cm above the water surface it shall be compacted until there is no discernible settlement under the equipment used for placing or compacting fill. Thereafter, normal backfilling and compaction shall be resumed.

Where swamps, marshes, bogs or other similar wet areas have to be traversed by the works, they shall be drained as directed by the Engineer according to the materials and conditions encountered. Prior to the formation of backfilling, embankments, fills, etc any unsuitable materials occurring on the Site shall be removed to such depths and widths as may be directed by the Engineer and the resultant excavations shall be properly backfilled with suitable and

approved excavated materials and shall be deposited and compacted to the satisfactions of the Engineer.

Where backfilling is to be placed on steep sloping ground, the surface of the ground shall be benched in steps or trenches as directed by the Engineer, or where the ground is wet or spongy or likely to be detrimentally affected by water, the contractor shall remove all unsuitable material and if necessary under drain the site as may be directed by the Engineer before benching or trenching is carried out.

2.2.5 Blasting

Fuses, detonators or blasting caps shall not be transported or stored with dynamite or other explosives under any circumstances. The location and design of the storage places, the transportation methods and the precautions that shall be taken to prevent accident shall be subject to the Engineer's approval or the security force's approval, but it is understood that this approval does not exempt the contractor of his responsibility with regard to the handling of dynamite or other explosives.

Drilling and blasting plans shall be submitted well in advance for the Engineer's approval prior to the commencement of any blasting work.

All blasting shall be carried out carefully by approved experts only and the Contractor shall be fully liable for any claims arising from damages or alleged damages, injury to the public, etc due to the blasting.

The Contractor shall insure with an approved insurance company against all claims with respect to damages and injury arising from blasting.

The Contractor shall not obtain or make use of any explosives without the express permission in writing of the security forces or other authorities concerned of GON.

The contractor shall comply strictly with the regulation as required by the authorities regarding purchase, storage, issuance and use of explosives and transport of same to and from the Site , and shall be deemed to have included in his tender all costs arising from the use, storage and transport of explosives arising from supervision of blasting by security forces.

Blasting shall furthermore be strictly and in every case subject to the Engineer's permission.

When blasting is carried out, trees, structures, etc. in exposed position shall be adequately protected from damage without additional payment.

Drilling and blasting shall be arranged and, where necessary, the rock being blasted shall be protected so as to prevent any scattering of the rock liable to cause injury to the public or damage to dwellings, buildings and other property and the works.

Blasting shall be carried out carefully, the methods shall be such that shock and vibration will be minimized and the loosening of rock surfaces are avoided, particularly in those cases where concrete is to be placed directly against these rock surfaces.

Modern controlled blasting methods such as pre-splitting cushion blasting, smooth blasting, and where applicable line drilling shall be used.

The Engineer may even order modified explosive charges or excavation without explosives. All these alternatives shall be included in the unit rates for excavation.

During thunderstorms and other electrical disturbances, no charging or firing will be permitted

Blasting shall be carried out at specified times to be agreed upon by the Contractor and Engineer. Sufficient notices and barriers shall be erected and immediately before blasting adequate warning shall be given to workers on the site and to the public so that no one may come within the danger zone until blasting is finished. Upon completion of blasting an "all clear" signal shall be given. This signal shall be withheld by the responsible blasting master or blasting

engineer until he is satisfied that all charges loaded have been detonated and that no delayed explosives or miss-firings can be expected. Adequate warning, as mentioned above, shall be given and the portion of site shall be cleared before electrical resistance measuring or testing of the firing line is carried out.

The Contractor shall record on agreed forms, all blasting events including location, time, charge, purpose etc. These records shall be available to the Engineer at any time.

When directed by the Engineer, prior to each blast in areas within 200 m of permanent structures the contractor shall submit information to the Engineer, about location of blast, number and depth of holes, weight and types of powder loaded per hole, delays used in the blast, method of wiring the blast, kilograms of powder per delay etc.

The Contractor shall be liable for any damage caused by scattering of rock, boulders or other materials being blasted and for the scattering of any material whatsoever overlying or in the immediate vicinity of the rock, boulder or other material which is being blasted and all such fragment shall be removed.

Underwater blasting will not be permitted beneath the water in contact with permanent structure.

2.2.6 Measurement and payment

The Earthwork in excavation and over cut excavation shall be paid in Cubic meter from the design line level and x-sections. The over excavation and excessive blasting shall not be paid, also the disposal of the over excavated material or material dumped from such consequences shall not be paid.

If the Engineer orders excavations beyond the lines indicated on the Drawings, the Contractor will be paid for the over excavation at the stipulated unit price.

Whatever mentioned in the definition of rock classification, the site engineer and geologist at site shall determine the type and will be final, only the variation of more than 10% in total excavation price shall only be entertained for revision from such changes in rock classification.

CHAPTER - 3

3. Embankments and backfilling

3.1 Fills

For the purpose of these specifications, the term "Embankment" includes all portions of dam or coffer dam construction and earth and/or rock works by filling with suitable material to lines and grades shown on the Drawings and/or as otherwise provided in the contract document or as directed by the Engineer.

To the greatest extent possible, all suitable materials obtained from excavation shall be used for the construction of embankment. Distribution within embankments of construction materials from excavation shall be done in the way indicated by the Engineer.

Materials for backfills shall be obtained from the borrow areas or from excavation for the works whenever the Engineer so approves.

The Contractor shall maintain all embankment fills and instruction until final acceptance of the work.

3.2 Materials

3.2.1 General

The miscellaneous fill portions of embankment such as core , filters, rock zones, etc shall be constructed of selected materials from excavation for structures on the work, from quarried or borrow areas as selected by the Engineer.

The location and extent of all quarries and borrow pits within the designed areas shall be as directed by the Engineer.

The Engineer reserves the right to modify the limits or location of quarries and borrow pits within the limits of the respective areas as shown on the drawing in order to obtain suitable material and to minimize stripping operations and the amount of waste material. All materials used to form dam embankment shall meet the requirements of the pertinent tests as ordered or directed by the Engineer.

The quantity and quality of the embankment material in its borrow areas shall be investigated by means of exploration in an adequate form before and during excavation for and by laboratory and field tests.

If the natural material does not fulfill the requirements for the embankment material as specified or as directed by the Engineer, the Contractor shall treat the material by appropriate methods like blasting , crushing, selection, mixing, screening, moistening, drying etc in order to obtain the required proportion.

3.2.2 Sealing Material

Natural Sealing Material

The construction of a sealing zone within an embankment shall preferably consist of cohesive soils available from selected borrow areas. The soil mechanics classification and properties shall be obtained by laboratory and field tests.

If necessary, the material shall be thoroughly mixed, dried or moistened or treated in any required way as described in the Contract Documents or as directed by the Engineer in order to obtain a uniform material of required condition throughout the sealing zone of the embankment. The material shall be free from any deleterious admixtures such as soluble or disperse minerals, organic material etc.

Artificial Material

The construction of a sealing zone within an embankment shall consist of artificial materials such as asphalt concrete, concrete, earth concrete, sheet piles etc. as shown on the drawings and/ or as directed by the Engineer in case no natural sealing material is available or for any other reason in the judgment of Engineer.

Classification, properties and dimension of the artificial sealing material shall be in accordance with the contract document or with the instructions of the Engineer. They shall only be used after approved of the Engineer.

If the materials are not in accordance with standard, the properties shall be determined by laboratory and field tests.

3.2.3 Earth-fill Materials

Earth- fill materials within an embankment shall consist of cohesive soil or non cohesive soil with cohesive components of medium to low permeability, Earth fill material can be obtained from overburden, colluviums, lateritic soil, river deposits, young uncompacted geological layers, decomposed and weathered rock etc.

3.2.4 Gravel-fill Material

Gravel material within an embankment shall consist of rounded gravel with or without sand and pebbles but without cohesive components of low permeability. Gravel fill material can be obtained from river deposits or from the excavated material.

3.3 Prevention of Damage in the Event of Floods

To prevent damage to slope protection, structures of any kind, etc, in the event of floods, the contractor shall make all possible efforts to protect unfinished slopes, embankment slopes, etc by temporary covers. The materials required for this purpose shall be stored by the contractor near the place of use.

3.4 Ground or Surface Water

Unless otherwise stipulated under the items covering bank protection work in the contract document, the contractor shall safely divert any ground or surface water without extra payment for this work.

3.5 Measurement and payment

The embankment and backfilling shall be paid in unit rate as per BOQ in cubic meter for the design volume to be filled in including haulage and supplying other reinforcement material, laying of geotextile however shall be paid extra based on square meter. The Contractor shall not be paid for the over excavation disposal and embankments from such items whatsoever

CHAPTER - 4

4. Gabions & Mattresses

4.1 General

If not otherwise specified in the contract documents, the Contractor shall submit a proposal of the type and dimension of gabions, the stone fill (type, strength, grain sizes), the method of placing and the time schedule for delivery and construction. He shall not commence with the order and construction of gabions before the approval of the Engineer. The standard type gabion shall be a flexible hot-dip galvanized gabion of the type and sizes specified below. It is made of wire mesh of the type and size and selvedge as specified in the following:

The gabion boxes and mattresses shall normally be machine woven rectangular units made from double twist hexagonal mesh of heavy galvanized mild steel wire. Hand woven gabions shall only be used with the approval of the Engineer if they can be shown to meet the standards below.

All edges of the standard gabions including diaphragms, if any, shall be mechanically selvedged in such a way as to prevent unravelling of the mesh and to develop the full strength of the mesh.

Where irregular-shaped gabions are required they shall be formed by folding standard gabions.

4.2 Type and sizes of gabions

Gabions boxes and mattresses shall be confirmed to the standard of the type and sizes shown in the table below:

Table 4-1 Details of gabion mattress and boxes

Classification	Mesh type	Mesh opening	Mesh wire ϕ mm	Selvedge wire ϕ mm	Lacing (binding) wire ϕ mm	Basket size (L×B×H) m	Tolerance in basket size
Mattress	6 x 8	64 mm ±10%	2.20	2.70	2.20	(3 - 6) x 2 x (0.17 - 0.3)	±5% on length and width and ±25 mm on depth
Box	10 x 12	100 mm ±10%	3.00	3.90	2.40	(1.5 - 4) x (1 - 2) x (0.5 - 1)	±5% on each dimension

Baskets up to a depth of 300 mm shall be classified as mattresses. Baskets greater than 300 mm shall be classified as boxes.

4.3 Materials

(a) Stone

Stones used for filling the gabion boxes or mattresses shall be clean, hard, sound, unweathered and angular rock fragments or boulders. The specific gravity of the stone shall be not less than 2.50 and the stones shall not absorb water more than 5 percent when tested as per IS: 1124. The length of any stone shall not exceed three times its dimension of the mesh of the crate. However smaller size of stones as spalls shall be allowed for filling voids and its volume including voids shall not be more than 20 percent of the total volume of the stone. Before filling any gabion boxes and mattresses the Contractor shall submit representative samples of the rock he proposes to use in the gabion for approval by the Engineer. Further representative samples shall be submitted for approval each time when there is a change in the type and strength of the rock.

(b) Gabion

Gabions shall consist of steel wire mesh crates. The steel wire shall be mild steel wire complying with NS 169-2045. All wires used in the manufacturing crates and diaphragms, binding and connecting lids and boxes shall be galvanized with an heavy coating of zinc by an electrolytic or hot dip galvanizing process. The weight of deposition of zinc shall be in accordance with NS 163-2045. Zinc coating shall be uniform and be able to withstand minimum number of dips and adhesion test specified as per NS 163-2045. Tolerance on diameter of wire shall be ± 2.5 percent. The tensile strength shall be between 300 to 550 N/mm²

The wire shall be woven into an hexagonal mesh with a minimum of 3 twists. All edges of the crates shall be finished with a selvedge wire at least 3 gauges heavier than the mesh wire. Gabions shall be manufactured in the standard sizes shown in Table 24.1 with mesh and wire sizes as shown in Table 24.2

Diaphragms shall be manufactured of the same materials as the parent gabion box and shall have selvedge wire throughout their perimeter. The number and size of diaphragms to be provided with each crate shall be as in Table 24.1. All crates shall be supplied with binding and connecting wire of the gauges shown in Table 24.2 of sufficient quantity to bind all diaphragms and closing edges.

Table 4-2: Standard Size of Wire Mesh Gabions

Dimensions in Meters (Prior to fill)	Number of diaphragms	Dimension of diaphragms in metres	Volume of crate in cubic metres
1 x 1 x 1	-	-	1
1.5 x 1 x 1	1	1 x 1	1.5
2 x 1 x 1	1	1 x 1	2
3 x 1 x 1	2	1 x 1	3
1 x 1 x 0.75	-	-	0.75
2 x 1 x 0.75	1	1 x 0.75	1.5
3 x 1 x 0.75	2	1 x 0.75	2.25
1 x 1 x 0.5	-	-	0.5
2 x 1 x 0.5	1	1 x 0.5	1
3 x 1 x 0.5	2	1 x 0.5	1.5
1 x 1 x 0.3	-	-	0.3
2 x 1 x 0.3	1	1 x 0.3	0.6
3 x 1 x 0.3	2	1 x 0.3	0.9

Table 4-3: Standard Size of Mesh and Wire in Gabions

Mesh opening mm	Mesh type	Thickness of mesh wire	Thickness of binding and connecting wire	Thickness of selvedge wire
(DxH)		S.W.G.	S.W.G.	S.W.G.
64 x 83	60 x 80*	11, 12	13, 14	8, 9
83 x 114	80 x 100	9, 10, 11	11, 12, 13	6, 7,
114 x 128	100 x 120	10, 9	12, 11	7, 6

** To be used in special cases subject to approval by the Engineer where stone of larger size are not available.*

Note: Equivalent diameter in mm as per NS 163-2045

SWG	6	7	8	9	10	11	12	13	14
mm	4.88	4.75	4.06	3.66	3.25	2.95	2.64	2.34	2.03

4.4 Gabion Basket assembly

The wire baskets shall be bound, tensioned and stitched to contain the rock fill and all openings closed off to ensure that the rock particles cannot be dislodged.

Gabions shall be assembled by binding the edges together at the selvages with binding wire. Binding shall be firmly secured at all corners. The binding shall be in the form of continuous lacing. The wire shall pass around the selvages and through each mesh in turn, a double twist being used at alternate meshes. The gabions has to be hexagonal double twisted at woven process and provided salvage wire of at least 8 swg at the corners. Wire baskets shall not be assembled in water.

4.5 Placement of gabion boxes

The foundation for the gabions shall be natural undisturbed common material or a prepared sub-grade. The sub-grade formation surface shall be cleaned and prepared in accordance with Specification for Earthworks

Prior to placing the gabion baskets on the ground Terram 1000 or SI 401 (I) filter cloth shall be placed between the gabions and the ground. Laps in the filter cloth shall be 0.5 meters.

The base of the basket shall be stretched and anchored by stakes driven into the ground to ensure that tightness of the mesh is achieved. The intermediate interlocking shall be provided binding opposite walls with addition wire during 1/2 filling of gabion boxes.

4.6 Rockfill for gabions

Rockfill for use in the gabion baskets shall be from the sources in the site (Mailun Khola) approved by the Engineer. Individual pieces shall be sound, hard, dense and durable.

Rockfill for gabion mattresses shall be graded in size within the range 90 – 150 mm, but never more than two-thirds the thickness of the mattress. Rockfill for gabion boxes shall be graded in size within the range 150 – 250 mm. If there is insufficient larger material, 90 – 150 mm rockfill may be used in the interior of gabion box compartments, subject to the approval of the Engineer. In this case the larger material must be placed to at least 250 mm from exposed sides and 200 mm from diaphragms and 150 mm from the base and lid.

4.7 Filling of gabions

Filling of the gabion baskets shall not commence until the basket has been placed in its final position and wired to all adjoining units.

The filling shall be carried out ensuring that the stone is tightly packed and has a minimum of voids.

Vertical bracing wires shall be provided between the top and bottom wire meshes at nominal 500 mm centres. Each vertical bracing wire shall be pulled through the filling and securely fastened to the top mesh. Horizontal bracing shall be provided in 1 m deep baskets at 500 mm centres placed at 1/3 and 2/3 height and shall be fastened when filling has reached the appropriate level.

Gabion baskets shall be filled to a level 25 - 50 mm above their tops, the last 100 mm being with small rock sizes but still within the ranges specified by Engineer. The basket lids shall be tightly stretched over the filling and securely bound with binding wire.

The top selvages of baskets placed and filled under water are to remain above water until completion.

On completion the baskets shall be completely and tightly filled, square, true to dimensions and correct in line and level.

4.8 Measurement and payment

The measurement and payment of gabion shall be made according to cubic meter of the gabion filled at position as described in typical design sheet or as described in the layout design drawings.

CHAPTER - 5

5. River Diversion and Cofferdams

5.1 Scope of works

The contractor shall be totally responsible for the accurate planning and performance of all works involved for the river diversion. All construction works shall be in accordance to the instruction of the Engineer.

The respective items for river diversion and cofferdams in the Bill of Quantities (BOQ) shall be deemed to include the following works.

- ❖ Supply, erection, operation and maintenance of a gauging station upstream of weir site location indicated by the Engineer, including all required survey works.
- ❖ Detailed hydraulic and design calculations for the diversion channel and the cofferdams.
- ❖ Any temporary access roads / crossings to the construction sites.
- ❖ Slope and bottom protection of the cofferdams and the diversion channel.
- ❖ Adequate sealing of the cofferdams and diversion channel to an extent to avoid destructive effects and additional dewatering during construction of the weir and other structures.
- ❖ All other required works and materials for the construction, operation and maintenance during the diversion period.

5.2 Material

Excavation of rock and soil required for the diversion channel will be paid under appropriate items in the Bill of Quantities according to the profiles approved by the Engineer. The excavated material shall be stockpiled at approved locations and used as far as suitable for the construction of the cofferdams and refilling of the diversion channel to the lines and levels shown in the construction drawings. Unsuitable materials shall be dumped in permanent disposal areas as directed by the Engineer.

5.3 Alternatives

The Contractor is free to propose alternate methods for the flood control and river diversion. For such alternate methods he shall submit with his tender calculations and drawings sufficiently detailed to enable the Engineer to verify the suitability of his proposed procedure. The item provide for the alternative proposal in the Bill of Quantities shall be deemed to include all works required for the river diversion.

5.4 Removal of Cofferdam

Removal of cofferdams, including dumping/compaction of materials, which shall be placed in permanent areas as directed by the Engineer or shall be disposed off in any other approved manner and in such a form that the shapes, grades and or finished surfaces shall be no eroding, free draining and shall blend with the existing surrounding.

5.5 Payment

Payment for river diversion shall be lumped based on the rate approved in BOQ as single item. It is deemed that the cost quoted in BOQ includes all sorts design, construction and removal of the cofferdam and protection works associated with this item.

CHAPTER - 6

6. Dewatering

6.1 General

This specification applies to dewatering during construction of all the structures of the work including borrow areas and shall include all necessary labor, materials, equipment and auxiliary works as required. The contractor shall also execute the work, permanent or temporary, necessary to keep seepage and water under control during the construction periods considered in this contract.

According to the specification covered by this chapter, the contractor shall design, construct and maintain, and remove all dewatering facilities and where necessary, channels, trough, drainage works, inlets gutters and all required works to keep construction areas free of water from whatever sources. Likewise, in order to remove the water, the contractor shall furnish, install, maintain and operates all pumps, piping, supports, electrical installations and necessary accessories to maintain the different works free of water during construction. In addition, the contractor shall have at his disposal sufficient reserve pumps with a capacity of at least equal to that of the installed pumps and all required auxiliary equipment. It is clearly understood that the removal of any amount of water that may be present at any moment and the permanent control of water and seepage is the entire responsibility of the contractor. The reserve units shall be kept ready for service when the failure of any of the installed units occurs.

Furthermore, the contractor shall ensure that all drainage water will be eliminated without causing interference to his own work and that of other contractors operating elsewhere on the construction site. The dewatering system shall be designed and installed in such a way that alternations and extensions of the systems during operations are possible.

The contractor shall submit to the engineer, for approval, the detailed planning of the dewatering systems, but the approval of the engineer of the contractor's dewatering system does not exempt the contractor from any of his obligations and responsibilities under the present Contract.

In case of emergency the contractor shall furnish and install the adequate dewatering system immediately also without prior approval by the Engineer.

The Contractor shall consider the possibility of the temporary failure of the electric power service. He shall install emergency power units with sufficiently capacity to feed the necessary power to the installed dewatering units at the moment of failure. There shall be neither time extensions nor additional compensations because of failures in the equipment of services rendered by them during the execution of the works.

The contractor shall be responsible for personnel addicts and for damages and inconveniences that may be suffered by his equipment or materials, the equipment and materials of the Employer, of the executed or in-execution works due to insufficient or inadequate control of seepage, poor operation, or failure of the dewatering system, insufficient capacity of the pumping system, lack of reserve units or any other reason imputable to the negligence of the Contractor or to the poor maintenance and operation of his equipment.

Upon completion of the works the contractor shall remove, in a way satisfactory to the Engineer, all installations for the dewatering systems, such as cofferdams, sheet piles, pump sumps, pipes, channels, etc and all other control works are delivered clean and according to the lines and grades of finished works, as shown on the drawings.

6.2 Dewatering Materials and Equipments

Materials and equipments to be provided by the contractor shall be in good working conditions and adequate to meet the requirements. Materials which are to be preliminary incorporated in

any structure shall be new and unused, shall be in accordance with accepted standards, and shall not have been previously used for such purpose as dewatering during construction.

6.3 Execution of Work

6.3.1 General

A working schedule with explanatory reports shall be submitted together with the Tender. This schedule shall show the quantity, type, capacity, stand by equipment, age, condition, arrangement, location etc of the proposed equipment.

The schedule and any amendments made there during the life of the contract shall be subject to the approval of the Engineer. The contractor is obliged to inform the engineer immediately of any symptoms of risk of subsidence or collapse. The safety measures required shall be performed by the contractor without delay.

6.3.2 Start and Duration of Dewatering

Before proceeding with any dewatering work which in the option of the contractor should be separately remunerated, the engineer's consent shall be obtained. The duration of dewatering will be determined according to the agreed construction time schedule and to other factors, e.g. third party's work which has to be carried out under the protection of this dewatering system.

Pumps operations shall not be stopped either pipes, channels and equipment for dewatering removed or altered in any way, except with the permission of the Engineer. Until then, the pumps and dewatering facilities shall be kept in proper working order without any extra payment being granted.

In the event of power failure, a diesel driven emergency generating set specifically for dewatering shall be available in addition to the stand by equipment provided under the site installation. This set shall undergo at least once a week, a trial run lasting thirty minutes.

The costs for mounting and removal of the diesel driven generating set, including all necessary connections, switches and electrical auxiliaries and controls as well as trial runs shall be part of the entire dewatering system.

Furthermore, a sufficient number of pumps shall be available on site to meet all requirements of dewatering in the event of power failure. The cost for the provision, maintenance and operation of such pumps will be deemed to be covered by the entire dewatering system. Pumps and pipes may be provided at the option of the contractor but the requirements of dewatering shall be guaranteed.

The provision of pumps shall include the complete sets of pumps sumps as required, including sheeting, bracing, etc the installation of electrical connections or the supply of fuel, the disposal of water and all other elements required to ensure an effective operational system. The pumps shall be located away from permanent structures wherever possible and in any way the location shall be agreed upon after consultation with the Engineer.

Supply of lubricants, accessories, spare parts, etc operation and maintenance including all additional works required for continuous functioning of the dewatering system, transport, including any intermediate storage, as well as installation and removal of all dewatering equipment and the sealing of pipes etc shall be included in the lump sum.

Upon completion of dewatering work, all pipes shall be closed off and the pumps sumps shall be removed and tightly filled by injection of cement mortar or by underwater concreting. These works shall require the prior approval of the Engineer.

6.3.3 Pumps Sumps and Channels

Provision of pump sumps and channels of dimensions required in each particular case shall include all necessary excavation of any kind of soil above and underwater, back fill and

consolidation, sheeting, bracing, stiffening, sealing, scaffolding access, as well as the disposal of water and all auxiliary works.

6.3.4 Precaution to avoid Dewatering

The contractor shall consider all difficulties and additional work due to the presence of water for the construction of the work.

Where it is possible to keep off divert water without special dewatering arrangements or where work can be carried out normally under of in water, no payment will be made for dewatering. Neither more pumping over into another pumps sump nor dewatering work which has been necessitated as a result of wrong techniques or delays in the construction time schedule and which is due to the fault of the contractor will not be paid for.

6.3.5 Ready for Service Condition

The contractor shall maintain ready for service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can immediately and safely be used without risk of accident. Any recommendations made by the Engineer in this matter shall be followed by the contractor.

6.3.6 Leakage

Block outs and pipe connections through structures and their closure, proper grouting of joints, etc or repair in the event of leakage shall be the responsibility of the Contractor.

6.4 Payment

There is no separate item for the dewatering the water course while doing foundation works including concreting. The dewatering item, its installation cost, running and maintenance costs thus has to be loaded in River diversion and shall effect together with the payment of River Diversion and Cofferdam as a lumped amount as listed and to be quoted in BOQ as a single item

CHAPTER – 7

7. Materials and Testing of Materials

7.1 Scope

This section covers the general requirements relating to materials, the specific requirements for basis materials, the tests and methods of testing which are required for the section and quality control of materials.

7.2 Quality of Material

The materials supplied and used in the works shall comply with the requirements of these Specifications. They shall be new, except as provided elsewhere in the contract or permitted by the Engineer in writing. The materials shall be manufactured, handled and used skillfully to ensure completed works to comply with the contract.

7.3 Sources of Materials

The use of any on kind or class of material from more than one source is prohibited, except by written permission of the Engineer. Such permission, if granted, shall set forth the conditions

under which the change may be made. The sources or kinds of material shall not be changed without written permission of the Engineer. If the product of any source proves unacceptable, the Contractor shall make necessary arrangements for the supply of acceptable material. Any claims for compensation associated with such arrangements or changes shall not be considered, unless the source of the unacceptable material is designated in the contract as a source of material.

In the case of borrow pits, gravel, sand, binder, soil deposits and rock quarries, the "source of material designated in the contract" shall be construed to mean:

- (1) any restricted area (within the pit or quarry) which is designated as the source of material;
or
- (2) the entire area of the pit or quarry, if no such restricted area is designated.

Movements of equipment within the "source" as above defined shall not be considered as a "change of source"

Selection and exploitation of material sources as well as use of the materials shall follow the DOR Environmental Guidelines (latest publication) and comply with other pertinent environmental specifications.

When any manufactured product, either new or used is to be furnished by the Employer, the location at which such material shall be delivered to the Contractor shall be designated in the contract. In such cases, the Contractor shall haul the materials from the designated delivery point to the point of use. The compensation for such hauling shall be included in the contract unit rate for placing the materials in the finished work.

7.4 Inspection and Acceptance of Materials

Final inspection and acceptance of materials shall be made only at the site of the work. The Engineer reserves the right to sample, inspect, and test the materials throughout the duration of the works and to reject any materials which are found to be unsatisfactory.

A preliminary inspection of materials may be made at the source for the convenience and accommodation of the Contractor, but the presence of a representative of the Engineer shall not relieve the Contractor of the responsibility of furnishing materials complying with their Specification.

The representative of the Engineer shall have free entry at all times to those parts of any plant which concern production of the Materials ordered.

7.5 Materials and Manufactured Articles

7.5.1 Order for Materials and Manufactured Articles

The Contractor shall, before placing any order for materials and manufactured articles for incorporation in the Works, submit to the Engineer the names of the firms from whom he propose to obtain such materials and manufactured articles, giving for each firm a description of the materials and manufactured articles to be supplied, their origin, the manufacturer's specification, quality, weight, strength and other relevant details. The Contractor shall submit the samples of such materials and manufactured articles when requested by the Engineer and when appropriate, manufacturer's certificates of recent test carried out on similar materials and manufactured articles shall also be submitted.

7.5.2 Storage

All materials and manufactured articles shall be stored on site in a manner acceptable to the Engineer. The Contractor shall carefully protect all work, materials and manufactured articles from the weather and vermin.

7.5.3 Test Certificates

When instructed by the Engineer, the Contractor shall submit to him all Test Certificates from the suppliers/manufacturers of the materials and/or manufactured articles to be used for the contract. Such certificates shall certify that the materials and/or manufactured articles concerned have been tested in accordance with the requirements of these Specifications. All Test results shall be enclosed along with such certificates. The Contractor shall provide adequate means of identifying the materials and/or manufactured articles delivered on the site with the corresponding certificates.

7.6 Defective Materials

All materials not conforming to the requirements of the contract shall be rejected whether in place or not. They shall be removed immediately from the site unless otherwise permitted by the Engineer. Even after rectification of the defects no rejected material shall be used in the work unless approved by the Engineer in writing. Upon failure of the Contractor to comply promptly with any order of the Engineer given under this Clause, the Engineer shall have authority to cause the removal and replacement of rejected material and to deduct the cost thereof from any monies due to the Contractor.

7.7 Trade Names and Alternatives

For convenience in designation in the contract, certain articles or material to be incorporated in the work may be designated under a trade name or the name of a manufacturer and his catalogue information. The use of an alternative article or material which is of equal or better quality and of the required characteristics for the purpose intended shall be permitted, subject to the following requirements:

The proof as to the quality and suitability of alternatives shall be submitted by the Contractor. He shall also furnish all information necessary as required by the Engineer. The Engineer shall be the sole judge as to the quality and suitability of alternative articles or materials and his decision shall be the final and binding upon the Contractor.

Whenever the specifications permit the substitution of a similar or equivalent material or articles, no tests or action relating to the approval of such substitute material shall be made until the request for substitution is made in writing by the Contractor accompanied by complete data as to the equality of the material or article proposed. Such request shall be made well in advance to permit approval without delaying the work.

7.8 Foreign Materials

Materials which are manufactured, produced or fabricated outside Nepal shall be delivered at a point in Nepal as specified in the contract where they shall be retained for a sufficient time to permit inspection, sampling, and testing. The Contractor shall not be entitled to an extension of time for acts or events occurring outside Nepal and it shall be the Contractor's responsibility to deliver materials obtained from outside Nepal to the point of delivery in Nepal. The Contractor shall supply the facilities and arrange for testing required at his own cost. All testing by the Contractor shall be subject to witnessing by the Engineer.

The Contractor shall furnish to the Engineer a "Certificate of Compliance" with the specifications from the manufacturer, producer or fabricator of foreign material where required. In addition, certified mill test reports clearly identifiable to the lot of material shall be furnished where

required in these Specifications or otherwise requested by the Engineer. Where structural materials requiring mill test reports are obtained from foreign manufacturers, such materials shall be furnished only from those foreign manufacturer who have previously established, to the satisfaction of the Engineer, the sufficiency of their in-plant quality control, as deemed necessary by the Engineer or his representative, to give satisfactory assurance of their ability to furnish material uniformly and consistently in conformance with their Specifications. At the option of the Engineer, such sufficiency shall be established whether by submission of detailed written proof thereof or through in-plant inspection by the Engineer or his representative.

If the welding of steel for structural steel members or the casting and pre-stressing of pre-cast pre-stressed concrete members is to be performed outside of Nepal, the following requirements shall apply:

- Such fabrication shall be performed only within the plants and by fabricators who have previously established to the satisfaction of the Engineer, that they have the experience, knowledge, trained manpower, quality control, equipment and other facilities required to produce the quality and quantity of the work required. At the option of the Engineer, prequalification of plant and fabricator shall be established either by the submission of detailed written proof thereof or through in-plant inspection by the Engineer or his representative, or both.
- The Contractor shall make written application to the Engineer for approval for such foreign fabrication at the earliest possible time and in no case later than 60 calendar days in advance of the planned start of fabrication. The application shall list the specific units or portion of a work which shall be fabricated outside of Nepal.
- The Contractor shall advise the Engineer, in writing, at least 20 calendar days in advance of the actual start of any such foreign fabrication.
- All documents pertaining to the contract, including but not limited to, correspondence, tender documents, working drawings and data shall be written in the English/Nepali language and all numerical data shall use the metric system of units of measurement.

7.9 General : Classification of Material

Classes of soil and classes of materials referred to in the relevant Section correspond to the General Classification of Soil and Materials for Road and Bridge Works in Nepal and are given in the Table 6.1, Table 6.2 and Table 6.3.

Table 6.1 shows the classification of rocks and soil and includes definitions, identifications criteria for stones and soils.

Table 6.2 shows conditions for rock and soil utilization as subgrade, capping layers and pavements

Table 6.3 shows Material Classification into Classes of Quality.

TABLE 6.1: General Classification of Natural Materials

	LITHOLOGIC TYPE	GENERAL TYPES	GROUP SYMBOL	TYPES IN SEPAI	COMMENTS ON CHARACTERISTICS
ROCKS	I. SEDIMENTARY ROCK & METAMORPHIC SEDIMENTARY ROCKS				EXCLUSIVE ROCKS TO BE REJECTED
	CALCAREOUS ROCKS	METAMORPHIC LIMESTONE	R1	Limestone, Marble, Travertine	Most limestone limestone involving in Clay
		DOLOMITE	R2	Dolomite	Very rare than above
	ARGILLOUS ROCKS	MARL, ARGILLYTES, PELITES	R3	Mudstone, Claystone	Most involve rocks producing Clay & Mud during Clay
	SILICEOUS ROCKS	QUARTZITE, SANDSTONE, PUDDING STONE, BROCKRAM	R4	Quartzite, Sandstone	Probably Sandstone disintegrating into sands
	II. MAGMATIC & METAMORPHIC ROCK				
	GRANITES, GABBRO, GNEISS, METAMORPHIC SCHISTS, MILES, SLATES, AMPHIBOLITE, PHYLLITE...	FINE GRAINS ROCKS	R5	Granite, Gabbro, Gneiss, Schists, Miles, Slates, Phyllite	Slates, Gneiss, Phyllite, miles weathered into clay soils
		LARGE GRAINS ROCKS	R6	Granite, Gabbro	Some Granite may be susceptible to disintegration
SOILS	SOILS CONTAINING LARGE BLOCKS OF ROCK MATERIAL OR BOULDERS WITHIN A MATRIX OF SOFT SOILS				
	BLOCKS SIZE > 0.1 m ³		RF 1	Unsuitable	
	BLOCKS SIZE < 0.1 m ³		RF 2	Acceptance materials	
GRAVEL & SAND	GRADATION GENERAL CHARACTERISTICS		GRADATION QUALITY REQUIREMENTS		GROUP SYMBOL
	I. GRAVEL & SAND				
	More than 50% of materials is larger than 0.075mm				
	GRAVEL		More than 50% of materials is larger than 4.75mm		
	Less than 5% of materials is smaller than 0.075mm	Well graded gravel	$C_u = D_{60}/D_{10} > 4$ and $C_c = (D_{30}^2)/(D_{10}D_{60}) = 1$ to 2	GW	Atterberg Limits below A Line or $PI < 4$
		Poorly graded gravel	Not meeting all Gradation requirements for GW	GP	Atterberg Limits below A Line or $PI < 4$
	More than 12% of materials is smaller than 0.075mm	Silty Gravel	Atterberg Limits below A Line or $PI < 4$	GM	Atterberg Limits below A Line or $PI < 4$
		Clayey gravel	Atterberg Limits above A Line or $PI > 7$	GC	Atterberg Limits above A Line or $PI > 7$
	SAND		More than 50% of materials is smaller than 4.75mm		
	Less than 5% of materials is smaller than 0.075	Well graded sand	$C_u = D_{60}/D_{10} > 4$ and $C_c = (D_{30}^2)/(D_{10}D_{60}) = 1$ to 2	SW	Atterberg Limits below A Line or $PI < 4$
		Poorly graded sand	Not meeting all Gradation requirements for SW	SP	Atterberg Limits below A Line or $PI < 4$
	More than 12% of materials is smaller than 0.075mm	Silty Sand	Atterberg Limits below A Line or $PI < 4$	SM	Atterberg Limits below A Line or $PI < 4$
		Clayey Sand	Atterberg Limits above A Line or $PI > 7$	SC	Atterberg Limits above A Line or $PI > 7$
	II. FINE GRAINED SOILS		More than 50% of materials is smaller than 0.075mm		
		0	Atterberg Limits below A Line	ML	Organic test positive
		Low Plasticity Clay	Atterberg Limits above A Line	CL	Organic test positive
		Organic Silt & Clay	Organic test positive	OL	
		High Plasticity Silt	Atterberg Limits below A Line	MH	
		High Plasticity Clay	Atterberg Limits above A Line	CH	Organic test positive

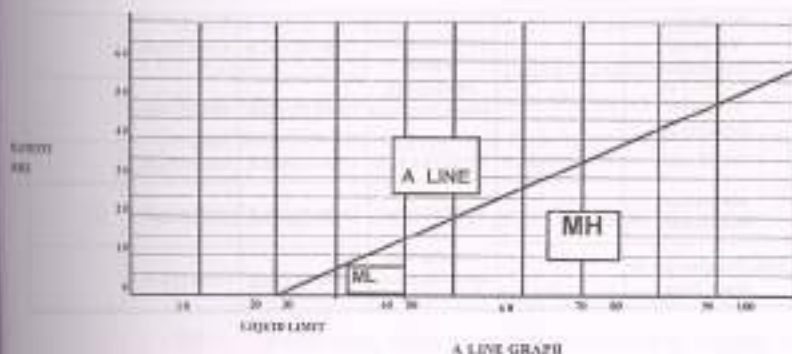


TABLE 6.2: Soils and Materials Identification and Utilisation
UTILISATION CONDITIONS Provided Compliance with the Specification and Special Specification

	GROUP SYMBOL	TYPES	IDENTIFICATION & CHARACTERISATION PROCEDURES	SUBGRADE	CAPPING LAYER	GRAVEL Wearing Course	SUBBASE	BASE	SURFACING
ROCKS	SEDIMENTARY ROCK								
	R1	LIMESTONE ROCKS	ACCORDING TO MATERIAL QUALITY CLASSES	SUITABLE provided compliance with the Specification for quality, grading & construction	SUITABLE provided compliance with the Specification	SUITABLE as Graded Crushed Stones (GCS)	SUITABLE as GCS Class D2	SUITABLE as GCS Class C1, B	SUITABLE as GCS Class A, B, (C1 seal coat)
	R2	DOLOMITE							
	R3	ARGILLOUS ROCKS	QUALITY CLASSES	UNSUITABLE	UNSUITABLE	UNSUITABLE	UNSUITABLE	UNSUITABLE	
	R4	SILICEOUS ROCKS		SUITABLE d ^o	SUITABLE d ^o	SUITABLE d ^o	SUITABLE d ^o	SUITABLE d ^o	
	MAGMATIC & METAMORPHIC ROCK								
R5	FINE GRAINS ROCKS	ACCORDING TO MATERIAL QUALITY CLASSES			SUITABLE d ^o as GCS depending on Quality, Grading, (Specification)	SUITABLE as GCS Class D2	SUITABLE as GCS Class C1, B	SUITABLE AS GCS Class A,B	
R6	LARGE GRAINS ROCKS								
ROCK FALL COARSE ALLUV. MATER.	RF 1	BLOCKS SIZE > 0.3 m ³	BLOCKS : According to material Quality Classes SOIL MATRIX : According to Soils & Gravels Testing Procedures	* Embankments : Not to be placed within 400mm of the formation level. * Cuttings : to be removed from the subgrade (300mm deep) Blocks > 0.05 m ³ not to be placed within 450mm the formation level	SUITABLE d ^o after processing for Size reduction	SUITABLE d ^o as GCS after processing for Size reduction	After processing for size reduction SUITABLE as GCS Class D2	After processing for size reduction SUITABLE as GCS Class C1	After selection, processing for size reduction SUITABLE as GCS Class A,B,C1
	RF 2	BLOCKS SIZE < 0.3 m ³							
LOSS MATERIALS & SOILS	GRAVEL								
	GW	Well graded gravel	According to Soils & Gravels Testing procedures	if CBR > 5,	if CBR > 15,	if CBR > 20	if CBR > 30	if CBR > 40	SUITABLE for Bituminous Mixes according to Specification
	GP	Poorly graded gravel		if CBR > 5,	if CBR > 15,	if CBR > 20	if CBR > 30	if CBR > 40	
	GM	Silty Gravel	d ^o	if CBR > 5,		if CBR > 20	if CBR > 30	if CBR > 40	
	GC	Clayey gravel	d ^o	if CBR > 5,		if CBR > 20	if CBR > 30 & PI < 15	if CBR > 40 & PI < 15	SUITABLE d ^o
	SAND								
	SW	Well graded sand	d ^o	if CBR > 5,	if CBR > 15,	UNSUITABLE unless mixed with medium plasticity soils & coarse some coarse materials	if CBR > 30	UNSUITABLE	Sand seal 0/10 Slurry Seal
	SP	Poorly graded sand	d ^o	if CBR > 5,	if CBR > 15,		if CBR > 30	UNSUITABLE	
	SM	Silty Sand	d ^o	if CBR > 5 or Mech. Stab.			if CBR > 30	UNSUITABLE	
	SC	Clayey Sand	d ^o	if CBR > 5,			if CBR > 30 & PI = 5-12	UNSUITABLE	
FINE GRAINED SOILS									
ML	Low Plasticity Silt	d ^o	if CBR>5 or Mechanical Stabilisation if CBR>5 or Mechanical Stabilisation		UNSUITABLE unless blended with coarse materials	UNSUITABLE	UNSUITABLE		
CL	Low Plasticity Clay	d ^o				UNSUITABLE	UNSUITABLE		
OL	Organic Silt & Clay	d ^o	UNSUITABLE	UNSUITABLE	UNSUITABLE	UNSUITABLE	UNSUITABLE		
MH	High Plasticity Silt	d ^o	Mechanical Stabilisation		UNSUITABLE unless blended with coarse materials	UNSUITABLE	UNSUITABLE		
CH	High Plasticity Clay	d ^o	Limic Stabilisation or Mech. Stab.			UNSUITABLE	UNSUITABLE		

Table 7-1: Classes of Material Quality

MATERIAL CLASSES		LAA %	A/V ACV %	SSS Test	Degradability Test %	Flakiness Index %	Crushing Ratio %
A		<25	<20	<12	<5	<20	100
B		<30	<20	<12	<5	<25	100
C	C1	<35	<25	<12	<5	<25	80
	C2*	<30	<20	<12	<5	<25	-
D	D1	<40	<30	<12	<5	<30	60
	D2	<35	<20	<12	<5	<30	-
E	E1	>35 & <50	<25	<18	<10	-	-
	E2	>40 & <50	<30	<18	<10	-	-
	E3	>50	<30	<18	-	-	-

: Criteria to be applied to crushed materials only.

* Classes for rounded materials only.

7.10 Definition of General Types of Materials

The following definitions shall apply to materials in this Section and other relevant Sections.

- “Topsoil” shall mean the top layer of soil that can support vegetation. It shall include all turf acceptable for trufing.
- “Suitable Material” shall comprise all that is acceptable in accordance with the contract for use in the works and which is capable of being compacted in the manner specified in Clause 9 and 10 of Section II to form a stable fill having side slopes as indicated in the Drawing. The material used in fill (except rock fill) shall not contain rock fragments with dimensions of more than 75 mm.
- “Unsuitable Material” shall mean other than suitable material and shall include:
 - (a) Material from swamps, marshes or bogs;
 - (b) Peat, logs, stumps, perishable material, organic clays;
 - (c) Material susceptible to spontaneous combustion;
 - (d) Material in a frozen condition;
 - (e) Clay of liquid limit exceeding 70 and/or plasticity index exceeding 45.

Materials stated above in d), if otherwise suitable shall be classified suitable when unfrozen.

- “Rock fill” shall consist of hard material of suitable size for deposition and compaction as given in Clause 9 of Section of Section II and also may comprise rock as defined in Clause 3 of Section II and broken stones.
- “Well Graded Granular Material” Consisting of gravel and/or sand shall conform to Clause 9.
- “Rock Fall”, coarse alluvial material shall be loose soils such as moraines, debris, or alluvial material containing large blocks or large boulders, individual blocks or boulders of hard materials greater than 0.3m³ each in volume, shall be classified as hard material.

- "Hard Material" shall mean any material which conform to the requirements of Sub-clause 3 (4) of Section II.

7.11 Sieve

IS sieve shall be used for all tests. Based on IS-460 the standard sieves series shall be as follows:

125; 90; 75; 63; 50; 45; 40; 37.5; 31.5; 25; 22.4; 20; 19; 16; 12.5; 11.2; 10; 9.5; 8; 6.3; 5.6; 4.75; 4.00; 2.8; 2.36; 2; 1.7; 1.4; 1.18; 1; 0.85; 0.71; 0.6; 0.5; 0.425; 0.400; 0.300; 0.250; 0.212; 0.180; 0.150; 0.125; 0.090; 0.075 mm

7.12 Soil and Gravels

7.12.1 Sampling and Samples

Sampling of soil and gravels shall be carried out as specified or as directed by the Engineer. Sample shall be prepared for testing as indicated in IS 2720 part I, except that:

- The mass (in g) of a sample required for sieve analysis is about 400D, D being the maximum particle size (mm)
- Sample containing particles larger than 19mm size shall be prepared for compaction and CBR tests as described hereunder, provided the proportion in weight of such particles is less than 30%:

An adequate quantity of representative material shall be sieved over the 50 mm and 19mm sieve shall be weighed and replaced with an with an equal mass of material passing the 19 mm sieve and retained on the 4.75 mm sieve. The material for replacement shall be taken from the remaining portion of the main sample.

When preparing gravel samples, the aggregations of particles shall be broken with a wooden or rubber hammer or pestle. Care shall be taken that no individual particles are crushed in the operation.

7.12.2 Standard Methods of Testing

Tests on soils and gravels shall be performed in accordance with the standard methods given in Table 6.4

Table 7-2: Tests Procedures Applicable to disturbed/Undistributed Samples of Soils and Gravels

Test	Test procedure	
Determination of:		
i) Moisture	IS 2720	Part 2 (Oven-drying method)
ii) Liquid Limit	IS 2720	Part 5 (Cone Penetrometer or by Casagrande apparatus)
iii) Plastic Limit	IS 2720	Part 5
iv) Plasticity Index	IS 2720	Part 5
v) Linear Shrinkage	IS 2720	Part 20
vi) Specific Gravity of Particles	IS 2720	Part 3
vii) Particles Size Distribution	IS 2720	Part 4
viii) Organic Matter content	IS 2720	Part 22
ix) Total Sulphate Content	IS 2720	Part 27

x) pH Value	IS 2720	Part 26 (Electrometric Method)
xi) Mica Content	-	Manual mineralogical counting
xii) Density - Moisture Content relationship (2.5 kg rammer)	IS 2720	Part 7
xiii) Density - Moisture Content relationship (4.9 kg rammer)	IS 2720	Part 8
xiv) California Bearing Ratio	IS 2720	Part 16
xv) Sand Equivalent	IS 2720	Part 37 (Mechanical Shaker or Manual Shaker Method)
xvi) Field Dry Density	IS 2720	Part 28/Part 29
xvii) Unconfined compression test	IS 2720	Part 10
xviii) Unconfined compression test	IS 2720	Part 15
xix) Direct shear test	IS 2720	Part 13
xx) Triaxial test	IS 2720	Part 11, 12
xxi) Hydrometer analysis	IS 2720	Part 4
xxii) Vane shear test	IS 2720	Part 30

It is further specified that:

- Wherever in the text of these Specifications and the Special Specification the term "x% of MDD (IS 2720 Part 27 and IS 2720 Part 28) is used it shall mean that a standard of compaction shall be achieved such that the dry density of the compacted material is x% of the maximum dry density determined from the respective tests mentioned in Table 6.4. Samples for the compaction tests shall be taken before compaction of the layers begins unless in the opinion of the Engineer the compactive effort proposed or applied by the Contractor is such that the material characteristics have changed in which case the samples for the tests shall be taken after all compaction is complete.
- Compaction tests: when the material is susceptible to crushing during compaction, a separate and new sample shall be used in the determination each point on the moisture/density curve.
- The dry density of material placed in the works shall be determined by the Sand Replacement Method unless the Engineer directs to use a nuclear method or other method. In the case of nuclear method, tests shall be done at least at the same frequency required when using the Sand Replacement Method, but at each nuclear densometer test location the average of three readings taken at positions rotated by 90° shall be used. A check/comparison test using the Sand Replacement Method shall be carried out at 10 test interval.
- Initial calibration of the nuclear density testing equipment shall be done by carrying out at least fifty tests in parallel with the Sand Replacement Method for each different material encountered. The check tests shall be used to update the initial calibration of the nuclear density testing equipment.

7.13 Stone, Aggregate, Sand and Fillers

7.13.1 Sampling and Preparation of Samples

Sampling shall be carried out as per ASTM-D75 and the samples shall be prepared in accordance with IS 2486 or according to sampling procedures specified for the Standard Methods of testing given in Table 6.5.

7.13.2 Standard Method of Testing

Tests on stone, aggregate, sand and filler shall be performed in accordance with the standard procedures given in the Table 6.5.

Table 7-3: Test Procedures Applicable to Stone Aggregate and Fillers

Tests	Test Procedure	
Determination of:		
i) Particle Size Distribution (Gradation)	IS 2386	Part 1 Part 2
ii) Clay, Silt, Dust in Aggregates	IS 2386	Part 1
iii) Flakiness Index	IS 2386	Part 3
iv) Specific Gravity	IS 2386	Part 3
v) Moisture Content	IS 2386	Part 3
vi) Bulk Density, Voids & Bulking	IS 2386	Part 117
vii) Soluble Chloride Content	BS 812	
viii) Mica Content	Manual mineralogical Counting	
ix) Water Absorption	IS 2386	Part 3
x) Crushing Ratio	Manual counting & weighing	
xi) Los Angeles Abrasion	IS 2386	Part 4
xii) AIV-ACV	IS 2386	Part 4
xiii) Polished Stone Value	IS 2386	Part 4
xiv) Degradability Test	NFP 94 - 067	
xv) Sodium Sulphate Soundness	IS 2386	Part 5
xvi) Alkali Aggregate Reactivity Test	IS 2386	Part 7
xvii) Bitumen Adhesiveness (Vialit Test)	NFP-98-274-1	
xviii) Deleterious Substances	IS 2386	Part 2
xix) Sand Equivalent	IS 2720	Part 37
xx) Crushing Strength of Stone	IS 2386	Part 4

7.14 Cement

Ordinary and High Strength Portland Cement (OPC and HSPC), Portland Slag Cement (PSC), Portland Pozzolana Cement (PPC) shall be sampled according to IS 3535 and tested according to IS 4031.

Chemical and physical requirements for Ordinary Portland Cement, High Strength Portland Cement, Portland Slag Cement and Portland Prozzolana Cement shall be in accordance with IS 269, IS 8112, IS 12269, IS 455, IS 1489 respectively.

The requirements on their physical characteristics shall be as given in Table 6.6

Table 7-4: Requirement on the Physical Characteristics of Cement

S.N.	Physical Characteristics	OPC/PSC	HSPC	Test Procedure
i)	Finess, m ² /kg: (by Blaine's Air Permeability method)	225	225	IS 4031 Part 2
ii)	Setting Time:			
	(a) Minimum Initial Setting Time (minutes)	45	45	IS 4031 Part 5
	(b) Maximum Final Setting Time (minutes)	600	600	

iii)	Soundness by Lechatelier Method, mm, maximum	10	10	IS 4031 Part 3
iv)	Compressive Strength: Minimum average Compressive Strength of three mortar cube (N/mm ²)			
	(a) 3 days	16	27	IS 4031 Part 6
	(b) 7 days	22	37	
	(c) 28 days	33	53	

7.15 Concrete

Sampling and testing on concrete shall be carried out in accordance with the standard methods given in the Table 6.9

Table 7-5 Tests Procedures Applicable to Concrete

Tests	Test Procedure
Determination of:	
(i) Air contents of fresh concrete	BS 1881 - 106
(ii) Density of hardened concrete	BS 1881 - 114
(iii) Compressive strength of concrete cubes	BS 1881 - 116
(iv) Tensile splitting strength	BS 1881 - 117
(v) Flexural strength	BS 1881 - 118
(vi) Compressive strength of concrete cores	BS 1881 - 120
(vii) Water absorption	BS 1881 - 122
(viii) Mixing and sampling fresh concrete in laboratory	BS 1881 - 125
(ix) Normal curing of test specimens (20° C method)	BS 1881 - 111
(x) Accelerated curing of test specimens	BS 1881 - 112
(xi) Marking test cubes from fresh concrete	BS 1881 - 108

Non destructive tests shall be carried out in accordance with the standard method and recommendations given in Table 6.10 as when required.

Table 7-6: Non-destructive Tests Applicable to Concrete

S.No.	Tests	References to Test Procedures
(i)	Method of hardened concrete for other than strength	BS 1881 - 5
(ii)	Guide to the use of non destructive methods of test for hardened concrete	
(iii)	Recommendation for surface hardened testing by rebound hammer	BS 1881 - 201
(iv)	Recommendation for measurement of velocity of ultrasonic pulses in concrete	BS 1881 - 202
(v)	Recommendation on the use of electromagnetic cover meters	BS 1881 - 203
(vi)	Recommendation for the assessment of concrete strength by near to surface tests.	BS 1881 - 204
		BS 1881 - 207

The test specimens shall be cured at a temperature of $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$

Water to be used in concrete shall be tested as specified in BS 3148

The total chloride content, expressed as chloride ion, arising from all ingredients in a mix including cement, water and admixtures shall not exceed the following limits, expressed as a percentage of the weight of cement in the mix:-

For prestressed concrete, steam cured concrete or concrete
containing sulphate resisting or supersulphated cement : 0.1 percent

For any other reinforced concrete : 0.4 percent

The total sulphate content expressed as SO_3 of all the ingredients in a mix including cement water and admixtures shall not exceed 0.4 percent by weight of the aggregate or 4.0 percent of the weight of the cement in the mix, whichever is the lesser.

7.16 Reinforcing Steel

All reinforcement for use in the Works shall be tested for compliance as specified in relevant Clauses of Section V in a Laboratory acceptable to the Engineer and two copies of each test certificate shall be supplied to the Engineer. The sampling and frequency of testing shall be as set out in the NS 84-2042 and NS 191-2045. In addition to the testing requirements described above, the Contractor shall carry out additional testing as instructed by the Engineer.

7.17 Testing of Welds

The tests detailed in Clause 6 of Section VII shall be carried out by the methods described in BS 709. The following requirements shall also be met with.

a. General

In any respect the test results of welded joints shall not be inferior to the British Standard test requirements for the parent material.

b. Procedure Trials

i) Tensile and Bend Test

Should any one of the weld joint pieces selected for transverse tensile and transverse and longitudinal bend test fail to comply with the requirements applicable to the parent metal of the joint, 2 additional test pieces shall be taken from the joint material represented by the test. Both the test pieces shall comply with the requirements in order to qualify for the acceptance.

ii) Charpy V-notch Tests

Should the average impact value obtained from any set of 3 Charpy V-notch tests on specimens fail to comply with the requirements, 3 additional test pieces from the same sample shall be tested. The average of the 6 test results shall comply with the requirements in order to qualify for acceptance.

iii) Revised Procedures

In the event of failure to meet the requirements, the Contractor shall carry out further trials, using revised procedures, and further tests to the satisfaction of the Engineer.

c. Production Tests

i. Tensile and Bend Tests

Should any one of the weld joint test pieces selected for transverse tensile and transverse bend tests fail to comply with the test requirements applicable to parent metal of the joint

represented by the test, additional specimens shall be taken from the same production test plates and the test shall be repeated. Should any of the additional tests fail to comply with the requirements, the joint shall be rejected.

ii. Charpy V-notch Tests

Should the average impact value obtained from any set of 3 Charpy V-notch specimens selected fail to comply with the test requirements, 3 additional test pieces from the same production test plates shall be tested. Should the average of the 6 results fail to comply with the test requirements the joint shall be rejected.

iii. Re-Welding and Re-Testing

In the event of failure to meet the test requirements the welded joint represented by the tests shall be completely cut out. The joint shall then be re-welded and the test repeated.

iv. Non-destructive Testing

A method of non-destructive testing agreed with the Engineer shall be used for the examination of butt welds in tension members.

7.18 Paint for Structural Steel Work

The Contractor shall submit the proposal to the Engineer about the paint system to be used in the Works

The system shall comply with Sub-clause 9 (9) of Section VII and shall be defined at least by the following informations, supported by the paint manufacturer's data sheets:

- Type of system, composition of each component.
- Minimum thickness of each coat.
- Drying time at 10°C within a range a relevant hygrometric conditions, including handling conditions, minimum and maximum time of overlap.
- Type of painting method and thinner content , (airless spray, brush, roller etc.)
- Thinner type
- Blending ratio.
- Maximum time limit of use, by 75% of relative humidity and for a relevant range of temperature and hygrometric conditions.
- Weather conditions constraint for painting and drying, including minimum and maximum ambient temperature and temperature of surfaces to be painted.

7.19 Bricks

Bricks shall conform to NS-1-2035 with the exceptions specified in Sub-clause 2052 (1).

7.20 Mortar

Mortar shall comply with relevant clauses of Section V.

7.21 Reinforced CPMCRETE Pipes

Reinforced concrete pipes shall comply with the requirements of NS 80-2042/IS 485:1988.

7.22 High Density Polythene Pipes

High density polythene pipes shall comply with the requirements of NS 40-2040.

7.23 Geotextiles

Geotextiles used for sub-surface drains shall be made of polyethylene or polypropylene or polyester or similar fibres, either woven or nonwoven. Unless otherwise shown on the Drawing, the geotextile shall:

- (a) sustain a load of not less than 10 kN/m at break and have a minimum failure strain of 10 percent when determined in accordance with BS: 6906 or shall have a grab tensile strength more than 0.4 kN/m and grab elongation corresponding to this limit in accordance with ASTM D 4632.
- (b) have apparent opening size as shown on the Drawing. If no size is shown on the Drawing, then the apparent size shall be 0.1 mm.
- (c) allow water to flow through it at right angles to its principal plane, in either direction at a rate of not less than 50 litres/sq.m/sec. under a constant head of 100 mm, determined in accordance with BS: 6909 (Part 3) or ASTM D4491, unless otherwise shown on the Drawing. The flow rate determined in the test shall be corrected to that applicable to a temperature of 15°C using data on variation in viscosity of water with temperature.
- (d) have a minimum puncture resistance of 200 N when determined in accordance with ASTM D 4833.
- (e) have a minimum tear resistance of 350 N when determined in accordance with ASTM D 4533. Geotextile used for drilled sub-surface drains shall be as specified in Clause 2405 of standard specification prepared by DOR.

7.24 Timber for Structural works

Timber used for structural works shall comply with IS:883.

7.25 Paint for Road Marking

Paint for road marking shall comply with NS 408-2054. Paint used for other purposes shall be as specified in the respective sections of these Specifications.

7.26 Manhole Covers and Frames

Manhole covers and frames shall be of cast iron and shall comply with IS: 1726-1991. For manholes constructed in carriage way and shoulder, heavy duty circular covers and frames shall be used. In footpaths, medium duty circular covers shall be used. In other locations light duty covers and frames shall be used.

7.27 Precast Concrete Channels

Precast concrete channels, kerbs, edging, quadrants and gutters shall comply with the requirements of IS: 5758 – 1984.

7.28 Cast Iron Drainage Gratings

Cast gratings for drainage purpose shall comply with the requirements of IS: 5961 – 1970.

7.29 Gabion

All wire used in the fabrication of gabions and wiring operations during construction shall comply with the requirements of NS: 169 – 2045. The wires shall be galvanized with heavy coating of zinc. The coating of zinc shall comply with NS: 163 – 2945 (Heavy Coated Wire).

7.30 Measurement and Payment

If otherwise not specified in the contract, no separate measurement and payment be made for sampling and testing of materials, trials and construction control/process control testing. It shall be deemed to have included in the rates of the relevant items for complying with the requirements of this Section.

CHAPTER - 8

8. Concreting Materials

8.1 Cement

(a) Quantity and Type

The cement used in the Works shall comply with NS49/2041 or IS269-1976 or BS12, For the purpose of cement testing under NS49/2041 or IS269-1976 or BS12, the site shall be deemed to have a tropical cold climate. The Contractor shall approve the name, brand, date of manufacturing, and grade before procurement and supply the test certificate accordingly.

(b) Packing

The cement shall be packed in proper bags in approved quality and the net mass of each bag be 50 kg. The permissible tolerance on the mass cement supplied in bags shall be $\pm 2.5\%$ per bag with an overall tolerance of $\pm 0.5\%$ per 10 tones wagon load bags cement.

(c) The method of deliver, transport, handling and storing shall be subject to the approval of the Engineer.

The cement shall be delivered to the site in good condition and shall be kept dry at all times until used in the Works. The Contractor shall be responsible for all risks of damage to the cement by water or otherwise. Defective, damaged or condemned cement shall be removed without delay from the site.

On delivery at the site, the cement shall be stored in suitable thoroughly dry and well ventilated sheds with raised timber floors. Each consignment shall be kept separate and suitable labels or markings shall be made on the bags to distinguish the consignment. Bagged cement shall not be stacked more than 10 bags high.

(d) Records, Certificates and Samples

Prior to delivery to the site, the Contractor shall supply to the Engineer the manufacturer's test certificate for each consignment of cement received at the site as provided for in clause 10 and 12 of BS 12. When each consignment is delivered to the site, the Contractor shall handover to the Engineer a statement showing the number of the consignment the name of the manufacturer, the number of tones in the consignment and the number of bags.

The Contractor shall forward a weekly report to the Engineer giving full particulars of the various consignments in store.

The Contractor shall maintain a record available for inspection by the Engineer of the locations of concrete made from each consignment.

The Contractor shall supply samples of cement for test and send them for testing by the Engineer when requested by the Engineer both from the Contractor's store on site and from the place of manufacture.

8.2 Aggregates

(a) Supply and Classification

The Contractor shall make his own arrangements for procuring, crushing, grading and delivering aggregate for the Works as required from sources to be approved by the Engineer.

Separate fine and coarse aggregate shall be used for the manufacture of concrete. The term 'fine aggregate' is used to designate aggregate mainly passing a 5 mm, IS 2386 or BS410 test sieve and containing only so much coarser material as is permitted for the various grading zones given in **Table 7.3**. The term 'coarse aggregate' is used to designate well graded aggregate mainly passing a 37.50 mm, BS 410 test sieve and only containing much coarser or finer material as is given in **Table 7.2**.

Coarse aggregate shall be supplied in the following primary sizes as given in **Table 5.1**.

Table 8-1 Sizes of coarse aggregates

Size Designation	Nominal Size
10	5 mm to 10 mm
20	10 mm to 20 mm
40	20 mm to 40 mm

(b) Aggregates shall be graded to produce a workable dense concrete.

All aggregates to be used in concrete shall be clean, hard, dense, sound, chemically inert, or limited porosity and uncoated particles free from clay or organic matter. Aggregates for concrete shall comply with BS 882: Part 2 and the following

Grading: in accordance with Table 8.1 and 8.2 herein

Mechanical Properties: when tested in accordance with BS 812, Part 3, the 10% fines value, shall be not less than 50KN.

Silt, clay and Dust Fraction: when determined in accordance with the decantation method given in NBC101-1994 or equivalent to BS 812, Part 1 the silt, clay and dust fraction by weight shall not exceed 1% for coarser aggregates, 3% for natural sand or crushed sand and 15% for crushed sand.

Water Absorption: when tested in accordance with BS 812 Part 2 the water absorption after 24 hours shall not exceed 4%

Soundness: when tested in accordance with the sodium sulphate soundness test specified in ASTM C88 the aggregate shall have a percentage loss of less than 15.

Alkali - Aggregate Reactivity: When tested in accordance with ASTM C289 aggregate exhibiting evidence of alkali- aggregate reactivity will not be accepted unless the contractor can show that the proposed cement aggregate combination, when tested in accordance with ASTM C227 or other tests, will not produce deleterious alkali-aggregate reactivity, as to which the Engineer shall be the sole judge.

Shrinkage: when determined in accordance with the BRE Digest 35 test the drying shrinkage shall not exceed 0.065%.

Mica content: shall not exceed 1% by weight

(c) Testing

Testing of aggregate is to be in accordance with BS 812 or as specified herein.

For each source of aggregate and at least six weeks prior to the preparation of trial mixes samples of aggregate together with the results of the tests listed below shall be submitted to the engineer for approval of the sources of aggregate and quality.

Grading analysis to BS 812, Part 1

Mechanical properties. 10% Fines Value Test to BS 812 Part 3

Silt, clay and dust fraction in both fine coarse aggregate decantation method to BS 812, Part 1

Specific gravity and water absorption to BS 812 Part 2

Sodium sulphate soundness test to ASTM C88.

(D) *Aggregates shall be washed and screened as necessary to produce aggregates meeting the specified requirements. All such washing and screening shall be to the satisfaction of the engineer.*

If mica be present in unacceptable quantities, its removal shall be effected by techniques approved by the engineer. The costs of all washing and screening shall be included in the Unit Rates for Concrete in the bill of Quantities.

(E) Storage

Aggregates shall be stored in separate stockpiles in such a manner that the intermingling of materials from separate stockpiles or bins is not possible and so as to prevent contamination by mud, rubbish, windblown dust or vegetation. Aggregate stockpiles shall be provided with adequate drainage of the aggregates. The storage arrangements shall be to the approval of the Engineer.

(F) Coarse Aggregates

Coarse aggregate shall consist of natural gravel, crushed rock or mucks. Friable and flaky pieces such as mica and shale not be present. Coarse aggregates shall be well graded within gradings given in **Table 7.2** and to the satisfaction of the Engineer.

Table 8-2 Coarse aggregates percentage by weight passing standard sieves

BS 410 standard Mesh (mm)	10 mm to 5 mm	20 mm to 5 mm	40 mm to 5 mm
75			100
37.5		100	95-100
20	100	95-100	37-70
10	85-100	30-60	10-40
5	0-25	0-10	0-5

(g) Fine Aggregates

Fine aggregate shall consist of natural sand, or a mixture of natural sand and crushed gravel or crushed rock. The engineer will permit the addition of crushed gravel or crushed rock fine aggregate to the natural sand only where in his opinion it is impracticable to obtain the required grading otherwise than by such addition.

The grading of the fine aggregate shall lie within one of the grading zones as set out in **Table 7.3** below and specified in BS 882.

Table 8-3 Grading zones defined by percentage by weight passing standard sieves

BS 410 Standard Mesh mm	Grading Zone 1	Grading Zone 2	Grading Zone 3	Grading Zone 4
10mm	100	100	100	100
5mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600	15-34	35-59	60-79	80-100
300	5-20	8-30	12-40	15-50
150	0-10	0-10	0-10	0-15

8.3 Water for Making Concrete, etc

Water used in mixing concrete, mortar or grout shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials or other substance that may be deleterious to concrete or steel. The water shall be to the approval of the Engineer and in accordance with RS3148.

The Contractor shall, at least six weeks prior to the making of the trial mixes, sample the water he proposes to use and deliver the samples to the Engineer for testing.

8.4 Chemicals in Concrete

The total sulphate content, whether as gypsum or more soluble salts, of the concrete ingredients when measured as sulphur trioxide shall not exceed 4% of the weight of cement in the concrete.

The chloride content of the concrete ingredients when measured as chloride ion shall not exceed 0.2% of the weight of cement in the concrete.

If instructed by the Engineer, the Contractor shall obtain samples from the concrete for testing, all in accordance with BS1881, Part 6. The cost of sampling and transport shall be covered by the unit rates for concrete.

8.5 Additives

Concrete shall be made from cement, aggregates and water as specified. No other ingredients shall be mixed with the concrete or mortar without the Engineer's approval.

If the use of retarding or workability agents is approved by the Engineer their use shall be subject to the following conditions:

There shall be reduction in characteristic strength at 28 days compared with additive free concrete of the same grade and class.

There shall be no reduction of minimum cement content specified and the use of the admixture shall be strictly in accordance with the manufacturer's instructions in respect of the conditions at the site. Admixtures shall be introduced to the concrete by approved dispenser. The Contractor shall use a retarder to facilitate the preparation of construction joints to the approval of the Engineer of the composition of the retarder and its methods of application.

CHAPTER - 9

9. Concreting and Tests

9.1 Classes and Grades of Concrete

The concrete used in the Works shall be of the grades or classes shown on the Drawings or indicated in the Bill of Quantities or approved by the Engineer.

The **Table 8.1** shows the tentative use of concrete class in the different structures unless otherwise instructed by the Engineer and/ or shown in the drawings.

Table 9-1 Concrete grades and place of use

Class	Use of Concrete
M35(CP35P/40)	- Reinforced concrete as per design and Drawing where ever specified.
M25(CP25P/40)	- Reinforced concrete at structural parts
M25(CP25P/25)	- Precast concrete units, operating Slabs
M20(CP20P/40)	- Secondary Structures, retaining wall, Guide wall, Spillways, Drainage networks, sumps, watchman's Quarter, lining etc.
M15(CP15P/40)	- Mass concrete (weir, gravity retaining wall)
M15(CP15P/40) with 30% plum	- Weir body (plum concrete)
M10(CP10P/40)	- Lean concrete

The characteristics of the mixes of concrete to be used in the various Works shall be as given in **Table 8.2** unless otherwise approved by the Engineer.

Table 9-2 Classification of concrete

Concrete grades	M25 25/40	M25 25/20	M20 20/40	M15 15/40	M15 15/20	M10 10/40
Maximum aggregate size (mm)	40	20	30	40	20	40
Characteristics Compressive strength N/mm ² (kg/sq.cm)	25(255)	25(204)	20(153)	15(153)	15(153)	10(102)
Minimum cement content of concrete (kg/cu.m)	340	340	290	140	260	3220
Maximum cement content of concrete (kg/cu.m)	400	400	400	400	400	400
Maximum free water to cement ratio by weight	0.43	0.43	0.55	0.55	0.60	0.60

9.2 Maximum Sizes of Aggregates to be used

Unless shown on the Drawings or given in the Bill of Quantities, the maximum size of coarse aggregate in concrete for any part of the Works shall be the largest of the sizes given in **Table 8.2**, the use of which is practical from the standpoint of satisfactory workability and consolidation of the concrete. The Contractor shall obtain the approval of the Engineer to the maximum size of aggregate for each section of the Works.

9.3 Compressive Strength Compliance

The compressive strength of the concrete shall be based on the compression testing of 150 mm concrete cubes, made and tested in accordance with BS 1881, Parts 1, 3 and 4 on testing equipment installed by the Contractor in site laboratory under the supervision of the Engineer.

The compressive strength of the concrete is the value of the cube compressive strength, when tested at an age of 28 days, below which not more than 5% of results shall fall.

The concrete in the works shall be considered to comply with the compressive strength requirements specified in **Table 8.2** if not more than 5% of the 28 days cube compressive strength test results fall below the specified characteristic compressive strengths and the following 28 days cube strength are equaled or exceeded.

Table 9-3 Cube strength compliance values

Concrete grade	Minimum Individual Cube result N/mm ²	Mean of any four consecutive cube results N/mm ²
25/40	21.3	25 + 0.82 δ
25/20	21.3	25 + 0.82 δ
20/20	17	20 + 0.82 δ
20/10	17	20 + 0.82 δ
15/49	12.8	15 + 0.82 δ
15/20	12.8	15 + 0.82 δ
10/40	8.5	10 + 0.82 δ

The standard deviation, δ in **Table 8.3** shall be determined from the cube results of at least 40 separate batches of concrete for each concrete grade produced on site from similar materials by the same plant under similar supervision. When 40 cube results are not available standard deviation for the mix designs shall be taken as shown in **Table 8.4**:

Table 9-4 Standard deviations for cube test results fewer than 40

Concrete Grade	Standard Deviations, N/mm ²
25/40	11
25/20	11
20/20	9
20/10	9
15/40	6
15/20	6
10/40	4

The concrete represented by a group of four consecutive test cubes shall include the batches from which samples were taken to make the first and last cubes in the group of four together with all the intervening batches. If only one cube result fails to meet the minimum individual cube strength given in **Table 8.3** then the result shall be considered to represent only the particular batch of concrete from which that cube was taken, provided that the average strength of the group of four results in which the low cube occurs satisfies the second requirement of **Table 8.3**. The action to be taken in respect of the concrete represented by test cubes which fail to meet the compliance values given in **Table 8.3** shall be determined by the Engineer which may range from qualified acceptance in less severe cases to rejection and removal.

9.4 Water Cement Ratio

The maximum water cement ratios specified in **Table 8.2** shall be the ratios by weight of free water to cement in the mix based on the aggregate being a saturated surface dry condition.

Throughout concrete production the actual water cement ratio shall be strictly monitored and the batch quantities of aggregates and water regularly adjusted to maintain the design water cement ratio.

9.5 Workability

Concrete shall be of such consistency that it can be readily worked into the corners and angles of the formwork and around reinforcement without segregation of the materials or bleeding of free water at the free surface against formwork. On striking the formwork the concrete shall present a face which is uniform free from honeycombing, surface crazing, or excessive dusting, and which shall not, in the opinion of the Engineer be inferior to the specified standards. Concrete to be placed underwater shall have high workability such that the specified characteristic strength is achieved without compaction.

Workability of the concrete shall be measured by the slump method or other approved method in accordance with BS 1881 Part 2 and to the approval of the Engineer.

Concrete workability shall be as low as practical for the placement and workability and shall be within the limits given in **Table 8.5** unless otherwise approved by the Engineer.

Table 9-5 Range of Slump Values (mm)

Kind of Concrete	Slump
Precast concrete	10 to 50
Mass concrete and plain concrete	25 to 75
Reinforced concrete	50 to 100
Underwater concrete	100 to 200

9.6 Mix Design

The contractor shall design suitable mixes for each grade of concrete required for the Works as shown in **Table 8.2**. Each grade of concrete shall be designed to a target mean strength of at least as presented in **Table 8.6**:

Table 9-6 Concrete grades and target mean strength

Concrete grade	Target Mean strength (N/mm ²)
25/20	25 + 1.64 δ
25/40	25 + 1.64 δ
20/20	20 + 1.64 δ
20/10	20 + 1.64 δ
15/40	15 + 1.64 δ
15/20	15 + 1.64 δ
10/40	10 + 1.64 δ

For each grade of concrete, well in advance of construction, the contractor shall submit information to the Engineer for his approval as follows.

- (1) full details of tests and trial mixes
- (2) the mix designs with the proposed quantities of constituents per cubic meter of fully compacted concrete and value of workability.

If the cube results are consistently and significantly in excess of the target mean strength then the contractor may modify the mix proportions provided the requirements hereof are still met and subject to the approval of the Engineer and any additional trial mixes that may require to be made.

If the cube results are consistently below the target mean strength then the contractor shall cease production of the relevant class of concrete, investigate the cause of the relative low strength and rectify to the satisfaction of the Engineer.

9.7 Trial Mixes

Trial mix design work may be undertaken by the contractor in the site laboratory of the contractor. At least five weeks before using any concrete in the Works the contractor shall produce and test trial mixes for each grade of concrete using the same type of construction plant and the same materials as proposed for the works. The contractor shall give 24 hours notice of such trials to enable the Engineer to attend.

For each trial mix of concrete three batches shall be made. Three cubes shall be made from each batch for testing at 28 days and three cubes made for testing at 7 days.

The trial mix proportions will be approved if the average compressive strength of the nine cubes tested at 28 days exceed. The average compressive strength of nine cubes for different concrete grades are shown in **Table 8.7**.

Table 9-7 Concrete grades and average compressive strength of nine cubes

Concrete grade	Average compressive strength of nine cubes (N/mm ²)
25/40 or 20	25 + 1.64 δ - 3.5
20/40	20 + 1.64 δ - 3.5
20/20	20 + 1.64 δ - 3.5
20/10	20 + 1.64 δ - 3.5
15/40	15 + 1.64 δ - 3.5
15/20	15 + 1.64 δ - 3.5
10/40	10 + 1.64 δ - 3.5

The contractor shall not commence placing concrete in the works until the results of the trial mixes have been submitted and the proposed initial mix designs have been approved by the Engineer. Once the proportions of the various mixes have been approved, the contractor shall not vary either the proportions of the mixes or the source of any constituent material without the approval of the Engineer.

9.8 Concrete Sampling and Testing

Sampling and testing shall be in accordance with BS 1881.

The contractor shall establish a system for regular sampling and testing of concrete to the approval of the Engineer. Samples shall be taken from randomly selected batches of each class of concrete used in the works, and at approximately equal intervals throughout the placement. Where more than one mixer is in use, sampling shall be from each mixer in turn. Rates of sampling and testing shall generally be as described in Table C.6, but the Engineer may at any time vary the rate and number. Higher rates of sampling and testing may be used at the start of the works to establish the quality quickly or during periods of production when quality is in doubt.

The contractor shall provide the necessary equipment, labor and transport for carrying out the sampling and testing in the site laboratory. The concrete test cubes shall be stored and tested at the site laboratory under the supervision of the Engineer.

Records of concrete sampling and testing shall be kept by the contractor and forwarded to the Engineer within 24 hours of sampling and testing. Samples for testing shall be taken at the point of discharge into the works.

Table 9-8 Concrete sampling and testing

Tests	Rates of Sampling and Testing
Workability	First and second batch from each
Slump test or similar approved	Mixer during any pour and thereafter on every 10 th batch

Tests	Rates of Sampling and Testing			
	and when sampling for each cube making.			
Temperature of fresh concrete	At the same intervals as the workability test is made.			
Cubes for compression testing at 28 days	One cube shall be made at the rates listed below but at least one for each day that concrete of that grade is made.			
Concrete Class	M25 Each 20 m' or 20 batches	M20 Each 20 m' or 20 batches	M15 Each 50 m' or 50 batches	M10 Each 50 m' or 50 batches
Cubes for compression testing at 7 days	At rates directed by the Engineer's Representative but in any case not exceeding those required for 20 days cube testing.			

9.9 Ready Mixed or Truck Mixed

Ready mixed concrete may be used only with the approval of the Engineer and shall comply with all requirements of the Contract.

The concrete shall be carried in purpose made agitators, operating continuously, or truck mixers, which shall comply with BS 4251, or similar approved. For each batch of concrete the time of introduction of cement and water to be aggregates shall be recorded on a delivery return to be forwarded to the Engineer. Water shall be added either at the delivery point or at the central batching plant. In no circumstances shall water be added in transit.

Concrete shall be discharged and placed within one hour after the time of loading or other such time as may be found necessary and approved by the Engineer to ensure that the concrete has the required workability at the time of discharge and placing. The time of loading shall be the time of contact between the cement and aggregates or, when these surfaces are dry, between cement and added water.

A mixer that has been out of action for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed in it. The first batch of concrete materials through the mixer shall contain an excess of cement, to coat the inside of the drum without reducing the required mortar content of the mix.

9.10 Equipment for concreting

The Contractor shall provide at the sites of the Work adequate mixing plants with the following specifications which will permit performance of the concrete work without delay in the approved time schedule for the Work.

The equipment shall be capable of combining the aggregate, cement, admixture and water into a uniform mixture within the time limit specified hereafter and of discharging this mixture without segregation. The complete plant assembly shall include provisions to facilitate the inspection of all operations at all times. The plant shall be subject to the approval of the Engineer.

An individual weight batcher shall be provided for each material except the admixture which may be batched by volume. Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of concrete.

The Contractor shall provide standard test weight and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Periodical tests in accordance with the manufacturer's instruction shall be made in the presence of the Engineer in such a manner and at such intervals as may be directed by the Engineer.

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregate and to change the weights of the materials being batched.

9.11 Transportation of concrete

Concrete shall be discharged from the mixer and transported within one hour to the final position by means to be approved by the Engineer, which will ensure that the concrete is of the required workability at the point and time of placing, and which will maintain a continuous delivery of concrete. All equipment used for this purpose shall be kept clean and in good condition. If concrete is to be poured by tipping, chutes must be used to keep it coherent, their ends being just above the placing points.

Pump lines must be laid so that the stream of concrete is not interrupted. Water content and particle size must be carefully watched when concrete is being pumped to prevent the pipes being plugged.

The slopes of troughs for conveying fresh concrete shall be chosen so that the concrete with minimum water content flows in a steady stream without segregation.

9.12 Placing of concrete

No concrete shall be placed until the site of placing including formwork, reinforcement and embedded items have been inspected and the Engineer has given his written permission for placing of concrete. Safe access arrangement shall be given for this purpose.

All concrete placed on earth shall be placed upon clean compacted, damp surfaces free from standing or running water.

Surfaces of rock upon which concrete is to be placed shall be clean and free from oil, standing or running water, mud, loose rock, objectioned coating, debris, and loose, semi-detached, or unsound fragments. Faults, fissures and seams shall be cleaned to a satisfactory depth and to firm rock on the sides. Immediately before concrete is placed all surfaces shall be cleaned thoroughly by the use of high velocity air-water jets, brooming, wet sand blasting, bush-hammering, or other satisfactory means including combinations of the above. All installation of pipes, drains and other installations necessary to produce a foundation free of running or standing water shall be installed by the Contractor and securely fastened in place so as to prevent them from being jarred loose by concrete placement. Where gravel drains are used to control seepage water, the drains shall be covered with low slump concrete which shall be allowed to reach its final set before placement may begin. No separate payment will be made for such installations. This complete operation and the extent thereof is subject to the approval of the Engineer.

All surfaces shall be in a damp condition at the time of placement. All free water shall be removed prior to the placement of mortar and concrete. All approximately horizontal surfaces shall be covered by a thin layer of mortar of the approved composition and broomed into the surface as directed by the Engineer. Concrete shall then be placed immediately upon the fresh mortar.

In placing concrete through reinforcement, care shall be taken that no segregation of the coarse aggregate occurs. On the bottom of beams or slabs, where the congestion of steel near the forms makes placing difficult, a layer of mortar of a composition compatible with the required concrete strength as directed shall be first deposited to cover the surface to a depth of approximately 3 cm.

In preparation for the placing of concrete all saw, dust, chips, and other construction debris and extraneous matter shall be removed from the interior of forms. Struts, stays and braces, serving temporarily to hold the form in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary.

These temporary members shall be entirely removed from the forms and not buried in the concrete.

Before concreting the forms shall be thoroughly wetted but no excess water shall remain in the forms,

Unless otherwise approved by the Engineer, all concrete shall be placed in its final position within 60 minutes of being discharged from the mixer.

Concrete shall not be placed in or in contact with standing or running water unless so specified or approved. Water accumulating during placing shall be removed. Concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a construction joint is formed as hereafter specified. When stoppage of concreting operations occurs for any reason, construction joints shall be placed either horizontally or vertically as needed, provided with keys to resist shear, and dowels to develop bond, as directed by the Engineer.

Before concreting operations are resumed, the surface of the concrete shall be cut or chipped to remove all laitance and to expose the aggregate. The surface of the concrete shall be thoroughly saturated and coated with a proportion by weight of 1:2 cement mortar if directed by the Engineer before the placing of the concrete is resumed.

Concrete shall be placed in the positions and sequence indicated on the Drawings or as directed by the Engineer. It shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, formwork, or embedded items and brought up in layers not exceeding 40 cm compacted thickness. Placing shall be continuous between specified or approved construction joints.

For the placing of the check dam bodies selected boulders shall be carefully arranged and embedded into the dam body concrete one after another by experienced labourers, so as to have a minimum voids or empty spaces to be filled with concrete class M15 completely. Prior to setting, the boulders shall be wetted sufficiently to take up its surface absorption, but no boulder having a film of water on its surface shall be used. Placing and embedding the selected boulders will be paid separately from concrete class M15 or as stated in the BOQ.

In case of massive structures the lift of concrete should not exceed 2 m or 1 m in the event of critical temperature, Concrete in adverse weather conditions.

Concrete shall not be dropped freely more than 1.50 m. The design and slope of chutes shall be to the approval of the Engineer and they shall be kept clean and in good repair. The use of pneumatic placers and concrete pumps shall be regulated so as to comply with the requirements of the Specifications.

The time between successive lifts shall be at least 24 hours for all structures. This time may have to be extended to 96 hours in case of massive structures during critical periods of high internal heat generator in the concrete. Time limits shall be subject to the approval of the Engineer. Outdoor concreting shall not be started during raining. If concreting is already in progress, it shall be suspended if the rain affects the quality of concrete at the judgement of the Engineer.

9.13 Compacting of concreting

The concrete shall be fully compacted to produce a dense homogeneous mass to the full extent of each layer of maximum 50 cm and successive layers shall be thoroughly worked together without any visible joint. Unless otherwise directed by the Engineer, approved power driven vibrators shall be inserted or otherwise applied to ensure that the concrete is fully compacted throughout. Vibrators shall be operated by experienced labourers only Immersion vibrators, having head diameters equal to or less than 10 cm, shall have a minimum speed of 7,000 r.p.m. Those with

head diameters more than 10 cm shall have a minimum speed of 6,000 r.p.m. Formwork vibrators shall operate at no less than 8,000 r.p.m. Immersion vibrators shall penetrate the full depth of the layer and shall enter the underlying layer, where this is of fresh concrete, so as to ensure proper integration of successive layers. They shall be inserted at sufficiently close intervals long enough to ensure proper compaction and shall be withdrawn slowly to prevent the formation of voids. Excess vibration causing segregation, surface laitance or leakage through formwork shall be avoided. Vibrators shall not be used to move concrete or in such a way as to displace or damage reinforcement or other embedded items or to damage formwork or concrete already set in position. A spare vibrator of required capacity shall be available and shall be tested to ensure that it is working, before concreting commences. Where more than three vibrators are in use, a second spare vibrator shall be available.

When concrete is compacted by hand, it shall be thoroughly rammed and spaded into place and around reinforcement and embedded parts and the stuttering by an adequate number of properly-trained men so as to give homogeneous mass and surface finish free from defects.

9.14 Curing and protection of concrete

The strength of freshly set concrete is appreciably increased by careful after-treatment. Freshly placed concrete shall be protected against sunshine, rain or running water, chemical attack and vibrations until it hardens and shall then be prevented from drying out in general for at least fourteen days. This may be done by:

- Moist curing such as spray, for saturated Dunlap, etc. under normal temperatures.
- Covering with a layer of absorbent fabric or a layer of sand kept constantly wet.
- Covering the thoroughly wetted concrete with a layer of approved waterproof membrane kept in contact with its surface.
- Application (except to surfaces which are to be bonded to subsequent concrete with an approved liquid curing membrane.

However, the use of membrane curing shall be subject to prior approval of the Engineer.

The use of cement other than ordinary Portland cement, special aggregates, or admixtures may involve modifications of the above requirements and these shall be subject to the approval of the Engineer.

Concrete shall not be subjected to traffic, vibration, shock or loading until the permission of the Engineer has been given.

No fire or excessive heat, including the heat resulting from the welding of steel or reinforcing bars, shall be permitted near or in direct contact with concrete at any time. All conduits and other openings through the concrete shall be closed during the entire curing period.

Horizontal construction joints and finished horizontal surfaces cured with sand shall be covered with a minimum uniform thickness of 5 cm of sand which shall be kept continuously saturated. Exposed concrete surfaces shall be kept more than 5 deg. C by the application of suitable insulation for at least 14 days immediately after placing during cold season.

9.15 Damaged or defective concrete surface

Defective concrete and concrete damaged from any cause shall be removed and replaced by the Contractor with acceptable concrete. Irregularities of alignment due to inaccurate finishing of surfaces, bulging of forms or other defects shall be rectified.

Patching and finishing work shall be done only by skilled or specially trained workmen and shall be subject to rigid inspection by the Engineer. Before final acceptance of the Work, Contactor shall clean all exposed concrete surfaces and shall remove all unsightly stains to the satisfaction of the Engineer.

All porous and fractured concrete and surface concrete, to which additions are required to bring it to prescribed lines, shall be removed by chipping to bare the reinforcing. The extent and dimensions of the chipped openings shall be directed by the Engineer.

The chipped openings shall be sharp edged and keyed and shall be filled to the required lines with fresh concrete, fresh mortar or dry pack mortar as directed by the Engineer. Where concrete is used for filling, the chipped openings shall be not less than 10 cm in depth and the fresh concrete shall be reinforced and dowelled to the surface of the openings as directed by the Engineer.

The mortar shall be fresh when placed and any mortar that is not used within two hours after preparation shall be wasted. Immediately prior to mortar application, the surface to which the mortar is to be bonded shall be dampened, then scrubbed with a small quantity of mortar using a wire brush.

Where repairs are more than 3 cm deep, the mortar shall be applied in layers not more than 2 cm thick to avoid sagging. After each layer, except the last, is placed, it shall be thoroughly roughened by scratching with a trowel to provide an effective bond with the succeeding layers. The last or finishing layer shall be smoothed with a trowel to form a continuous surface with the surrounding concrete; The addition of a small quantity of water to the finished surface of the patch to aid in securing a smooth finish may be permitted but no other additional water than this shall be used. All patches on exposed surfaces shall be neat and smooth and as near as possible of the same color as the adjoining concrete. All patches shall be thoroughly bonded to the surfaces of the chipped openings and shall be sound and free from shrinkage cracks and dummy area.

All patches and repairs shall be kept continuously damp for a period of not less than 7 days and kept out of the direct rays of the sun for at least 7 days immediately following completion of the patch of repair.

All remedial work shall be carried out as directed by the Engineer and without cost to the Employer.

9.16 Plum Concrete

The selected stone are placed on concrete during casting which should be of designed size, free of dust, soil and dirt. The stone should be touch each other of the bond between plum concrete should be intact. The minimum distance between plum and reinforcement bar is 30 cm if unspecified by the engineer, at site.

Concrete shall be placed in proper parts of the structure only with the Engineer's approval and full details of the method proposed shall be submitted for approval by the Engineer in advance of placing.

9.17 Boulder Concrete

Boulder concrete is simply a plum concrete as mentioned in 8.16, the difference is that the large boulder found in the weir or river base is embedded in plum concrete. While the weir base is cleared to the required level, some large boulder may be found during excavation. If such boulder are sufficiently extended to below the required level of foundation, then such boulder will be used without removing it and embedded in the plum concrete which will obviously increase the weir stability. Such boulder will be taken extra advantage of weir stability. Engineer's instruction is final whether such boulder is used as boulder concrete or need to remove.

For measurement, the boulder volume is taken into consideration when it is used as boulder concrete, remaining concrete volume is measured on the standard basis as mentioned in the following subheadings. The total volume of boulder concrete is calculated based on the separate measurement of boulders and plain concrete. The percentage of boulder is considered 30% of total volume of boulder concrete.

9.18 Concreting Under water

No concrete shall be placed in flowing water.

Concrete shall be placed underwater only with the Engineer's approval and full details of the method proposed shall be submitted for approval by the Engineer in advance of placing. The method of placing shall be in accordance with CP 2004: Foundations.

No concrete shall be placed in position by termite tube, or approved underwater skips. Underwater concrete shall be placed in single lift, no horizontal joints will be permitted. Underwater concrete shall not be vibrated and shall be subjected only to the least amount of disturbance required to place and screed the finished surface. During and after concreting underwater, pumping or watering operations in the immediate vicinity shall be suspended until the Engineer permits them to be continued.

The minimum cement contents for concrete placed underwater shall be 360 kg/m³. The maximum cement content given in **Table 8.2** may be exceeded for concrete placed underwater to the approval of the Engineer.

9.19 Converting in Adverse Conditions

The contractor shall not place concrete in the works.

- (1) During heavy rains or dust storms.
- (2) When the (shade) air temperature exceeds 38 °C.
- (3) When the air temperature is less than 2 °C.
- (4) If the temperature of the concrete is less than 4 °C or more than 30 °C without taking necessary measures to endure acceptable concrete temperatures all to the approval of the Engineer.
- (5) When the (shade) air temperature exceeds 30 °C without taking precautions to the approval of the Engineer to ensure that maximum internal temperature of the concrete does not exceed 38 °C during the initial test.
- (6) When the temperature of the formwork or reinforcement exceeds 30 °C.

9.20 Concrete Curing and Protection

The contractor shall not less than 7 days protect the concrete from the harmful effects of frost, wind, sun, high and low temperature changes, premature loading, deflection, impact, running water and aggressive groundwater. Protruding steel shall be kept cool.

All exposed concrete surfaces shall be kept continuously moist for not less than 7 days after casting, by watering, by covering with hessian or shading which shall be kept fully saturated at all times or by other methods approved by the Engineer.

Curing membranes approved by the Engineer shall be applied in conformity with manufacturer's instructions. They shall be applied to un-shuttered surfaces within 1 hour of concrete deposition and shall incorporate aluminum or other approved reflecting agent. Surfaces with applied curing membrane shall be shaded from the sun. Curing membranes shall not be used on concrete surfaces which are to be waterproofed.

9.21 Embedded Items

Before placing concrete, care shall be taken upon the fact that all embedded items are securely fastened in place as shown in the drawings or otherwise as directed by the Engineer. All embedded items shall be thoroughly clean and free from oil and other foreign matters such as loose coatings of rust, paint, scale, mortar etc. The embedding of wood in concrete shall be prohibited unless specifically approved by the Engineer.

Any pipelines or other materials embedded in structures under the Contract, as construction expedients, shall conform to the above requirements and upon completion of their use, shall be backfilled with concrete at no extra cost to the Employer.

9.22 Blockouts

Concrete blockouts shall be formed where metalwork and other various items specified under the Contract are to be installed by the contractor.

Where blockouts are to be made, the concrete surfaces shall be chipped, roughened, cleaned and kept moist for at least 4 hours. After such surfaces have been approved by the Engineer and the metal work and such other items as specified above have been installed in position, the contractor shall place reinforcement (if required) and cement mortar composed of more than 500 kilograms of cement, of concrete of the same type as that specified for the surrounding concrete.

If blockouts are filled with concrete as specified above, care shall be taken on the conditions that the freshly placed concrete is tightly bonded to the previously placed concrete and that the complete adhesion between the concrete and all metalwork and other items in the blockouts is obtained.

The cost of making and backfilling blockouts shall be included in the unit rate of the respective concrete bed in the Bill of Quantities.

9.23 Concrete for embedded of machine parts

Where the installation of hydraulic, electrical and mechanical equipment is carried out by other contractors, the Contractor shall place the anchorages, bracket, edges, or any part of thereof required for embedment or installation as shown on the Drawings. The Contractor shall place the reinforcement and concrete and ensure that all voids are properly filled with concrete. The Contractor shall cooperate with the other contractors in installing equipment and shall place concrete as introduced by the Engineer after the equipment or any part thereof has been positioned.

Surface of blockouts, anchor holes, etc. shall be thoroughly cleaned from contamination and dust and so prepared that very tight contact between blockout surfaces and the poured concrete is obtained.

The whole space must be absolutely filled by fine grained concrete type A as indicated on the Drawings or ordered by the Engineer.

9.24 Construction joints

Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be as indicated on the Drawings or approved by the Engineer. The Contractor shall submit a drawing with full details of the proposed joints (in addition to those shown on the Drawings and prescribed by the Engineer) with the shuttering and reinforcement details involved in sufficient time to enable the Engineer to review the implication of the proposal.

Construction joints in highly stressed parts and in water retaining structures shall be avoided as much as possible.

The faces of vertical joints shall be shuttered with expanded metal or the rough material. Where watertight concrete is specified, the expanded metal has to be removed completely before the adjacent lift is poured.

At exposed faces joints must appear strength vertically or horizontally or lines produced by templates fixed to the shuttering, under any circumstances unshuttered joints on a slope exceeding 20% shall not be permitted and feather edges of concrete at joints must be avoided.

Joints shall be located in column at the underside of slabs or beams or at the top of footings and floors. Column haunches and drop panels shall be concreted with the slab. Joints shall be perpendicular to the main reinforcement. The upper surface of lifts in walls and columns shall be horizontal.

When work has to be resumed on a surface which has set, the surface shall be treated as follows:

- Concrete in place for not more than 4 hours will have a laitance film at the surface with loose and porous material below it, which shall be carefully removed by the use of dry or wet sand blasting assisted by a light brushing or by an alternative approved method without loosening or damaging the body of the concrete. New concrete shall then be placed immediately.
- Concrete in place for more than 4 hours but not longer than 3 days will have a laitance film at the surface with loose and porous material below it, which shall be removed as above. The surface beneath this shall be thoroughly washed with clean water. Immediately before the fresh concrete is deposited, the surface shall be coated with an approx. 10 mm layer of cement mortar of the same consistency as that embodied in the concrete mix if directed by the Engineer.
- Concrete in place for longer than 3 days shall be chipped or wet sand blasted so as to expose an entire fresh surface of Sound homogeneous concrete without cracks or loosened aggregate. Immediately before the fresh concrete is deposited slurry of neat cement with consistency of thick cream shall be well worked into the prepared surface and followed by an approx. 10 mm layer of cement mortar of the same consistency as that embodied in the concrete mix if directed by the Engineer.

In the case of permanently visible joints the mortar layer shall be kept 5 cm from the exposed face. The treatment of the construction joints shall be included in the unit price of concrete.

After being roughened, the surface of the concrete shall be cleaned thoroughly of all loose fragments, line and other objectionable substances, and in such a condition so as to assure good bond between the existing and the new concrete. Such surface shall be moistened for at least 48 hours prior to placing the new concrete.

The method used in disposing of waste water employed in cutting, washing and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures. Methods of disposal shall be subject to approval of the Engineer.

Contraction joint and P.V.C. Waterstop

Contraction joint as indicated on the Drawings or the location as directed by the Engineer shall be treated by the Contractor. The joint material will consist of a layer of bituminous coating or as instructed by the Engineer on the face of the first concrete.

PVC water stop strip will be placed across the joints which have to remain watertight. The specifications of water-stop shall be complied with the tensile strength of more than 125 kg/sq.cm and an elongation before rupture not less than 300%. Water stop strips can be glued together at temperature of about 150 deg. C. Gluing and placing shall be done in accordance with the manufacturer's instructions. Physical characteristics of the water-stop strips shall confirm the requirements of IS, Flexible Polyvinyl Chloride (PVC) Water-stop, or approved equivalent.

The water-stop strips shall be symmetrical in shape and the dimensions of both types shall be as follows:

Dimensions (mm)	Type A	Type B
Width	300	230
Thickness	6	6
Allowance: width	± 5%	
Thickness	±10%	

Except as otherwise shown on the Drawings, water-stop strips shall be installed with an approximately equal width of material embedded in concrete on each side of the joint.

All waterstops shall be installed and carefully positioned so as to form a continuous watertight diaphragm in each joint. Adequate provision shall be made to support and completely protect the waterstop in proper position during the progress of the Work, and particular care shall be taken for their protection during form removal. The Contractor shall replace or repair, at his expense, any waterstop torn, punctured or otherwise damaged before final acceptance of the Work. Suitable guards shall be provided to protect exposed projection edges and ends of partially embedded. All splices shall be neat with the ends of the joined materials in true alignment.

Splices in the continuity or at the intersections of runs of plastic waterstops shall be performed by heat sealing the adjacent surfaces in the accordance with the manufacturer's recommendations or as directed by the Engineer. Concrete shall be carefully placed and vibrated around waterstops to ensure maximum concrete imperviousness and density, the complete filling of the forms in the vicinity of the waterstop, and complete contact between the concrete and all surfaces of the waterstop.

The water tightness of joints and structure for which waterstops are provided shall be the contractor's responsibility. The Contractor shall supply all materials and labor and perform all the works necessary to rectify leaking joints and structures to the Engineer's directions and satisfaction.

9.25 Removal of formwork minimum stripping periods

The removal of formwork is subject to the permission of the Engineer. All forms shall be removed without damage to the concrete. Before slab forms or scaffolding are removed, the concrete shall be exposed by removal of the side forms or otherwise as required by the Engineer, to ensure that it has hardened, and slab form shall in no case be removed until the concrete has reached a strength of at least twice the stress to which the concrete may be subjected at the time of removal.

Forms shall not be removed before the expiration of the minimum time indicated below, except as otherwise directed or specifically authorized by the Engineer.

Open Air Structures:

-	Supports of beams, frames and wide-spaned slab	336 hrs
-	Arches, conduit roofs, beams and deck-type slabs	168 hrs
-	Side form of beams	96 hrs
-	Columns and walls	72 hrs
-	Mass concrete	48 hrs

9.26 Measurement and Payment of Concrete

Measurement for Payment of concrete will be made based on the number of cubic meters of each concrete type placed within the lines, grade and pay-lines shown on the Drawings, in accordance with these Specifications, or if approved based on the actual quantities placed.

Unless otherwise stated, no payment will be made for concrete placed outside these limits, and the measurement shall not include any over break unless recognized as due to geological conditions.

No measurement will be made for rounded or leveled edges, fillets, scorings chamfers, or space occupied by metal work, nor for voids or embedded items which are either less than 0.15 cubic meters in volume or 0.1 square meters in cross section. Measurement will be made for items with or exceeding the above dimensions. No recesses created by the Contractor for his own convenience during construction provided they shall be filled as directed.

No measurement for payment will be made for processing and transportation of aggregates, foundation preparation, surface cleaning and washing, construction joint treatment, including the mortar applied before placing concrete, repair, architectural features etc., for curing or for hot weather concreting and the entire cost thereof shall be included in the Contract unit prices stated in the Bill Quantities.

No measurement for payment will be made for collection of seepage water or water in break from rock surfaces and diverting it into the drainage systems.

Each month the Contractor shall state in duplicate to the Engineer the amounts of different types of concrete poured. This statement should be accompanied by a drawing indicating the monthly progress.

Payment will be made at the respective unit prices of the concrete as stated in the Bill of Quantities including all cost of aggregate production such as borrowing transporting, crushing, screening, washing, storing and mixing of aggregate; all costs of batching, mixing transporting, placing, compacting, surface finishing, curing, protecting, repairing of concrete, all costs of treatment of construction joints and include also all necessary equipment, tools, labour and any other items required.

No payment will be made for defective and wasted concrete. Any concrete with the Contractor places or uses for his own installations or on his own initiative shall be at the Contractor's expense.

CHAPTER - 10

10. Shotcrete or Spread Concrete

Sprayed concrete may be applied at slope protection in different areas un-reinforced or reinforced by wire mesh or fiber reinforcement.

10.1 Materials

10.1.1 Cement

Cement for sprayed concrete shall comply with the same quality as mentioned in concreting

10.1.2 Silica fume

Silica fume shall be from a source approved by the Engineer. Silica fume/ water slurry shall be regularly agitated by circulation pumps prior to use. The optimum content of silica fume shall be determined during site trials based on the manufacturer's recommendation.

10.1.3 Aggregates

The nominal maximum particle size shall be 10 mm unless otherwise agreed with the Engineer, and the grading shall lie within the envelope given in the following table unless otherwise approved or specified elsewhere.

Table 10-1 Table 10-2 Aggregate grading limits for sprayed concrete

Sieve size, mm	Percentage passing by weight	
	maximum	minimum
10	100	100
5	100	70
2.36	100	45
1.18	75	30
0.6	50	18
0.3	30	10
0.15	15	5

The grading and moisture content of the individual fractions of the aggregate shall be checked and recorded daily by the Contractor.

10.1.4 Water

Water for sprayed concrete shall comply with Specification of water quality.

10.1.5 Admixtures

An accelerating admixture may be used where necessary in order to apply the sprayed concrete successfully or to maintain safe conditions. The objective in adding such an admixture should be to obtain high early strengths appropriate to the conditions.

The required characteristic values and consistency of delivery to the site shall be agreed in writing with the manufacturer of each admixture before commencement of concrete spraying. Storage conditions and usage of admixtures shall comply with the manufacturer's recommendations.

Only liquid accelerators shall be used unless agreed otherwise with the Engineer. Only the minimum quantity of accelerator necessary shall be permitted in normal spraying operations

and shall be within the limits recommended by the manufacturer. The quantity shall be determined by site trials subject to a maximum dosage of 6% by weight of cementation material.

Plasticizers and retarders shall only be supplied from manufacturers approved by the Engineer. Plasticizers and retarders may be used to reduce the quantity of the mixing water and to improve the pumpability of the concrete. The effects and optimum dosages of plasticizers and retarders shall be determined by site trials.

Plasticizers and retarders shall be checked regularly for setting time, water reduction and development of strength as compared with the base concrete.

10.1.6 Fibre reinforcement

Where fibre reinforced sprayed concrete is applied, the wet mix method shall be used. The content of steel fibres shall be 50-100 kg/m³ with a fibre size ranging from 14 - 30 mm in length and 0.3 to 0.6 mm in diameter. Only fibre types approved by the Engineer shall be included in the mix when fibre reinforcement is used.

Fibres shall be stored in dry sealed containers until ready for use and shall be free from corrosion, oil, grease, chlorides and deleterious materials which may reduce the efficiency of mixing or spraying processes, or which may reduce the bond between the fibres and the sprayed concrete.

10.1.7 Mesh reinforcement

Unless otherwise directed by the Engineer, the reinforcement shall comprise a single layer of welded steel mesh fabric of 4 mm wires at 100 mm centres (or another mesh of equivalent weight per unit area) or a built up system made from reinforced steel, as agreed with the Engineer.

10.2 Mix design

The sprayed concrete mix shall be developed in two stages:

- The production of a suitable base concrete
- The production of a sprayed concrete mix from the base concrete

The Contractor shall submit the following to the Engineer for approval at least one month before he expects to be called upon to supply sprayed concrete:

- a) Proposed mix details including gradings and admixture details
- b) Plant details and method of operation.

The mixes for sprayed concrete shall lie within the following limits:-

Table 10-3 Contents of sprayed concrete

Cement content	300 – 450 kg/m ³
Silica fume	10 – 15 % by weight of cement
Aggregate/cement ratio	3.0 - 5.0
Water/cement ratio	0.35 - 0.45
Characteristic strength	27 N/mm ²

In determining the water/cement ratio, account shall be taken of the water content of aggregate.

Water shall be added in sufficient quantities to minimize rebound while simultaneously avoiding any sloughing of the sprayed concrete during placing.

Where the use of an accelerating admixture is agreed to be necessary in order to apply the sprayed concrete successfully or to maintain safe conditions, the amount used shall be within

limits recommended by the manufacturer. The objective in adding such an admixture should be to obtain high early strengths appropriate to the conditions.

10.3 Testing

The 28-day strength is that of 100 mm diameter cores 70 - 80 mm long. If an alternative method of sampling is used by the Contractor an equivalent 28 day strength is to be agreed with the Engineer.

The target mean strength for the base concrete shall be 1.3 times the characteristic strength for the sprayed concrete.

10.4 Shotcrete Method

10.4.1 General

Sprayed concreting shall be carried out by experienced operators only.

The wet mix method shall generally be used. The dry mix method shall only be used with the approval of the Engineer.

10.4.2 Preparation and approval

The surfaces to which sprayed concrete is to be applied are to be barred down of all large loose material and the area cleaned down with a mixture of water and air applied at high pressure.

Where the inflow of groundwater renders the surface too wet for the normal application of sprayed concrete, the Engineer may require that the water be suitably drained before shotcreting commences so that the surface is free of running water. The Engineer will determine the extent to which grouting may be necessary to reduce water inflow to acceptable limits, and shall approve the routing of drains which may be necessary to dispose of the water. Alternatively the Engineer may, if approval is requested, permit the use of accelerator .

All surfaces to receive sprayed concrete shall be moist but free of all traces of dirt, oil, rebound or other deleterious material.

Where sprayed concrete is to be placed over a previous layer, that layer shall first be allowed to reach its initial set and then cleaned of all laitance, rebound or other loose material by brooming or sluicing to the approval of the Engineer.

Sprayed concrete shall not be applied to any surface without the approval of the Engineer. Where rock conditions require that sprayed concrete be carried out urgently the Contractor shall inform the Engineer, so that he may examine the freshly exposed rock and order immediate application of sprayed concrete if considered necessary, in which case it shall be applied within four hours and where applicable before drilling for explosives.

10.4.3 Mesh reinforcement

Where directed, steel mesh reinforcement shall be fixed before application of the sprayed concrete.

The steel mesh shall be securely fixed at maximum centers 100 mm both ways at the optimum distance from the rock face for the application process such as to minimize rebound and prevent voids. The minimum cover between the reinforcement and the exposed face of the sprayed concrete shall be 30 mm or greater cover if ordered by the Engineer. Laps shall be 250 mm minimum (or two times mesh spacing whichever is the greater) for mesh. For steel bars the minimum lap shall be 50 diameters.

Where possible the steel mesh shall be placed over a first layer of sprayed concrete and fastened to the surface with dowels.

10.4.4 Equipment

All the equipment used for the application of sprayed concrete shall be of approved design and in proper working order. Water needed for the process is to be clean, chemically satisfactory and supplied at the steady pressure of 4 bar. Air for the equipment is to be clean, dry and oil free and to be provided at the equipment within pressure range 4 to 7 bar.

10.4.5 Batching

Materials shall be batched by weight unless otherwise agreed with the Engineer and cement shall not be added more than 1 hour before the anticipated time of placing the sprayed concrete.

10.4.6 Placing

There shall be no significant inclusion of rebound in the finished work, no hollow areas, good adherence to the rock and a reasonably smooth surface finish. Rebound shall be kept clear of sprayed concrete being placed and an air jet shall be provided for this purpose.

The Contractor shall prove the layer thickness to the Engineer by probing, depth pins or other approved means. Construction joints in the layer shall be formed at 45° to the face and precautions shall be taken to prevent weak and unsightly edges at construction joints. If necessary, timber strips may be temporarily fixed in place to give a neat, strong edge. Before placing the adjoining work the edge shall be cleaned and thoroughly wetted.

Before the succeeding layer is placed the existing work shall be checked for hollow or non-adhering areas and these shall be cut out and replaced to the satisfaction of the Engineer.

The described thickness shall be an average thickness, unless otherwise directed by the Engineer. Minimum thickness shall be 60% of described thickness and thickness of more than 2 times the described thickness counts as only 2 times the described thickness in calculation of average thickness.

10.4.7 Curing

For above ground applications the sprayed concrete shall be sprayed with an approved curing compound or kept moist continuously for 7 days. Spraying with a fine mist of water is to be anticipated at intervals not exceeding four hours.

10.4.8 Test panels

Sprayed concrete shall only be carried out by experienced operators or under their immediate supervision. When required by the Engineer, each crew shall demonstrate their proficiency by producing test panels before beginning production work.

At least two weeks before he expects to produce any sprayed concrete for inclusion in the Permanent Works, the Contractor shall prepare not less than three test panels for each mix for testing. The methods for carrying out test panels and taking samples for strength testing shall be agreed on site between the Contractor and Engineer.

All the panels shall be a minimum thickness of 80 mm or as directed by the Engineer and shall be placed in the presence of the Engineer's Representative. When the final set has taken place samples shall be taken from the test panels and transported to the laboratory where the crushing strength of the samples will be determined. No trial strength shall fall below the minimum specified for each design grades

During sprayed concrete operations, routine test panels shall be prepared beside the application zones for the purpose of quality control. Three panels shall be supplied for approximately each 1000 m² of sprayed concrete and shall be tested as described above.

The quality of the sprayed concrete will be considered satisfactory if every test result is at least 80 percent of the specified characteristic strength and if at least 80 percent of all results exceed the specified characteristic strength.

10.4.9 Core cutting

Core cutting shall be carried out at the surface of sprayed concrete for testing its strength and thickness of the layers. The Contractor shall be requested for core cutting and testing if Engineer likes to confirm the quality and quantity of the sprayed concrete that is already in place.

10.5 Measurement and Payment

Measurement of sprayed concrete for payment will be made only to the neat lines of the structures as shown in the Drawings or as directed by the Engineer. In measuring sprayed concrete for payment, the rates shall be the unit rate per square meter of area for different defined thickness. Appropriate percentage (10 %) of rebound volume shall be allocated for the payment of sprayed concrete either un-reinforced or reinforced which shall be determined by engineer from the field judgment.

The wire mesh shall be measured and payment be made as per weight of the bars placed in the sprayed concrete in accordance with the Drawings or as directed by the Engineer. Payment for furnishing and placing wire mesh will be made at the unit rate per metric ton which unit rate shall include the cost of furnishing reinforcement bars, and making the mesh, if used, and of delivering, unloading, hauling, storing, cutting, bending, cleaning, placing and securing maintaining in position all reinforcement bars, as shown in the Drawings or as directed by the Engineer.

CHAPTER - 11

11. Formwork

11.1 General

Forms shall be simple, they shall be rigidly constructed of approved materials and shall conform to be shapes, lines and dimensions shown in the drawings. Forms shall be braced and shuttered to withstand the pressure resulting from placing and vibrating the concrete, constructional loads, wind and other forces without appreciable deformation.

The contractor shall submit to the Engineer, before commencing construction, a set of forms complying with the above requirements, but such submission to the Engineer or approval by him shall not relieve the Contractor of any his responsibilities under the Contract for successful completion of the structure.

Surfaces of the forms to be in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, grooves, splits or other defects. Shuttering boards shall be carefully jointed and so arranged as to be able to swell under the influence of humidity of the concrete, without causing any deformation to the forms, interstices shall be properly filled with glazier's putty and the waterproofing of the form shall be sufficient to prevent escape of cement resulting from excess of water in the concrete. However, the use of paper tamping shall be strictly forbidden.

Openings (if required) for inspection of the inside of the forms and for removal of water used for washing down shall be provided and so formed as to be easily closed placing the concrete.

Scaffoldings (if required) shall be firmly constructed to the satisfaction of the Engineer. No separate payment will be made for scaffoldings unless otherwise approved by the Engineer.

Before placing any concrete, all bolts and the like (if required and which are to be built in) shall be fixed in their correct positions, and cores and other devices for forming holes, openings, etc. shall be fixed to the forms. No holes shall be cut in any concrete unless approved by the Engineer. The use of wire ties for supporting the forms shall not be permitted in concrete walls which are to be subjected to water, or when the finished surface required as determined by the Engineer is to be permanently exposed wire ties used for other concrete works shall be cut off flush with the concrete surface, after the forms are removed. In case embedded metal rods are used for holding form, the rods shall terminate not less than 3 centimeters from the formed surfaces of the concrete in which the maximum size of aggregate is 40 millimeters.

Non-staining commercial oil or other approved materials shall be applied to the faces of the forms before concreting to prevent adherence to the concrete. Care must be exercised to prevent the material applied to the faces of the form from coming in contact with the reinforcement, but if this should inadvertently occur, the reinforcement must be cleaned.

When forms have been built and have been prepared ready for concreting, they will be inspected by the Engineer and no concrete shall be placed until the forms have been approved by him. In order to avoid delays in obtaining approval, the contractor shall inform the Engineer, at least 24 hours in advance, of his intention to have the forms ready for inspection.

11.2 Removal of Forms

The Contractor shall take full responsibility to that the time span has elapsed for the concrete to attain sufficient strength before forms are removed. Nevertheless, the forms shall not be struck without the prior approval of the Engineer, and in any case at least three (3) days shall elapse before forms are struck.

Connections shall be so formed as to permit the easy removal of the forms without hammering and without the necessity of levering against the surface of the concrete.

11.3 Measurement and Payment of Formwork

Measurement of formwork for payment will be made only for the forms which have been used on the approval of the Engineer. Payment for formwork measured will be made at the unit rate per square meter. The unit rate shall cover the cost of furnishing all labours, equipment and materials, erecting and removing the forms and scaffoldings and also the cost of all necessary work connected therewith.

CHAPTER - 12

12. Reinforcement Steel

12.1 General

Reinforcement steel shall consist of round deformed bars rolled from new billet stock, and shall confirm to the requirements of the appropriate standards referred to Clause hereof. Steel shall have a tensile strength of 49 to 63 kg/mm² and a minimum yield point of 30 kg/mm². A cross section of any bar to be delivered shall be exact shape and have the specified diameter at any point of the bar. The average diameter of 20 bars which are to be selected at random free shipment of the same size shall not be bigger or smaller by 2 percent than the specified diameter. Bars shall be free of scale, oil, dirt and structural defects.

When required by the Engineer, the contractor shall submit three copies of mill sheets of steel bars issued by the iron and steel works for the approval of the Engineer before each shipment, and inspection at site will be made by the Engineer in accordance with the specification and the above mill sheets.

12.2 Placing Reinforcement Steel

The number, size, form and position of all reinforcement steel bars, fabric, ties, links, stirrups and other parts of the reinforcement are to be placed in exact accordance with the drawings and kept in the correct position in the forms without displacement during the process of vibrating, tamping and ramming the concrete in place. The Contractor shall provide all necessary distance pieces and space bars at his own cost to maintain the reinforcement the correct position.

Any ties, links or stirrups connecting the bars shall be bent so that the bars are properly braced, the inside of their curved parts shall be in actual contact with the bars around which they intended to fit. Bars shall be bound together with the best black annealed mild steel wire which is subject to the Engineer's approval, and the binding shall be twisted tight with proper pliers. The free ends of the binding wire shall be bent inwards.

Before any steel reinforcement is embedded in the concrete, any scale, loose rust, oil, grease or other deleterious matter shall be removed. Partially set concrete which may be adhered to the exposed bars during concreting operations shall likewise be removed.

When the reinforcement has been placed and is ready for concreting it will be inspected by the Engineer and no concrete shall be placed until the reinforcement has been approved by him. The contractor shall inform the Engineer at least 24 hours in advance of his intention to have the reinforcement has been approved by him. The contractor shall inform the Engineer at least 24 hours in advance of his intention to have the reinforcement ready for inspection.

12.3 Cover to Reinforcement Steel

The concrete cover to reinforcement shall be as shown in the Drawings or as directed by the Engineer. The Contractor shall provide any necessary cement pads for enduring that cover is attained and in no case may the use of timber packing be permitted.

12.4 Preparation of Reinforcement Drawings

The Contractor shall prepare at his own expense all details reinforcement drawings. The drawings shall include all bar placing drawings, bar bending schedules, bars lists, and any other reinforcement drawings as may be required to facilitate fabrication and placement of reinforcement bars.

Reinforcing drawings shall be submitted to the Engineer for approval. Reinforcing drawings and bar lists prepared by the Contractor shall conform to the standard practices of the industry.

12.5 Measurement and Payment of Reinforcement Steel

Measurement for payment of furnishing and placing reinforcement bars will be made only for the weight of the bars placed in the concrete in the accordance with the Drawings or as directed by the Engineer. Payment for furnishing and placing reinforcement bars will be made at the unit rate per metric ton which unit rate shall include the cost of furnishing reinforcement bars, and attaching wire ties and metal supports, if used, and of delivering, unloading, hauling, storing, cutting, bending, cleaning, placing and securing maintaining in position all reinforcement bars, as shown in the Drawings or as directed by the Engineer.

No separate measurement and payment will be made for the reinforcement bars placed in pre-cast concrete items of which unit rates include the cost of reinforcement bars.

CHAPTER - 13

13. Pre-Cast Concrete

13.1 General

The Contractor may manufacture the pre-cast concrete units at the site with an approval of the Engineer in accordance with the Specifications. All materials to be furnished and used for pre-cast concrete units by the Contractor shall be approved by the Engineer. Forms or molds of concrete units shall conform to the shapes, lines and dimensions as shown on the Drawings or may be directed by the Engineer, and the Contractor shall submit details of the form or mold proposed for the approval of the Engineer.

13.2 Precast Construction Alternatives

Pre-cast construction may also be employed for structures, other than above units, of such dimensions and function for which such construction would be suitable.

Should the Contractor wishes to employ pre-cast construction, in such cases he shall submit to the Engineer full details in writing of his proposals including all proposed modification to thickness of concrete section, concrete specification and reinforcement to suit such construction, and his proposed methods of handling and bedding pre-cast units and backfilling to the same, etc. The Engineer may approve such proposal with or without modifications, and Contractor will be paid for such pre-cast units as if constructed to the details on the Drawings.

13.3 Pre-cast Concrete Units

Pre-cast concrete units to be manufactured at the site shall be of concrete with adequate strength for bearing loads as directed by the Engineer.

Mould for the pre-cast concrete shall be of steel construction. The Contractor shall submit details of the mould to the Engineer for his approval.

The concrete units shall be cast in horizontal position, unless otherwise directed by the Engineer. The concrete shall be placed continuously in each of these units and compacted by vibrating in a manner acceptable to the Engineer. Special care shall be exercised in tamping and vibrating the concrete so as not to displace the reinforcement.

The concrete units shall remain in their molds for three (3) days before being stripped, during which time the exposed face shall be covered with sacking or matting and kept constantly wet. In addition, the sides of the forms or molds shall be shielded from the direct rays of the sun. After removal of forms or form of the moulds, the units shall be kept moist continuously for a minimum period of eleven (11) days. After stripping, such units as piles, slabs, panels etc shall be stacked for a period of not less than thirty(30) days, unless otherwise directed by the Engineer, so as to leave a free air space between each of these pre-cast units. Each of such pre-cast units shall be clearly marked with the date of casting, if prescribed by the Engineer.

13.4 Measurement and payment

Precast units shall also be paid according to cubic meter as that of concrete PCC rate of the grade. Such precast units are basically deemed to be same as cast in Situ and shall comply weight limit, and can be handled without machine and due care in order to regard same as concrete on slab and covers.

CHAPTER - 14

14. Cement Mortar

14.1 General

A mortar consisting of a mixture of Portland cement, sand and water shall be used as required by their specifications for brick works, pointing, plastering, wet rip rap and masonry for which mortar is required. Surface to become in contact with mortar shall be cleaned thoroughly of all loose materials, dirt and other contaminations.

14.2 Composition of Mortar

The mortar mix shall contain the proportion of cement to sand or fine aggregates as prescribed in the applicable clause in which mortar is used. The water/cement ratio of the fresh mortar in place shall be approximately 0.55.

14.3 Mixing

The mortar shall be thoroughly mixed for a period of not less than one and half minutes. Mixed material that stands longer than an hour shall be rejected for use.

14.4 Equipment

The equipment and tools used for mixing and placing shall be of an Engineer's approved type and sufficient capacity to perform the work.

14.5 Placing, Curing and Payment

The application of the mortar shall be done by experienced personnel with proper workmanship. Water curing may be discontinued after ten (10) days unless otherwise specified. No separate payment will be made for mortar described above except in case of plastering and the costs shall therefore be included in the work items in the Bill of Quantities for which mortar is required as binding agent.

CHAPTER - 15

15. Joint Sealing

15.1 Scope

Under these items, the contractor shall furnish and install water-stops of polyvinyl-chloride in the shape and dimensions as specified and in the locations as shown on the Drawings or as directed by the Engineer. For convenience of placement in forms, a water-stop utilizing a split flange may be used; however, prior to placement of final concrete or mortar can enter between the two split portions of the flange.

Two kinds of waterstops, 230 mm wide and 150 mm wide, shall be used depending on the magnitude and importance of the works as designated on the Drawings or as directed by the Engineer.

15.2 PVC Waterstops

15.2.1 Scope

Under these items, the contractor shall furnish and install water-stops of polyvinyl-chloride in the shape and dimensions as specified and in the locations as shown on the Drawings or as directed by the Engineer. For convenience of placement in forms, a water-stop utilizing a split flange may be used; however, prior to placement of final concrete or mortar can enter between the two split portions of the flange.

Two kinds of waterstops, 230 mm wide and 150 mm wide, shall be used depending on the magnitude and importance of the works as designated on the Drawings or as directed by the Engineer.

15.2.2 Workmanship

The Contractor shall furnish all materials, equipment and electric energy required for making field splices and installing the waterstops. Field splices for waterstops shall be made by cutting the waterstops as required, heating the ends to the melting point and jointing them to form the desired splice ends shall be made by means of the splicing machine recommendation by the watestop's manufacturer or by any other approved electric heating device.

Care shall be taken in installing the waterstops to ensure that the centers of the waterstops coincide at the joints. The Contractor shall suitably support and protect the waterstops during the progress of the Works.

15.2.3 Material Properties

The PVC water-stops shall be fabricated from virgin polyvinyl chloride, contain no reclaimed or scrap material. The material shall be fabricated and cured in such a manner that any cross section will be dense, homogeneous and free from porosity and other imperfections.

Waterstops shall be manufactured by extrusion process from an electrometric plastic compound, the basic resin of which is hundred (100) percent polyvinyl-chloride (PVC). The product shall be dense, homogeneous and free from holes and other imperfections.

The waterstops as described herein shall have the following physical properties:

Specific gravity	:	1.33 ± 0.33 at 23 °C
Tensile strength	:	1.55 to 176 kg/cm at 23 °C
Ultimate elongation	:	360% to 400% at 23 °C
Brittleness	:	- 48 °C

Durometer : 65-75

The PVC materials, when tested in accordance with the relevant Standards, shall have the physical properties mentioned there under.

The water-stops shall be installed so that they are securely held in their correct position during the placing of the concrete, which shall be fully and correctly compacted around the water-stops so that no voids or porous areas are let. Where reinforcement is present, adequate clearances between it and all water-stops shall be left to permit proper compaction of the concrete. A no has shall be made through any water-stops. Jointing other than welding shall not be permitted.

- Physical Properties of Polyvinyl Water-stops tests shall be carried out at 250°C.
- Durability : Unchanged by oil, river water, and solar radiation
- Impermeable : Free of pores and cracks
- Tensile Strength(min.) : 140 kp/cm²
- Elongation at break(min) : 285%
- Hardness Degree (Shore) : 42-52 ShA
- Water absorption total immersion in distilled water for 48 hours at 500C(in% by weight) : 0.6%
- Cold Crack Temperature not higher than : -250C
- Accelerated Against Test
 - Retention of initial tensile strength: 85% (minimum)
 - Retention of initial elevation at break: 85% (minimum)
- Stability in Effect of Alkali Test
 - Weight gain after 7 days : 0.25% (maximum)
 - Weight gain after 30 days : 0.40% (maximum)

15.3 Rubber Waterstops

15.3.1 General

Whenever possible, complete waterstop systems shall meet the specific requirements of the Work and ensure easy and economical placement with minimum joining up on site.

Dumb-well Waterstops will be suitable for partial contraction joint and construction and partial contraction joggle joints, i-e, joints where no differential movements is permitted and planer movement is only by construction.

Center Bulb Waterstops may be used where it is necessary to accommodate various degree of planar and differential movement in joints and expansion joggle joints.

The appropriate width of waterstops shall depend upon the thickness of the concrete, the size of the aggregate and the position of the reinforcement. The following rules shall be applied to ensure a satisfactory selection:

- The overall width of the waterstops shall not be greater than the thickness of the concrete into which it is cased.
- The distance from the face of the concrete to the waterstop shall not be less than the width of the waterstop.
- To obtain satisfactory compaction, the width of waterstop shall not be less the largest aggregate size.

- The waterstop shall not be positioned closer to any reinforcement member than a distance equal to twice the size of the largest aggregate, in order to avoid unsatisfactory compaction.

Where expansion joints are concerned, the maximum width of the joint shall be added to the figure by applying the above rules.

15.3.2 Material Properties

The rubber waterstops shall be fabricated by moulding or extruding with integrals cross sections as shown on the construction drawings. The materials shall be fabricated and cured in such a manner that any cross section will be dense, homogeneous and free from porosity and other imperfections.

Minor surface defects such as surface peel covering less than 6.5 cm^2 , flow lines less than 0.16 cm deep, and non fills and air traps less than 0.64 cm in longest dimension and less than 3 such defects shall occur in any 1.5 m length of waterstops. Any defects, which do not meet the above tolerance, shall be either repaired to the satisfaction of the engineer or removed from the finished product by cutting out the defective length and splicing. Waterstops other than special sections shall be furnished in continuous un-spliced minimum lengths of 15 m.

Rubber for the waterstops shall be high grade, thread type compound. The basic polymer shall be natural rubber, synthetic rubber or a blend of both. The rubber, when tested in accordance with the relevant Standards shall have the physical properties mentioned herein under.

Gum rubber and rubber cement shall be suitable for making field connections in rubber waterstops

The Contractor shall furnish connection plates, bolts, nuts and washers for field splicing of rubber waterstops, and metal seals with rubber waterstops as required by the Engineer.

Except as otherwise specified, all field splices and intersections of rubber waterstops and metal seals shall be made as shown on the construction drawings so as to provide watertight connections. For bolted connections, contact surfaces shall be buffed and coated with rubber cement. Where necessary to remove bulbs cutting shall be performed carefully. Vulcanized field splices will not be required. Intersections of rubber waterstops may be furnished as factory molded special sections. Field splices in rubber waterstops including filled intersections of rubber waterstops for which special sections are not available may be chemically bonded using an approved type of seal splice in accordance with the manufacture's instructions. Suitable support and protection shall be provided during the progress of the work to prevent damage, deterioration or warping of the waterstops. The waterstops shall be installed with approximately an equal width of the material embedded in the concrete on each side of the joint. The concrete shall be carefully placed and vibrated around the waterstops and a complete contact between and all surfaces of the waterstops. In the event that a waterstop is installed in the concrete on one side of a joint more than two weeks prior to the scheduled date of placing the concrete on the other side of the joint, the exposed waterstop shall be covered to protect it from the solar radiation.

No rubber waterstop shall be shipped from the factory until certified tests reports of the rubber waterstop have been submitted to and approved by the Engineer. Rubber waterstop shall be stored so as to limit free circulation of air about the rubber and shall be protected from contact with oil or grease.

Physical Properties of Rubber Waterstops

<i>Durability</i>	: unchanged by oil, river water and solar radiation; impermeable: free of pores and crack
Tensile strength (min)	: 210 kp/cm ²

Elongation at break (min)	: 500%
Hardness Degree (Shore)	: 60-50 shA tolerance
Compression set by Const. Deflection Method	: max.% of original deflection 20%
Water absorption after 48 hrs at 70°(% by wt):	0.6%
<i>Accelerated Aging Test:</i>	
(48 hours at 70 degree centigrade and 21 kp/cm ² of oxygen pressure)	
Retention of initial tensile strength	: 75% (minimum)
Retention of initial elongation at break	: 75% (minimum)

All joints shall be internal waterproofing and shall be provided with rubber waterstops jointed to metallic strips by vulcanization. Joints between monoliths shall be provided with surface waterstops which shall be water tight fixed to galvanized steel strips by means of galvanized bolts.

15.3.3 Measurement and Payment

Measurement for payment for waterstops shall be made for the length in meters of waterstops in place measured along the centerline of the waterstops in accordance with the Drawings. Payment for waterstops, 230 mm wide and 150 mm wide, shall be made at the respective unit rates per linear meter which unit rate shall include all costs of furnishing and placing the waterstops as described above.

15.4 Metal Seals

Metal seals shall be made from corrosion-resisting copper or steel, hot or cold -rolled finish, as called for in the construction drawings.

Nails and welding rods shall be of type and composition approved by the Engineer for nailing and welding the corrosion-resisting metal seals as specified.

The contractor shall supply and place all metal seals as shown on the drawings or as directed by the Engineer. The Contractor shall furnish washers and nails for fastening the seals to the forms and materials for welding metal seals.

The seals shall be joined carefully together by welding so as to form continuous watertight diaphragms in the joints. Adequate provisions shall be made to support and protect the seals during the progress of the work. The Contractor shall replace or repair as directed by the Engineer, any metal seals punctured or damaged. Damaged of type, shape and joint connections of the seals and splicing of metal seals to rubber Waterstops shall be in accordance with the Construction Drawings or as directed by the Engineer.

15.5 Dowel Bars

In the contraction joint, dowel bars shall be provided as shown on the Drawings or as directed by the Engineer. The dowel bars shall be of straight plain round steel bars as approved by the Engineer.

A half length of dowel bar shall be covered by PVC house or pipe or other approved materials to prevent bond and shall be placed at intervals shown on the Drawings or as directed by the Engineer. The other half shall be bonded firmly on one side of joint.

Measurement for payment of dowel bars shall be made for the design weight of bars actually placed in the concrete at contraction joint in accordance with the Drawing or as directed by the Engineer. Payment for dowel bars shall be made at the unit rate per kilogram which unit rate shall include all costs of furnishing and placing, dowel bars as stipulated above including furnishing and providing cover materials such as PVC house, tube or pipe.

15.6 Joint Filler

Joint filler shall be resin bonded cork such as Expedite 'Hydrocor' or similar approved. It shall be obtained from manufactures approved by the Engineer and shall be stored and fixed in accordance with the manufactures approved by the Engineer and shall be stored and fixed in accordance with the manufacturers approved by the Engineer and shall be stored and fixed in accordance with the manufacturer's instructions.

Resin bonded cork filler shall comply with US Federal Specification HH-F-341e Type II Class B with the following limitation when tested in accordance with the said Specification:

- the load required to compress the material to 50% of its thickness shall be more than 0.035 N/mm^2 and less than 0.35 N/mm^2
- the recovery after compression to 50% of the original thickness shall be not less than 95% of the original thickness.

The Contractor shall supply the manufacturer's test certificates for each consignment of each type of joint filler delivered to site if requested supply sufficient of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure.

Measurement for payment of joint filler shall be made for the surface area in sq.m. of joint in accordance with the Drawings or as directed by the Engineer. Payment for joint filler shall be made at the unit rate per sq.m.

15.7 Joint Sealant

Joint sealer shall be Expanditite 'Thioflex 600 grey gun grade', or similar approved. It shall be obtained from manufacturers approved by the Engineer and shall be used in accordance with the manufacturers' instruction inclusive of the supply and application of any priming materials. An approved bond breaker shall be supplied for placing between the sealant and the joint filler.

The Contractor shall supply the manufacturer's test certificate for each consignment of each type of joint sealer to the site and shall if required supply sufficient of each type and consignment for confirmatory tests to be carried out in accordance with appropriate test procedure.

Measurement for payment of joint sealer shall be made for weight of sealer in kilogram actually placed in the joint in accordance with the drawings or as directed by the Engineer.

15.8 Bitumen Joint Coating

Bitumen for coating concrete joints shall be a straight bitumen, grade 40/50 penetration or other approved by the Engineer. No separate payment will be made for bitumen. It shall be included in unit rates of concrete in the Bill of Quantities.

15.9 Anchor Bars

Anchor bars shall be placed at joint between old concrete of existing structures and new concrete as designed in the Drawings or as directed by the Engineer.

A hole of designed diameter and depth shall be drilled on the old concrete by approved method. Then a deformed steel bar of designed size shall be inserted at the center of the hole and the void around the steel bar shall be grouted with a mortar of one part of cement and two parts of sand in volume.

Measurement for payment of anchor bar shall be made for the weight of bars actually placed in accordance with the Drawings or as directed by the Engineer. Payment for anchor bar shall be made at the unit rate per kg which unit rate shall include all cost of furnishing and placing

anchor bar as stipulated above including cost of drilling hole, and furnishing and grouting mortar.

CHAPTER - 16

16. Stone Works

16.1 Stone Quality

Stones used for stone works shall be carried from the rivers or crushed rocks as approved by the Engineer. The stones shall have a specific gravity of not less than 2.5, and shall be free from seams and other defects, and shall be hard, sound and durable.

Unless otherwise directed by the Engineer, flush pointing is required for stone masonry and wet stone masonry.

16.2 Stone Masonry

Stone masonry will be used for construction of retaining wall, piers and abutment of bridge.

The stones shall be approximately uniform size so that these have no large voids or gaps among stones when placed. Maximum size of the stones shall be two-third of the wall thickness.

The stone masonry shall be neatly constructed by hand and the stones shall be struck and consolidated by steel hammer to assure that each stone is thoroughly enveloped in mortar and is in complete liaison with mortar in all faces. Joints among boulders shall not be so narrowed, but not exceed 4 cm.

Mortar for stones masonry shall be of a cement/sand ratio of one part of cement and four parts of sand in volume if unspecified in special cases. The mortar ratios shall confirm 18.2

Joints among stones on exposed surface of stone masonry shall be neatly finished by pointing in the manner that the mortar in the joints shall be scrapped out by 4 cm in depth and entirely cleaned up with a mortar of one part of cement and two parts of sand in volume. All the exposed surface of stone masonry shall be cleaned up all surplus mortar upon completion of the pointing operation.

If directed by the Engineer, plastering shall be given on crown or top surface of stone masonry. The plastering method and workmanship are same for brick work or as directed by the Engineer.

Where and when new stone masonry is jointed to the old masonry the mortar in the joint portions shall be removed to a depth of 5 cm and the removed surface shall be brushed and washed until perfect clean and sufficient asperities appear to assure good bond between the two masonries. A layer of cement slurry shall be applied to continue such joint.

Measurement and payment

Measurement for payment of stone masonry will be made to the line of the structures as shown in the Drawings or as directed by the Engineer. The unit rate shall cover the cost of all labors, materials, equipment and tools, and operations required for stone masonry which includes flush pointing.

The masonry having more than 1m height shall be provided with sufficient weep holes in wall and the back side of the hole provided with filter gravel material so that the hole will not be clogged.

The backfilling of stone masonry wall shall be provided with stone packing as per the instruction of engineer.

16.3 Stone Soling

Selected stones from site are laid in required dimension after leveling ground and placed intact so that the load from superstructure shall be transformed to foundation uniformly. The

Thickness shall be provided by engineer if unspecified at the drawings. Soling has to be in uniform bedding and leveled. The level difference in foundation shall be covered with sufficient provision so that the top s leveled.

The ground is prepared and checked thoroughly by site in charges before soling, the stones are stacked in pattern and are never tilted or laid one over other

Measurement and payment

Measurement and Payment of Stone soling shall be based on unit rate as mention in BOQ in Cubic mentsers as per shown in design drawings or as directed by the Engineer.

16.4 Wet Rip-rap

Wet rip rap will be employed for canal protection or canal lining. Thickness of wet rip rap shall be as shown on the Drawings or as directed by the Engineer. Cement mortar for wet riprap shall be of one part of cement and six parts of sand in volume, unless otherwise directed by Engineer.

Measurement and payment

Measurement for payment of wet riprap will be made by volume to the lines shown on the Drawings or as directed by the Engineer. The unit rate shall cover the cost of all labors, materials, equipment and tools, and operations required for wet riprap including flush pointing.

16.5 Dry Rip-rap

Dry riprap will be employed for upstream or downstream protection work of hydraulic structures like weir and sluice structure.

Riprap shall be taken from hard rock layers of quarries or rock excavation or underground rock excavation as approved by the Engineer. The rock shall be of compact, firmly bound and uniform grains texture and absolutely weather resistant, shall not have cracks, holes, laminations or detrimental materials.

The rock blocks shall be of natural irregular cubic shape and of the size from 0.5 m to 1.0 m for placement in the bottom. Thin-sliced blocks shall not be accepted. Any blocks covered by impurities shall be cleaned thoroughly before used. Moisture absorption of rock blocks shall be limited to such a quantity that any cracking, bursting and chipping as a result of wave action or weather influence will not occur.

Unless it is indicated otherwise, the Contractor shall submit rock samples to be used in the bottom and slope protection for the approval of the Engineer. Furthermore, he shall send samples at his own cost to the place assigned by the Engineer for the performance of the all required tests and at least 30 days before the beginning of the rip rap placement.

The use of rocks mixed with soil, sand, clay, and decomposed or decomposable materials, or the use of small rock fragments shall not be permitted. The Contractor shall not use weathered, fractured, dirty, inadequate grain-size distributed material or any material that, in the Engineer's opinion, is not sufficiently durable, and because of this, the Contractor shall not demand compensation different from the unit prices established for riprap.

Thickness of dry riprap shall be as shown in the drawings or as directed by the Engineer.

Stone not meeting requirements shall be rejected and the Contractor shall without delay follow instructions to remove such stone from site at the Contractor's own expense.

Stones shall be tightly placed so that the gaps or voids among stones are reduced as much as possible. The exposed surface shall be neatly combined and leveled so that no stone can be easily removed by men, animal or water flow.

Thickness of dry riprap shall be as shown on the drawings or as directed by the Engineer.

Measurement and payment

Measurement for payment of dry riprap will be made by volume to the lines shown on the drawings or as directed by the Engineer. The unit rate shall cover the cost of all labors, materials, equipment and tools, and operations require for dry riprap.

The Contractor shall in no circumstances be entitled to payment for stone which has not been accepted. Unless otherwise specified in the contract documents the following shall apply for riprap.

16.6 Riprap Protection

The Contractor shall place riprap as shown on the Drawing or as directed by the Engineer. The riprap material shall meet the following requirements.

- From 50% to 80% by weight of the rock fragments shall weigh 2500kg or more shall be 60 cm -100cm in diameter.
- No more than 5% of any truck load of this material shall pass the No.4 ASTM Sieve

The riprap can be placed over the gravel bedding to produce a dense and stable rock blanket over the surface required protection, and shall be constructed within the specified to clearance the lines and grades shown on the Drawings.

The rip rap shall be placed to its full course thickness in on operation and in such a manner as to avoid displacing the underlying materials. The finished riprap shall be free from objectionable pockets of small stones and clusters of large stones of the riprap.

Rearranging of individual stones of the riprap may be required to the extent necessary in the opinion of the Engineer when the finished riprap is judged to be arranged in disordered distribution.

Measurement and Payment

Measurement for payment of riprap will be made of the riprap in place to the lines, grades and dimensions shown on the drawings or established by the Engineer.

Payment for riprap will be made at the unit price per cubic meter which unit price shall include the entire cost of providing and placing the riprap but excluding the cost of excavation and haulage.

16.7 Stone pitching

The Contractor shall perform the stone pitching to the lines and grades as shown on the Drawings or as directed by the Engineer.

If not otherwise specified or directed by the Engineer, the foundation for stone pitching shall be constructed with a continuous layer of concrete M15 as specified in CONCRETE WORK.

Stone shall be arranged to avoid extreme irregularity of the pitching surface, and joint surfaces shall be smoothed with hammers. Gaps shall be filled with concrete so that each stone will not move.

Placing of the stone pitching shall not begin until the finishing stakes set as shown on the Drawings, which work have been inspected and approved by the Engineer.

The stones shall be cleaned and thoroughly saturated with water immediately prior to any pitching is placed, and the foundation bed which shall be cleaned and moistened before the

concrete is spread. The joints shall be full and flushed with concrete. The exposed faces of individual stones shall be parallel to the face of the slope.

The stone pitching with the concrete shall be satisfactorily protected from the sun and shall be kept thoroughly wet for at least three days for curing. The stone pitching shall be provided with the drain holes and expansion joint as directed by the Engineer.

The surface of completed stone pitching shall be even to line and level or slope with a protruding tolerance not exceeding 10 cm.

Measurement and payment

Measurement for payment of stone pitching will be made on the basis of placed area in square meters determined by the lines and grades as shown on the Drawings or as directed by the Engineer.

Payment will be made for the number of square meters measured as provided above at the respective unit prices per square meter stated in the Bill of Quantities, which unit price for stone pitching shall constitute full compensation for the cost of all labour, tools, equipments, and materials including selection, bedding, placing, grading and joining the stone pitching, concreting and mortaring, gravel bedding if required, in foundation and other items necessary to complete the Works.

16.8 Hard Stone lining

The Contractor shall perform the hard stone lining to the lines and grades as shown on the Drawings or as directed by the Engineer.

Stone for hard stone lining shall be quartzite, granite without mica, or other approved stone. The stone shall be of good hard durable quality, free from defects of any kind. The rebound hardness measured by Schmidt hammer shall be 50 minimum.

The thickness of the hard stone lining armouring layer shall be 300 mm and will comprise one block only. The mortar joint at the base of the layer shall be 10 mm minimum to 40 mm maximum. Dressed stone masonry armouring of concrete walls shall include 12 mm anchors drilled and grouted into at least 20% of all blocks, distributed such that every unanchored block is in contact with at least one anchored block.

The dimensions of blocks shall be 150 mm minimum in the direction of flow and 200 mm minimum generally perpendicular to the flow direction. At the edge of a panel the dimension of blocks in both directions may be 150 mm minimum to create staggered jointing. Larger blocks shall be used if possible.

Blocks shall be dressed and placed so that the finished surface is within 8 mm of prescribed levels and grades. In addition abrupt irregularities in the finished surface shall be less than 3 mm step up or 6 mm step down in the direction of flow. Internal faces of blocks shall be dressed to 10 mm tolerance so that internal joints shall be 5 mm minimum thickness and 15 mm maximum. Joints shall be kept as small as practicable, especially at the exposed surface, but never less than 5 mm. Dressing on the bottom face will not be required, provided that the tolerance on the base mortar thickness is met.

Blocks armouring slabs shall be laid in courses at right angles to the direction of the flow, with joints between adjacent courses staggered. Blocks armouring walls shall be laid in horizontal courses, with joints between adjacent courses staggered. Foliation planes in quartzite shall be perpendicular to the flow.

Measurement and payment

Measurement for payment of hard stone lining will be made on the basis of placed area in square meters determined by the lines and grades as shown on the Drawings or as directed by the Engineer.

CHAPTER - 17

17. Geo-Textiles

17.1 General

In areas shown on the Drawing or specifically designated by the Engineer, the Contractor shall place in position geo-textiles as the integral part of the structures. Terrafix or approved equivalent (Type-A) and secutex or approved equivalent Geo-textiles (Type-B) shall be used by the Contractor for it.

The Contractor shall submit detailed design together with working drawings of geo-textiles installation supported with literature, case studies and technical advice from the manufacturer.

17.2 Scope of Work

The work specified in this clause consists of the use of:

- Geo-textile terrafix 600 or approved equivalent (Type-A) shall be used at the bottom of the Reservoir, Desanding Basin, Weir and Intake as mentioned in the Drawings or as instructed by the Engineer.
- Geo-textile Secutex 316R or approved equivalent (Type-B) shall be used at the sides of the Reservoir, Desanding Basin and Canal as mentioned in the Drawings or as instructed by the Engineer.

17.3 Specification for Supply (Type-A)

Geo-textiles (Type-A) are mechanically bonded single layered non woven filter fabric. The fibres form a labyrinthic structure with countless pore channels. This represents an idle copy of the original soil structure. A typical Terrifix 600 Geo-textiles commonly used for hydraulic structure/drainage system comprise of the following technical requirements.

Product description	:	Single layered non-woven filter fabric
Bonding	:	Needle-punching
Raw material	:	PES/PP/PA
Average Mass/m ²	:	603 gm
Average Thickness	:	5.3 mm
Maximum tensile strength (longitudinal)	:	≥ 12,0 kN/m
(Transverse)	:	≥ 12,0 kN/m
Elongation at Maximum tensile strength (longitudinal)	:	≥ 70%
(Transverse)	:	≥ 45%
Effective opening size	:	0,08 mm
Water permeability coefficient to BAW	:	1.8 x 10 ⁻³ m/s
Filter stable towards soil type according to BAW	:	1/2/3

17.4 Measurement and Payment

Measurement and payment of Geotextile shall be made against measured square meter of laid geotextile in the field. However the laps and folds in application shall be reduced in the calculation for preventing double counting of the area and application surfaces.

CHAPTER - 18

18. Surface and Subsurface Drain

18.1 Scope of Work

The work under this Clause shall cover the construction of drainage structures including the general items pertaining to materials, excavation, foundation, construction or installation, and backfill in connection with drainage structures.

18.2 Materials

18.2.1 Steel drain pipes and fittings.

The Contractor shall furnish and install steel drain pipes including necessary fittings as shown on the Drawings or as directed by the Engineer. The steel Pipe shall conform to the requirements of IS, Carbon Steel Pipes for Ordinary Piping or approved equivalent.

18.2.2 Reinforced concrete drain pipes

The Contractor shall furnish and install reinforced concrete drain pipes as shown on the Drawings or as directed by the Engineer. Reinforced Concrete Pipes shall conform to the requirements of IS or approved equivalent, and provisions stipulated in CONCRETE WORK.

18.2.3 P.V.C drain pipes and fittings

The Contractor shall furnish and install the Poly Vinyl Chloride (P.V.C.) drain pipes including necessary fittings as shown on the Drawings or as directed by the Engineer. The P.V.C drain pipe shall conform to the requirements of IS, unplasticized poly vinyl chloride pipes or approved equivalent, and provisions stipulated in CONCRETE WORK.

18.2.4 Side ditch

The Contractor shall furnish and install side ditch with cobble stone and concrete and concrete type M15 shall be prescribed in CONCRETE WORK. Cobble stone to be used for side ditch shall be complied with the minimum/maximum range of 80 mm to 100 mm.

18.2.5 Concrete ditch

The contractor shall furnish and install concrete ditch. The concrete type M15 which shall be as per prescribed in CONCRETE WORK. Gravel foundation shall be clean, sound and angular gravel and well graded with maximum partical size of 40 mm. Execution of gravel foundation shall be done as prescribed in 2.3.3 (2) execution of work. The concrete ditch is either precast or placed in site.

18.3 Drainage Pipe Installation

Excavation for trenches shall be performed in accordance with the applicable requirements , Open Cut Excavation, in these Specification. Bedding surface shall provide a firm foundation of uniform density. Each section of pipe shall rest upon the pipe bed for its full length, with recess excavated to accommodate bells and joint.

Each pipe shall be carefully inspected before it is laid. Any defective or damaged pipe shall be rejected. The laying of pipe shall proceed upgrade beginning at the lower end of the pipeline. Under no circumstances shall pipe be laid in water and no pipe shall be laid when the trench conditions or weather is unsuitable for trenches during construction shall be born by the Contractor.

When pipe laying is interrupted, the Contractor shall seal the ends of the pipe line to prevent the entry of water or foreign matter. No backfill or concrete shall be placed over or around the pipes until the installation has been approved by the Engineer.

Unless otherwise specified or shown on the Drawings, bedding material below pipe shall be clean sand or other approved granular material and remaining backfill in the pipe trenches shall be done with approved material free from stones larger than 80 mm and other objectionable material.

Concrete used for drainage structures shall conform to the applicable requirements of CONCRETE WORK, in these Specifications. Mortar shall be stiff and composed of 1 part Portland cement and not more than 2 parts sand.

Surface drainage with concrete gutters, ditches and catch basins, and drain pipes installed on the shot concrete protective coatings are considered a part of concrete work.

After Cutting, and before threading, all steel pipes shall be reamed and have burs removed. All screw joints shall be made with graphite or other approved compound applied to made threads only. Thread shall be full cut and not more than 3 threads on the pipe shall remain exposed.

Flanged joints shall be faced true, packed and made up perfectly square and tight Gaskets shall be ring type 1.5 mm thick sheet asbestos.

Joints in P.V.C. pipes and fitting shall be socket or threaded joints made up as recommended by the manufacturer.

After the bedding has been prepared and the pipe or ditch installed, backfill material, at a moisture content which will facilitate compaction, shall be placed alongside the pipe or ditch in layer not exceeding 15 cm in depth unless otherwise specified or shown on the Drawings.

Care shall be taken to ensure thorough compaction of the fill under the ditch or pipe. Each layer shall be thoroughly compacted by rolling, tamping with mechanical rammers, or by hand tamping with heavy iron tampers of which the tamping face area shall not exceed 150 sq.cm. This method of filling and compacting shall be continued until the fill has reached an elevation 30 cm above the top of the Pipe or ditch. The remainder of the trench shall be backfilled and thoroughly compacted in layers not exceeding 15 cm. The density of compaction shall be as specified by the Engineer.

18.4 Measurement and Payment

18.4.1 Steel drain, reinforced concrete, P.V.C drains pipes and fitting.

Measurement for payment of drain pipe will be made on the basis of placed length at center line of steel Pipe in linear meters determined by designed line as shown on the Drawings or directed by the Engineer.

Payment will be made for the number of linear meters measured as provided above at the respective unit price per meter stated in the Bill of Quantities, which unit price for drain pipe shall

constitute full compensation for the cost of all labour, tools, equipments and materials jointing the steel pipes and fittings, and other items necessary to complete the Works.

18.4.2 Side drain/ditch

Measurement for payment of side ditch will be made on the basis of placed length at center line of side ditch in linear meters as shown on the Drawings or directed by the Engineer.

Payment will be made for the number of linear meters measured as provided above at the respective unit price per meter stated in the Bill of Quantities, which unit price for side ditch shall constitute full compensation for the cost of all labour, tools equipment and materials including furnishing, loading, hauling, unloading, installing and concreting the side ditch and other items necessary to complete the works.

No additional payment shall be made for clearing and stripping, excavation, backfill and the other items related to the construction of side ditch.

18.4.3 Concrete ditch

Measurement for concrete ditch will be made on the basis of placed length at center line of concrete ditch in linear meters determined by the designed lines as shown on the Drawings or directed by the Engineer.

Payment will be made for the linear meters measured as provided above at the unit price per linear meter stated in the Bill of Quantities, which unit price shall compensate the cost of all labours, tools, equipment and material including gravel foundation. The cost shall include furnishing, loading, handling, unloading, installing and concreting the ditch and foundation and other items required to complete the works.

No additional payment shall be made for clearing and stripping, excavation, backfill and the other items related to the construction of concrete ditch.

18.5 PERFORATED PIPE

18.5.1 Scope of Work

The work under this Clause shall cover the fabrication or procurement, installation and testing of perforated pipes for Intake, Power Canal and Desanding Basin as specified in the Drawing or instructed by the Engineer. The perforated pipe is defined to be reinforced concrete pipe with a number of small holes to collect the submerged water.

18.5.2 Materials

The Contractor shall fabricate or procure the perforated pipe in the following manner:

- | | | | |
|-----|---------------------|---|--------------------------------------|
| (1) | Structure | : | Reinforced concreted perforated pipe |
| (2) | Shape | : | Circular type |
| (3) | Internal diameter | : | 300 mm or as shown in the Drawings |
| (4) | Unit length of pipe | : | 2.5 m to 3.0 m |
| (5) | Class of pipe | : | NP3 (NS) |
| (6) | The number of holes | : | between 20 to 30 per m ² |
| (7) | Size of holes | : | between 10 mm and 20 mm in diameter |

The Contractor shall submit the detailed Drawings for fabrication or procurement of the perforated pipes to the Engineer for approval.

18.5.3 Testing prior to installation

The Contractor shall submit the procedures of testing to check the workability of the perforated pipe prior to installation. Testing shall be made at site where the perforated pipes are placed. It required to prepare a few sample pipes for testing before fabrication or procurement of the required number of the perforated pipe. The Engineer may change the design of the perforated pipe if necessary

18.5.4 Installation of the perforated pipe

The exact location of the perforated pipes to be placed is as shown in the Drawing or directed by the Engineer. The arrangement of the perforated pipes is depended on the flow direction of the submerged flow. The Contractor shall confirm the final decision of the perforated pipe arrangement to the Engineer prior to installation.

18.5.5 Joint between the perforated pipes

Joint between the perforated pipes shall be inserted type with un-fixed joint, which is not mortal and other joint materials shall be provided for the connection. The Contractor shall provide the inserted joint at the edge of the perforated pipes at time of the fabrication or procurement.

18.5.6 Backfill with selected materials

Backfill shall be carried out after approval of the Engineer. The materials of the backfill are as shown on the Drawings or directed by the Engineer. The Engineer may change the materials of backfill depended on the test results. The Contractor shall confirm the backfill materials prior to the preparation of the materials to the Engineer.

18.5.7 Measurement and Payment

Measurement for payment of perforated pipe will be made on the basis of placed length at center line of perforated pipes in linear meters determined by the designed line as shown on the Drawings or directed by the Engineer.

Payment will be made for the number of linear meters measured as provided above at the unit price per meter stated in the Bill of Quantities, which unit price shall constitute full compensation for the cost of all labor, tools, equipments and materials, for fabrication, transportation, installation, jointing and fittings and other items necessary to complete the works.

CHAPTER - 19

19. Brick Masonry Work

This specification covers all construction work of powerhouse and control building wall at Switchyard Area and Power House Area.

19.1 Materials

- (a) Brick units shall be sound, well burned, and free from defects that would impair its strength or affect its service-ability.
- (b) Cement shall be ordinary portland as per ASTM C150 Type 1 or equivalent.
- (c) Sand shall be clean, fine, sharp granules, free from foreign or deleterious matter.
- (d) Water shall be clean and free from acid, alkalis, oil or organic matter.

The Contractor should submit samples of cement, sand and lime for Employer's/Employer's Representative's approval.

19.2 Mortar mixtures

The type of mortar mixture for brick masonry shall be done in 1:4 mix ratios, but for all other purposed the following shall be used.

Table 19-1 Typical Ratio for Mortars for masonry and plastering works

Purpose	Proportion by weight	
	Cement	Sand
Plastering (internal walls of buildings)	1	6
Blockwork; brickwork; rubble stone masonry (general). Plastering (external walls of buildings)	1	4
Rubble stone masonry (high water velocity/turbulence). Plastering (hydraulic structures)	1	3
Dressed stone masonry. Pointing or plastering channels with very high water velocity. Inverts in drains, manholes, etc.	1	2

The cement and sand shall first be mixed dry until the cement colour. The mix however has to be verified before starting work from the Engineer at site.

19.3 Brick masonry laying

- (a) Lay brick masonry in accurately spaced courses, level, plumb and true to line.
- (b) Soak brick units in clean water for six hour before laying. Units shall be damped when laid.
- (c) Lay brick in running bond with joints approximately 10mm wide.
- (d) When brick masonry walls cross the recessed floor cable trenches provide and install cast-in-situ concrete Lintels of sufficient size and strength to support and carry masonry walls across the trench sprays.

- (e) Reinforced all masonry walls with cast-in-situ reinforced concrete formed flush with the masonry surfaces for cement plaster-finish.
- (f) Provide concrete pilasters and horizontal tie for every 9 square meters of masonry wall surface, plus at all corners and door Jambs.
- (g) All brick masonry wall shall be constructed in brick thickness with english or flemish bond as shown in the drawings

19.4 Curing

Spray masonry surfaces with water thrice daily for a period of 10 days, or until the surface receives a plaster finish.

19.5 Protection

Where exposed to weather, protect top of masonry with water tied material in such a way that it will protect the completed work. Masonry wall shall set for 48 hours before any load is applied on the completed work.

19.6 Measurement and payment

Measurement and payment of brick works shall be done based on cubic meter of the volume of wall as directed in design drawing or as directed by Engineer. There will be deduction on opening from such quantity. There will be no other payment against curing and extra shoring, protection arrangement for the purpose of lying of brick masonry wall. The Rate quoted in BOQ shall include all sorts of arrangements needed for brick masonry works including curing.

CHAPTER - 20

20. Plaster & Tile Work

20.1 Plaster

20.1.1 Materials

Shall conform to the respective specifications and other requirements specified below:

(a) Sand

Sand shall be coarse, clean sharp sand, free from clay, loam or other impurities. Sand shall be uniformly graded from coarse to fine.

(b) Portland cement

Portland cement shall be as per ASTM C150 Type I or equivalent. Only one brand of cement of 53 grades shall be used in the work.

(c) Water shall be clean, fresh and free from injurious amount of oils, acids, alkalis and organic matter.

20.1.2 Construction

(a) Thickness of plaster

Thickness of plaster from the face of the plaster base to the finish plaster surface shall be 2.0 cm.

Should it be necessary, the Employer/Employer's Representative can require that temporary metal grounds be used to assure a full true finish surface. Voids left by removal of ground shall be filled flush with plaster.

(b) Preparation for plastering

Concrete surfaces shall be thoroughly cleaned and free of paint, efflorescence, oil, grease, acids, and other loose or foreign matter prior to application of base coats. No plasterwork shall be applied on masonry work less than 2 weeks old.

(c) Mixing of plaster

Plaster shall be mixed in mechanical mixers where hand mixing is approved for small quantities. Caked or lamped material shall not be used. Each batch shall be proportioned by volume, accurately measured by manual or mechanical devices, and thoroughly mixed with the minimum amount of water until uniform in color and consistency. Re-tempering will not be permitted and plaster that has begun to stiffen shall be discarded. Mortar 90 minutes after mixing shall be rejected for the plastering work.

(d) Proportions

These are to be differentiated into 2 types :

(1) 1 PC: 3 sand

(3) 1 PC: 4 sand

Type (1) is to be used on all external walls, ceiling and floors.

Type (2) is to be used everywhere else.

20.2 Tiles

20.2.1 Terazzo tiles

(a) Materials

(1) Precast terazzo tiles

Terazzo tiles shall be 30cm x 30cm and wall base units of grade 1, according to American Standard or equivalent.

Tiles shall consist of two layers:

- First layer is 10mm thick with a special weight of 2.34kg consisting of:
60% "Tulung Agung" chips (4-10mm), and
40% Cement & cement color material
- Second layer is 15mm thick, consisting of 1 part Portland cement and 4 parts "Concrete Sand".

Average weight of tiles is to be 5.62kg and tensile strength shall be 58.3kg/cm²., Samples shall be verified from site engineer before placement.

(2) Mortar

Mortar shall consist of one part Portland cement and two parts of sand.

(3) Sand

Sand shall be hard, clean, free from mud and other material not desirable for setting mortar.

(4) Cement

Portland cement shall be as per ASTM C150 Type I or equivalent. Only one brand of cement of 53 grades shall be used in the work.

(5) Water

Water shall be fresh, clean and free from acids, alkali sewage and other organic matter.

(b) Installation

(1) Setting beds

Settings beds shall be composed by volume of 1 part Portland cement to 2 parts damp sand, and mixed with the minimum amount of water necessary to produce a workable mass.

Area of setting bed spread at one time shall be only as large as can be covered with tiles before the mortar has obtained its initial set. Surplus mortar shall be removed.

Setting beds shall be spread and tampered to force out air pockets screened to a true plane, and sloped to drain or leveled as required.

The average thickness of setting bed in any room or space shall be less than 30mm, but in no case shall be setting beds less than 20mm or more than 30mm thick.

(2) Setting

Before installation, the upper surface of precast terazzo tiles shall be preserved with material specified by the Manufacturer. The preservative will not discolor the terazzo nor leave a tacky or stickily film of the surface after power polishing.

Precast terazzo floor tiles shall be laid individually so that the joint between the tiles will be uniform and not less than 3mm nor more than 6mm in width.

(3) Grouting

All joints in floor terazzo tiles shall be thoroughly filled and flushed with a grout mixture composed of 1 part cement to 2 parts sand by volume, and mixed with a minimum amount of water. Color pigment shall be added to obtain the same color of mortar, to match the color of the adjoining terazzo tiles. Joints shall be tooled smooth, excess grout shall be removed by use of a sponge, squeegee, or burlap to finish the joints and clean the surface without disturbing the floor surface.

(4) Grinding

Carborundum disc shall be used for grinding. First grinding is to be carried out at least three days after setting: a good supply of water is used in this grinding. After the grinding, the whole area must be scrubbed with water to remove the slurry caused by the grinding. Should this first grinding be not sufficient to produce the required polish, a second grindings, after a further five days is made with finer grained disc. The whole is washed with hot water and pure soft soap after the final grinding.

20.2.2 Ceramic Tile

Manufacturer's original containers, bundles, or packages shall be delivered to the site unopened with seals unbroken and labels intact. Floor- tile operations in spaces requiring wall tiles shall not be started until after the wall-tile installation has been completed. Ceramic tile shall be installed in wall of bathroom up to the height of 2m.

Surface to receive applications of materials shall be clean and free from dirt, dust, oil, grease, and other objectionable matter.

(a) Materials

- (1) Ceramic tiles shall be 11cm x 22cm/22 cm x 22 cm. standard grade. Colors and patterns shall be selected later by the Employer/Employer's Representative.

- (2) Epoxy-resin grout

Epoxy-resin grout shall consist of an intimate of epoxy-resinous material non-volatile extenders, properly selected filler materials, and setting agent.

- (3) Portland cement

Portland cement to be used shall be white cement conforming to ASTM or equivalent.

(b) Installation

Joints shall be straight, level, perpendicular, and of even width not exceeding 1.6mm. Wainscots shall be built of full courses. That may extend to a greater height but in no case lower than the height shown.

Vertical joints shall be maintained plumb for the entire height of the tile work. Damaged or defective tiles shall be replaced.

Setting bed of ceramic tile shall be of cement sand mortar 1: 1 of 10mm thickness. The entire joint shall be provided with white cement.

(c) Grouting

Tiles shall have the edges wetted and shall be grouted full with a plastic mix of neat, white cement immediately after a suitable area of tiles has been set. The joints shall be tooled slightly concave, and the excess mortar shall be cut off and wiped from the face of the tiles. Interstices or depression left in the mortar joints after the grout has been cleaned from the surface shall be roughened at once and filled to the spring line of the cushion edge before the mortar begins to harden.

(d) Cleaning and Protecting

Upon completion, wall surface shall be thoroughly cleaned. Acid shall not be used for cleaning of glazed tiles. After the grout has set, tile wall surface shall be given protective coat of a non-corrosive soap or other approved method of protection.

(e) Samples

Samples of materials proposed for use shall be submitted to the Employer/Employer's Representative for approval before materials represented by the samples are delivered to the site.

20.3 Measurement and payment

Measurement and payment of Plaster and tile works shall be done based on square meter of the area of applicable wall and floor as directed in design drawing or as directed by the Engineer. There will be deduction on opening from such quantity. There will be no other payment against curing and extra shoring, protection arrangement for the purpose of lying of plasters and tiles in wall and floors. The Rate quoted in BOQ shall include all sorts of arrangements needed for such works in complete finishing.

CHAPTER - 21

21. Door and Window

The Contractor shall furnish and install doors and windows. The Contractor shall prepare and submit shop drawings of doors and windows to Employer/Employer's Representative for approval, prior to the execution of the erection work from floor level.

21.1 Aluminium Doors and Windows

Doors and windows shall be of the types indicated below. Each window shall consist of a unit including frame, mullions where indicated or required, and anchors. aluminum doors shall be used in entrance in two panels. Windows shall be provided with top removable ventilation. Size of the window shall not be less than 1.20m x 1.60m (w x h).

(a) Frames

All frame sections shall be tubular extruded aluminum shapes and of alloy 6063-T52. Frame sections shall be not less than 45mm face dimension x 115mm deep. Members shall be designed for recessed glazing to receive 19mm thick insulating glass, glazed with vinyl glazing inserts.

(b) Doors and Windows

Doors and windows shall be arranged for inside glazing with aluminum snap-in glazing beads designed to accommodate insulating glass as specified. Snap-in glazing beads shall securely interlock into the extruded window sections. Glazing rebate legs shall not be less than 19mm in height.

(c) Mullions, Sills and Trims

Mullions, sills, trim and other window sub-assemblies, indicated on the drawings or as necessary to properly complete each aluminum door and window installation, shall be of size and design to suit the window assembly, be compatible with the windows, and conform with the requirements for these sub-assemblies as specified in Section 1, General Requirements, Part A, in ANSI A134.1.

(d) Anchors and Clips

Anchors, clips, bolt and screws necessary to secure doors, windows and mullions shall be provided and shall be, at manufacturer's option, either aluminum non-magnetic stainless steel, or zinc coated steel.

(e) Installation

Doors and windows shall be installed without forcing or distortion so that sills and heads are level and jambs are plumb.

Window frames shall be securely anchored into the supporting construction. Joints between metal windows and metal members including mullions shall be set in mastic of the type recommended by the window manufacturer. Excess mastic shall be removed before hardening. Metal surface shall be cleaned and any staining or discoloring of the finish shall be restored or the unit replaced.

21.2 Timber Doors and windows

21.2.1 Materials

Timber shall be subjected to Employer's/Employer's Representative's approval.

(a) Salwood**- Sizes and pattern**

Lumber shall be surfaced four sides, and worked according to patterns as are indicated or specified on the drawings. Exposed members for transparent finish shall be matched for compatibility of grain and color between adjoining members; for paint finish, is not required. The size of frame of panel shall not be less than 40mm x 100mm and the size of door frame shall not be less than 75mm x 120mm.

- Moisture content

At the time of delivery, the moisture content shall not exceed 15% for material of 2.5cm or less in thickness, and shall not exceed 19% for material over 2.5cm in thickness.

(b) Teak Plywood

All interior plywood for transparent finish shall be of equal and uniform of color and graining, such as for door panels. Hardwood plywood shall be or premium grade. Plywood for paint finish matching for compatibility is not required, such as for ceiling.

(c) Veneers

Veneers on wood doors, panels and other exposed wood work shall be of 4mm thick.

(d) Fasteners

Only galvanized fasteners will be used.

(e) Glue

Fully waterproof throughout, such as "herein" or equal.

(f) Putty

Shall conform to IS Standards or equivalent.

21.2.2 Construction**(a) Fastening for Exposed Members**

Other than two small positioning nails per sub-assembly of plywood no exposed nails shall be used. All exposed members are to be glued using either pressure of electric wood welder. All traces of excess glue shall be removed. Tops shall be fastened to sub-or web frames with concealed clips, screws, glue blocks or similar hidden fastenings. Exposed ends shall be lock mitered and glued to face plates.

(b) Edge Treatment

Visible edge shall be banded with lumber edging, glued under pressure with no nails allowed. Species shall match the face veneers of plywood, but may be of any species on particleboard.

(c) Size of Door

Unless and otherwise specified, the size of door panel shall not be less than 1.0 x 2.30m (W x h)

21.2.3 Hardware

Hardware such as hinges, cylinder locks, handles and door closers shall be stainless steel of excellent quality. Samples of hardware shall be submitted to Employer/Employer's Representative for approval. Cylinder locks and door closers shall

be installed with the doors and windows according to the instructions of Employer/Employer's Representative. Master key for all locks shall be provided.

21.3 Rolling Shutter

Metal Rolling Shutters should conform to IS: 6248. The rolling shutter accessories should be as specified and approved should be suitable for fixing in position as specified i.e. outside or inside; on or below lintel or between jambs of the opening.

Rolling shutter is hand operated. Hand operated shutters are of push and pull type. The shutter consist of 80 mm wide MS laths 1.25 mm thick or gauge as specified of mild steel sheet machine rolled. Laths are inter-locked together throughout its entire length and jointed together at the end with end locks. These are mounted on specially designed pipe shaft.

21.3.1 Cold Rolled Steel Strips

Cold Rolled Steel Strips used for rolling shutter lath sections shall conform to temper No. 5, Dead soft quality of IS: 4030.

21.3.2 GI Sections

GI Sheets and Plates used for manufacturing the guide channels, brackets and lock plate should be of hot rolled steel of thickness not less than 18 gauges conforming to IS: 5986. These shall be free from surface defects and the edges shall be cleanly sheared. All components of rolling shutter to be hot dip galvanized with a zinc coating containing not less than 97.5% pure zinc. The minimum weight of zinc coating to be 230 g/sq.m. The coating shall be free from flaking/peeling.

21.3.3 Steel Pipe

GI Pipes used for the suspension shaft of the roller should be heavy duty pipe suitable for mechanical purposes and shall conform to IS: 1161.

21.3.4 Cast Iron Castings

Cast Iron Castings used for roller pulley wheels, U-clamps shall conform to Grade 15 of IS: 210. These should be free of blow holes, surface defects such as cracks, burrs etc.

21.3.5 Springs

The springs used in the roller for counter balancing the rolling shutter should be made either from high tensile spring steel wire or flat spring steel strip. The spring steel wire used or helical spring should conform to Grade 2 of IS: 4454. Flat spring steel strip used for spiral spring shall be from 0.8 to 1.0 percent carbon steel strip especially hardened and tempered.

Both the side guides and bottom rails are joint less and of single piece of pressed steel of minimum 16 gauge thickness. The top cover of shaft, spring etc. should be of the same materials as that of lath. Hood, brackets etc. are required to cover the shaft etc. The reduction gear arrangement operated by the mechanical device should be of the best quality and easy in operation.

21.3.6 Fixing of Rolling Shutter

First the brackets are fixed on the lintel/beam or under the lintel/beam as required with raw plugs and screws, bolts, washers etc. The shafts along with the spring are then fixed on the brackets. The lath portion (shutters) is laid on ground and the side guide channels are bound with it. The shutter is then placed in position. The side guide channels are fixed to the wall through the plates welded to the guides. These plates and brackets should be fixed by means of steel screws, bolts and raw plugs drilled into the wall.

The plates and screws, bolts shall be concealed in plaster to make their locations invisible. Fixing should be done accurately so that the operation of the shutter is easy and smooth. The smooth and easy working of shutters is ensured. To prevent rusting of shutters, it is cleaned off dust, scales, rust etc. and priming with a coat of red oxide paint is done before fixing the shutter in position and then it is painted with two coats of flat/synthetic enamel paint.

21.4 Measurement and Payment

Measurement and payment of door and windows shall be based on square meter of area of applicable door and window opening. That shall include all sorts of material for posts, frames, anchors, grouts, nails, paints and all finished and placed in positing as directed in drawing or as directed by the Engineer.

CHAPTER - 22

22. Plumbing, Drainage and Sanitary Fittings

22.1 General

The Contractor shall furnish, install and test the complete indoor Potable Water, Service Water, Plumbing, Storm Drainage and Sanitary Sewer Systems. This shall also include connection of water pipes to the existing water system, as the case may be, and installation of complete system.

All necessary incidentals such as sanitary fittings, wash bowl water closet, equipment supports, flashing, excavation and backfill, disposal of surplus dirt and rubbish, permits and inspections, insurance, taxes, expenses and materials required for complete, satisfactory and legal installation shall be borne by the contractor.

The Contractor shall furnish satisfactorily functioning installations. All items of labor, material of equipment not specifically mentioned herein, but incidental to or required for a complete installation and proper operation of the above-mentioned systems, shall be included.

The Contractor shall furnish and install 50mm dia G.I. Pipe for boring, 1 cubic m capacity of G.I. Water tank at roof and 2HP Centrifugal pump to fill the water in the elevated water tank and all necessary associated appurtenance.

Drip drains for the air-conditioning installations and equipment drains are included in this scope.

22.2 Standards

The work shall be carried out in accordance with Codes National Plumbing Code, U.S. Department of Commerce, unless otherwise indicated.

22.3 Workmanship

The installation shall be made in neat, orderly and workmanship manner, conforming in every way to the accepted standards of the best commercial practice.

22.4 Design requirements

The plumbing and drainage of all the buildings shall be as per the National Standard Plumbing Code.

For the potable and service water supply to the building, and over storage tank of 1 cubic m storage capacity will have to be provided by the Contractor. The tank will be mounted on the roof. The water distribution inside the building will be taken from this overhead tank.

The design of the plumbing system shall be developed by the Contractor. Floor drains, drain from washbasin and drain from the equipment shall be run separately from sanitary sewer and connected to the outdoor switchyard water drainage system.

Sanitary sewer drain from the building will be connected to the septic tank (1.0m x 2.5m x 1.5m) and outlet from septic tank connected to the soak pit (1.0m dia. and 3.0m deep). Overflow from the soak pit shall be connected to the switchyard drainage system.

- (a) Septic tank shall be constructed in double compartment in 240mm thick brick masonry wall with 1: 4 cement concrete 1: 2: 4 in 20mm thickness. The septic tank shall be provided with removable R.C.C. slab cover.
- (b) Soak pit shall be constructed in honeycombed brick wall of 240mm thick with 1: 4 cement sand mortar. The pit shall be filled with brick of size longer than 60mm.
- (c) Sewage pipe shall be heavy quality cast iron and not less than 100mm dia. in size.

- (d) Drain pipe to connect drainage system from soak pit shall be used of 100mm dia. of polyethylene pipe of heavy quality.
- (e) All the water supply pipe shall be heavy quality of galvanized steel pipe required size.

22.5 Measurement and Payment

Measurement and payment of plumbing works shall be paid for the set of bathroom fitting as mentioned in drawings or as directed by the Engineer. That shall include all sorts of material procurement, transportation and fixing in position and connecting the water pipeline from the water supply system or providing from the source identified. The safe disposal of wastage and sanitation all shall confirmed and included in one set of bathroom and fitting works.

CHAPTER - 23

23. Paint, Glazing, and CGI Roofing

23.1 Painting

23.1.1 General

All surfaces shall be painted except the following:

- (a) Exterior:
Roofing, paving, concrete, nonferrous metals, glass, pre-finished items.
- (b) Interior:
Ceramic tile, glass, pre-finished surfaces, non-ferrous metals, stainless steel, attic surfaces.

23.1.2 Materials

A list of the painting materials and their colors, which are to be applied to the specified surface, shall be submitted to the Employer/Employer's Representative for approval.

23.1.3 Paint application

The finished surface shall be free from runs, drops, ridges, waves, pales, brush marks, and variations in color, texture, and finish. The hiding shall be complete, and coat shall be so applied as to produce film of uniform thickness. Special attention shall be given to insure that all surfaces including edges, corners, crevices, welds, and rivets receive a film thickness equivalent to that of adjacent painted surfaces.

Adjacent areas and installations shall be protected by the use of drop cloths or other approved precautionary measures.

Metal or wood surface adjacent to surface to receive water-thinned paints shall be primed and/or touched up prior to the application of water-thinned paints. The first coat on plaster shall include such repeated touching up of suction spots or overall applications of primer sealer as necessary to produce a uniform color and gloss. The first coat on both faces of wood doors shall be applied at essentially the same time.

(a) Coating Progress

Sufficient time shall elapse between successive coats to permit proper drying. This period shall be modified as necessary to suit adverse weather conditions.

Oil base or oleoresinous solvent-type paints shall be considered dry for recoating when the paint feels firm, does not deform or feel stickily under moderate pressure of the thumb, and the application of another coat of paint does not cause lifting or loss of adhesion of the undercoat.

Coating shall be as follows:

- (1) All interior and exterior plastered surfaces:
 - First coat: 1 coat of Alkali Resistance Primer
 - Second coat: 2 coat of Weather shield Exterior Wall Finish in waterproof snow cem paint
- (2) Gloss finish wood:
 - First coat: 1 coat of Wood Primer
 - Second coat: 2 coat of Synthetic Super Gloss

- (3) Interior transparent finish wood:
 - First coat: 1 coat of Wood Primer
 - Second coat: 2 coat of Teak Oil
- (4) Metal surface:
 - First coat: 1 coat of Metal Primer Chromate
 - Second coat: 2 coats of Aluminum Paint

(b) Storage, Mixing and Thinning

At time of application, paint shall show no signs of hard settling, excessive skinning, leveraging, or other deterioration. Paint shall be thoroughly stirred, strained, and kept at a uniform consistency during application.

Where necessary to suit conditions of surface, temperature, weather, and method of application, package pint may be thinned immediately prior to application in accordance with the manufacturer's directions, but not excess of 0.5 liter of suitable thinner per 4 liter. The use of thinner for any reason shall not relieve Contractor from obtaining complete hiding.

Samples shall be clearly identified by designated name, specification number batch number, project contract number, batch number, intended use, and quantity involved. At the discretion of the Employer/Employer's Representative samples may be tested before approval, or materials may be approved for use based on the test reports furnished. In the latter case the samples will be retained by the Employer/Employer's Representative for possible future testing should the material appear to be defective during or after application.

Measurement and payment

Painting works shall paid in square meter of the area covered in applicable area as directed by the Engineer. That should include complete items including procurement, transportation, preparation, shoring and protection arrangement, etc complete.

23.2 Glass and glazing

- (a) Sheet glass to be used for door and windows shall be 6mm thick, tinted glass except as otherwise specified. It shall be of the best quality, free of unevenness, stain or bubbles, and where so required, figured glass shall be used.
- (b) Glazing compounds shall be of suitable type approved for the application. The use of non-skimming compounds, non-resilient type preformed sealers, and preformed impregnated type gaskets will not be permitted. Metal sash putty will not be permitted. Materials used with aluminum frames shall be aluminum colored, non-staining, and not require painting.
- (c) Channel glazing compound shall be equal in performance to, but not limited to the following:
 - (1) Non-drying, knife grade polybutene sealant
 - (2) One-part acrylic terpolymer sealant
- (d) Shop-painted items
Surfaces of fabricated and assembled items that are finish painted by the manufacturer, or specified to finish painted under other sections of the specifications, are exempted from the following schedule requirements for surface preparation and painting shop primed items shall receive surface preparation and finish painting as required by this section.
- (e) Colors and tints, including shades of stain, shall match the respective color specimens selected by the Employer/Employer's Representative.

Stains shall conform in shade to manufacturer's standard color. Undercoat shall vary slightly from the color of the next coat.

(f) Surface preparation and pretreatment

Cleaning and pretreatment of surface prior to painting shall be accomplished in accordance with the detailed requirements specified.

(g) Cleaning

Clots and cotton waste that might constitute of fire hazard shall be placed in closed metal containers or destroyed at the end of each day. Upon completion of the work, staging, scaffolding, and containers shall be removed from the site or destroyed in an approved manner.

Paint spots, oil or stains upon adjacent surface shall be removed and the entire job left clean and acceptable.

Measurement and payment

Glass and glazing works shall be paid in square meter or area covered in opening applicable to glazing as directed by the Engineer. That should include complete items including procurement, transportation, cutting and fixing in position, wastage etc.

23.3 CGI Roofing

Galvanized mild steel sheeting

Hot dipped galvanized mild steel corrugated sheeting shall be used of 22 gauge. Sheets shall be laid with 250 mm end laps and side laps of 1½ corrugation on the side away from the prevailing wind.

The sheets shall be fixed to each purlin with 8 mm diameter galvanized mild steel J-bolts each with one rubber washer, one galvanized dome steel washer and galvanized steel nut. There shall be a minimum of 3 J-bolts across the width of a sheet.

Holes for bolts shall be punched from the inside of the sheet and shall be in the ridges of corrugations as fixed and not in the hollows.

Measurement and payment

CGI Roofing shall be paid in square meter or area covered in roof as mentioned in BOQ, Sheet Roofing also includes all the cost of truss, purlin, rafter, cover, drain water gutter, cover and drain water pipes required down to the surface drain.

23.4 Roof Truss

A roof truss shall be made of mild steel tubular "Medium Class" pipes. The steel for roof truss shall be from approved manufacturer. Truss rafters shall be used as main load bearing element for roofing purpose. The size of roof truss elements shall be as shown in the drawings or as approved by the Employer's Representative.

The truss shall be primed with two coats of red lead primer.

The truss shall be painted with two coat of enamel paint as specified in the drawings or as directed by the Employer's Representative to get uniform painted surfaces.

Measurement and payment

Measurement and payment of steel roof truss works shall be made in Kg of steel used .

CHAPTER – 24

24. Miscellaneous Works

24.1 False ceiling works

24.1.1 General

A false ceiling is a secondary ceiling, hung below the main structural ceiling. False ceiling is also referred as a suspended ceiling or drop ceiling. The area above the false ceiling is called the plenum space as it is sometimes used for heating, ventilation and air conditioning.

The main purposes of providing false ceiling are to run communications, to hide pipes, wires, duct works. Sound insulation is other primary purpose of providing false ceiling. Sound waves have a chance to dissipate in the space between the false ceiling and the overhead structure, so sounds from above are muffled in the room. Similarly, the lightweight panels will reflect sound back into the room, improving sound travel in the room that contains the ceiling.

24.1.2 Material

Gypsum board ceiling

The gypsum board ceilings are provided in the office rooms and meeting hall. These boards are in various design and texture.

9.5 mm gypsum board tiles of 610 x 610 mm size conforming to IS 2095: 1982 & 2542-1981. The tiles shall have texture and design pattern. The suspenders are galvanized mild steel straps of 28G and horizontal and transverse members are galvanized mild steel channel of 16 G. Construction Procedures.

24.1.3 Construction procedures

The board ceilings are suspended from the concrete ceilings, and or truss and purling by steel hangers to suspend the horizontal steel channels. The horizontal members are screwed with steel screws and grip in the wall. The suspenders are clamped to the truss and purling with steel screws. After the framing is completed the Employer's Representative in charge shall check the framing before allowing fixing the ceiling boards.

The ceiling boards free of damages are fixed to the framing in perfect line and level. The joints are sealed with plaster of Paris and non-woven paper tapes without forming any bubble. Once laying of ceiling is completed the dust and floors are cleaned for the painting works.

24.2 Hand Rails

The hand rails shall be constructed in locations as in the Drawing or as directed by the Engineer. The hand rails shall consist of three layers of 50mm NB "Medium Class" Galvanized pipes laid in parallel at the interval 500mm center to center. These pipes will be supported by same size pipe columns at 2 m c/c spacing. The pipe columns shall be fixed to concrete slab or block with 8 mm thick plate welded to pipe column and bolted securely to the base. The handrails shall be coated with one layer of primer coat and two layers of silver paint. in accordance to Clause 22.1 [Painting] of this specification.

24.3 Fencing

The work shall be executed as per the description of item given in the 'BOQ',

Bottom most row of the horizontal barbed wire shall be 75 mm to 150mm above the ground level. The post shall be reinforced concrete pole of 100 mm * 125 mm * 2100 mm size with 8 mm dia. for bars with stirrups@ 150 mm c/c.

The post shall be buried 500 mm in the ground with 1:2:4 concrete and clear heights above the ground shall be 1.6 m. No extra cost shall be paid for the clearance of bushes or grass or trees along the fencing. The spacing of the post shall be 2 m c/c.

The fencing should have with five rows and two diagonal barbed wires

The diagonals of barbed wire shall be continuous & stretched between adjacent posts from top horizontal row of barbed wire of one of post to the bottom horizontal row of the second post. For fixing diagonals of barbed wire, separate nails of hook shall be provided in the posts.

G.I. barbed wire at ends and at joints shall be given eight turns & either tied with G.I. wire of not less than 16 gauge at three places with at least six wraps at each place or clamped with two U-Bolts and nothing extra shall be paid on this account. G.I. barbed wire shall be 12 gauge galvanized conform to IS 278: 1978

The fencing should also include a wooden gate with wooden post (Sal wood) and all necessary accessories and fittings in each component such as Settling basin, powerhouse, surge pipe etc.

The fencing work shall be executed in the following sequence.

- Alignment of fencing and earth work in embankment.
- Excavation of foundation holes.
- Fabrication, and erection of posts/struts and casting of foundation.
- Laying C.C. pavement.
- Fixing of barbed wire, tightening/straightening bolts.
- Stretching of barbed wire.
- Fabrication & fixing of gate posts & gates.

CHAPTER – 25

25. Electrical

25.1 Luminaries Light Fixtures

Dome light	PHILIPS, Crompton Greaves, OASIS or Prior approvals by the Engineer
Wall Bracket	PHILIPS, Crompton Greaves, OASIS or Prior approvals by the Engineer

25.2 FTL

Sets Surface/ Recess	Havells, Crompton Greaves, OASIS or Prior approvals by consultant
FTL	CG, Havells, GE, OASIS or Prior approvals by the Engineer
PL/GLS/CFL	CG, OSRAM, Havells, GE or Prior approvals by the Engineer

25.3 Fan

Exhaust	CG, GEC, Khaitan or Prior approvals by the Engineer
Ceiling/Wall	CG, GEC, Khaitan or Prior approvals by the Engineer

25.4 Switch/Socket

2 pin 6A	Prior approvals by the Engineer
3 pin 16 A	Prior approvals by the Engineer
Gang switches	Prior approvals by the Engineer

25.5 Distribution Board

MPB	HIMALAYAN BIJULEE/HYONJAN or Prior approvals by the Engineer
DB/SDB	HIMALAYAN BIJULEE/HYONJAN or Prior approvals by the Engineer

25.6 Circuit Breakers

MCB	Merlin Gerin, GE, ABB or Prior approvals by the Engineer
MCCB	MITSUBISHI, GE, ABB, MG or Prior approvals by the Engineer

25.7 Cable/Wire

TRISHAKTI, PRAKASH, DELTA or Prior approvals by the Engineer

25.8 Board/Box

There are a number of boards/boxes to be used in the project; viz. DB, MPB and JB etc. They vary in size, shape quantity, materials and in other aspects and shall be governed by the followings:

25.9 Distribution Board (Db)

There are numbers of DBs having internal components. These DBs shall be wall mounded, flush type front opening, double cover/single cover. Each DB having push bottom lock shall

contain and independent bar for neutral and earth. Other details to be followed are in alphabetical order, below:

25.10 Cable Socket

Cable socket metallic with screw, shall be used for each and every cable entry / exit, into/from the concerning DB/MPB.

25.11 Lighting

A circuit is intended to feed and control light points viz. GLS, FTL, CFL, Fans some 2/3 pin convenient outlet etc. A light circuit shall not have > 8 such points or < 1 KW loading whichever is less. During execution, independent and separate light circuits for each group of points (i.e. GLS group, FTL group, Fan group etc.) shall be made; in case of 3 pin convenient outlet earth continuity shall be maintained.

25.12 Power

A power circuit is intended to feed the convenient outlet sockets with earth continuity (Conductor) such as 3/5/6 pin plugs of different capacities.

25.13 General Circuit

Any circuits not belonging to above mentioned i.e. dedicated power circuit is termed as general circuit and may contain convenient outlets of different types (e.g. 2 pin/ 3 pin/ 5 pin etc.) and numbers depending upon the situation.

25.14 Length of the Circuit

Circuits may vary from case to case. The length to be considered shall be the distance between the concerned MCB/ cut out usually positioned inside the DB's and the points via switches and JB s for certain circuit, regardless of its nature (light circuit/power circuit).

25.15 Clearance from Communication Cables

The horizontal and vertical separation between power and communication cable shall be > 500 mm (for any core of cable). Where this cannot maintained, the cables should be laid solid in insulating compound.

25.16 Clearance from Water Mains

A minimum clearance of 400 mm shall be provided between the water and the power mains.

25.17 Colour Codes

Color codes for visual aids shall be applied in the electrical as listed hereunder:

Red, Yellow and Blue	: for phases
Black	: For neutral
Green	: Earth/Ground
White	: for return wires e.g. say from switch to lamp or vice versa.
Gray	: for the 3 rd middle point connection as in the case of 2 way control system.

25.18 Discrepancy/Dispute

If any discrepancy is found relating to any item specified or anywhere in the text, the contractor shall immediately report this in writing to the engineer and shall not start the work unless clarification has been received with the approval by the engineer.

Should there be any dispute or differences of opinion, then it shall be solved mutually between contractor and engineer. The Engineer's opinion shall be final and binding to the contractor who must comply with the architect's decision.

25.19 Earthing / Grounding

The grounded neutral of the secondary distribution system shall be supplemented by an equipment grounding system to safeguard equipment and personnel properly. Equipment grounding system shall be incorporated to all metallic enclosures, cabinets and other conductive items in close proximity with electrical circuits and shall operate continuously at ground potential and shall provide a low impedance path for possible ground fault currents. The system shall comply with IS, BS & NBC

There shall be a number of earthing points. In general they are of the following types:

Equipment earthing meant for the cover/chassis of the electrical equipment normally devoid of any voltage.

Main system earthing for earth continuity of convenient outlet sockets DB/MPB etc.

25.20 Extra Works / Quantity

Any extra or additional work shall only be executed after the written permission of the engineer and after prices and budgets for this has been ascertained and approved.

25.21 Inspection and Testing

Upon the physical completion of the job and before putting the installation into service, inspection and testing shall be thoroughly done and its data recorded in the prescribed tabular form. This process of inspection and testing shall be continued until all the satisfactory results desired and designed for as described herein are obtained. The following tests shall be performed:

- I.5.1 Leakage (Insulation) Test Between Conductors.
- I.5.2 Leakage (Insulation) Test between the Installation and Ground earth
- I.5.3 Physical/Mechanical strength test
- I.5.4 Circuit Test
- I.5.5 Ring Main Continuity
- I.5.6 Earth/Ground/Lightning protection System Test
- I.5.7 As described by manufacturer test
- I.5.8 Schedule test

25.22 Joints of Wires and Cables

All wires inside the JB's shall be joined with the mechanical connectors wherever possible and if not then by PVC tapes (of appropriate colors) where conductors have lap and twist joints (not twist and knot joints). They shall be taped and colored coded joints in through run of any circuits except at JB's are prohibited.

25.23 Lightning Protection System

In order to protect the high voltage electrical equipment and the personnel against atmospheric lightning surges the incoming over-head lines and the metallic parts of the building should be effectively earthed with minimum impedances, to discharge the surge prior to reaching surge voltage to the equipment or personnel to be protected. (if necessary)

25.24 Qualification of Working Personnel

The working personnel shall be experienced and shall have suitable qualification from a recognized technical school. It is desirable that even the lowest technical class of workers shall be able to certificates to authenticate their claims of experience.

25.25 Scope

The works covered shall include furnishing all labor, materials, equipment and services in connection with the complete work as indicated.

25.26 Wire

Wires of various, sizes, types and lengths, shall be used. In any thorough runs the wires shall not be joined. Similarly, dissimilar material e.g. Al, Cu shall not be joined tighter. Bare wire shall not be used, unless main earth anywhere in this project.

25.27 Light Point

Loop-in-system shall be employed in our case of light circuit(s) where the following shall be maintained.

Phase wire must be looped right from the switch bank and in no case be looped directly from the light point.

Neutral may be looped either as the phase wire or also may be looped directly from the light point as the case may be.

No joints throughout the wiring run of the given circuit are allowed.

25.28 Workmanship

Good workmanship is an essential requirement for compliance with the clause in this documentation.

The workmanship shall be evaluated from some of the following stand points through it shall not be limited to them:

W.4.1 Connection of wires/cables inside DB/MPB

W.4.2 Fitting of outlet socket for light fixtures.

W.4.3 Fixing of PVC channels, wooden batten, links clips etc.

W.4.4 Terminating of cables in to the boxes.

W.4.5 Tightening screws etc.

W.4.6 Adherence to color coding practice during the wiring.

W.4.7 The way of laying of different items viz. pipe, conduit, trench, wire.

W.4.8 The technology of earthing.

W.4.9 Professional dedication and interest in the work.

W.4.10 Neatness and cleanliness on the work site at all times

25.29 GENERAL

The whole Electrical System has designed to provide and Electrical service and distribution system of adequate capacity and protection required for the design intent of the building with compound. The following system has been incorporated within the designed.

Light: Normal/Special

Power: Appliances, General, PC, special (Normal/Essential)

HVAC: Air conditioner, Fan

Telephone: Direct, PABX

FA: Fire Alarm (if necessary)

PART II- I.C: TECHNICAL SPECIFICATIONS FOR HYDRO-MECHANICAL WORKS**TABLE OF CONTENTS**

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TECHNICAL SPECIFICATIONS FOR HYDRO-MECHANICAL WORKS

1. GENERAL PROVISIONS

1.1 Scope of Work

The broad scope of the work includes design, procurement, fabrication/manufacturing, supply, inspection, shop assembly, shop testing & painting, transportation (to site and within site), site storage & site erection and installation including site assembly and site painting, testing and commissioning including acceptance test, guarantee services and remedying of defects for all equipment as specified in the Technical Specifications.

In addition, the Contractor shall provide training to the Employer's personnel as required, to establish a well-trained operation and maintenance crew.

If the specifications and/or drawings of these Bidding Documents do not contain particulars of materials or works which are obviously necessary for the proper and safe completion, operation and maintenance of the equipment in question, all such materials and works shall be deemed to be included in the supply.

The following equipment shall be supplied under the contract:

- Under Sluice Gate: One Vertical wheel type with guide frame hoists and accessories all complete set with Electric Operated System
- Under Sluice Stop Log : Vertical lift slide with guide frame hoists and accessories all complete set (1 Nos) with Manual Operated System
- Intake inlet Gates: Two Vertical wheel type with guide frame hoists and accessories all complete set with Electrical Operated System is provided to regulate flow into the waterway. In front of the gate a coarse trashrack is provided with 16 dia. MS bars @ 100 c/c spacing.
- Settling basin inlet gates: Two Vertical wheel slide with guide frame hoists and accessories all Complete set with Electric Operated System..
- Settling basin flushing gates: Two Vertical wheel slide with guide frame hoists and accessories all complete set with manual operated system.
- Settling basin outlet gate: Two Vertical wheel slide with guide frame hoists and accessories all Complete with Electric Operated System.
- Fine Trash Rack at Forebay : One Trash rack with supporting beam and accessories all Complete Set
- Tailrace gate: One complete set of tailrace gates with its guide frame and hoists with their accessories.
- Forbay Inlet Gate : One Vertical wheel slide with guide frame hoists and accessories all complete set with Electric operated system
- Stop-log: Stop-logs are provided to facilitate repair of main gates and at places where the operation will not be frequent. Some of the stop-logs provisioned for Saniveri Utarganga MHP are at undersluice and Tailrace.
- Butter Fly Gate Valve with 400 Dia. and penstock pipe including its accessories as per BOQ
- Flushing Sluice Valve with 500 Dia. With all fittings and accessories completed set

The Contract shall also include the supply and installation of all electric and control equipment associated with the foregoing work. All works shall be in accordance with the Specification, the accompanied drawings and tender schedules.

2. DESCRIPTION OF THE COMPONENTS

2.1 Steel Penstock Pipe

2.1.1 General Requirements

The water from forebay is conveyed to powerhouse in steel penstock pipe having different thickness and diameter. Mild steel plates of grade IS 2062-B will be used for the fabrication of pipe at factory and transported to the site. A penstock pipe is provided to cope with the existing topographical and geological features of the site. Penstock pipe is designed with Mild steel Pipe having diameter of 1.1m with varying thickness of 4-8mm. The total length of pipe is 292.53 m. There are altogether 9 numbers of anchor block provided at each horizontal and vertical bends of the pipe. The expansion joints are provided after each anchor block to prevent contraction and expansion of pipe during the seasonal variation. The pipe will be restrained longitudinally by Anchor blocks and supported in 6 m interval in support piers. The Bifurcation pipe is designed 0.85 dia. with thickness of 10mm and cumulative length of 25.5m. The pipe will need the following components:

- Pipes
- Bends
- Expansion joints
- Base plate
- Washout valve
- Stiffener Plates
- Anchor ring
- Strainer Pipe

The thickness is calculated based on to be operated in isolated mode and transients traveling all the way to forebay in the long penstock. The opening and closing time of turbine is considered as **6s minimum**.

Table 2-1 As per preliminary design following steel pipes are to be supplied by the Contractor:

SN	Description	Length (m)	Thickness (mm)
1	MS Headrace Pipe 5 mm thick with 1100mm internal dia. including bends	94.15	5
2	MS Headrace Pipe 6 mm thick with 1100mm internal dia. including bends	160.50	6
3	MS Headrace Pipe 8 mm thick with 1100mm internal dia. including bends	45.10	8
4	MS Branch Penstock pipe 10 mm thick with 850mm internal dia. including bends after Bifurcation	21.50	10
5	Gravel Flushing pipe at gravel trap of dia 500mm with 4mm thick	23.50	4

Anchor ring, strainer pipe and stiffeners are provided inside anchor block and these details including penstock pipe with accessories have to be prepared after review of design and calculation by the Contractor.

2.1.2 Standard for design and testing

The material, design, fabrication, installation, painting and testing of penstock pipe shall conform to the following Standards as per table. Other International Standards e.g. American society for testing & material (ASTM) / American society of mechanical Engineers (ASME) or Deutsches Institute fur Normung (DIN) or ASCE Manual 79 may be followed as per best international practices for the parts which are not covered by the equivalent Indian standards unless specified in this specification.

S.No.	Description	Standards
A.	Pressure Vessel / Boiler Quality Plates for Steel plate liners and stiffeners	ASTM-A 537 class II and ASTM-A - 517-Grade F
B.	M.S. Bolt-studs, nuts and washer S.S bolts and Nuts	IS 1364
C.	Backing Strip	IS : 2062 E 240
D.	Gasket or jointing material	BS 1737
E.	Welding Electrodes	IS : 2825 , IS: 814 ASME –Boiler and Pressure vessel Code Section XIII Division I
F	For Design and Details : a) For penstock including bifurcations, bends and reducer	IS: 11639 Part – 2 for underground works and IS: 11639 Part – 1 for exposed parts of Liner.
	b) Manhole	IS: 2825 / ASME Sec VIII Div.1
	c) Thrust ring	ASCE manual 79 / IS:11639 Part – 2 / ASME Sec.VIII
	d) Welding	IS: 2825 / ASME Sec VIII Div.1
G.	Surface Preparation and Painting	SA 2.5 and AWWA-C- 203-78
H.	Inspection and Testing	IS 2825-1969 / ASME Section VIII Division 1 and Section V

2.2 HDPE sheet

The caps of saddles are provided with minimum 6mm thick HDP sheet to facilitate the uniform distribution of load on the bearing area. The base plate will hold pipe at least in 120 degrees at the lower part. The HDP sheet will be anchored in cap concrete with the help of mild steel bar welded in base plate at the time of laying and fixing. The plate width on saddle is 1.0m and has curved surface to fit sufficient for 1100mm dia. pipe.

2.3 Expansion Joints

There are about 9 expansion joints needed for headrace/penstock pipe.

2.4 Gates and Stoplog

2.4.1 General Requirements

For controlling of discharge, 11 gates and 2 Stoplog are provided in different locations of the subproject. There are 1 for undersluice, 2 intake gates, 1 for gravel trap flushing, 2 Settling basin inlet gate and 2 settling outlet flushing Gates and 1 forebay gates respectively. The minimum skin plate thickness including a corrosion allowance should be 14 mm. The operating platform is made with 12.5cm slab and the side channel is extended up facilitating the lifting arrangement. Out of 2 stop logs, 1 is for undersluice and 1 are for tailrace gates. The details of gates are described in Table below.

Table 2-2 Details of gates and Stop logs

SN	Description	Unit	Qty.	Size (W x H) m	Type
1	Stop log for Undersluice	Set	1	2.5 x 2.5	Vertical lift slide with guide frame hoists and accessories all complete set (2 Nos) with Manual Operated System
2	Intake Gate	set	2	1.7 x1.0	Vertical wheel type with guide frame hoists and accessories all complete set with Electrical Operated System
3	Coarse trash rack Intake Gate with 16 Dia bars @ 100 c/c spcing	set	2	1.7 x 2.5	Trash rack with supporting beam and accessories all complete set.
4	Undersluice Gate	Set	1	2.5 x 2.50	Vertical wheel type with guide frame hoists and accessories all complete set with Electric Operated System
5	Settling Basin Inlet Gate	Set	2	1.2 x 1.5	Vertical wheel slide with guide frame hoists and accessories all Complete set with Electric Operated System.
6	Settling Basin flushing Gate	Set	2	0.5 x 0.5	Vertical wheel slide with guide frame hoists and accessories all complete set with manual operated system
7	Settling basin outlet gate	Set	2	3.5 x 1.5	Vertical wheel slide with guide frame hoists and accessories all Complete with Electric Operated System.

8	Fine Trash Rack at Forebay	Set	1	6.0 x 3.30	Trash rack with supporting beam and accessories all Complete Set
9	Forbay Inlet Gate	Set	1	1.5 x 1.5	Vertical wheel slide with guide frame hoists and accessories all complete set with Electric operated system
10	Stop log for Tailrace	Set	1	1.20 x 1.00	Vertical wheel slide with guide frame hoists and accessories all complete set
11	Butter Fly Gate Valve with 400 Dia.	Set	1	400 Dia.	400 Dia Butter Fly Gate Valve with all complete set.
12	Gravel trap Flushing Sluice Valve of 500 Dia	Set	1	500 Dia	500 Dia Flushing Sluice Valve with all fittings and other accessories all complete set

The side channels in gates are extended up to the top of wall where operating platform is provided with handle and gear arrangement. The gate is operated by a hoisting mechanism. Main parts of the gate are side channels, skin plate, front seal, stiffener angles, lifting device with handle.

2.4.2 Standard for design and testing

Following is the list of Indian Standard Specifications. The latest Edition of these standards shall be followed wherever the detailed requirements have not been outlined in these specifications. Reference should be made only to the relevant Indian Standard Specification. However, where such code is silent on certain specific provision, reference may be made to other appropriate & relevant American society for testing & material (ASTM), American society of mechanical Engineers (ASME), Deutsches Institute fur Normung (DIN), Japanese Industrial Standard (JIS), British standard (BS) International electromechanical Commission (IEC), or European Standard (EN).

S.No	Title of Code	Standards
1	Recommendation of structural design of fixed wheel gates.	IS: 4622
2	Code of practice for design of rope drum and chain hoists for hydraulic gates.	IS: 6938
3	Code of practice for electric overhead Traveling cranes and gantry cranes other than steel work cranes.	IS: 3177-1999
4	Code of practice for design, manufacture, erection & testing of cranes & hoists.	IS: 807-1976
5	Code of practice for use of structural steel in general building construction.	IS: 800
6	Recommendation for inspection, testing & maintenance of fixed wheel & slide gates.	IS: 7718
7	Approval test for welding procedures	IS:7307(Part I)
8	Approval testing of welders working to approved welding procedures	IS: 7310(Part I)
9	Approval tests for welders when welding procedures approval is not required.	IS: 7318

10	Code of practice for liquid penetrate flow detector.	IS: 3658
11	Code of practice for Ultrasonic tube echo testing by contact and immersion methods.	IS: 3664
12	Code of practice for magnetic flow detector.	IS: 3703
13	Code of practice for radiographic testing.	IS: 2595
14	Code of practice for structural safety of buildings loading Standard.	IS: 875
15	Code of practice for plain & reinforced concrete.	IS: 456
16	Guidelines for Painting Systems of Hydraulic Gates & Hoists	IS: 14177
17	Criteria for Earthquake resistant design of structures	IS: 1893
18	General Requirements for Rubber Seals for Hydraulic Gates	IS: 11855

2.5 Trash Racks

There is provision of Trash racks in order to prevent the entry of floating stuffs, small rock and debris through the channel. Intake Trash rack will have clear opening of 100mm and the racks are rectangular shaped with round head welded at the top. The Rack will be inclined in 80 degrees and 73 degree for Coarse and Fine trash Rack respectively, So that the cleaning operation of rack can be easy. The detail of the trash racks used in the project is described in Table 6.4 below.

Table 2-3 : Details of Trash racks

SN	Description	Unit	Qty.	Size (W x H) m	Type
1	Coarse trash Rack at Intake gate	set	1	1.7 x 2.5	Trash rack with supporting beam and accessories
2	Fine Trash Rack at Forebay	Set	1	6.0 x 3.3	Trash rack with supporting beam and accessories

A trash rack with 50 mm clear spacing is provided at penstock inlet to prevent the entry of floating debris to the turbine. The trash rack has to be cleaned manually with the help of scraper periodically from the operating platform.

3. DESIGN, CALCULATION, DRAWINGS & MANUALS WITH SOFT COPY

3.1 Design and Drawings

Before manufacturing of the equipment and site construction works are to commence, the design criteria, calculations, dimensioned drawings and diagrams showing all details of the equipment and materials to be used as well as all arrangement related to other Contractor's works shall be submitted to the Engineer for approval and to the Employer simultaneously. In any case these drawings shall be submitted in sufficient time allowance to permit modifications to be made, if such are deemed to be

necessary and/or are instructed by the Engineer, without delaying the completion of the Works. The drawings to be modified as necessary by the Engineer shall be resubmitted for re-approval.

When the Contractor prepare his construction schedule, as required herein, he shall make allowance for and indicate, on the schedule, the time for approval of drawings for the Engineer. A period of at least four weeks should be allowed for such approval and another one week for return to the project office. Claims or extensions of time will not be permitted on account of the late submission of drawings to Engineer or for delay caused by drawings being not approved by the Engineer.

After approval of drawings by the Engineer, the Contractor shall supply the approved drawings to the Employer and the Engineer.

Drawings submitted for reference shall be submitted in the same manner as approved drawings. Should any modification is required, the Engineer may instruct the Contractor to do so, and the drawings so modified shall be resubmitted for approval.

It shall be understood, however, that approval of the drawings will not exonerate the Contractor from any responsibility in connection with the work.

All drawings submitted for approval or sent to the Employer or the Engineer for any other reasons shall be sent by registered air courier to Project office.

The title of the drawing, the signature of the Contractor's responsible engineer, the date prepared, the number of the drawing, etc. shall appear in the bottom right hand corner of the drawing. The size of drawings shall be as follows:

- A1 (594 mm x 941 mm)
- A2 (420 mm x 594 mm)
- A3 (297 mm x 420 mm)
- A4 (210 mm x 297 mm)

After all items of the work have been manufactured and erected, electronic copy of drawings and calculation sheets as well as As-built Drawings (hard and soft copy) shall be submitted to the Employer and the Engineer.

The Contractor shall submit the following approved drawings for all foundations and/or concrete requirements for all the plant that shall include the location and size of block outs and anchor bars to be embedded in the first stage concrete immediately after the Engineer's approval so as to reach the Engineer within the times stated hereunder, reckoned in calendar months from the issuance of Letter of Acceptance.

Numbers of drawings to be submitted to the Employer and the Engineer shall be as follows:-

During the course of Construction Work

Drawings for approval	3 sets
Approved drawings and drawings for reference	3 sets

After completion of the work

Complete set of Electronic copy	1 set
Complete sets of As-built Drawing	3 sets

Further copies of particular drawings during the course of construction work are to be provided if required.

No separate payment will be made for Drawings, Reports, Manuals, etc. and such cost shall be deemed to be included in the respective unit or lump sum prices in the Price schedule (BoQ).

3.1.1 Design & Drawing for penstock Pipe

Within 6 months of contract award, the contractor shall submit to the employer/engineer for the following approval.

- Detailed design calculations including design of welds, lifting lugs, supporting members, anchorages, temporary bracings and any other provisions required for permanent installation and for protection during transportation and erection.
- Plate formation Drawings for all steel Works
- Preparation of detailed Shop Fabrication Drawings, erection drawings, and installation methods for all components of the penstock.
- Preparation of shop and field welding procedures and weld repair procedures, Sand blasting and painting procedures, qualification records for tackers, welders, welding operators, qualification certificates for welding inspectors and non-destructive testing personnel, Hydro testing procedures and Post Weld Heat Treatment procedures
- Mill test certificates and reports, non-destructive examination procedures, paint inspection procedures, inspection and testing procedures, non-destructive examination, inspection and test data, documents, records and reports pertaining to steel penstock plates
- Manufacturer's technical Data sheets for electrodes, wires and fluxes that will be used for welding qualifications and welding production shall be submitted with the welding procedures.
- Manufacturer's Technical Data Sheet for paints and their application procedure.
- Mill test certificates, Inspection and testing procedures , test data, documents, records and reports for welding consumables (electrodes, wires and fluxes)

3.1.2 Design & Drawing for Gates and Stoplogs

The contractor shall submit design computations and drawings along with manufacturer data to the Employer/ Engineer for review and approval which shall include in sufficient details to show:

- Design calculation for all components and parts in accordance with design criteria & specification to prove their adequacy supported by catalogues / technical literature of all bought out components with selection criteria & characteristics.
- General arrangement drawing indicating all the dimensions, sections and detail of components
- Assembly/installation drawings showing the details of welding sizes adopted in design calculation, dimensions of the parts of the equipment to be supplied under the contract.
- Sub assembly drawings and detailed component drawings of all equipment to be supplied under the contract
- Material lists covering specifications, sizes, quantities, weight of each component from which the various parts will be made.

- Machining and assembly tolerances and fits.

3.2 Inspection and Test Procedure

The Contractor shall submit to the Employer/ Engineer for approval, during or immediately following the submission of drawings, inspection and test procedure to be performed during manufacture, erection and tests on completion. Procedure shall define sequence of inspection and test, equipment preparation, operation procedures to be followed and, detailed procedure for conducting the inspection and tests, and moreover shall contain design values, technical particulars or any other standard data for testing which will be treated as the criteria for evaluation of each inspection or test. Procedure shall be separately prepared for the inspection and tests to be performed at the shop and at the Site, and submitted for approval and distributed in the same manner for drawings as set out in the previous sub clause.

Numbers of procedures to be submitted to the Employer and the Engineer shall be as follows:

Inspection and tests procedure for approval : 3 sets

Approved Procedure : 3 sets

The cost of the above works shall be included in the BoQ (Price Bid).

3.3 Instruction Manuals

The Contractor shall submit to the Employer/ Engineer for approval the instruction manuals concerning the correct manner of erection for the work as early as possible before dispatch of the Plant and those for the operation and maintenance not later than six months before Taking over of the Works, with special references to any recently developed features. Instruction manuals shall describe in detail erection procedure and use of all erection equipment and measurement devices. Procedure for assembling, adjusting, operating and dismantling of each component system and machine shall be described and illustrated.

Maintenance of each component shall be described in detail including the recommended frequency of inspections and lubrication. The instruction manuals shall include easily readable diagrammatic drawings of the equipment to facilitate understanding the descriptive information. The Contractor shall, in preparing the instruction manuals, take into account the lack of experience and familiarity of the operating personnel with this type of equipment. The instruction manuals shall include a complete list of all drawings prepared for this Contract, spare parts list, and a parts list for each component of item of equipment. The parts list shall include manufacturer's code and serial numbers and ordering instructions and shall be detailed as far as possible for only the equipment supplied.

Number of manuals to be submitted to the Employer and the Engineer shall be as follows:

Manuals for approval 3 sets

Approved manuals 3 sets

The cost of the above works shall be included in the BoQ (Price Schedule).

4. UNITS AND MEASUREMENT

In all correspondence, in all technical schedules and on all drawings metric units of measurement shall be employed. On drawings or printed pamphlets where other units have been used, the equivalent metric measurement shall be marked in addition.

5. PROGRESS

5.1 Periodic Schedules during Erection

(a) Daily Work Schedule

The Contractor shall at the end of each day submit two (2) copies of a written daily schedule, in a form approved by the Engineer, for the Main work items which are the work progress executed and the works to be performed during the successive day. The schedule shall contain appropriate comments in regard to the work which is to be performed on each major activity.

(b) Weekly Work Schedule

The Contractor shall at the end of each week submit three (3) copies of a written weekly schedule listing the Main work items which are to be accomplished during the successive week. The schedule shall be in a format approved by the Engineer and is to contain appropriate comments in regard to the work which is to be performed on major items. One page of the schedule shall list each day of the week.

(c) Monthly Work Schedule

The Contractor shall at the end of each month submit three (3) copies of a monthly bar chart type of schedule to show the work which is proposed to be accomplished during the successive month. This schedule will show, by means of bars, the days within the month which each Main activity will be worked on. The schedule shall be submitted to the Engineer by the first day of each month for his review and comments.

5.2 Joint Progress Meetings

A regular meeting between the key personnel of the Engineer and the Contractor shall be held once a week or fortnight at a time agreed by both parties. The purpose of these meetings will be to discuss the progress being made, the work proposed for the forthcoming week and any problems having a direct bearing on the immediate to near-term work activities. The Employer may attend such meetings or hold separate meetings whenever necessary.

6. EMPLOYER'S SHOP INSPECTION

The Contractor shall arrange the Engineers and the Employer's staff to inspect and witness the test of the plant/equipment/material on the Contractor's/Manufacturer's premises or other premises where any plant is ready for testing. Such kind of inspection can be made for different manufacturing and nondestructive, destructive and other testing processes. The cost of testing/inspection shall be borne by the Contractor.

The Contractor shall give notice at least four (2) weeks in advance to the Employer on the proposed inspection and test of major items and their schedule to which the Employer's staff will witness so as to make travel arrangement to the test site.

All the necessary expenses for travel, accommodation, personal expenses(DSA), inland travel expenses etc. to any country where any plant is ready for testing and inspection etc. shall be borne by the Employer out of contingencies/provisional sum.

7. TROPICALIZATION

In choosing materials and their finishes, due regard shall be given to and the humid tropical conditions under which the power plant will be called upon to work. The Contractor shall submit, upon the Engineer's request, details of his practices which have proven satisfactory and which he recommends for application on the parts of the work which may be affected by the tropical conditions. The materials and finishes used shall be approved by the Engineer.

8. PACKING

The whole of the Plant shall be packed or bundled properly so that no damage shall be sustained during transportation to the Site and by rough handling. For the transport of unit pipes for penstock and headrace steel pipe nesting of unit pipes shall be allowed, but limited to pieces.

The contents of packing cases shall be securely bolted or fastened in position with struts or cross battens. Cases shall be opened after packing to prove no movement of the contents.

Wood wool shall not be allowed for packing purposes.

Waterproof papers and felt linings shall overlap at seams and the seams secured together in an adequate manner, but the enclosure shall be provided with screened openings to obtain ventilation.

All cases, packages, bundles, etc., shall bear at least the identification mark relating to the appropriate shipping documents, the contents and total weight.

Such shipping marks on the outside of casing or on the metal tags attached to bundles shall be protected by shellac or varnish to prevent obliteration in transit.

Each case, package or bundle shall contain a packing list in a waterproof envelope and copies in triplicate shall be forwarded to the Engineer prior to dispatch. All items of materials shall be clearly marked for easy identification against the packing list.

The Engineer 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 or damage due to faulty packing.

Shipping mark shall consist of the following information in sequence and in frame commensurate with the size of container:

- (a) Consignee
- (b) Contract No :
- (c) Destination :
- (d) Item number (if applicable)
Package number in sequence,
and quantity per package:
- (e) Description of Contracts
- (f) Net and gross weight,
Cubic measurement

9. DESIGN AND WORKING STRESSES

The design, dimensions and materials of all parts shall be such that they will not suffer damage under the most adverse conditions nor result in deflections and vibrations which might adversely affect the operation of the equipment. Mechanisms shall be so constructed to avoid sticking due to rust or corrosion.

All parts, which will have to be dismantled or which might have to be dismantled for the purpose of servicing or replacement, shall be retained with anti-corrosive fasteners. The type, material and size of all fasteners shall be selected to safely withstand the maximum superimposed direct, alternating, kinetic and thermal loads and all loads included by workman when installing or removing the fasteners during the life of the equipment.

The design shall be such that the installation, replacement and general Maintenance may be undertaken with the minimum of time and expense. The tolerances used for dimensions and finishes shall be selected with due consideration to the particular properties and functions of the parts and the corresponding accuracy required to obtain proper operation and tight sealing.

Wherever possible, all similar parts, including spare parts, shall be made to gauge and interchangeable. Such parts shall be of the same materials and workmanship and shall be constructed to such tolerances as to enable substitution or replacement from spare parts to be made easily and quickly.

Suitable structural steel bases or frames shall be provided where necessary to transmit to the concrete foundations all loads imposed by the various parts of the equipment. Such bases or frames shall be supplied complete with suitable anchor bolts and shall be so proportioned that the bearing loads imposed on the concrete foundations will not exceed 50 kgf per square centimeter.

All plant shall be designed to minimize the risk of fire and consequential damage, to prevent ingress of vermin, dust and dirt, and accidental contact with electrically energized or moving parts. The plant shall be capable of continuous operation with minimum attention and Project attendance in the exceptionally severe conditions.

Upon request by the Engineer complete information regarding the design assumptions, loading and operating conditions, deflections and unit stresses used in the design shall be provided by the Contractor.

The Contractor shall be deemed to have examined the specifications and drawings herewith and unless stated specifically, to have concurred with the design and layout of the works as being sufficient to ensure reliability and safety in operation, freedom from undue stresses, adequate drainage and other essentials for a satisfactory working plant.

It should be noted that the Specification Drawings shown only the general type of equipment and the governing dimensions and are not intended to define the exact details of the equipment to be furnished. Alternative details and arrangement will be considered. The drawings indicate the outline of the structure in which the equipment is to be installed. Any recesses required in this structure for alignment and grouting of embedded parts shall be determined by the Contractor.

10. GROUNDING

All electric equipment in the Plant shall be substantially grounded to the grounding system comprising Main grids and stubs to be installed by the other Contractor. Grounding wiring and connections from the equipment to the ground stubs shall be provided by the Contractor. Adequate size of copper

grounding conductors, based on the maximum ground fault current and the protection in the circuit shall be used, but the minimum size shall be 100 square millimeters, and where possible, shall run inside the conduits with power conductors.

11. MATERIAL

11.1. All materials incorporated in the work shall be new and both workmanship and materials shall be of first-class quality, free from defects and imperfections, and, here indicated by the Specifications, of the classification and grades designated therein. Materials not specifically designated shall be suitable for the purpose and shall comply with the latest specifications of the IS Codes, ASTM Standards, DIN Standards or equal.

11.2. All work shall be performed in accordance with the best modern fabrication/manufacturing and installation practices. All work shall be performed by personnel adequately skilled and qualified in the related professions and trades.

11.3. Materials having relative motion with each other shall be selected so that they are non-galling with respect to each other. Also, all dissimilar material shall be isolated from each other by use of insulating material.

11.4. All parts, components, and assemblies which are heavier than 15 kg shall be provided with suitable provisions for handling such as eyebolts, hooks, or holes with rounded corners for passing slings.

11.5. Materials Specifications

S. No.	Material	Specifications
1	Structural Steel	IS 2062 / ASTM A36 / A572
2	General Purpose Corrosion Resistant Steel	IS 1570 Part V / ASTM A 276 or A 240, Type 304 or 304 L
3	Corrosion Resistant Steel for Machinery Use and for Bolts and Bars	IS 1570 Part V / ASTM A 276, Type 410 Compatible Nuts for 410 Bolts: ASTM B21 Alloy 464 Half Hard (Naval Brass)
4	Hardened Corrosion Resistant Steel Machinery Use for High Strength Bars	ASTM A 564, Type 630 or Equal
5	Corrosion Resistant Steel for High Strength Bolts and Nuts	Bolts: ASTM A 193, Class 2, B8 Nuts: ASTM A 194, Grade 8S
6	Forged Steel	IS 2004 / ASTM A 668
7	Steel Bolts and Nuts	IS 1367, IS 1363 / ASTM A 307, A 325, A 490

8	Cast Steel	IS 2644, Grade 3 (CS 840) / ASTM A 27, Grade 65-35 and ASTM A 486 Class 70
9	Brass/Bronze	IS 318 / ASTM B21, Alloy 464 Half Hard (Naval Brass)
10	Self-Lubricating Bearings and Washers (Coefficient of Friction with Stainless Steel less than 0.15)	"Lubrite", including Cast Bronze Alloy (ASTM B22, Alloy 863) with Type G self-lubricating inserts as manufactured by Merriman Bros., Inc., 100 Industrial Park Road, Hingham, MA 02043, or Karon V with ASTM B22 Alloy 863 or equal
11	Concrete Anchor Studs	Nelson Concrete Anchor Studs, Type H, as manufactured by Alemite Division of Stewart Warner Corp, 1826 W Diversey Parkway, Chicago, IL 60614, USA or Equal
12	Wire Rope	IS 2266
13	Wire Rope Fittings	IS 2485, IS 3937
14	Epoxy Grout	"Nordbak", an epoxy-resin manufactured by Rexnord Inc., 3073 S Chase Ave, Milwaukee, WI 53201, or Equal
15	Rubber Seals	IS 11855, IS 15466
16	Fluoro-Carbon Clad Rubber Seals	Rubber seals shall be specified as per IS 11855, and IS 15466. A fluoro- Carbon sheath shall be bonded to the rubber on the sealing surface. The sheath shall be abrasion resistant. The outside surface of the fluo-carbon sheath shall be free of adhesive on bonded rubber
17	Elastomeric Sealing Rings (O- rings)	IS 9975, Vulcanized compound of nitrile butadiene rubber, Durometer A hardness 55 +/- 5. 176 Kg/cm2 minimum tensile strength.
18	Hydraulic Cylinder	ASTM A 333, Grade 8 Seamless
19	Piston Rod	ASTM A 276, Type 316, Chromium plated
20	Chromium Plating for Piston Rod	IS 1337 / ASTM B 177 with 0.08 mm minimum thickness of plating after finish grinding and polishing.

12. CHANGE OF MATERIAL OR EQUIPMENT

The Contractor shall not make any changes to the equipment or in the materials to be incorporated in the equipment from that specified or implied by these Specifications without the written approval of the Employer/Engineer. Such changes or alterations shall in no way be detrimental to the interest of the Employer and shall not result in any increase to the Contract Sum.

13. LABELS AND PLATES

All duty labels, data, name plates and instruction plates on cubicles and equipment shall be in English.

14. STANDARDS AND WORKMANSHIP

14.1 General

All materials shall be new; the best of their kinds and of such as are usual and suitable for work of like character.

All workmanship shall be of the highest class throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not render them liable to distortion, undue wear, or damage under the most severe conditions encountered in service.

All parts shall conform to the dimensions shown on and shall be built in accordance with approved drawings. All joints, datum surfaces, and mating components shall be machined and all castings shall be spot faced for nuts. All machined finishes shall be shown on the approved drawings. All screws bolts, studs and nuts and threads for pipes shall conform to the latest standards of the International Organization for Standardization covering these components and shall conform to the standards for metric size.

14.2 Standard and Supplemental Specification

All workmanship, materials and equipment where applicable and unless otherwise stated in the Contract Document shall comply either:

- With the relevant American, British, German, Japanese, and Indian Standards or Codes of Practice current on the date fixed for receipt of tenders, or
- with other standards or codes of Practice proposed by Contractor at the time of tendering, provided that those Standards or codes of Practice are equivalent or superior to the relevant American, British, German, Japanese and Indian Standards or Code or Practice.

If the Bidding Documents conflict in any way with any or all of the above standards or codes, the bidding documents shall have precedence and shall govern.

14.3 Material Inspection and Testing

Materials, parts and assemblies thereof, entering into the Work shall be tested, unless otherwise directed, according to the best commercial method for the particular type and class of work. When the manufacturer desires to use stock material not manufactured specifically for the equipment furnished, satisfactory evidence that such material conforms to the requirements herein stated, shall be furnished, in which case tests on these materials may be waived. Certified mill test reports of plates and sections will be acceptable. In addition to the mechanical tests required by the Specifications, all

materials shall be examined in the shop for laminations and imperfections before incorporating them into the work and any defective material shall be rejected.

Witness tests and inspection of material may be made at the place of manufacture by an Inspector appointed by the Engineer, unless otherwise specified. Such witnessing and inspecting will be conducted so as to interfere as little as possible with manufacturing operation. The Contractor shall however comply with any reasonable request made by the Inspector concerning the method of test or correction of defective workmanship.

All castings weighing 226.8 kilograms or more shall have test coupons attached from which test specimens may be prepared. The number, size and location of the test coupons shall be to the approval of the Engineer. Faulty material or materials found to be inferior to that specified shall be rejected and removed at once, and shall not be used in any part of the work.

Test pieces of other structural materials shall be provided as required by the Engineer.

The ultimate strength, limit of elasticity, ductility, hardness, etc., will be determined from such test pieces.

The Contractor shall furnish, free of charge, all test pieces, blankets, etc., cut and machined to the sizes, shapes and dimensions as directed by the Engineer. The testing of the specimens will be carried out by the Contractor at his own expense, and shall be performed as directed by the Engineer.

Test pieces which represent rejected material shall be preserved and become the property of the Employer. Copies of all test reports shall be Mail unlined to the Engineer.

The Contractor shall supply to the Engineer and the Inspector, as requested, certified test reports giving the chemical analysis and physical properties of materials used.

Waving of inspection by the Engineer shall not relieve the Contractor of the responsibility for supplying material and workmanship acceptable to the Engineer.

14.4 Shop Assembly

All items of equipment shall be assembled in the shop prior to shipment and tests shall be performed by the Contractor as may be required to demonstrate to the satisfaction of the Engineer the adequacy of the equipment and its component parts. All tests should be simulated normal operating conditions as closely as possible. All dismantled parts shall be properly match marked and dowelled to ensure correct assembly in the field.

14.5 Castings

All castings shall be dense, sound and true to pattern, of workmanlike finish and of uniform quality and condition, free from blowholes, porosity, hard spots, shrinkage defects, cracks or other injurious defects, and shall be satisfactorily cleaned for their intended purpose.

All castings shall be checked for defects before final machining. Castings shall not be repaired, plugged, or welded without permission of the Engineer. Such permission will be given only when the defects are small and do not adversely affect the strength, use or machinability of the castings. Excessive segregation of impurities or alloys at critical points in a casting will be cause for its rejection. The largest fillets compatible with the design shall be incorporated wherever a change in section occurs.

Surfaces which do not undergo machining and are exposed in the final installation shall be dressed to provide a satisfactory appearance so that they will not require surface smoothing at site prior to painting.

Iron Castings, Steel casting with fully annelid, bronze casting, phosphor bronze castings shall be in accordance with General Specification-14.2

14.6 Forgings

Forgings shall be in accordance with General Specification-14.2 The ingots from which the forging are made shall be cast in metal moulds, the workmanship shall be first-class in every respect and the forging shall be free from all defects affecting their strength and durability, including seams, pipes, flaws, cracks, scales, fins, porosity, hard spots, excessive nonmetallic inclusions and segregation.

The largest fillets compatible with the design shall be incorporated wherever a change in section occurs. All finished surfaces or forging shall be smooth and free from tool marks.

14.7 Mild Steel Plate, Bars, etc.

Steel plates for gates, valves and pipe lines and Steel plates for trash racks and structural steel shall be constructed of material according to the standard stated in the General Specification 14.2 Steel bolts, nuts and washers, high-strength steel bolts, nuts and washers for friction grip joint and lock washers shall be in accordance with standard specification mentioned at General Specification-14.2

14.8 Corrosion - Resisting Steel Plate, Bars, Etc.

Corrosion-resisting steel and bars shall be in accordance with standard specification 14.2

14.9 Bronze

Bronze for bushings, bearings and thrust discs shall be in accordance with standard specification 14.2 or approved equivalent standard.

Bronze for other purposes shall meet with the approval of the Engineer.

14.10 Checkered Plate

Checkered plate shall be of an approved raised pattern. All edges of plate shall be planed and joints shall be cut so as to maintain continuity of pattern.

14.11 Machine Work

(i) General

All tolerances, allowances and gauges for metal fits between plain cylindrical parts shall conform to the standard specification mentioned at General Specification 14.2 or other approved equivalent Standards for the class of fit as shown or otherwise required. Sufficient machining stock shall be allowed on locating pads to ensure true surfaces of solid material,. Bearing surfaces shall be true and exact to secure full contact. Journal and sliding surfaces shall be polished and all surfaces shall be finished with sufficient smoothness and accuracy to ensure proper operation when assembled. Parts entering any machine shall be carefully and accurately machined. All drilled holes for bolts shall be accurately located and drilled from templates.

(ii) Finished Surfaces

Surface finish shall be indicated on the Contractor's drawings and shall be in accordance with the standard specification mentioned at General Specification 14.2. Compliance with specified surface will

be determined by sense or feel and by visual inspection of the work compared to standard roughness specimens, in accordance with the provisions of the above stated standards.

(iii) Unfinished Surfaces

So far as is practicable, all work shall be arranged to obtain proper machining of adjoining unfinished surfaces. When there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined, to secure proper alignment. Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and rough spots. Depressions or holes not affecting the strength or usefulness of the parts may be filled in an approved manner.

(iv) Keys and Keyways

Keys and keyways shall conform to the requirements of the standard specification mentioned at General Specification 14.2, unless otherwise specified or required.

(v) Pins and Pin Holes

Pin holes shall be bored to gauge, smooth and straight, and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position. Pins shall be of hardened and ground steel and positively held in position. Wheels or rollers for use in gates shall be mounted on removable pins and have self-lubricating bushings and brass washers.

(vi) Lubrication

Before assembly, all bearing surfaces, journals, and grease and oil grooves shall be carefully cleaned and lubricated with an approved oil or grease. After assembly, each lubricating system shall be filled with an approved lubricant. Self-lubricating bearing shall be cleaned with clean rags, and grease with an approved lubricant before assembly. Solvent shall not be used on the self-lubricating bearings. The specification of all approved lubrications will be mentioned in the operating and Maintenance instructions.

(vii) Balancing

All revolving parts shall be truly balanced both statically and dynamically so that when running at normal speeds and at any load up to the maximum, there shall be no vibration due to lack of such balance and the plant shall operate with the least possible amount of noise.

14.12 Miscellaneous materials

(i) Self-lubricating bearing and Galvanized stranded wire ropes shall be in accordance with standard specification 14.2. Wire rope fittings shall be the manufacturer's standard fittings for the type of wire rope used. Cable and conduit fittings, rigid steel conduit and zinc coated conduit shall be in accordance with standard specification 14.2

(ii) Rubber gate seals shall be molded from a high-grade, tread type compound. The basic polymer shall be natural rubber, a co-polymer of butadiene and styrene, or a blend or both. The compound shall contain not less than 70 per cent by volume of the basic polymer, and the remainder shall consist of reinforcing carbon black, zinc-oxide accelerators, antioxidants, vulcanizing agents and/or plasticizers. The compound shall have the following physical properties.

Property	Limits
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Tensile strength	210 kgf/cm ² minimum
Ultimate Elongation	450% minimum
Durometer Hardness (shore type A)	50 to 70
Sp. gravity	1.1 to 1.3
Water absorption (70oC for 48 hrs)	5% maximum by weight
Compression set (as a percent of total original deflection)	30% maximum
Tensile strength after oxygen bumb aging for 48 hrs at 70oC before aging.	80% minimum. of tensile strength

14.13 Welding

All welding shall be done either manually by the shielded metallic arc process or automatically by the shielded arc or submerged arc method.

The Contractor shall submit a welding procedure for the approval of the Engineer. After the welding procedure has been approved, the Contractor shall record it on a special drawing which shall thereupon become one of the drawings of the Contract. Weld sizes and types shall be shown on all Contractor's drawings where welding is required.

Radiographic inspection shall be carried out by the Contractor when required by the standards, these specifications of the design criteria employed. All important welds which, in the opinion of the Engineer, may be subject to the full stress induced in the adjacent plate, or which in the opinion of the Engineer or Inspector, do not appear to conform to the welding standards, shall be radio-graphed when required by the Engineer.

Suitable meters shall be provided to show the welding current and the arc voltage at all times during the welding operations. Unless otherwise specifically stated, welded parts requiring machine finished shall be completely welded before being finished. Plates to be joined by welding shall be accurately cut to size and rolled by pressure to the proper curvature which shall be continuous from the edge. Flattening in the curvature along the edges with correction by blows will not be allowed. The dimensions and shape of the edge to be joined shall be such as to allow thorough fusion and complete penetration and the edges of plates shall be properly formed to accommodate the various welding conditions. The surfaces of the plates for a distance of 25 millimeters from the edge to be welded shall be thoroughly cleaned of all rust, grease and scale, to bright metal.

(i) Qualification of Welding Procedure

The technique of welding employed, the appearance and quality of the welds made and the methods used in correcting defective work, shall conform to the standard specification 14.2

(ii) Qualification of Welders and Welding Operators

All welders and welding operators assigned to the work shall have passed a qualification test, within the preceding six months, for welders and welding operators, in accordance with standard specification 14.2 The Contractor shall furnish the Engineer with certified copies of reports of the results of physical tests of specimens welded in the qualification tests. If, in the opinion of the Engineer, the work of any welder at any time appears questionable, he shall be required to pass the appropriate prequalification test. All costs of qualification tests shall be borne by the Contractor.

(iii) Welding Electrodes

The weld electrodes shall conform to standard specification 14.2 Stainless type weld metal, where used in the water passages for protection against pitting, shall be of chromium nickel steel. The type, chemical composition and number of welding rods for this purpose shall meet with the approval of the Engineer.

(iv) Test after Welding

All the welded portion shall be tested by X-ray test or dye-penetration test or ultrasonic test for defects when and where required as per decision of the Engineer.

(v) Welding Procedure Qualification Tests

a) Procedure qualification tests shall include tensile, bend, hardness and Charpy V notch impact tests, tensile test for filler material, chemical analysis for deposited material, microscopic and macrographic examination etc. in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Sections VIII, Division 1 and Sec.IX of ASME. Hardness and impact tests shall be carried out for the weld metal and the heat affected zone for each welding process. Impact properties shall be the same as those required for the base material. Hardness shall be measured by the Vickers or the Rockwell method. The other tests may be carried out as required to ensure the weldability of base material and filler material.

b) The procedure qualification tests shall be performed for all type of welds and welding procedure, type of filler material & welding electrodes and for all position of weld and thicknesses of plates and with similar shop / site condition before the commencement of actual work fabrication / erection. Moreover, production welding test shall also be performed to monitor the soundness of welds on routine basis. The procedure for qualification and production welding tests and test reports shall be submitted to the Engineer in Charge for approval.

c) Unless otherwise specified, welds shall be examined in accordance with the requirements of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1.

15. ELECTRIC EQUIPMENT AND WIRING**15.1 Motors**

The motors shall be of horizontal shaft, high starting torque, low starting current, squirrel cage, induction type, designed for full voltage starting, weatherproof and totally enclosed. Wound rotor motors will be accepted only if a squirrel cage type would not be satisfactory for the duty.

The motors shall have class E insulation and continuous rating at 35 degree centigrade ambient temperature. Motor lead insulation shall be class E and cable terminal boxes shall be provided preferably with stud - type connectors.

The capacity of motor shall be more than 100 per cent against the value calculated from the most adverse combination of loads, which will occur during opening and closing operation of the gate. The starting and maximum torque of motor shall be more than 200 and less than 300 per cent of its rated torque respectively.

Windings and connections shall be suitable impregnated to render them moisture proof, non hygroscopic and unaffected by conducting dust.

All motor bearing shall be of the ball or roller type with an inner grease seal to prevent grease entering the winding. Bearing housing shall be fitted with a "ball in head" grease fitting and a removable plug for the escape of grease.

15.2 Motor Brakes

The brakes mounted on motors shall be of spring-applied and A.C solenoid released type. The rated capacity shall not be less than 150 per cent of the rated full load torque of the motor. The brake shall be arranged for automatic application, when the motor power supply is cut off, and release when the motor is energized. The brake enclosure shall be weather proof with convenient access for Maintenance operation.

15.3 Electric Cables and Wiring

The Contractor shall be responsible for wiring, laying and furnishing of control and power cables and/or wires which are necessary for the required operation. All the power cables for the Equipment or plants shall be of armored types.

All wiring in the control cabinets shall be with PVC insulated stranded conductor, formed neatly into groups and properly supported. There shall be no splices in the wires or cables and all connections shall be made only at terminal blocks or studs.

All external wiring between the control cubicles, motors, limit switches, etc., shall be with multicore copper, PVC insulated, PVC sheathed, 600 volt grade jacket type cable.

15.4 Motor Starters and Ammeters

All starters shall be suitable for direct-on-line starting of motors, provided with 3 phase induction type over current relays for overload phenomenon with manual resetting, open-phase relays and undervoltage release feature. Overcurrent relays shall be field adjustable to be rated full load currents of motors. Backup protection shall be provided with high rupturing capacity enclosed fuses or molded case circuit breakers. The control voltage shall be 230 volt. AC.

All motors shall be provided with disconnect switches or quickbreak no-fuse circuit breakers with operating handles lockable in "off" position" They shall be rated to interrupt the full load current of motor or other equipment in the circuit.

15.5 Conduits

Rigid steel conduit shall be galvanized. It shall be of a minimum thickness of 2.3 millimeters and have a minimum inside diameter of 16 millimeters.

15.6 Enclosures

Motor enclosures shall be weatherproof and totally enclosed. Enclosures for all other equipment shall in general be dust proof, weatherproof and vermin proof where required. Enclosures, trim and doors shall be coated with two coats of a suitable primer and finished with enamel paint, the colour of which will be decided by the Employer.

15.7 Convenience Outlets

Convenience outlets shall be of 2-pin with scraping earth or 3-pin type rated for 15 amps at 230 volts, suitable for English pattern plug used inside the power plant. Outlets shall be in weatherproof enclosure or suitably protected from weather.

15.8 Limit switches

The limit switches shall have weatherproof enclosures and shall be mounted suitable for easy adjustment and for rigidly locking in position after being adjusted. They shall be of heavy-duty rating and shall have stainless steel rotating parts and permanently lubricated bearings. They shall allow the arm to be fully deflected by the operator without damage to the switch.

15.9 Indicating Lights, Instruments and Meters

All indicating lights shall be of filament with colored plastic lenses type for long life and service under conditions of shock, vibration and rough handling.

All instruments and meters shall have approximately 110 millimeters dial, shall be of heavy-duty, industrial type suitable for extreme shock and severe vibration applications.

15.10 Lighting Fixtures

The lighting fixtures shall be complete with lamps. Fluorescent lighting fixtures shall be equipped with complete fittings for A-C, 230-volt, 50 Hz source and a ballast or ballast of high power factor.

Incandescent lighting fixtures shall have lamp holders in accordance with the local standards.

The lighting fixtures for outdoor use shall be weatherproof type.

Special care shall be exercised on selection of fixtures so that illumination of the lamps is not obstructed by accumulation of insects and dust.

15.11 Electrical Relays

Electrical relays for controls and auxiliary relays for protection circuits shall be of the plug-in type and the plug-in connections shall be made and broken by pressure contacts. Alternatively, the Engineer may approve the use of plug-in trays containing groups of relays.

Relays shall be provided with non-flammable dust and moisture proof cases.

Relay contacts shall be adequately rated for the service conditions. Relay coils shall be continuously rated whether the control scheme requires them to be continuously energized or not.

At least one spare normally opened contact and one spare normally closed contact shall be provided on each relay in addition to the contact required by the control scheme.

15.12 Terminal Strips

Terminal strips shall be of double stud and 2-hole solid link design with the studs moulded into an insulating base. Pinch-type terminal blocks and slotted links are not acceptable. Studs shall be of brass and 6 mm diameter except that studs of 4.7 mm diameter in stainless steel or phosphor-bronze may be approved.

Terminal strips shall be arranged in vertical rows not less than 225 mm above floor level. Sufficient terminals shall be provided on each item of equipment to permit the connection of all incoming cable cores plus 10 per cent spare terminals.

Removable transparent insulating covers shall be provided over all terminals. An insulating barrier shall be provided between adjacent pairs of studs.

16. INDICATING INSTRUMENTS

Instruments shall be capable of withstanding or shall be adequately protected from the vibrations which are encountered in service. Instruments and associated apparatus shall be capable of Maintaining their accuracy and sensitivity without excessive Maintenance.

Instruments on panels shall be flush mounted and provided with narrow bezels. The bezels shall have a uniform high grade finish.

All instrument cases shall be dust-proof.

All instruments scales shall be of wide angle type clearly printed in black figures and divisions on a white background. The quantity measured shall be clearly marked on the instrument dial in black capital letters. The names or titles of the instrument manufacturers and other printing which may interfere with the clear observation of the reading shall not be printed on the dials. However, initials or similar markings may be shown un-obstructively as approved.

Drawings showing in detail all markings to be made on the dial shall be submitted to the Engineer for approval.

Unless otherwise specified or approved all instruments shall have circular scales with a total pointer deflection of not less than 240 degrees. Normal working indication shall be at a point corresponding to approximately 75 per cent of full scale deflection. Scales shall be provided with red-coloured marks at points corresponding to the normal working values (or full-load current of the equipment in the case of ammeters) and as approved.

The scales for ammeters in motor circuits shall be compressed so that 20 per cent of full scale deflection (F.S.D) occurs at about 40 per cent full load current (F.L.C.) and 90 per cent of F.S.D. at about 120 per cent F.L.C. The scale shall be approximately linear in the range 40 per cent to 120 per cent and compressed above 90 per cent F.S.D. to indicate 6 times F.L.C. at 100 per cent F.S.D.

Devices for routine checking, zero adjustment and re-calibration shall be easily accessible from the front of the panels. Where such devices are not included in the instrument case, they shall be flush mounted on the panels adjacent to the associated instruments, so that adjustments can be made conveniently while watching the indicator.

If required by the Engineer, the Contractor shall submit samples of instruments to the Engineer for approval.

17. EQUIPMENT WIRING AND WIRING ACCESSORIES

This clause applies to all connections within equipment enclosures and all interpanel wiring working at voltages not greater than 400 V nominal. All wiring shall be carried out in accordance with wiring diagrams so that the arrangement of the wiring is consistent throughout the plant and identical for those parts of the plant performing the same duties.

Wiring diagrams shall be drawn as seen from the back (i.e., wiring side) of the panel (except for front connected equipment) and shall show all terminals on selector switches, relays, contactors, terminal blocks, etc. in their correct relative positions. Terminal blocks shall be shown arrange in vertical rows and all wiring to those blocks shall be arranged to run in numerical order from top to bottom.

Wiring shall be neatly and securely bunched or cleated, and enclosed in ducts, or conduits or supported on trays and run in the most efficient manner from point to point. The bunching of wiring shall be kept in bunched condition by means of strips of special plastic ribbon material at suitable

intervals. Lacing of wire bunches with textile or plastic cord or metal buckle type clips will not be accepted. Wherever wiring is cleated to metal work, it shall be insulated from the metal surface and shall be cleated by means of insulated straps in an approved manner. All wiring shall be left sufficiently long and neatly looped to allow a fresh termination to be made should the original termination device break off.

Circuits of similar nature shall be grouped together and terminal blocks terminals in A.C. circuits with voltage above 110V shall be segregated and fully shrouded to prevent accidental contact with live parts.

All secondary wiring under the contract shall employ conductors of minimum cross-section 2.0 square millimeters with not less than seven strands of tinned copper wire. Internal wiring of miniaturized and solid state equipment may use flexible conductors having a minimum size of 50/0.18 mm where wiring is made off to clamping type terminals and 30/0.18 mm where the termination is made by soldering.

Current transformer secondary circuits shall be run with the conductor route length as short as possible. The burden of the leads associated with current transformers and protective relays shall be sufficiently low to ensure correct operation of the protection under all conditions and this may require a cross section of conductor greater than 2.0 square millimeters.

Insulation shall be PVC of 250 V or higher grade appropriate to the service conditions and shall be self-coloured in accordance with a code which is the same for all of the plant. The Contractor shall submit the colour code to the Engineer for approval and shall make such changes in the code as are required to achieve consistency with other Contractors and with the Employer's standards.

Each end of each wire shall be provided with an approved termination and with a numbered ferrule. Wire numbers shall be allocated by the Contractor and shown on the Contractor's final circuit diagrams forwarded for approval.

If required by the Engineer, samples of the secondary wiring, terminations and terminal blocks shall be submitted by the Contractor for approval before the work is carried out.

18. SAFETY PRECAUTIONS

Prior to any of the work being energized, the Contractor shall be responsible for supplying and fixing in prominent positions near to each item of the Work concerned, large multilingual temporary signs giving clear warning of danger in areas which might previously have been regarded as safe.

During erection, the Contractor shall provide all temporary scaffolding, ladders, platforms with toe boards and handrails essential for safe and convenient access of workmen, inspector and other authorized persons employed about the Works. All dangerous opening or holes in floors shall be provided with handrails or cover; preventative measures shall be taken to protect workmen from falling materials.

The Contractor shall take all necessary precautions for the safety of his employees and to other persons on the site appropriate to the nature of the work and conditions prevailing at the site. The Contractor shall comply with all statutory requirements and with such directions as the Engineer may from time to time consider necessary or desirable. Safety precautions shall include, but not be limited to adequate life protection and lifesaving equipment, adequate illumination for night operations, adequate ventilating equipment for enclosed places, instructions in accident prevention to all employees, including where necessary care in the use of explosives, adequate traffic control, such machinery guards, safe walkways, handrails, scaffolds, ladders, bridges, gang planks and other

safety devices, equipment and apparel as are necessary to prevent accidents, injuries or fires, and adequate facilities for the proper inspection and Maintenance of all safety measures.

The maximum possible safety must be afforded to personnel directly engaged on this contract or those who frequent the working area or those who in the normal course of their occupation find it necessary to utilize temporary works erected by the Contractor.

19. PROTECTION, CLEANING AND PAINTING

19.1 General

All parts which will ultimately be buried in concrete shall be cleaned and protected, before leaving the manufacturer's shop, by a cement wash or other approved method. Before being installed, they shall be thoroughly descaled and cleaned of all rust and adherent matter. Such cleaning shall not detrimentally affect the strength or final operation and function of the equipment.

All machine parts of bearing surfaces shall be cleaned and protected from corrosion, before leaving the manufacturer's shop, by the application of an approved rust preventive lacquer, or a peelable plastic film. Where the latter is impracticable such parts shall be heavily covered with high melting point grease. After erection such parts shall be cleaned with solvent and lapped or polished bright.

All parts, other than machined parts, which will be exposed after erection shall be thoroughly cleaned and protected, before leaving the manufacturer's shop by an approved method and procedure.

Primer shall be applied to surfaces prepared in accordance with the paint manufacturer's instructions. The surface shall be wiped clean immediately prior to applying the paint. The primer and finish coats of paint shall be applied using the methods and equipment recommended by the manufacturer.

The paint system selected, except for the inside surface of the steel pipe, shall have a proven life expectancy of not less than ten years in the atmosphere prevailing at this Project.

The internal surface of all pipe lines shall be cleaned out by approved methods before installation and again prior to commissioning, to ensure freedom from dirt, rust, scale, welding slag etc. The code system shall be approved by the Engineer.

The finish colour of all equipment shall be approved by the Employer and Engineer but the Contractor shall propose a colour scheme for the equipment and shall submit colour chips or paint samples. A colour chip shall be included with the approved colour schedule, for each type of finish to be applied at the Site.

The painting of metal work shall include the preparation of the metal surfaces, paint application, protection and drying of the paint coatings, as well as the supplying of all tools, labours and materials necessary for the entire painting work.

Sufficient paint shall be provided for field painting and touch-up of shop painting by the Contractor.

Paint shall be the product of reputable manufacturer and its selection shall be approved by the Engineer.

19.2 Surface Preparation

All oil, paraffin, grease and dirt shall be removed from the surfaces to be painted by using solvents. Following solvent cleaning, all weld spatter, slag, burrs, loose rust and mill scale and other foreign substances shall be removed by sandblasting to "near-white" metal. The interior surface of the steel pipe shall be mechanically cleaned or sandblasted to a commercial standard. Special attention shall

be given to cleaning of corners and converging angles. If rust forms or the surface become contaminated in the interval between cleaning and painting, re-cleaning to the same degree shall be required. Surfaces not to be painted shall be protected by appropriate and adequate masking during the cleaning and painting of adjacent metal work. Effective means shall be provided for removing all free oil and moisture from the air supply lines of blasting equipment. All surface preparation shall be subject to approval of the Engineer before any paint is applied.

19.3 Application Procedure

All paint, when applied, shall provide a satisfactory film and a smooth, even surface. Paint shall be thoroughly stirred, strained, and kept at the uniform consistency during application. No painting work shall be performed under the conditions of it being extremely high or low atmospheric temperature or high humidity of the air or there being some fear of its raining before drying of applied paints. Surfaces shall be free from moisture at the time of painting. Painting shall be performed by brushing or spraying. The first coat shall be applied immediately after surface preparation. Each coat shall be allowed to dry or harden thoroughly before the succeeding coat is applied.

19.4 Surfaces not to be Painted

Bronze, brass, surfaces or gear teeth, finished ferrous surfaces, surfaces in rolling or sliding contact after field assembly and hoist ropes shall not be painted.

All corrosion resisting steel surfaces for bearings and machinery parts shall not be painted.

On completion of cleaning, the surfaces shall be coated with an adhesive plastic film to protect the surfaces from minor mechanical damage and corrosion during shipment and storage at the site. The film shall be stripped off immediately prior to field erection of the equipment.

19.5 Paint Schedule

The painting shall be performed as follows:

(i) One primer coat and three coats of coal-tar epoxy resin paint, final total thickness of 450 micron minimum shall be applied to the following items:

- Interior surfaces of steel penstock
- Exposed surfaces of Drain Pipes and Valves.
- Interior surfaces of Drain Pipe and Valves.
- Exterior or exposed surface of penstock and steel pipe

The surfaces to be painted shall be descaled and cleaned by blast cleaning to near white.

(ii) One primer coat and four coats of epoxy resin paint, final total thickness of 250 micron minimum shall be applied to the following items:

- Exposed surfaces of all guide frames
- All gate
- All trash racks
- Exposed surfaces valves.
- all stoplogs

The surfaces to be painted shall be descaled and cleaned by blast cleaning to near white.

(iii) All unfinished surfaces of ferrous metal except those specified above shall be given one primer coat and three coats of oil resistant alkyd paint. Final total thickness of these coats including primer coat shall be 150 micron minimum. The surfaces to be painted shall be cleaned by hand tool or power tool cleaning to the satisfaction of the Engineer.

(iv) Commercial equipment shall be painted in accordance with the manufacturer's standard practice.

All finish surfaces of ferrous metals including screw threads that will be exposed during transportation or while awaiting installation shall be cleaned and given a heavy uniform coating of gasoline soluble, rust preventive compound.

20. EMBEDDED STEEL WORK, OPENING

Unless otherwise specified, any foundations, walls and roof openings and coverings, concrete floor filling and sleeves in the foundations and walls related to civil works only will be provided by the other Contractor.

The Contractor shall supply and install anchors, fasteners, embedded steel work, pipings, conduits and sleeves associated with and required for the equipment being provided and installed under this Contract, except as otherwise provided in the specifications.

The Contractor shall show the location and full details of foundations, openings, block-outs and all embedded components on his drawings and shall be responsible for the completeness and accuracy of his drawings and the informations which are to be supplied to others, Anchorage to be embedded in primary concrete shall be installed by the other Contractor according to his drawings. The Contractor shall be responsible for the adequacy of location of all embedded components.

All adjustment to foundation levels, embedment, bedding and grouting of the plant on foundations and cementing into walls and floors will be carried out by the other Contractors, but all levelling and adjusting of the plant on foundations shall be carried out by the Contractor.

The grouting shall be carried out under the supervision of the Contractor and the mix and grouting pressure shall be suggested by the Contractor. The Contractor shall satisfy himself that the grouting has been carried out to his entire satisfaction.

The foundation bolts, embedded steel parts, anchors, braces, posts, supports, shims etc. and all steel work as may be required for temporary or final support of anchorage of the plant, except concrete and concrete reinforcing steel, shall be provided and installed by the Contractor as part of this contract.

Any steelwork which is to be built into the concrete foundations shall not be painted or coated unless otherwise approved.

21. ORDERS ISSUED TO SUBCONTRACTORS

Three copies of orders for all subcontracted plant and material are to be submitted to the

Employer/Engineer for approval at time any such order is placed. No prices are required to be shown on such orders. This clause shall not apply to subcontracts given to regular suppliers of the Contractor for stock materials and minor components

22. TESTS

During the construction and after the installation of each item of the work, the Contractor shall perform the tests in accordance with the requirements of the relevant clauses of detailed specifications.

The tests and test procedures shall be approved by the Engineer. No part of the Work shall be considered acceptable until it has successfully complied with these tests to the satisfaction of the Engineer.

Test records, data, calculation sheets and photographs, if any, shall be submitted to the Engineer in three (3) copies within one (1) month after the test had been conducted.

22.1.1 Hydrostatic Testing

- The Contractor shall confirm that Hydrostatic testing for penstock pipe shall be conducted in the shop and as per ASME section VIII Division.1 or IS: 2825. Details of the testing procedures shall be furnished to the Employer/Engineer for approval.
- Test pressure for steel liner during hydrostatic testing shall be equal to 150 percent of the design pressure. The maximum permissible stress at test pressure should not exceed the 90 percent of yield stress in shell.
- Suitable vent(s) shall be provided at a high point to vent possible air pocket while the penstock shells, bends, bifurcations etc. are being filled.
- 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.
- After being completely filled with water, the pressure in steel pipe assembly to be tested shall be increased slowly and uniformly until the specified test pressure is reached.
- 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. When a leak or an evidence of a defect is detected, the test pressure shall be released immediately.
- 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 through out.

23. SPARE PARTS

The Contractor shall recommend and furnish the necessary spare parts other than the parts listed in Technical particulars. Any spare parts supplied shall be packed or treated in such a manner as to be suitably stored in the climate at the Site for a period of not less than two years, and each part shall be clearly marked with its description and purpose on the outside of the packing.

Spare parts so provided shall be delivered into such stores as may be nominated by the Employer and delivery will not be deemed to be complete until the packages have been opened by the Contractor, their contents checked by a representative of the Employer and the articles re-protected and repacked by the Contractor to the satisfaction of the Employer, or assembled into units at the Employer's option.

24. MAINTENANCE EQUIPMENT AND SPECIAL TOOLS

The Contractor shall recommend one set of Maintenance equipment and special tools sufficient for the proper Maintenance of all the plant provided by the Contractor.

The Maintenance equipment and special tools shall be supplied in lockable cabinet(s) fitted internally so that the tools may be safely stored in an orderly manner.

The cost of Maintenance equipment and special tools shall be included in the cost for spare parts and shall be delivered with the plant.

25. REFERENCE LIST OF STANDARDS

The following Indian standards or equivalent approved International Standards shall be followed.

S. No.	Description	Standard
1	Recommendation for inspection, testing & Maintenance of fixed wheel & slide gates.	IS 7718
2	Recommendation for Inspection, testing & maintenance of Radial gates & their host	IS 10096 (Parts I,II &III)
3	Approval test for welding procedures	IS 7307(Part I)
4	Approval testing of welders when working to be approved welding procedures(Part I)	IS 7310 (Part I)
5	Approval tests for welders when welding procedures approval is not required.	IS 7318
6	Code of practice for liquid penetrant flow detector.	IS 3658
7	Code of practice for Ultrasonic tube echo testing by contact and immersion methods.	IS 3664
8	Code of practice for magnetic flow detector.	IS 3703
9	Code for unfired pressure vessels.	IS 2825
10	Code of practice for radiographic testing	IS:2595

Part II- SECTION I. Part D. TECHNICAL SPECIFICATIONS FOR ELECTRO MECHANICAL WORKS

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PART D1:– Specifications of Turbines and Inlet Valves

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D1: – Specifications of Turbines and Inlet Valves

1. GENERAL TECHNICAL SPECIFICATIONS

1.1 Design and Workmanship

The design of the equipment shall conform to the best current engineering practice. Each of the several parts of the equipment shall be of the Contractor's standard design, provided that this design is in general accordance with the Equipment Specifications and shall use components proven to be satisfactory by previous experience.

The essence of design shall be robustness, simplicity and reliability in order to give long continuous service with high economy and low maintenance cost.

All equipment, including its accessories and auxiliaries shall be built and installed to expeditious internal and external access in order to facilitate inspection, cleaning, maintenance and replacement work. Identical parts must be fully interchangeable between themselves and with the spare parts. Except in cases where for functional reasons or due to a specific design a special arrangement of the equipment is necessary, the inspection, maintenance and replacement of a part of the equipment shall as far as practicable not entail dismantling of other permanently installed equipment.

The design, dimensions and materials of all parts shall be such that they will not suffer damage even after prolonged service as a result of stresses under the most severe service conditions. The materials used in the construction of the equipment shall be of the highest quality and selected particularly to meet the duties required of them. The equipment shall be designed and constructed to minimize corrosion. Water must not collect at any point.

Workmanship and general finish shall be suitable to the application.

1.2 Applicable Standards

Except otherwise specified, the standards under which the equipment is to be designed, constructed manufactured and tested shall be the following:

- European Standards (EN)
- International Electrical Committee (IEC)
 - ✓ IEC 60041:1992, Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines
 - ✓ IEC 60193:1965, International code for model acceptance tests of hydraulic turbines
 - ✓ IEC 60308:1970, International code for testing of speed governing systems for hydraulic turbines
 - ✓ IEC 60609:1978, Cavitation pitting evaluation in hydraulic turbines, storage pumps and pump turbines
 - ✓ IEC 60994:1991, Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump turbines)
- ISO 3740:1980, Acoustics – Determination of sound power levels of noise sources – Guidelines for the use of basic standards and for the preparation of noise test codes
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS)
- American Society of Mechanical Engineers (ASME)
- National Electrical Manufacturers Association (NEMA)
- Deutsche Industrie Normen (DIN)

The product must be from the following reputed manufacturing brand. **(ANDRITZ or VOITH or GEPPERT or FLOVEL or BHEL or EFG Turbien, CINK or Schimmer)**

It shall be understood that the latest revision or edition in effect at the time of the tender call shall apply.

If it is desired to use equivalent standards or to deviate from the above-cited standards, a corresponding application together with one copy of the respective standards shall be submitted to the Employer for approval. The decision of the Employer in the matter of equality

will be final.

1.3 Tolerances

Tolerances and allowances for the limiting sizes of mating parts for any class of metal fit shall be in accordance with the ISO "System for limits and fit" or with the American Standards for "Tolerances, Allowances, and Gages for Metal Fits" or VDE/DIN Standards.

1.4 Materials

All materials used in the manufacture of the equipment supplied shall be selected as the best available for the purpose for which used, considering strength, resilience, durability and other physical properties, as well as best engineering practice. They shall be new and of first class commercial quality, and free from defects and imperfections.

All materials, supplies and articles not manufactured by the Contractor shall be the products of recognized reputable manufacturers.

The Contractor shall be responsible for the standardization of all small mechanical and electrical equipment, materials and elements for the equipment, and shall assure the utmost possible interchangeability of parts and spares.

The Contractor shall arrange and perform the necessary coordination work with his subcontractors for the purpose of such standardization.

1.5 Welding

1.5.1 Preparation for Welding

Design of welded joints and selection of weld filler metal shall be in accordance with DIN or other approved standards and shall allow thorough penetration and good fusion of the weld with the base metal.

The edges of surfaces to be welded shall be sound metal, free of visible defects at least 50 mm back from the edge of the weld, such as laminations or defects caused by cutting operations, and free from rust, oil, grease, and other foreign matter.

1.5.2 Qualification of Welders

The Contractor shall be responsible for the quality of the work performed by his welding organization.

All welders and welding operators assigned to the work shall have passed a performance qualification test for welding operators at least equal to that specified in the latest edition of the "Standards Qualification Procedure" of the American Welding Society (or DIN 8563).

All expenses in connection with making the qualification tests for welding operators shall be borne by the Contractor.

Operators welding certificates shall be furnished to the Employer, if requested by him.

1.6 Pipe, Valves, Flanges and Joints

All piping, flanges, sockets, joints, seals, gaskets, shall be of suitable materials to withstand the highest pressure and temperature conditions involved in operation of the equipment under all operating conditions including water-hammer where appropriate, and shall incorporate an ample factor of safety.

All piping under internal pressure exceeding 16 bar, whether water or oil, shall be seamless.

All gauge and instrument piping and or tubing shall be of stainless steel.

All piping and or tubing of the high-pressure oil systems shall be stainless steel.

All bends, tees and other fittings shall be of the same material as the pipe.

All oil pipes shall be thoroughly cleaned and pickled and fitted with temporary blank flanges or plugs before being packed and dispatched.

All valves over 65 mm bore for pressures exceeding 16 bar shall be of forged or cast steel.

Valves for water over 65 mm bore shall be of the external rising stem type. Valves for oil shall be of the non-rising stem type.

All valves shall have replaceable wearing parts. Water carrying valves will have stems, seals and seats of corrosion resistant material. Their seals and seats shall be of ample proportions and of suitable materials to ensure that galling or overloading will not occur in any service condition, including partial opening.

Shut-off valves shall be suitable for opening and closing against full unbalanced pressure, including closure against free discharge. If necessary, by-passes are to be provided to meet these requirements.

All valves shall be provided with hand-wheels of ample size and, where necessary, extended stems and/or gearing so that any valve may be easily and conveniently operated by one man under any service condition.

All valves shall close with a clockwise rotation of the hand-wheel, which shall be marked to show the direction of closing.

1.7 Color Code for Piping and Mechanical / Electrical Equipment

The final color of finishing coats shall be prepared and submitted by the contractor and shall be subject to the Employer's approval.

1.8 Corrosion Protections and Painting

Surface preparation and painting shall be in accordance with this specification, or, with the Employer's approval, the Contractor's Standard Paint Specification may be used.

1.8.1 General

The supply shall include the surface treatment, priming, corrosion protection and painting of the equipment furnished according to the specification hereinafter or to other equivalent methods. Such work shall comprise the workshop finish painting-and at site touch up painting.

All priming and painting material shall satisfactorily fulfill the requirements imposed by the Site conditions, as well as the Stresses to which the respective equipment is subjected during its operation. At the request of the Employer, painting samples for the different coats and colors shall be provided.

All furnished surfaces shall present a neat and pleasing appearance.

Each coat for primer and painting shall be compatible with the previous and subsequent coats.

The Contractor shall supply full details regarding the extent of which sand-blasting, priming and painting will be carried out in his workshop (or of his subcontractors).

It is essential that before any primer and coat of paint is applied, the surfaces are properly prepared. Such preparation shall include any cleaning, smoothing, drying and similar operation that may be required to ensure that the primer and/or paint are applied on suitable surfaces. Clean cloths and clean fluids shall be used to avoid having film or greasy residue on the surfaces being cleaned.

Each coat shall be free from runs, drops, pinholes, waves, laps, sags and unnecessary brush marks, and shall be allowed to dry or to harden before the following coat is applied.

For removing rust and mill scale from structural steel, plate, sheet, piping and other steel surfaces, as well as from other parts suitable for blast-cleaning, sand or metal-blasting shall be carried out down to clean bare metal, according to the requirements shown in the Contractor's Standard Paint Specification.

Parts which cannot be blast-cleaned using the method above may, at the discretion of the

Employer, be sand-blasted or shall be cleaned free from rust and scale by power-tool cleaning to the highest possible degree, according to the above standards or equivalent approved standards. Stainless steel surfaces susceptible to carbon steel contamination shall be cleaned in such a way as to prevent contamination.

Cleaned surfaces shall receive a quick-drying shop-coating immediately after cleaning.

All pipes carrying water shall, if provided for galvanizing, be heavily galvanized by the hotdip process. Galvanizing shall be carried out in accordance with the relevant Standards.

1.8.2 Quality Control

The work of anti-corrosion protection will be checked and the check will include:

- Check of the cleanliness of the cleaned surfaces
- Check of the thickness and adhesion of zinc and paint coatings
- Check of quality of the materials applied.
- The thickness of the zinc and paint coatings shall be checked at about 10 check points per square meter. For the acceptance, the guaranteed thickness of the coating shall be decisive and not the number of coats applied.
- The coating of small parts shall be checked at random with respect to thickness by the magnetic-static method and with respect to absence of pores by means of the Elcopinhole detector (ASTM E376 or equivalent DIN Standard).

1.8.3 Execution of the Work

The priming coats and the first finishing coat, respectively, shall be applied by best means in order to obtain adhesion.

Paint work damaged during shipment, storage and/or erection shall be properly restored by the Contractor after localized removal of the damaged coating.

The repair coating and painting shall be carried out as per the above Specifications and reach the minimum dry film thickness stipulated.

When executing the paint work the air humidity shall not exceed 60% at the working place, and all necessary fans, air heaters, ventilation ducts and dust absorbers shall be provided by the Contractor.

1.9 Nameplates

All major equipment shall be provided with a securely fastened nameplate showing the maker's name, model, serial number, year of manufacture, main characteristic data of the respective equipment and further relevant information specified in the applicable standards or necessary for the proper identification of the equipment involved. The plates shall be in English.

1.10 Packing

All the Equipment shall be carefully packed so as to withstand the long time transportation by sea and land in tropical moist climate. The electrical equipment shall be completely protected against moisture.

The spare parts shall be packed and crated firmly to withstand storage for a long time, and those in need of rust preventive treatment shall be so treated. The spare parts shall be packed separately from other articles. Packages of spare parts shall have notation on them, which clearly indicates that the contents are spare parts and shall be accompanied by a list of contents which sets forth directions for storing.

1.11 Tests

The factory and site tests required in this specification shall be performed by the Contractor in accordance with the item "Inspection and Tests" herein and applicable standards.

All equipment and material necessary for the performance of these tests shall be furnished by

the Contractor.

No material shall be shipped without prior written consent of the Employer.

Acceptance of material and equipment by Employer does not relieve Contractor from the responsibility that all material furnished shall be free from defects and suited in all respects for the purpose intended.

2. HYDRAULIC TURBINE

2.1 Scope of Supply

This specification covers the design, manufacture, testing at the factory, transportation from factory to site, storage, complete erection, testing and commissioning of 2 (two) 590 kW horizontal shaft Francis Turbines with scope of supply as specified below including all auxiliary equipment, accessories, spare parts and tools required for successful installation, operation, dismantling, tests, inspection and maintenance of the units.

The scope of supply for each set of turbine shall include, but not limited to the following:

One (1) turbine runner

One (1) turbine shaft (included in Generator as combined shaft)

One (1) set of shaft seal

One (1) set of turbine guide bearing

One (1) set of turbine covers with labyrinth seal rings

One (1) set of spiral casing and stay ring

One (1) set of wicket gates

One (1) set of operating mechanism with servomotors

One (1) draft tube and liners

One (1) set of expansion/dismantling pipe

One (1) set of equipment for drainage of turbine

One (1) set of air supply equipment

One (1) set of materials for foundation and anchor bolts

One (1) set of equipment for measurement, control and safety

One (1) set of piping and electrical materials

The Contractor shall supply an installation setup comprising all material and equipment to ensure its satisfactory operation and its suitability for its intended purpose. Initial filling of oil and grease shall be included in the supply.

All works, material and services though not expressly called for in this specification, but necessary for the complete and proper operation of the power plant shall be included in the proposal and the Contract.

The Contractor shall provide layout and foundation drawings for all equipment in his supply together with all plant dimensions, loads, forces and other information necessary for the design of the foundations and other requirements of the power plant so as to enable the Civil Works detail construction drawings.

The Contractor shall supply all necessary bed plates, sole plates, foundation bolts, nuts, frames, trench covers, girders, steel packing, templates etc. related with equipment.

The Contractor shall level, align and securely fix the equipment in his supply on its foundation prior to concreting or grouting and shall provide all equipment necessary for leveling and alignment.

The Contractor shall check the concreting or grouting of the Civil Works related to the

equipment in his supply (whether or not located by templates) and shall ensure that the levels and alignment are not disturbed thereby.

The contractor can offer alternative equipment layout schemes if the performance of turbine, etc. will not be affected, while increasing the quality and reliability.

To the extent possible, wherever in this Specification the Employer's approval is required; such approval shall be obtained prior to commencing the Work.

2.2 Hydraulic System and Turbine Basic Data

The following basic parameters and other pertinent data apply to the turbine to be furnished.

- Nominal rated output 590 kW
- Rated net head 50.12 m (as calculated based on site condition)
- Rated flow 1.2 m³/s
- Rated speed 750 rpm
- Maximum speed rise less than 30%
- Turbine efficiency greater than 86%
- Diameter of distributor to be coordinated at connection with the shut-off to shut-off valve design

Table 1: Basic Project Data

S.N.	Descriptions	Data
i)	Full reservoir / supply level	EL 2171.00 m
ii)	Tail water level	EL 2116.00
iii)	Gross head	55 m
iv)	Rated Net head	50.12 m
v)	Elevation of turbine runner centre line	To be verified at site
vi)	Diameter of penstock (internal)	
	A) up to bifurcation from headrace outlet	1.15 m
	B) after bifurcation towards each turbine	0.85 m
vii)	Length of penstock	
	A) Total length of Penstock	310 m
viii)	Design discharge (total for 2 machines)	2.4 m ³ /sec

NOTE:

- (i) The turbine shall be capable of operating at rated head and discharge mentioned above.
- (ii) The Bidder shall provide characteristic curves of the machine showing the relationship between flow, efficiency and power output.
- (iii) The Bidder shall state the maximum and minimum head limits under which the turbine can be operated safely and the maximum and minimum discharge the machine can handle safely.

2.2.1 Power Plant Parameters for Saniveri Utterganga Mini HPP

The Francis turbines shall be designed considering the following parameters:

Table 2: Basic Parameters for Turbine

Turbine type	Francis Horizontal
Number of units	Two (2)
Full reservoir / supply level	EL 2171.m
Tail Water Level	EL 2116.00
Maximum tail Water Level below machine (TWL).	EL 2116.2 m
Gross head	55 m
Net head (2 units running at 100% load)	50.12 m (as calculated)
Rated Discharge for each machine for maximum output	1.2 m ³ /s
Rated Output at Net Head = 51.7 m & Rated Discharge of each unit = 1.2 m ³ /s	590 kW
Pitch circle diameter of runner	To be proposed by the Bidder
Over speed period	To be proposed by the Bidder
Rotational Speed of the Unit	To be proposed by the Bidder
Direction of rotation	Clockwise
Runner centre line elevation	To be proposed by the Bidder
Shaft coupling face elevation	To be provided by the Bidder

2.3 Guaranteed Data

The guaranteed data shall be according to the following prescriptions and shall be compared with data listed in Technical Data Sheet, VI G. In case of non-compliance with Contractual Guarantees Employer shall apply penalty where applicable.

2.3.1 Synchronous Speed

The synchronous speed of the unit shall be 750 rpm.

2.3.2 Power Output

The rated output of one turbine shall amount to 590 kW. This output is required at the turbine shaft for a nominal operating level. The corresponding net design head amounts to approximately 51.7 m. The discharge of one turbine is 1.2 m³/sec. The turbine shall have sufficient capacity to produce 10% overload at maximum net head of 50.12 m. The bidders shall include the turbines performance characteristics in their bids.

The performance of the turbine under the conditions stated herein shall be within the specified normal operating limits of temperature rise, noise, vibration, cavitation, pressure fluctuations, load fluctuations, frequency and speed fluctuations or any other conditions that adversely affect the normal performance. All the limits of tolerances in the performance parameters shall be within the acceptable limits defined under IEC 60041 and IEC 60193.

Should the Contractor fail to achieve the output guarantees, then he shall undertake

measures within 120 days in order to fulfill the guarantee. If the guaranteed output as specified cannot be achieved by means of a modification, an amount of **US\$ 3,485** for each turbine for every kilowatt by which the output is below the guaranteed output per turbine shall be deducted from the Contract price.

2.3.3 Efficiency

The Contractor is required to guarantee efficiencies from 40 to 100% of the power output from the maximum to the minimum net head. The guaranteed turbine efficiency shall be established/ confirmed and fulfilled on the basis of previous test results conducted on laboratory scale homologous model under similar site conditions and liquidated damages for efficiency default are foreseen as specified below. The cost incurred with regards to confirmation of efficiency, output and other guaranteed requirements with results of homologous model tests shall be borne by the Contractor.

The guaranteed turbine efficiency shall not be less than **89%**.

The weighted average efficiency shall be determined by the following formula. The efficiency shall not be less than the guaranteed value.

The Formula:

$$\mu_w = (w_1\mu_1 + w_2\mu_2 + w_3\mu_3 + w_4\mu_4) / (w_1 + w_2 + w_3 + w_4)$$

where w_1 , w_2 , w_3 , etc. are weighing factors given below and μ_1 , μ_2 , μ_3 , etc. are efficiencies determined at the following loading conditions of the turbines at rated net head and μ_w is the guaranteed weighted average efficiency.

μ_1 = efficiency at 100% power output

μ_2 = Efficiency at 80% rated power

μ_3 = Efficiency at 60% rated power

μ_4 = Efficiency at 40% rated power

w_1 , w_2 , w_3 , and w_4 are 0.35, 0.45, 0.15 and 0.05 respectively.

The Contractor shall pay a penalty for each turbine an amount equivalent to **US\$ 3,800** for each 0.1% decrement in weighted average efficiency below the guaranteed value. If the weighted average efficiency is less than 86%, the turbine shall be rejected.

2.3.4 Conditions of Regulation

The Contractor shall submit evidences justifying the calculation of over pressures, over speed and general regulation conditions, preferably with a diagram giving the evolution of pressure, discharge and speed as function of time for tripping with and without guide vane closing.

2.3.5 Maximum Momentary Pressure

Water hammer calculation by taking into account particularly turbine discharge curve and closing time shall be made by the Bidder and submitted with bid.

The water way characteristics and the calculation shall be shown in the submitted drawings.

The turbine and its control system shall be designed in such a way that under any net head and any load rejection, the pressure rise at spiral case with maximum level in the head pond never exceeds 45%.

2.3.6 Over Speed and Runaway Speed

The maximum over speed and the maximum runaway speed shall be defined by the Contractor in accordance with turbine and generator manufacturers and system requirements.

Speed rise calculation shall be submitted by the Contractor. The maximum momentary speed rise shall not exceed 55% of the rated speed in the most unfavorable conditions at head of 51.7 m.

The Contractor shall clearly indicate the pressure rise for sudden tripping at 4/4 (guarantee), 3/4, 2/4 and 1/4 (for information purposes) of the respective full load.

Regulation optimization study shall be made by the Contractor for determination of the equipment characteristics. Moreover, the turbine and generator shall safely withstand the stress rising from the operation of the unit at the maximum runaway speed for minimum 15 minutes without permanent damages.

The Contractor shall guarantee the maximum runaway speed in the most unfavorable head and gate conditions.

2.3.7 Critical Speed

The first critical speed of the combined turbine-generator unit shall be at least 25% higher than the maximum runaway speed as per above.

Documentary evidence of the critical speeds of the unit shall be submitted by the turbine manufacturer, who will also perform the necessary computations.

2.3.8 Operation Guarantees

The turbine and accessories shall operate at any output lower than the maximum guaranteed and during transients within the guaranteed head range without damaging pressure, power fluctuations and vibrations. Within the guaranteed operating limits the following conditions are also required. The vibrations measured on the guide bearing housing shall not exceed the amplitude indicated by VDI Standard, group G, level "good".

2.3.9 Guaranteed Hydraulic Thrust

The maximum hydraulic axial thrust shall be lower than the guaranteed value. Should the thrust bearing show unacceptable operating conditions, due to an excessive hydraulic thrust, the turbine shall be rejected.

2.3.10 Cavitation/Pitting Guarantees

As for material loss due to cavitation, the turbine shall be guaranteed for a period of not less than 8,000 hours of operation (or 2 years from the Operational Acceptance) in the operating ranges guaranteed by bidder. The guarantee against excessive cavitation pitting shall be based on the following conditions of operation during the cavitation guarantee period:

- Operation at powers greater than the maximum specified shall not exceed 100 hours of accumulated operation;
- Operation at powers lower than the minimum shall not exceed 500 hours of accumulated operation;
- Operation with tailwater levels lower than the minimum specified shall not exceed 200 hours of accumulated operation.

Cavitations shall be deemed excessive if the removal of metal due to cavitation from the runner, discharge ring or wicket gates of the turbine exceeds the following value:

$W = 0.15 D^2$ per 1,000 hours of operation

Where: W: is the maximum loss of material in kg;

D: is the diameter of the runner discharge in meters; In any case all cavities deeper than 5 mm and/or all single continuous damaged areas of 25 cm² or more with an average depth of not less than 1 mm shall be considered parts showing excessive cavitation. If the turbine fails to meet the guarantee for material loss as stated above, the Contractor shall repair all damaged areas by welding and grinding in a manner satisfactory to the Employer. If necessary, the damaged parts shall be replaced. For any repair work Employer shall only dewater the turbine and provide free of electric power to the Contractor, all other facilities and works shall be at Contractor charge.

Subsequent to any repair, the turbine shall be subject to a renewal of the guarantee for another period of 4,000 hours of operation.

The contractor shall also provide free of charge services of a qualified engineer for post installation inspections to be carried out on each unit after 4,000 and 8,000 hours of accumulated operations.

2.3.11 Noise

The supplier shall guarantee the noise level in the generator turbine floor. The noise level shall be measured at a distance of 1.5 meter in front of the turbine. The measured noise level shall be less than 65 dB.

1.3.12 Vibration

The Supplier shall guarantee that under normal operating conditions, the vibration level measured on the turbine bearing support is that corresponding to an RMS velocity below 4.5 mm/s. RMS velocity is as defined in VDI 2056 group K standard.

2.4 Main Design Criteria

2.4.1 General Requirements

The turbine shall be runner connected to the generator shaft with coupling. The turbine shall operate at any gate opening, under any head and under any tail water level within the guaranteed operating ranges without unacceptable torque and/or pressure oscillations and without unacceptable cavitation, vibration and pulsation. The turbine and draft tube design shall be carried out taking into account the penstock and generator characteristics in order to avoid any dangerous oscillatory conditions. In case the prototype shows unacceptable torque and/or pressure pulsations due to the units and/or to resonance effects of the system unit/penstock, the Contractor shall be responsible to correct such defect at his own cost. If necessary air injection or other approved devices for limiting vibrations and pulsations shall be supplied and installed on the prototype by the Contractor at his own cost.

2.4.2 Allowable Stresses and Transients

The turbines shall be designed to withstand the maximum over speed and overpressure and the maximum runaway speed which may occur in the most unfavorable conditions with the safety coefficients. The increase of speed and pressure during transient conditions as stated in paragraph are based on available data; final values will be determined by the Contractor but any case the specified maximum pressure and the maximum guaranteed over speed and runaway speed shall not be exceeded. Calculation relevant to speed and pressure transients, including under pressures in the draft tube shall be submitted for approval.

2.4.3 Penstock Coupling

Penstock coupling flanges shall be supplied, adjusted, installed and welded by the Contractor. The Contractor shall be responsible for the checking of the correct positioning of the unit.

2.4.4 Turbine-Generator Shaft Alignment

The contractor is fully responsible for the alignment of the unit shaft performed under the direct responsibility of the turbine and generator manufacturers.

2.5 Turbine Components Construction Details

2.5.1 Casing

The Casing shall be made as an integral assembly unit having proper hydraulic form and shape.

The casing shall withstand an internal pressure equal to the maximum pressure including water hammer. Furthermore, the spiral case shall also withstand an external relative pressure.

The Casing shall be of welded construction and formed of steel plates. It shall be fabricated as one piece if there will be transport limitation it may be fabricated in two sections; in this case joints at the edges of each section shall be arranged for field welding.

All sections to be assembled or welded at site shall be duly match marked. At work shop or site, the spiral casing shall subject pressure test under 1.5 times the maximum design pressure.

After completion of welding interior stresses shall be relieved and 100% inspection shall be performed to confirm that there are no void, slag, inadequate melting, cracks, under- cuts, etc.

At the inlet of the casing, the coupling flange with the dismantling joint of the inlet valve shall be foreseen. A flange will also be provided for coupling with the by-pass of the valve.

The contractor shall supply four stainless steel pressure taps, equally spaced around the inlet section of the spiral case, installed on diameters at 45 degrees, and separately connected to a pressure collector. The taps shall be in accordance with the IEC Code. Each connecting pipe shall be made of stainless steel, shall be protected by suitable means against damage that may occur during concreting. Furthermore, three pressure taps shall be installed on a spiral case section to allow the flow measurement with the Winter-Kennedy method. These taps shall be connected to the collector in the same way as specified above for the inlet taps.

A flow meter, for the indication of the turbine flow shall be furnished for each turbine. The meter can be designed to operate from the pressure differential obtained from the spiral case Winter-Kennedy taps. The instrument shall be designed to indicate the instantaneous flow and total flow (in cubic meters per second) through the turbine on a uniformly graduated, direct reading dial or counter indicator. The flow meter shall be capable of measuring all the operating ranges even leakages with enough sensitivity. The flow meter shall be furnished with all required interconnecting piping, vent valves, shut-off valves, and transducer for the indicator and relevant accessories for initial calibration.

Casing drainage line including a manually operated valve shall be furnished with piping connecting the bottom of the spiral case to drainage pit or tail water.

2.5.2 Stay Ring and Stay Vanes

The stay ring shall be made of annealed cast or carbon steel or may be fabricated by shop welding. The stay ring shall be designed to resist the upward and downward thrust due to water pressure in the spiral case and in the water chambers above and below the runner.

The weld between spiral casing and stay ring shall be subject to 100% radiographic examination. If the spiral case and stay ring are to be made of different materials, the skirt plates used to make the stress transition shall be made of the stronger material.

Pipe drains may be installed in the stay vanes in order to drain the leakage water from the head cover. The capacity of the drains shall be sufficient to remove twice the leakage resulting from a total loss of the pacing in the turbine shaft seal, under the worst operating conditions.

An appropriate number of stay vanes shall be designed to guide the flow of the water properly to the wicket gates and to carry the tensile load due to the water pressure in the spiral case.

2.5.3 Runner

The runner shall be a one-piece stainless steel (ASTM A743 Gr.CA-6NM) casting (13% chrome 4% nickel) for Francis turbines well suited for site repair welding.

The runner shall be designed and manufactured to operate at any load, head and speed within the limits given, as well as runaway speed at maximum head, without exceeding the allowable stresses and without undue cavitation or vibration. The construction of the runner shall be ample in size and strength to withstand safely the centrifugal forces under the severest operating conditions and avoid excessive vibrations. The case of emergency shutdown under maximum head at runaway speed must be considered.

All surfaces of the runner exposed to the flow of water shall be carefully machined and finished smooth to templates. There shall be no hollows, depressions, waviness, projections, other surface imperfections that might lead to local disturbances, erosion and/or cavitations.

The finished runner with its wearing and labyrinth rings attached shall be statically shop balanced and heat treated for stress relieving. In the event of damage in transit, it shall be balanced again at the site at the Contractor's expense. The finish of the runner castings (blades, crown, band and coupling flange) shall be in accordance to the rules of relevant standards.

The runner blades shall be ground smooth and hand-finished where necessary and inlet and outlet edges properly shaped in accordance with the best industry practice.

The movement of the runner shall be sufficient to permit the uncoupling of the generator flange if two shafts are used. On the runner crown suitable passages, if necessary, shall be foreseen to allow the drainage of the runner seals leakage and reduce the hydraulic thrust.

Coupling bolts between runner and shaft shall be appropriately protected against the operating water and carefully machined. Bolt holes shall be shop reamed on both runner and shaft flanges using a suitable template or other equivalent methods, in order to ensure the interchangeability of the runners. All coupling bolts shall be made of corrosion resistant material and shall be equipped with suitable locking device.

Runner crown and band shall have machined grooves to match with the labyrinth seal rings attached to the turbine covers. Maximum and minimum axial hydraulic forces on the turbine runner as well as weight of turbine rotating parts shall be stated in the Bid.

If the runner coupling to the shaft made by mechanical expansion device, in this case, a special tool shall be provided for disassembly of the runner for maintenance.

2.5.4 Shaft

The design of the shaft shall be such that its critical speed shall be above 25% of the runaway speed of the turbine. This critical speed of the combined turbine and generator shafts shall be carried out in agreement with the generator manufacturer. The turbine and generator manufacturers shall co-operate and jointly provide all the arrangements necessary to ensure the correct coupling-up and assembly of turbine and generator shafts. They shall also agree on all dimensions associated with this shaft connection.

The alignment of the combined turbine and generator shafts shall be checked by means of a rotational check at site.

The Contractor shall supply all the instruments required for this alignment check. Permissible tolerances on the turbine and generator shaft alignment shall be as quoted in NEMA Standards Publications.

2.5.5 Combined Thrust and Guide Bearing

A thrust and guide bearing which is called combined bearing will carry all weights of rotating parts as well as hydraulic thrust of the turbine runner. Provisions shall be made in turbine design to minimize the unbalanced hydraulic thrust under all operating conditions.

Alternatively, lithium-base grease lubricating antifriction bearing/oil lubricated sleeve bearing as per Manufacturer's design can be proposed, in which case the generator shafts and bearings will be designed accordingly.

The bearing shall be located on the shaft so that access to the shaft seal would be possible without dismantling the bearing.

The axial loads on the shaft should be taken up by the thrust pads with appropriate number which is fitted on the bearing shoulders. Pads shall be Interchangeable.

The bearing shall be equipped at both ends with adequate type of seals to prevent the bearing from external effects.

Lubrication and cooling of the combined bearing shall be effected by means of loose or fixed lubrication rings.

A cooler with finned or smooth tubes in the oil sump shall be provided to cool the oil with a

water temperature of 25°C. The cooling water shall be supplied from the cooling water system of the plant.

The combined bearing shall operate under the conditions listed below without damage, without bearing metal temperature rise above 65°C.

Continuous running at any speed between 90% and 110% of normal speed at least 15 minutes or for the time required for the unit to come to a complete standstill (wicket gate closed) from maximum speed occurring during operation after a full-load rejection, whichever is longer, without cooling water.

All instruments required for proper operation as per industry practices is deemed included in this scope of works.

2.5.6 Shaft Seal

The shaft seal shall be designed and constructed so that inspection, adjustment and replacement can be easily made and shall be designed taking into account the vertical movements of the unit during normal operation and maintenance. Provisions shall be made for water lubrication and cooling of the seal. The design shall include suitable precautions against contamination of the guide bearing oil by a stream of water shooting upward from a failure in the shaft seal.

The shaft seal shall be provided with a corrosion resistant revolving ring and suitable seal of approved material. A hydraulic system of well proved design is recommendable. Spring type seals are also acceptable. Packing studs and springs shall be of corrosion resistant metal.

Teflon packing and labyrinth system can also be accepted.

The agreement shall make the best possible provision for access to the gland without dismantling other equipment on the turbine cover.

The shaft seal shall be durable and very efficient in preventing leakage of water. Adequate provisions shall be made for the drainage of the water leakages from the shaft seal. Suitable packing wear indicator shall be foreseen in an easy accessible position within the head cover. It shall be fitted with a limit switch.

The shaft seal housing shall be sufficiently rigid to prevent distortion. Filtered water shall be taken from the unit cooling water system to lubricate and cool the gland surfaces, if required.

Fine filters shall be provided for each unit.

A thermometer shall be provided for measuring gland temperature, fitted with two contacts for initiating on alarm at just above normal maximum temperature and shutdown at higher temperature.

2.5.7 Turbine Head Cover

The head cover shall be fabricated in steel component, inner surface with replaceable stainless steel protecting shield. It shall be designed to accept all the loads imposed on it, hydraulic pressure, wicket gate stems and gate operating mechanism without exhibiting deflections that could impair wicket gate operation. It shall transmit loading through a flanged bolted connection on its outer periphery to the stay ring.

The head cover shall be flanged for bolting to the stay ring and sealing box. The head cover shall be dimensioned and reinforced so as to withstand, without excessive deformation, the maximum water pressure and all other forces acting upon it.

Water passing through the labyrinth shall be suitably drained in order to prevent excessive pressure under the head cover or excessive hydraulic thrust on the runner hub.

2.5.8 Bottom Ring and Discharge Ring

The turbine snail has a combined bottom ring/discharge ring. This component shall be a fabricated steel component with replaceable stainless steel protecting shield. The discharge ring will connect the stay ring with the draft tube. Both connections will be by machined bolted

flanged connections sealed by o-rings.

The stationary wearing ring shall be removable and replaceable, fabricated of aluminum bronze.

The inner surfaces of the head cover and bottom ring where facing guide vanes shall be equipped by stainless steel face plates or filled by stainless steel welding. The face plate and wearing ring shall be solidly secured to the head cover by stainless steel set screws.

2.5.9 Wicket Gates (Guide Vanes)

The turbine shall be provided with an appropriate number of wicket gates. All wicket gates shall be interchangeable. The wicket gates shall be of annealed stainless steel castings with integral stems or forged. They shall be accurately machined along the lines of contact in the closed position.

The number of wicket gates, stay vanes and runner blades shall be coordinated in a manner to ensure that the turbine will operate without vibration.

The wicket gates shall be uniform in shape and their cross-sections shall be such as to direct properly and accelerate gradually the water entering the runner with a minimum of friction and hydraulic disturbance.

The wicket gate profile and pitch circle relative to the runner blades shall be homologous with the model on which the guarantees are based.

2.5.9.1 Wicket Gate Stem Bearing and Seales

Each gate shall be supported by two bearings in correspondence of the head cover and one bearing in correspondence of the bottom ring. Bearing bushes shall be mounted in suitable removable housing bolted to the head and bottom ring, so as to allow bushes disassembling without removing the wicket gates (if possible).

The gates shall be provided with means for individual adjustment and shall be so designed that when gates are fully closed, leakage shall not exceed the guaranteed value.

An adjustable seal shall be fitted on the upper part of the wicket gate stem to prevent leakage.

The material used in this seal shall be of fully reliable quality. A pressure seal consisting of rings of synthetic rubber (or similar), shall be provided for each wicket gate stem.

2.5.9.2 Bending Link

A steel bending link shall be provided which will be bored to fit over the top of the wicket gate collar and lie adjacent to the gate key. The bending link shall bend from forces acting in either opening or closing gate movement direction before any other part of the gate operating mechanism is damaged. The bending link shall be easily replaceable.

2.5.10 Wicket Gate Operating Mechanism

2.5.10.1 General

The wicket gate operating mechanism shall be of sturdy design and of ample strength in order to prevent distortions and/or vibrations and to ensure a safe operation under any normal or abnormal condition, including runaway speed.

The entire gate mechanism and connections for controlling the wicket gates shall be mounted outside the turbine case and shall be readily accessible for inspection, adjustment and repair.

The means shall be provided for adjusting any individual gate independently of the others.

All the parts having relative motion and contact shall be provided with self-lubricated bushes approved by the Engineer.

Each wicket gate shall be connected through a steel lever and a shear pin to an operating ring which shall be operated by hydraulic servomotor(s). A mechanical scale and pointer shall

be provided to indicate wicket gate position.

2.5.10.2 Gate Operating Ring

Gate operating ring shall be made of cast steel or welded steel plate with all welds stress-relieved and shall be properly guided by renewable bronze guide strips at points of contact with stationary parts. The ring shall be supported by renewable bronze or roller bearings. The gate operating ring shall be connected to the servomotor(s) at opposite points through adjustable steel connecting rods.

2.5.10.3 Breaking and Friction Elements

A suitable breaking element shall be provided between each gate lever and the operating ring. These links shall be strong enough to withstand the maximum normal operating forces, but shall be designed as the weakest elements which will break from excessive forces acting in both the opening and closing directions in case the gate gets stuck, and thereby protect the other parts of the gate mechanism from damage. In this connection the maximum normal operating force shall be considered not less than the force resulting from full servomotor pressure with equal closing force on each wicket gate. The design shall be such that if any individual gate becomes disconnected from the gate mechanism, no part of the gate can come in contact with the turbine runner or with the other gates and failure of one element shall not cause progressive failure of others.

A limit switch shall be installed on each wicket gate lever to provide an alarm circuit contact in case of intervention of a break circuit or a friction one.

2.5.10.4 Servomotor(s)

The servomotor(s) shall be designed to supply the maximum force expected in all normal and abnormal operating conditions of the turbine, including runaway speed, even with minimum oil pressure.

The piston rods shall be coated with hard industrial chromium to minimize wear.

Suitable devices shall be foreseen to slow down the closing velocity of the servomotor(s) in the last part of closing stroke, position and value of the devices shall be easily adjustable without servomotor(s) disassembling. The servomotor shall be mounted and rigidly bolted to the machine.

Pressure oil shall be supplied to the servomotor by the governor pressure system and controlled by the governor system. All pipes between the servomotor and governors shall be supplied by the Contractor.

The cross-sectional area of the servomotor shall be such that, under the minimum oil pressure available from the governor, they can produce the maximum force required to operate the wicket gates under the worst possible load and discharge conditions, from the fully open to the fully closed position, within the time specified to ensure that acceptable overpressure and over speed limits are not exceeded.

Suitable conveniently operated mechanically locking systems shall also be provided on the servomotor, to firmly maintain the wicket gates in the fully-open or fully-closed positions even with full oil pressure in the servomotor cylinders.

The servomotor shall be tested at the shop under a pressure equal to 1.5 times the normal operating maximum pressure with a type of oil similar to that which will be used in the governing oil system.

2.5.11 Draft Tube

The draft tube shall be made of welded steel plates using rolled steel for general structure. The Contractor shall be responsible for the hydraulic design of the complete draft tube profile and shall furnish the draft tube up to the start of tailrace.

The discharge portion shall be embedded in the concrete and opened to the tailrace channel. Its outside surfaces shall be provided with sufficient ribs for reinforcement to surrounding

concrete.

Adequate anchor rod attachments shall be provided by the Contractor for securely maintaining the alignment and anchoring tube in concrete. The draft tube shall be equipped with internal bracing as necessary to prevent distortions during transportation and embedding.

2.5.12 Unit Braking System

A braking system shall be provided for each turbine whereby the period of slow running of the machine before stand-still will be minimized. The brake system shall be designed as to operate automatically and continuously by oil pressure when the speed of the unit decreases about 20% of the rated speed and to bring the unit to stand-still within a reasonable time without injurious heating. Brakes shall be automatically reset after complete stop of the unit.

The brake shoes shall be of replaceable type. A stopper shall be provided to prevent the brake-shoe holder advancing excessively in case the brake shoe shall have been abraded. The Position switches with contacts to prevent unit from starting unless all brakes are in "off" position shall be provided.

2.5.13 Instruments, Control Equipment and Safety Devices

The turbine shall be provided with instruments, controls and alarm and protection switches and devices for complete operation and regulation in order to obtain the highest degree of safety and reliability in operation and continuity of service.

Instruments, control and protection devices shall be located so as to be easily accessible, clear and readable. All transmitters, contacts etc. for remote operation and remote indication of the turbine shall be provided.

1.2.14 Turbine Inlet Pipe Assembly

The turbine inlet pipe assembly shall include flange on the casing inlets, flanged expansion/dismantling pipes, turbine inlet valves and flanged reducing cones between the inlet valves and the penstock manifold branches.

The penstock manifold branches will include extra length on each branch for cutting, trimming and edge preparation for matching with the inlet of the reducing cones.

It is the responsibility of the Contractor to calculate the plate thicknesses on the basis of the offered steel quality and the design criteria given. Information about steel quality and plate thickness shall be provided to the Employer. The stresses computed on the basis of internal pressure and all other relevant factors, shall establish a decent factor of safety relative to the minimum material yield strength.

Axial forces shall be considered by assuming the butterfly valve to be closed and subject to the corresponding maximum design pressure, water hammer included. All axial forces shall be transmitted to the penstock branches of the penstock manifold.

Each turbine inlet pipe assembly shall be furnished with the following equipment:

- 1 (one) manhole with appropriate internal diameter, conveniently located for access. The manhole cover shall be made with the inside surface flush with the steel lining. A hinge arrangement on the side part of the cover shall be provided. The cover shall open outside.
- 1 (one) flange for the bypass pipe of the butterfly valve
- 4 (four) tapping for pressure measuring, 90° apart, with stainless steel valves, pipes, manometers, etc.
- 1 (one) flange at the bottom for emptying the turbine casing. This flange shall be located at the lowest point of the cylindrical part of the inlet pipe assembly, downstream of the closed disc of the inlet butterfly valve.
- 1 (one) drain valve with necessary piping to lead the drainage water to the dewatering sump pit.

1.2.15 Drainage System

For the drainage of the turbine parts, the following equipment shall be included for each unit:

Drain pipes from shaft seal box and turbine cover to the dewatering sump.

Drainage piping from the turbine inlet pipe to the draft tube. Each piping shall include one isolating valve of the gate type flanged directly to the inlet pipe, one valve of the needle type for flow regulation; stainless steel embedded piping with flexible coupling from the valves to the draft tube.

Drainage pipes of appropriate size from bottom of draft tubes.

All pipes for drainage purpose shall be of stainless steel and furnished with all necessary valves, intake strainers, etc.

1.2.16 Air Supply against Cavitation

Each turbine shall be designed and fabricated with all the necessary air admission provisions, including piping, valves and air control devices, to inject compressed air to the runner and/or draft tube during partial load and other operating conditions when there is the possibility of cavitation.

The location of the air admission inlets, pipe and valve sizes shall be based on turbine manufacturer's experience. The Contractor shall document the experiences in his/her Bid.

Necessary air supply required for admission in partial loading shall be arranged from the [station air supply](#) at adequate pressure.

1.2.17 Electrical Materials

All necessary electrical cables, wiring materials and components, terminal blocks, enclosures and other elements connecting equipment furnished by the Contractor shall be supplied by him as specified in General Specifications. Wiring which extends beyond turbine equipment shall terminate in a terminal box furnished by the Contractor. The terminal box shall be provided with terminal blocks suitable for outgoing wiring and clearly marked with identifying numbers. The location of this terminal box shall be subject to approval by the Engineer.

1.2.18 Piping

All piping within the turbine shall be provided complete with valves, pipe hangers and supports. Unions and breakdown flange shall be provided for convenient disassembly and maintenance.

All sleeve piping for gauges and thermometers shall be furnished by the Contractor. Flexible tubing for the dial thermometers shall be armored.

Tubing shall be of copper or stainless steel. Shut-off valves shall be provided at all gauges together with suitable blow off valves.

2.6 Model Tests Report (Optional)

Model tests Report should be submitted (optional).

2.7 Shop Tests

The Contractor shall provide all equipment, including measuring and recording instruments, necessary to carry out the tests.

Acceptance of material by the Employer does not relieve the Contractor from the responsibility that all materials furnished shall be free from defects and suited in all respects for the purpose intended.

All materials, elements, devices, etc. related to or contemplated for incorporation in the equipment while in the process of manufacture at the Contractor's shop shall be subject to such tests and inspections as may be necessary to prove compliance with the requirements of the Contract.

Drawings shall be submitted to the Employer for approval showing the location of test pieces.

Test certificates shall state the specified properties of the material and heat treatment given.

Shop assembly is required to extent necessary to assure proper fitting of the various parts to one another and for the purpose of checking the correctness of dimensions, clearances and tolerances. Parts thus assembled shall be match-marked for re-assembly at the site.

The various parts and components of the equipment shall be delivered pre-assembled to the greatest practical extent. All cubicles, panel boards, control boards, etc. shall be completely assembled and all equipment within these shall be completely wired at the Contractor's premises.

The inspection and testing shall comprise, but not necessarily be limited to, the following items.

- Chemical analysis of the material used for the main components; runner, shaft, guide vanes, fixed and rotating sealing rings, stay vanes, spiral casing, turbine covers, servomotor cylinders, oil tanks.
- Mechanical resistance tests on materials used for same components shall include tensile strength, yield point, elongation, bend, resilience, hardness tests.
- Ultrasonic inspection of the steel plates used for spiral casing, turbine covers, pressure vessels and other important stress carrying components.
- The following pieces shall be ultrasonically or dye penetration examination (DPE) or magnetic particle examination (MPE) tested: runner, shaft, wicket gates, flanges, plates for spiral case, covers, pressure tank and all pieces for stay ring and covers.
- 100% ultrasonic and/or radiographic examination and/or DPE according to the standards shall be carried out on the following welds in case of doubt after MPE or DPE: spiral case, stay rings, servomotors, covers, discharge rings, cone and pressure tank.
- Turbine runner blades shall be checked for surface roughness originally specified by the Contractor, especially on the water flow side.

2.8 Type Tests

The Contractor shall submit certificates of type tests carried out by third parties on governors of the same family of the proposed governor.

2.9 Hydraulic Tests

All materials and equipment to be operated under pressure shall undergo hydraulic tests which shall last a period of time sufficient to achieve a satisfactory verification of their tightness.

Turbine servomotor shall be tested with hot oil at a pressure not less than 1.5 times the maximum operating pressure for one hour, valves, piping and heat exchanges shall be tested at a at a pressure not less than 1.5 times the maximum operating pressure for 30 minutes.

After spiral case have been fabricated it shall be filled with water and tested under a hydrostatic pressure not less than 50% above the maximum static head plus water hammer.

The pressure shall be raised gradually until the test pressure is attained. The test pressure shall be held for a period of not less than 60 minutes to inspect for leaks or sign of failure. After inspection, pressure shall be reduced slowly. When pressure has been relieved the spiral case shall be vented to prevent vacuum. If leaks or sign of failure are observed, the hydrostatic test shall be repeated following repair of the defects.

2.10 Shop Assembly and Tests

The Contractor shall preassemble, in his workshop, those assemblies, subassemblies and pieces of equipment which require a precise fit for field erection. Shop assembly shall be done after all shop welding has been completed. The following tests shall be carried out.

- Dimensional checks to confirm that model and prototype are homologous.
- Static and dynamic balance of runner with cone piece and sealing rings in position.

- Run-out of shaft on an alignment checking rig. Requirements shall be generally in accordance with NEMA publication MG.5.2-1972
- Runner and guide vane clearances
- Electric panels and equipment functional tests
- Checking of the range of all the governor parameters

During the tests the governor dead band, inaccuracy, dead time and linearity shall also be checked. The controlled system shall include the water inertia time, the generator acceleration constant, the turbine and the network load characteristics.

The Contractor shall submit for approval a proposed detailed list of tests based on the above prescriptions, on the IEC Publication 60308 and other IEC applicable recommendations.

2.11 Field Tests

A comprehensive schedule of all tests to be carried out at the field together with the test and inspection sheets and English copies of related standards or specifications shall be prepared by the Contractor and submitted to the Employer not less than two months before the tests are due to commence.

After the turbines, governors and inlet valves have been installed and before placing equipment in service, they shall be given Preliminary Acceptance Tests. Upon completion of satisfactory performance of the Preliminary Tests, the equipment will be placed in operation by Employer's operating personnel under the direct supervision and responsibility of the Contractor. After completion of satisfactory operation of the equipment for at least the period specified, Final Acceptance Tests shall be carried out.

The procedures for testing of the equipment to check its conformity with the specifications will be in accordance with IEC. Pub. No. 545 "Guide for Commissioning Operation and Maintenance of Hydraulic Turbines" The Contractor shall, for duration of the tests, be entirely responsible for the care and protection of the equipment and shall supply all personnel, equipment, materials and supplies required to ensure the provision of care and protection up to date of the equipment's acceptance by the Employer. The following tests shall be carried out by the Contractor in the presence of the Employer's representatives.

2.11.1 Field Tests during Installation

The tests to be carried out shall be detailed by the Contractor taking into account the requirements of the applicable Standards. After each turbine and governor and their associated equipment have been installed, they shall be given preliminary tests to determine whether the installation has been carried out properly and the equipment is ready to be put into operation.

The tests shall include, but shall not be limited to the following ones:

- Wicket gates operations,
- Checking of guide vane seal,
- Operation and adjustment of all automatic and safety devices,
- Control of the clearance of runner which will be carefully checked in four positions at intervals of 90° of rotation as the runner is rotated 360°,
- Pressure test of hydraulic system at maximum operating pressure for at least 30 minute,
- Operational test of electrical connections for all installed equipment,
- Checking of grounding connections,
- Insulation measurement of all equipment,

The turbine and generator shaft alignment shall be checked by rotating manually the unit shaft. The maximum eccentricity amplitude measured in correspondence of the lower flange of the generator shall not exceed 0.05 mm.

2.11.2 Field Tests after Installation

After the equipment has been installed and before it is considered ready for commercial operation, the equipment shall be subjected to functional, performance and reliability tests to

prove compliance with the Contract independently from such tests performed in the shop.

All instruments and equipment required for the tests will be furnished by the Contractor. The tests shall include, but shall not be limited to the following ones:

- Checking of start-up and shut-down sequences and normal operation with water,
- Checking of then transients including over-speed and overpressure during emergency shut-down of each and all units, increasing gradually the load up to full load,
- Closure of each inlet valve under the maximum flow at the prevailing head,
- Servomotor capacities,
- Checking of guide vanes leakages.

During these tests the following magnitudes shall be recorded:

- Unit speed,
- Wicket gate opening,
- Inlet valve opening,
- Penstock pressure,
- Wicket gate servomotor oil pressure (both sides of the piston),
- Inlet valve servomotor pressure (both sides of the piston),
- Thrust on the thrust bearing,
- Penstock water flow (on the Winter Kennedy transducer),
- Radial vibrations of the guide bearing housing,
- Displacement of the head cover in the worst position,
- Draft tube water pressure,
- Generator guide bearing radial vibrations,
- Generator thrust-guide bearing radial and axial vibrations,
- Generator output.

In addition to wet tests, commissioning tests include also tests on control equipment and automatic run tests. These tests include the tests of governor to give evidence that governor system and joint control, including the oil supply system operate correctly and properly integrate with the characteristics of the plant, particularly of the electric system.

Since the performances of electric governor panel have been tested on the workshop no specific frequency regulation tests are required at site.

Anyway the Contractor shall submit, during tests in the workshop, a comprehensive program for demonstrating at site that the governor meets the prescriptions of these specifications and the Contractor guarantees.

This program shall include at least:

- Operation of governor during transients,
- Tests off-line,
- Tests on-line.

3. GOVERNOR

The governor and associated oil pressure system shall be of modular type of proven design suitable for control and operation of the type of turbine unit described herein. It must be manufactured by a reputed international company specialized in the production and distribution of governor equipment. The governor and associated equipment must be manufactured and tested according to IEC 308 (1970) "International Code for Testing of Speed Governing System for Hydraulic Turbine". The Bidder shall supply a type and routine test reports of the governor confirming to the similar type being offered in this Bid.

3.1 Scope

2 (two) governors PLC-based digital type with PID controller shall be supplied. The supply shall include the following equipment:

- Speed governor with panel

- Pressure oil supply system for speed governor and turbine inlet valve. Each governor shall be complete and independent and shall include:
 - An electronic governing head protected against surge and high frequency interference from the electrical supply line or from various electrical inputs and outputs,
 - Various components of the hydraulic power system such as pilot valves, safety electro-valves, distributing valves, etc. for controlling the turbine and inlet valve,
 - Electrical feedback system, tooth-wheel type speed signalizer and power supply systems,
 - Piping, wiring and all other accessories and all the components required to constitute a completed assembly for regulating the speed.

Complete specifications and preliminary drawings shall be submitted with the bid. A manual shall be supplied describing in detail the governor operation, furnishing a complete parts list and defining the frequency and type of maintenance required to assure normal life for the governing system.

3.2 Design Data

- Type: PLC-based digital with PID controller
- Rated frequency: 50 Hz
- Frequency signal: Electronic speed detector
- Servo-positioner: Electrohydraulic with position transmitter
- Analog outputs: Minimum 6 mA
- Digital inputs and outputs: Galvanically isolated
- Controls: Load frequency (unit online) speed control (no-load) opening limiter
- Feed-back: Head pond (optional), opening and/or power.
- Speed setting range: 20-180 %
- Permanent speed drop: 0-10%
- Load changer range: 0-115%

3.3 Type and Description

The governors shall be PLC-based digital type with PID controller. The design shall have a proven record of reliable commercial operation of not less than five years at the time of contract.

The proposed system shall be clearly indicated by the Bidder.

The governors shall be designed and completely equipped for individual or point operation of the units under local and remote control. In particular, the governors shall be able to match the existing control and supervisory equipment. The governor shall be designed for manual control and for the automatic operation off and on line.

The governor will be capable of performing the following functions:

- Controlling one unit from standstill to no load up to the maximum power, over the full range of specified net heads,
- The frequency variation shall not exceed $\pm 3\%$ for sudden load variation of 5% expressed in percent of maximum kW output of the unit at full gate opening of wicket gates under the water head considered,
- Operate the unit between 90% and 110% of the rated frequency, allowing synchronization and operation up to full load over this range,
- The operating modes will be standstill -no load- generation (single or under joint control),
- During synchronization the speed level shall automatically adapt the unit frequency to the grid frequency under the control of the synchronizing equipment,
- The return at off line no load condition shall always be such that the unit will run at rated speed,
- After synchronization the unit shall automatically take load up to the adjustable preset value,
- Creep detection with selectable brake operation,

Protective devices of the governing system shall be effective under all operating modes. The governors shall be provided with a built-in failure detection system and with at least all the indicators specified in the annexed list.

All the electronic equipment shall be protected against the high voltage "spikes" or noises expected in the supply voltage and from any electromagnetic influence or noise produced by the surrounding equipment.

The panels/cubicle shall also be protected against the mechanical vibrations produced by the other equipment.

The power supply and frequency signal system shall be selected by the Contractor taking into account the design data indicated above. Automatic switching of the power supply shall be provided by the Contractor, if necessary.

Any internal or external switching from one state to another shall not cause sudden undue variation of the wicket opening.

Servomotor feedback shall be of electric type. The governor shall be provided with all the speed switches required for its correct operation and with at least one free input for possible future applications.

The design of the governing system and guarantees shall be based on the following conditions:

- Each turbine shall operate singly from no-load up to the maximum power over the full range of the specified net heads,
- The steady state frequency of the network may vary between 90% and 110% of rated frequency and the units may be synchronized and operated up to full load over this range,
- The generator fly wheel effect guaranteed,
- The penstock water inertia times shall be calculated based on drawings and the whole operating range shall be considered,
- Turbine characteristics as determined by the Contractor,
- Possible disturbances due to hunting effects shall be considered in the design; governing system cut-off frequency shall be such as to avoid any resonance effect.

Therefore, to the effect of governor stability, resonance effects will be considered to be nil,

- To the effect of governor stability guarantees, the load self-regulation factor to be considered shall be equal to -1 that is the load shall be purely Ohmic.
- Frequency governor control software shall also be submitted to the employer.
- The Contractor shall perform calculations and tests also considering different characteristics of the load/Network,

3.4 Performance Guarantees

- (a) The governing system shall guarantee stable control within the whole range of the controlled system characteristics: with a speed insensitive set at 0.02% and the permanent speed drop-speed regulation set 2% or above (or no load and/or with sustained load).
- The amplitude of the sustained speed oscillation shall not exceed ± 0.15 % of the rated speed; and under no load conditions.
 - The amplitude of the sustained power output oscillation shall not exceed ± 1 % of the turbine rated capacity.

Moreover, all parameters and adjustment rangers indicated here and/or in the guaranteed data shall be subjected to test in the workshop. The frequency regulation stability and quality shall be demonstrated by the Contractor with a linear mathematical model in the workshop or at site.

The stability analysis of the transfer function of the linear mathematical model of the whole governing and controlled system under the worst operating conditions shall be made and subjected to approval by the Employer.

(b) Alternatives

The Employer wishes to make clear to all bidders that, notwithstanding the accompanying specification, the Employer may give consideration to alternatives which the bidder considers advisable by reason of his own manufacturing requirements and experience or by reason of Employer's interest, provided attention is clearly drawn to such alternatives in the bid and descriptive matter submitted, pointing out wherein the recommended arrangement or device is equal to, or superior to that required by the accompanying specification.

3.5 Speed Governing System Characteristics

3.5.1 Speed Governing System

Speed governing system shall be constituted by PID type electronic speed governor complete with unit frequency measuring devices and by unit servo-positioning system complete with electronic components, transducers, actuators, distributing valves, static feedback and all necessary devices to control wicket gates servomotor(s). Unit servo-positioning system shall reproduce speed governor signal.

Governing system shall be so designed to enable an easy control of servomotor(s) operating time, in saturation condition, without any modification to hydraulic system. Servomotor(s) operating time adjustment shall be carried out on servo positioner electronic circuits. Governor shall be provided with double feed circuits with a start-up circuit, suitable to assure unit control during acceleration, and with a PID (Proportional, Integral and Differential) circuit suitable to maintain unit control during and after synchronization. Start-up and PID circuit parameters shall be easily adjustable.

3.5.2 Start-up, No-load and Synchronization

During start-up, acceleration shall be maintained constant for almost the whole slope at the pressure value.

Start-up signal shall increase distributor opening with a preset gradient up to start-up; as soon as unit frequency is different from zero, distributor opening shall be transferred under loop control. Such control shall be performed only with proportional action. Only at the end of the slope integral action shall become operative and acceleration shall be gradually decreased down to an almost nil value when frequency error, compared with network frequency, shall become minor than maximum acceptable value for synchronization. Waiting for synchronization, speed governor shall maintain slip to an adjustable value within zero value and maximum acceptable value for synchronization.

3.5.3 Operation in Parallel

At synchronization, governor shall be switched from start-up circuit to PID circuit. Power reference value shall be maintained to a pre-set value and PID outlet shall be set to the value corresponding to frequency error, With respect to reference frequency, divided by speed drop. Opening of unit main circuit breaker shall switch governor PID circuit to start-up circuit, while a load increase/decrease with main circuit breaker closed shall be controlled by PID circuit.

3.5.4 Speed Detector

Unit frequency shall be detected through magnetic detectors faced to a toothed disk installed on unit shaft; the whole detecting device shall be housed in an adequate carter. Other approved systems may also be used.

3.5.5 Control, Selectors and Indicator

The speed governor shall be equipped with local control for load limiter (opening) and for speed-load changer; both devices shall also be remotely controlled. Selectors for the following parameters shall be installed on front of governor panel:

- Permanent speed drop,
- PID Proportional, integral and differential parameters,

- Dam water level (optional),
- Power,
- Minimum required time for servomotor operation, within limits imposed by installed on hydraulic circuits,
- Start up acceleration,
- The following analog indicators shall be provided locally:
 - Unit speed,
 - Load limiter position,
 - Speed-load changer position,
 - Gate opening,
 - Power.

Transducers for remote indication of actual servomotor opening position shall be supplied.

3.5.6 Protection and checking

The speed governor front panel shall be equipped with suitable led to show status of all digital inlets and outlets.

The speed governor shall be also equipped with a self-checking system transmitting outside the signals.

3.5.7 Joint Control

The governor shall be designed with an option to allow joint control of the units.

3.5.8 Other Characteristics

The speed governor shall comply with the following additional prescriptions:

- Governor software shall be housed in permanent memories with sufficient capacity to allow future software increase,
- Governor software shall be so written to allow its use by governing system experts, with no specific knowledge of program languages,
- Permanent memories shall be site adjustable utilizing a PC available on local market, equipped with standard accessories,
- Software shall be provided together with the equipment. Training of software will be provided as document at site.

4. PRESSURE OIL SUPPLY SYSTEM

4.1 Design Criteria

The system shall be used to supply required pressurized oil for the governor and inlet valve. The governor oil system shall be designed for the safety valve maximum setting pressure. Minimum servomotor closing and opening times shall be independently adjustable within a wide range with a secure method for locking the adjustments. The ports of the main oil distributing valve shall restrict the flow of oil to cause a full stroke of the servomotor(s) in not less than the prescribed time and shall be arranged so that the maximum rate of movement of the wicket gates cannot exceed under any circumstances the maximum value for which they are adjusted. The leakage through the oil hydraulic part of the governor system shall be such that, with no active regulation, the time interval for the pressure in the pressure tank to decay to 90% of nominal value shall not be lower than two hours, with the governor pumps idle. Speed governor and pressure oil supply system shall be designed in compliance with ANSI/IEEE standard 125-1988 or equivalent.

4.2 Requirements for Construction and Characteristics

4.2.1 System

Each system shall consist of;

- two (2) sets of oil pumps (one for regular use and the other for stand-by),
- one (1) oil sump tank,

- one or two hydraulic accumulators,
- all pipes, valves, oil distributors, pressure and level relays, and other necessary equipment and accessories for the operation of the pressure oil supply system and compressed air system, if any.

The pressure oil system shall have a capacity sufficient to assure the operating guarantees of the turbine and inlet valve.

Continuous running system by an unloader shall be applied. The start and stop of these pumps shall be controlled automatically and manually by the switch mounted on the Control Board.

4.2.2 Oil Pump

The oil pumping set shall consist of two AC electric motors driven screw type oil pumps directly mounted on the oil sump tank.

The motors shall be direct-connected to the pumps and shall be of 3-phase AC 380 V, 50 Hz, low-starting current, induction type designed for full voltage starting. The motors shall have closed conduit boxes and windings shall have moisture and oil-resistant insulation. Each pump shall be equipped with a fully automatic starting device to ensure the no-load pump starting and to load the pump only when rated speed has been reached.

Provisions shall be made to allow the complete disconnection of whichever pump from the system for maintenance purpose without compromising the system operation.

One of the pumps shall operate as main and the other as stand-by, being automatically put in or out of service respectively when the oil pressure on the outlet of the main pump drop below or rises above preset values. It shall be possible to change-over the main and stand-by pump for maintenance without interruption of the operation. Each pump shall be equipped with check valve, outlet valve, safety valve and all other accessories necessary for fully reliable operation.

All control devices and accessories shall be installed inside the oil sump tank and shall be easily accessible for maintenance and setting. The oil pumping set shall be designed to operate for without cooling water, with oil at steady temperature and both pumps in service, maintaining acceptable temperatures. A main oil distributing valve installed in the sump tank shall direct oil flow to and from the servomotor(s). The valve shall be controlled by an electro-hydraulic system forming the interface between the electronic control circuits and hydraulic circuits. Failure of the control signal shall cause the main oil distributing valve to close the wicket gates.

Continuous running system by an unloader shall be applied. The delivered oil quantity of one pump set shall not be less than the oil quantity enough to close the guide vanes without supplying oil from the oil pressure tank.

The pumps shall be interconnected so that they can be operated independently. The necessary valves shall be furnished so as to permit complete isolation of any pump from the oil system and to permit removing the pump for repairs without shutting down the governor.

4.2.3 Hydraulic Accumulator

The hydraulic accumulators shall be of bladder type which uses the nitrogen as compressible fluid for storing the oil under pressure.

The accumulator shall be designed, constructed and tested in accordance with the approved standards.

The following accessories shall be furnished with the hydraulic accumulators;

- Pressure relays (for the conditions of turbine start, oil pump start, alarm, turbine stop and other necessary conditions.)
- Safety valve
- Oil supply and drain valves

- Inert gas supply valve
- Name plate and instruction plate
- Other necessary instruments

4.2.4 Sump Tank

Each governor shall be provided with a sump tank having a capacity of not less than 110% of the total oil quantity in the entire governor oil system (oil in hydraulic accumulators, sump tank, servomotor, piping, etc), plus oil required for inlet valve hydraulic system.

The sump tank shall be provided with suitable access openings. It shall be equipped with an oil level indicator, a low level switch, an oil thermometer with oil temperature switches and shall have suitable connections for filling and draining the tank, connections for a portable oil purifier.

An oil cooler shall be provided with connecting piping and valves to limit the maximum oil temperature.

Double oil filter screens shall be provided in the sump tank, arranged so that one screen is operating whilst the other is removed for cleaning. A duplex type of filter shall be provided for oil supplied to the electro-hydraulic valve. It shall be possible to change over the filter elements without momentary reduction of output pressure and each filter element shall be suitable for convenient removal and cleaning.

The inside surfaces of the sump tank shall be free from any cracks, open joints, and blind holes liable to trap dirt in the oil. All internal welds shall be continuous. All joints shall be welded. Outside surfaces shall be perfectly smooth and free from scratches, bumps or rough welds, to ensure the absence of undesirable reflections when painted. All traces of rust, oil, grease and dirt, shall be removed from both inside and outside surfaces. Inside surfaces shall be sand-blasted and then painted immediately with an oil-proof enamel to prevent corrosion.

4.2.5 Piping and Valves

The Contractor shall supply all pipes and valves between the pump units, oil sump, pressure oil tank and servomotor(s) of inlet valve and wicket gates and also all drain piping leading to the oil sump. All pipes shall be dimensioned for a maximum oil flow velocity not in excess of 5 m/sec over the full range of servomotor travel at its fastest rate. The piping shall be seamless steel tubing with suitable pipe fittings. The Contractor shall as far as possible carry out the maximum amount of pipe work at the shop, subject to erection, transport and handling limitations, in order to reduce work at the site to a minimum.

The Contractor shall supply all pipe hangers and supports required to prevent vibration or displacement of the pipes due to sudden changes of pressure in the circuits.

Contractor shall also supply all studs, bolts, washers, collars, oil seals, pipe brackets, etc. required for the erection of the oil circuits.

4.2.6 Compressed Air Supply System (if necessary)

The low pressure compressed air for the air-oil accumulator and generator braking system shall be supplied by an individual compressed air system for both units. Air system shall include two compressors, one spare to the other if the Contractor proposes air-oil pressure system. A second compressed air supply system will be provided with a capacity limited to maintenance works only.

5. COOLING WATER SYSTEM

5.1 Use

The System shall provide cooling water for;

- Generator air coolers (if necessary)
- Generator guide bearings
- Turbine combined bearing (if separate)

- Governor oil sump tank coolers (if necessary)
- Turbine shaft seal

5.2 Requirements for Construction and Characteristics

5.2.1 System

Cooling water shall be provided from the tailwater or from the penstock. Closed circuit system may also be acceptable.

One (1) set of the system shall consist of two (2) sets of motor-driven water pump (one for regular use and the other for stand-by), two (2) automatic washing strainers, two (2) automatic sand separators, one (1) control panel for water pumps, one (1) control panel for automatic washing strainers, one (1) control panel for automatic sand separators and necessary accessories including valves, piping and fittings.

Water pumped up from the draft tube by these pumps shall be directly supplied to cooling devices of various equipments through the washing strainer.

The start and stop of these pump sets shall be controlled manually by the switch mounted on the control board in the control room and/or on the control panel mounted on the control center.

5.2.2 Water Pump

Compound gauge at the suction side and pressure gauge at the delivery of the water pump shall be provided. The water pump shall be also used for draining water inside the draft tube.

5.2.3 Automatic Washing Strainer

Two (2) automatic washing strainers, one for regular use and the other as a stand-by unit, shall be furnished together with control devices. The strainer shall be electrically driven by 3 phase, AC 380 V, 50 Hz.

The strainer shall be of a rotary screen type capable of automatically carrying out a series of flushing actions at every given interval by a time relay, which is used to operate the washing strainer and shall be adjustable in a range of 0-24 hours. It is required to change the strainer from the one (1) in regular use to the stand-by unit or vice versa manually at the site.

Pressure gauges shall be provided at the inlet and outlet of strainer.

5.2.4 Automatic Sand Separator

Automatic sand separators shall be used as washing strainer of sealing water to the sealing box. The sand separator shall consist of sand separator, header, and sand collector, automatic drain device, pressure gauge, valves, fittings, and necessary accessories.

The automatic drain device shall be capable of automatically draining sand using 3 phase, AC 380 V, 50 Hz at every given interval by a time relay and shall be adjustable in a range of 0-24 hours.

5.2.5 Control Panel and Accessories

The control panel for the system shall be mounted on the control center.

5.2.6 Water Flow Relay

The water flow relays shall be provided on the primary or the secondary side of the generator air cooler and the bearing coolers of the turbine and generator as shown in the attached drawing. The relay shall transmit an alarm to the control board in the control room in the event that cooling water stops to flow, and shall be provided with an alarm contact. The water flow relay with window shall be of simple construction and shall be accurate and reliable in operation.

5.2.7 Thermometer and Temperature Detector

Rod type thermometers shall be equipped at inlet and outlet of each cooling circuit of the

water supply system. A resistance type temperature detector shall be equipped at inlet of the cooling water supply system. It is to be used in combination with temperature recorder furnished by the power plant equipment supplier.

5.2.8 Piping and Valves

The Contractor shall provide all piping and valves for connecting the equipment to be supplied by the Contractor under the Specifications, and complete set of flanges, bolts, packing, pipe supports and fittings required therefore. Size and scope of supply of the water supply pipes to the generator bearing coolers, generator cooler and diesel engine will be decided after award of the Contract.

5.2.9 Wiring

The Contractor shall supply all wiring required to connect up the various items of equipment to the Unit, Power Plant Control Centre/Board.

5.2.10 Miscellaneous

Drain cocks, vent valves and air vents are necessary to ensure satisfactory operation when filling or draining the system shall be provided.

6. TURBINE INLET VALVES

6.1 Scope of Work

This section covers the furnishing and installation of turbine inlet valves including all accessories, by pass valve, inspection tube, hydraulic operating mechanism, foundation bolts etc. required for the project. The contractor shall supply, modify, adjust install and welding adjusting, section between penstock end flange and butterfly valve flange in order to compensate errors between spiral case axis and penstock axis. The loads applied by the turbine inlet valve on the penstock shall be calculated and submit in due time by the Contractor before design calculation of the penstock.

6.2 Type and Description

The inlet valves shall be of pressure oil operated "butterfly" type with horizontal shaft construction and counter weight closing.

The valves will be installed on the valve pits just before the turbine spiral casings in the machine hall. In order to facilitate erection of the valve a dismantling joint shall be provided on downstream end of each valve.

The inlet valve together with by-pass line and operating equipment shall be designed to fit into space available with proper regard to accessibility and passageway. The valve shall be supported on concrete pedestals and secured by anchor bolts.

6.3 Design Characteristics

- Number of valves: 2
- Nominal diameter: correspond to existing penstock at site
- Operating water elevation: 2171.0 masl (verify at site)
- Valve axis elevation: verify at site
- Maximum net head: 52.03 m
- Design head (Gross): ~55m
- Nominal flow per valve: 1.2 m³/s
- Opening and Closing time (adjustable): 30 to 150 s
- Operating equipment: hydraulic servomotor(s) /counterweights
- Maneuvering conditions (closing): full flow
- Maneuvering conditions (opening): balanced pressure

The valve shall be designed to withstand the maximum transient hydraulic pressure and shall be free from vibration and any abnormality under the whole operating range of turbine

including any transient conditions of operation.

The exact diameter shall be determined by the Contractor.

The valve shall be so designed as to be capable of closing from fully opened position under the conditions of maximum flow at maximum head. Furthermore, the valve shall be capable of closing safely and completely against full unbalanced flow occurring as a result of a burst of the downstream piping within the valve chamber. The butterfly valve will be a security device to ensure the shutdown during maximum flow condition.

The butterfly valves shall be designed to resist dynamic charges caused by a closure with the turbine runaway flow. The valves shall be assembled and tested in shop at 1.5 times the maximum operating pressure for half an hour.

A double eccentricity design with peripheral one-piece profile seals which surround the trunnions is preferred. The design shall be such that a closing tendency shall be ensured for all operation conditions, as well as for maximum opening.

The closure angle shall be 90°. Valves having a closure angle less than 90° will not be allowed.

6.4 Requirements for Construction and Material

6.4.1 Valve Body

The valve body shall be fabricated of rolled steel plate for welded structure or made of carbon steel casting as in one piece and shall be heat treated before machining, so as to reduce internal tensions of the material. Both ends of the body shall have properly faced and drilled flanges for making watertight connections with the upstream and downstream piping.

A highly erosion-resistant stainless steel sealing ring shall be provided at convenient place in the valve body.

The trunnion bearing blocks (housings) shall be of first class cast steel and welded on the body so as to form an integral part. The bearings shall be self-lubricating type and shall be incorporated in the valve body together with readily renewable packing for the trunnions.

Support of the valves shall be by pads welded onto the valve body. The supporting face of the pads shall be machined so to ensure perfect setting and alignment of the valves.

An indicator with scale pointer shall be provided for each valve to indicate the disc position. It shall be of reasonable size and located at a convenient height.

The supply shall include also a mechanical locking device to hold the valve in closed position against the maximum force of opening cylinder.

6.4.2 Valve Disc, Bearings and Trunnion

Valve disc shall be of either cast steel or welded-steel plate or combination of both with trunnions attached in accordance with the manufacturer's normal practice. The trunnions shall be of forged stainless steel material and securely fastened to the valve disc. Attention shall be given to a convenient and smooth shape of the disc so as to minimize disturbances of the water and head losses.

The valve disc shall be heat treated before the execution of mechanical elaborations, so as to reduce internal tensions of the material.

The valve disc shall have a carefully formed aerodynamic profile to diminish losses of pressure; it must be nevertheless sufficiently rigid to avoid vibrations and deformations of the valve disc. If the valve body is composed by two halves the trunnions may be fixed to the valve disc directly. In case the valve body is made of only one piece, the trunnions must be connected to the valve disc by means of bolts. The steel trunnions shall have a stainless steel overlay in correspondence to the bearings and the gaskets. The valve disc shall be completed by rubber gaskets and blockage ring in stainless steel with stainless steel screws. The valve disc's support surface shall be protected by a stainless steel overlay. Both

trunnions shall have an extension to allow the external application of the operating lever.

The neoprene gasket of the valve disc shall be vulcanized in one piece. Glued gaskets are not allowed.

All surfaces of the trunnion shall be properly machined with the bearing and sealing surfaces polished.

The trunnions guide bearings shall be realized in self-lubricating material and completed with stainless steel supports, gaskets and covers. Furthermore, the bearings shall be replaceable without need to disassemble the valve disc.

The material chosen for the trunnions shall be easily weldable so as to allow, in case of wear, welding reparations with stainless material.

6.4.3 Servomotor

The solution with one servomotor as well as the one with two servomotors (and two weights) is accepted.

The servomotor runs in one direction. The piston is opened and maintained in this position by oil pressure; it is closed by the weight.

The piston shall be chromium plated. Servomotor, control valves and pipes should be tested at 1.5 times the maximum operating pressure.

6.4.4 By-Pass Valve

By-Pass valve shall be dimensioned to allow filling of the spiral case and intermediate pipe in a reasonable time and designed to assure the least amount of corrosion due to cavitation and cause the least amount of noise and vibration during operation.

The by-pass shall comprise an oil operated by-pass valve and a hand operated shut off valve. The operation of by-pass valve shall be carried out by oil pressure commonly used for the main valve. Hand operated shut-off valve normally locked in open position shall be installed in the upstream connection to permit repair or inspection of the by-pass valve without emptying the penstock.

The by-pass piping shall be of steel with steel flanged connections, and the part between the oil operated valve and the downstream pipe shall be made of stainless steel. The necessary bolts and gaskets for a complete installation shall be furnished.

6.4.5 Upstream Piping

Each inlet valve shall be provided with an upstream pipe of welded plate steel construction. It shall be conical or straight, have a length suitable for welding connection of the valve body to the respective penstock.

The downstream end shall be equipped with a flange matching properly the upstream flange of the valve body. Its upstream end shall be welded to the penstock at site. The making of the welded joint between upstream piping and the penstock will be carried out by the supplier of the penstock and end preparation for welding shall be subject to approval of the Employer.

The following take-offs, taps etc shall be provided on each upstream pipe:

- One (1) take off with two (2) shut-off valves for penstock drainage.
- One (1) take-off for by-pass piping
- Two (2) stainless steel taps and one pressure gauge (with air exhaust valve and stop valve) for measuring penstock pressure.

Piping between pressure gauge and the tap is included in the supply.

6.4.6 Downstream Piping

Each inlet valve shall be provided with a downstream pipe of welded plate steel construction. The upstream end shall be equipped with a color flange and loose intermediate flange so as to ensure a telescopic fitting of the valve body with downstream pipe. Its downstream end

shall be for site welding to the spiral case extension pipe and have, therefore, an allowance in length approx. 200 mm.

The following take-offs, taps, openings, etc. shall be provided on each downstream pipe:

- One (1) take-off with one (1) shut-off valve for spiral case drainage
- One (1) take-off for the inlet valve by-pass pipe connection

6.4.7 Dismantling Sleeve

The inspection tube of butterfly valve shall have the following functions:

- Facilitate the butterfly valve dismount,
- Facilitate the inspection of the valve and allow the substitution of the valve disc rubber gasket while the upstream pipe is under the maximum exercise pressure,
- Compensate the axial displacement of the butterfly valve, which may be caused by a thermal deflection of the upstream pipe and its elastic lengthening caused by pressure on the closed valve disc.

The tube shall be realized in welded plate, heat treated before the further machining, to reduce the material's internal tensions. The slide flange shall be downstream. The slide surfaces shall be realized with stainless steel overlays. The slide flange will not transmit axial forces, it shall nevertheless be possible to transmit transversal forces and bending moments which can act with a rupture of the inspection pipe.

6.4.8 Aeration Valve

An aeration valve must be foreseen in the top of the turbine inlet cone for the aeration of the turbine spiral case in case of butterfly valve closure and during the spiral case filling. The internal valve mechanism shall be constructed in stainless material or with a rust protection.

6.5 Control and Operating Mechanism

The opening of each inlet valve shall be performed by one or two servomotor(s) and closing shall be by the closing weights and the disc's hydraulic self-closing tendency. During closing of the valve by counterweights, this servomotor shall act as a brake.

Inlet valves having own independent pressure oil supply system is preferable. However, Contractor may also use the pressurized oil from the turbine oil pressure unit for operation of the butterfly valve on the condition that system capacity shall be determined accordingly.

The valve's opening time can be regulated by the diaphragm. Opening and closing time shall be adjustable.

The servomotor shall have opening and final position amortization characteristics.

The valve's closure is done by the main control panel which gives the order to close to the solenoid valve.

The oil pressure circuits shall be realized in seamless carbon steel or special flexible pipe. The fixing points shall be in polypropylene.

Special supports shall be realized if necessary in the floor passages, so as to grant the drain water run-off.

The servomotor may be attached to the valve body or rested on the valve chamber's floor. In the latter case heavy supporting plates with anchor bars, fastening, etc. shall be provided for the respective floor area.

The operating mechanism including that for the bypass valve shall be provided with a manual-locking device which can lock both the main and by-pass valves when they are closed. When the valve is locked, opening of the valves shall be impossible.

Operation of the valve shall be such that in opening, the by-pass valve is opened first and after balancing the pressure on both sides of the valve an electric circuit shall be closed

through a differential pressure switch then the main valve will be opened. In closing, the main valve is closed first and by pass valve will be closed after the main valve is closed.

The following modes of control shall be provided for:

- Manual remote from the control center/board,
- Automatically (for starting-up and stopping of the respective generating set),
- Emergency closure of the inlet valve shall be obtained if the unit goes the over-speed or runaway,
- In case of mechanical failure (such as bearing fault) quick stop (no speed rise) of the unit including the closure of inlet valve shall be made,
- Inlet valve may stay open in case of some electrical faults and no-load and no excitations run operation.

The controls shall be so arranged that the motion of each inlet valve can be reversed at any time during opening or closing stroke. All control and indicating devices shall be mounted on the control board of the turbine. The necessary contacts for remote control from the control centre/board shall be also provided.

All parts shall be designed and constructed so as to exclude distortions and deflections under all operating conditions. Special attention shall be paid to inspection and maintenance.

The cylinder shall be of cast steel and the bore shall be machined ground so as to assure a concentric and smooth finish from porosities and other defects.

The pistons shall be of nodular cast iron or steel, with the piston assembly fastened properly to the piston rod. The finish shall be so as to ensure perfect fit with cylinders. Piston rings, packing and cup leathers shall be designed and arranged so that inspection and replacement can be effected without disassembly of the cylinders. The piston rods shall be either of stainless steel or of S.M. Steel with nickel chromium protective layer. Dimensioning of the rods shall be so as to transmit all operational forces without deflections. All pivots shall be preferably of self-lubricating type.

The closing weights of the valve shall be of cast iron and fastened securely to the lever.

6.6 Weights and Operating Levers

One weight or two weights are accepted. The steel operating levers shall be fixed by means of keys on the valve disc's trunnions, with supports for the servomotor and the closure weight.

The weights for the gravity closure shall be mounted on the extremity of the operating levers.

The valve shall be equipped with an indicator of the disc's position. To allow workings inside the turbine, the operating lever shall have one security locking bolt.

The bolt shall have the necessary dimensions to resist the thrust of the servomotor(s).

6.7 Wiring

The necessary electrical wiring and electric conduits between the inlet valve and the unit local control board shall be furnished.

The required remote control and indicating devices and the wiring between control room and unit local control board will be furnished.

6.8 Tests

a) Tests on Raw Components

- Chemical analysis and mechanical tests on the materials used for inlet valve body, disk, trunnions, servomotor cylinders, piston rods, upstream and downstream piping.
- Ultrasonic inspection of the material used for the above mentioned components.

b) Tests on Finished Components and Assemblies

- 100% ultrasonic testing of important welded parts such as valve body, disc, servomotor

cylinders, upstream and downstream piping.

- Radiographic inspection of all cross-point of welds, as well as all welds showing doubtful ultrasonic indications.
- Dye-penetrant testing of the disc trunnions and piston rod heads.
- Dimensional checks of finished components.
- Hydrostatic pressure testing of the inlet valves (with open and closed disc) under a pressure of 1,5 times the maximum static pressure plus water hammer for 30 minutes.
- Hydrostatic pressure testing of the assembled servomotor(s) under a pressure 1,5 times the maximum operating pressure for 60 minutes. No permanent distortion will be allowed.
- Seal leakage test on the inlet valve under a hydrostatic pressure equal to maximum static head. The leakage shall not exceed the amount guaranteed by the Contractor.

Operational tests including at least three opening and closing strokes, with timing checks on the valve disc movement. Confirmation of correct seal release/engagement and operation of interlocks and limit switches shall be provided.

7. TOOLS AND DEVICES FOR ASSEMBLY AND MAINTENANCE

7.1 Turbines

The scope of work shall include all normal customary tools not included in the tool list of the workshop equipment. Furthermore, the scope of works shall include all devices and tools which are specially made and/or required for complete assembling, dismantling, adjustment and maintenance of all turbine equipment. The stipulations in the General Technical Specifications must be observed accordingly.

Selection of tools and devices shall consider that all maintenance and repair work requiring standstill of the turbine must be carried out within the shortest possible time. All turbine components to be dismantled shall be equipped with eyebolts, lugs and/or other devices to facilitate handling, installation and removal.

The following devices shall be included in the supply:

- One lifting bracket for attachment to the powerhouse crane to be used for handling the runner and turbine shaft.
- One shaft and runner supporting ring.
- Equipment for the alignment of wicket gate assemblies during erection of spiral casing and installation of wicket gates.
- Two hydraulic coupling bolt pre-stressing devices complete with flexible hose, hand pumps for installation and dismantling.
- Water pump, piping and valves for pressure testing of spiral casing and other pressure tests.
- One set of runner templates for use during runner maintenance.

7.2 Governor

The scope of supply shall include all normal customary tools necessary for the assembly, erection and maintenance of the governors and associated equipment.

The supply shall also include all devices and tools which are specially made and/or required for complete assembling, dismantling, adjustment and maintenance of all equipment specified.

7.3 Main Inlet Valve

The scope of work shall include all customary tools not included in the tool list of the workshop equipment. Furthermore the scope of work shall include all devices and tools, which are specially made and/or required for complete assembling, dismantling, adjustment and maintenance of all equipment specified.

A special device shall be provided to turn the butterfly valve disc for repair and maintenance, when the penstock and the turbine are empty. This device shall be applied using the

powerhouse crane.

All heavy components shall be equipped with eyebolts, lugs or other lifting facilities to allow handling, installation and removal by means of the powerhouse crane.

7.4 Other

Complete sets of all special tools, necessary for the assembly, disassembly and maintenance of the energy dissipating valve, cooling water system and compressed air systems shall be provided.

All tools and devices shall be listed in the Price List.

8. SPARE PARTS

The following spare parts are given as a reference; the Contractor shall submit his proposal list to approve by the Employer.

All spares furnished shall be interchangeable with the corresponding original parts. They shall also be the same material and workmanship, and shall have all the features and provisions of the corresponding original parts.

8.1 Turbines

- Wicket gate elements with bushings Four (4)
- Breaking links or Shear pins for wicket gates of one turbine One (1) Set
- Lever and key for one wicket gate Two (2) Sets
- Thrust pads and bearing shell for combined bearing One (1) Set
- Complete set of packing and seals for one turbine One (1) Set
- Wearing rings and facing plates Two (2) Sets

8.2 Speed Governors

- Printed cards for electronic governing head One (1) complete set
- Speed signal generator or speed detector One (1) complete set
- Potentiometers One (1) of each type
- Main and auxiliary distribution valves One (1) of each type

8.3 Pressure Oil Supply System

- Hydraulic Accumulator One (1) set
- Unloader One (1) set
- Safety valves One (1) each type

8.4 Turbine Inlet Valve

- Three (3) sets: complete set of seat rings, seal rings and seal packing of all types for each inlet valve.
- Three (3) sets: complete set of needle and seat ring for the by-pass control valve.
- Two (2) sets of spindle bearing sleeves (each set complete for one butterfly valve).
- Two (2) sets: spare needles and seats for each by-pass guard valve.

9. DRAWINGS AND DOCUMENTS

The Contractor shall provide all necessary documents, data and drawings necessary to enable the Employer to install, erect, test, operate and maintain the equipment, irrespective of, whether or not such documents are listed in this specification. The required documents to be provided shall include, but will not be limited to the following:

9.1 Drawings

9.1.1 Outline Drawings

The Contractor shall submit outline drawings of the equipment to be furnished under this Contract together with estimated weights, external, forces, anchoring details, and sufficient overall dimensions; to facilitate preparation of final designs of the structures into which the

equipment is to be incorporated.

Such drawings shall include but not be limited to the following:

- General arrangement drawings of the equipment (plan view, longitudinal and transverse sections).
- Cross-sectional drawing of the turbine and inlet valve showing general design and arrangement, outline dimensions, critical elevations and parts for identification.
- Drawings showing built-in parts (embedded in concrete) and other necessary data for dimensioning structures and for elaborating civil engineering drawings with the loads and stresses on floor and on structures.
- Control diagrams to illustrate the functioning of all principal component parts of the turbine, governor, inlet valve, pressure oil and lubrication systems.
- General drawings of the unit local control board and control cubicles of auxiliary equipment showing the location of various instruments and accessories.
- Outline drawings of pressure oil supply system, grease supply system (if any), cooling water system and drainage and de-watering system, with schematic diagrams and schematic diagrams of automatic control.

9.1.2 Detail Drawings

Before proceeding with manufacture of the equipment, the Contractor shall submit general assembly drawings, sufficient subassembly drawings, and details to demonstrate fully that all parts will conform to the provisions and intent of the Contract Documents and to the requirements of their installation, operation, and maintenance.

These drawings shall show all necessary dimensions, all field joints, location and sizes of auxiliary connections for oil, grease, water and air; and terminal boxes and wire sizes for electrical circuits.

Drawings will also include the material part numbers, tolerances clearances, surface machining symbols, heat treatment information, surface protection, material weight and other necessary information.

All field welds and connections shall be clearly marked on the drawings. Design criteria, calculations and detail specifications shall also be submitted with the drawings.

1) Turbine Detail Drawings

- General unit assembly drawings with generator,
- Assembly drawings (sections and plans) of the entire turbine,
- Complete and detailed plan views and section views for the whole supply, chiefly for:
 - Runner,
 - Shaft and shaft attachment to runner and generator shaft or flywheel respectively,
 - Combined bearing and bearing support,
 - Lubrication oil supply system,
 - Shaft seal,
 - Wicket gate operating mechanism including servomotor(s), operating rods,
 - Regulating ring, links and levers,
 - Wicket gate and wicket gate bearings and seals,
 - Spiral case, stay ring and stay vanes,
 - Head cover, bottom ring, discharge ring and wearing rings,
 - Inlet extension,
 - Unit breaking system.
- Civil work (foundation) drawings of all parts set into or coming in contact with concrete, showing method of supporting and method of anchoring into concrete,
- Detailed drawings of all parts embedded in concrete,
- Detailed drawings of all parts connecting to or related with equipment supplied by other manufacturers or to equipment furnished by the Employer,
- All details pertaining to every part subject to wear, or which is provided with adjustment,

- Location of detectors, gauges, limits switches, etc.

2) Speed Governor Detail Drawings

- General assembly of all governing equipment,
- Such sub-assemblies, cuts, illustrations, or drawings as are necessary to illustrate the functioning of the various parts of the governing system,
- Detail drawings of the unit local control board showing the location of the various instruments,
- Details of the mounting and dimensions of the individual instruments and apparatus,
- Principal control and wiring diagrams showing the operation principals and connections,
- Regulation scheme.

3) Inlet Valve Detail Drawings

- General assembly drawings with connection to penstock and spiral case,
- Assembly drawings (section and plans) of the inlet valve showing all parts number,
- Detailed drawings for the whole supply, chiefly for:
 - Valve body,
 - Valve disc and sealing arrangement,
 - Valve operating mechanism including servomotor(s), rods, links, levers, etc.
 - Valve trunnions,
 - Bearings and sealing,
 - Dismantling joint,
 - Upstream and downstream piping,
 - By-pass valve and piping,
- Civil work (foundation) drawings showing method of supporting and anchoring into concrete and operating forces including maximum loads on the foundation,
- Drawings showing locations of gauges, limit switches, etc.

4) Piping Wiring and Accessories

- Detail piping drawings for pressure oil system, grease supply system (if any), cooling water system, drainage and de-watering system with dimensions,
- Detail drawings of pressure oil system equipment including sump tank, pressure tank, oil pumps, piping, fittings and etc.
- Wiring diagrams.

9.2 Calculation Sheets

The following calculation sheets shall be submitted to the Employer together with the drawings for review and approval:

9.2.1 Turbine Calculation Sheets

- Turbine hydraulic characteristics,
- Calculation of maximum hydraulic pressure,
- Calculation of maximum momentary speed variation,
- Calculation of fly-wheel effect and closing time,
- Calculation of critical speed,
- Calculation of servomotor capacity, oil pump capacity and oil pressure tank capacity,
- Calculation of flow, pressure and head losses in the cooling water system,
- Detail hydraulic and mechanical design calculations of the turbine components,
- Calculation of hydraulic thrust.

9.2.2 Inlet Valves Calculations

- Inlet valve hydraulic Torque characteristics,
- Strength calculations of the body, disc, trunnions, servomotor(s), and other components,
- Calculation of servomotor capacity,
- Calculation of operating forces on the foundation,
- Opening and closing time calculations.

9.3 List of Drawings

The Contractor shall furnish a list of drawings and documents and the list of parts with their individual serial number and references

9.4 Test Programs and Reports

- The programs for shop and field tests including test and inspection sheets and specifications.
- The reports of all the shop tests including material certificates.
- The reports of all the field tests.

9.5 As-Built Drawings

After completion of the work under the contract the Contractor shall furnish to the Employer all drawings of structures and equipment as finally built, including any field changes.

9.6 Instructions

9.6.1 General

Upon completion of the design, the Contractor shall submit detailed installation, operating, and maintenance instructions for the equipment.

The instruction shall be submitted as early as possible so that final reviewed copies can be made available to the field for use in planning the work well in advance of actual installation and operation.

9.6.2 Installation Instructions

Detailed instructions for the installation of the equipment shall be submitted together with reduced size copies of applicable drawings showing the erection sequence. The instructions and drawings shall include information of handling and slinging the major pieces of equipment, erection tolerances, and special precautions to be taken in the installation.

9.6.3 Operating and Maintenance Instructions

Detailed operating and maintenance instructions, which shall include reduced-size copies of applicable drawings, applicable parts lists, and catalogues covering all equipment furnished and which may be needed or useful in operation, maintenance, repairs, dismantling or assembling, and for repair and identification of parts for ordering replacements, shall be submitted one month in advance from the starting of erection.

Detailed operating and maintenance instructions and circuit diagrams of all electronic parts on the level of components including measuring and test points shall be also submitted.

10. TECHNICAL DATA AND GUARANTEED CHARACTERISTICS

The Bidder shall submit the following information and data together with the Bid.

10.1 Turbines

1) Output, efficiency and turbine discharge

The Output and efficiency shall be guaranteed. The efficiency values shall be indicated with three figures, the fourth figure will be disregarded.

Net Head

(m)

Turbine Output

(%)

100

80

60

40

Best Efficiency Point

Maximum Head

Turbine Output (kW)

Efficiency (%)

Turbine Discharge (m³/s)

Normal Head

Turbine Output (kW)

Efficiency (%)

Turbine Discharge (m³/s)

Minimum Head

Turbine Output (kW)

Efficiency (%)

Turbine Discharge (m³/s)

Weighted Average Efficiency

2) Expected performance curves

The Bidder shall furnish the curves showing efficiencies, output and discharge of the turbine from 40% to 100% of full rated power output for maximum, normal and minimum net heads.

3) Direction of rotation (viewed from Generator side)

4) Rated speed rpm

5) Maximum Runaway speed (guaranteed) rpm

6) Turbine discharge at runaway m³/s

7) Specific speed m-kW

8) Maximum speed rise %

9) Maximum pressure rise %

10) Moment of Inertia (GD₂) (guaranteed) ton-m²

11) Wicket gate closing time s

Wicket gate opening time s

12) Combined Bearing

- Type

- Type of self lubrication ring

- Bearing Temperature (guaranteed) °C

13) External oil supply unit for bearings

-Oil pumps for lubrication

Number

Type

Discharge

-Lubrication oil for bearing

Quantity required l/min.

Brand and grade to be recommended

-Required cooling water for bearings

Quantity required l/min.

Head m

14) Maximum axial hydraulic thrust load on runner kg

15) Wicket Gate Servomotor

-Volume (one servomotor) l

-Dynamic capacity kgf

-Minimum operating oil pressure bar

-Opening force kgf

-Closing force kgf

16) Shaft seal

-Type

-Filtered water flow for cooling (if any) l/s

-Leakage (guaranteed)

17) Wicket gates

-Number of wicket gates per unit pcs.

-Lubrication type of wicket gate bearing

-Leakage (guaranteed)

18) Runner

-Number of runner blades pcs.

-Clearance between runner crown and head cover mm

-Clearance between runner skirt and discharge ring mm

19) Spiral Case

-Number of stay vanes pcs.

-Volume of spiral casing m³

20) Draft Tube

-Mean water velocity at the outlet of draft tube at maximum discharge m/s

21) Weight of Turbine ton

10.2 Inlet Valve

1) Inlet valve

-Manufacturer

-Valve type

-Nominal diameter mm

-Length of valve (flange to flange) mm

-Disc type

-Head loss at maximum discharge (guaranteed) m

-Clear flow section m²

- Maximum leakage through closed valve l/min. (under maximum static head)
- 2) Bypass valve
 - Manufacturer
 - Type
 - Diameter mm
- 3) Operation times
 - Inlet valve
 - Opening time s
 - Closing time s
 - By-pass valve
 - Opening time s
 - Closing time s
- 4) Time required fill-up the spiral case and its extension through the by-pass valve
- 5) Oil pressure
 - Normal operating pressure bar
 - Minimum oil pressure required to open the valve under maximum head bar
 - Maximum force acting on servomotor base ton
- 6) Valve trunnion bearing
 - Bearing pressure bar
 - Method of lubrication
- 7) Servomotor
 - Number ea.
 - Oil quantity l
 - Dynamic capacity kgf-m
 - Opening force under maximum static head kgf
- 8) Weight of Valve ton

10.3 Speed Governor

- 1) Manufacturer
- 2) Type
- 3) Power supply
- 4) Operating Characteristics
 - Range of permanent speed drop %
 - Temporary speed drop %
 - Range of speed change %
 - Maximum power oscillation under parallel operation condition as a percentage of rated output %
 - Maximum dead band, or sensitivity, at any gate opening in percent of rated speed %

- Maximum dead time for a sudden load change S.
- Total opening time of wicket gates S.
- Total closing time of wicket gates S.
- 5) Maximum over speed at:
 - 100% load rejection (guaranteed) %
 - 75% load rejection %
 - 50% load rejection %
 - 25% load rejection %
- 6) Speed Signal Device
 - Manufacturer and type

10.4 Pressure Oil Supply System

- 1) Oil Pumps
 - Manufacturer and type
 - Number of oil pumps
 - Delivery pressure bar
 - Delivery rate l/s
- 2) Induction Motor
 - Manufacturer and type
 - Rated output kW
 - Speed rpm
- 3) Hydraulic Accumulator
 - Manufacturer and type
 - Total volume l
- 4) Oil Pressure bar
- 5) Oil Sump Tank
 - Manufacturer
 - Total volume l
 - Effective capacity l
 - Required cooling water l/min.

10.5 Cooling Water System

- 1) Strainers
 - Manufacturer and type
 - Capacity m³/h
- 2) Motor-Operated Valve
 - Manufacturer and type
 - Number of valves
- 3) Water Flow Relay
 - Manufacturer and type

10.6 Items to be specified and submitted by the Bidder

- a) Detailed description of type and construction of the proposed equipment.
- b) Description of assembly and disassembly method of the equipment (including drawings).
- c) Explanation of water and oil leakage prevention and leakage drain method from sealing box, turbine bearing and governor oil supply system.
- d) Drawings to be submitted with the Bid:
 - General arrangement drawings showing plan and sectional views,
 - Outline drawings of the equipment with dimensions,
 - Drawings showing methods of shaft couplings
 - Schematic hydraulic governing diagram of the proposed system;
 - Schematic control diagram.
 - Schematic drawings of cooling water and drainage system,
- e) Calculation sheets to be submitted with the Bid:
 - Calculation of maximum hydraulic pressure,
 - Calculation of maximum momentary speed variation,
 - Calculation of fly-wheel effect required by the turbine,
 - Calculation of wicket gate and inlet valve servomotor(s) capacities,
 - Calculation of runaway speed.
 - Calculation of foundation forces,
 - Calculation of oil pumps, oil tanks and hydraulic accumulator capacities.

D2 – Specifications of AC Generator and Excitation System

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D2 – Specifications of AC Generator and Excitation System

1. GENERAL

1.1 Scope of Work

The work to be performed under this contract consists of furnishing all the material and performing all the work of synchronous generators in Saniveri Utterganga Mini HPP as specified herein.

The Contractor shall design, supply, manufacture, install and test all items of equipment as defined in these specifications. The equipment including all machinery, tools, accessories and spare parts shall be of first class quality, free of all manufacturing defects or imperfections and shall be in accordance with the requirements of bid documents. The supply shall also include all the accessories required for the erection, dismantling, inspection and maintenance of the equipment such as tools, ladders, slings, lifting beams, gangways, etc. also any accessories and instrumentation required for the tests, with the exception specified in the specifications. Initial filling of oil and grease shall be included in the supply.

All works, material and services, though not expressly called for in these specifications but necessary for the complete and proper operation of the supplied equipment will be deemed included in the present contract.

1.2 General Service Conditions

This section describes the general service conditions applicable to all and any equipment intended for the Saniveri Utterganga Mini HPP Generator units and the related electrical equipment. Particulars as to operating conditions are given in the technical part of the specification for the equipment considered.

1.2.1 Project Description

a) General

The powerhouse is designed for two (2) horizontal Francis turbines each 590 kW operating under a gross head of 50 m at full flow of 2.4 m³/s (2 Units). The generators will have a rated capacity of 650 kVA. The generated energy will be evacuated through 11 kV overhead Transmission Line of 91.94 km and distributed locally at different village of Putha Utterganga Rural Municipality at voltage level of 0.4/0.22kV via distribution transformer. The power is generated at 0.4kV.

b) Hydraulic Turbines

Type: Horizontal Shaft Francis Turbine

Number: Two (2) sets

Rated head (net): 51.7 m (as calculated)

Output at normal head: 590 kW

Discharge at normal head: 1.2 m³/s

Rated speed: 750 rpm

c) Generators

Type: Horizontal shaft, air cooled, three phase AC synchronous generator

Number: Two (2) sets, Operating duty: Continuous overload of 10%

Rated Capacity: 650 kVA, Voltage: 0.4 kV

Power factor: 0.80 (lag), Frequency: 50 Hz

Rated speed: 750 rpm

Excitation: Brushless excitation

Insulation Class (stator/rotor): F/F

1.2.2 Control Power Source

The power to be used for control shall be 110 V DC and shall be supplied by power plant stationary batteries. The voltage may vary within the range +10 % and –15 %.

1.2.3 Station Service

The service power for use within the plant shall be supplied with 3-phase, 4-wire, 50 Hz, 380/220 V AC. The terminal voltage of auxiliary equipment shall be 380 V and 220 V for 3- ϕ and 1- ϕ respectively.

1.2.4 Service Conditions

All the equipment shall be designed and manufactured for satisfactory operation at an ambient temperature 55°C and -5°C.

1.3 Design, Materials and Workmanship

1.3.1 Design and Workmanship

All work shall be performed in accordance with the most advanced practice in engineering for each class of equipment and completed in a thorough workmanlike manner following the best modern practice in the manufacture of high grade equipment. All work shall be performed by mechanics skilled in their various trades.

Machining of renewable parts shall be accurate and to specific dimensions so that replacements made to drawing size may be readily installed. Like parts and spare parts shall be interchangeable.

The International Metric System of measurement shall be used for all work under the Contract and all units of measurement shall be expressed in that system.

1.3.2 Standards

Except as provided in the specifications, all materials, equipment, and fabrication and testing thereof shall conform to the latest applicable standards contained in the following list.

International Electromechanical Commission (IEC)

American Society for Testing and Materials (ASTM)

American Welding Society (AWS)

American Society of Mechanical Engineers (ASME)

National Electrical Manufacturers' Association (NEMA)

Deutsche Industries Normen (DIN)

It shall be understood that the latest revision or edition in effect at the time of the tender call shall apply. If it is desired to use equivalent standards or to deviate from the above-cited standards, a corresponding application together with one copy of the respective standards shall be submitted to the Employer for approval.

Machine work tolerances and allowances for the limiting sizes of mating parts for any class of metal fit shall be in accordance with ISO "system for limits and fit" or with the American Standards for "Tolerances, Allowances, and Gauges for Metal Fits".

The product must be from the following reputed brands (ANDRITZ or VOITH or GEPPERT or FLOVEL or BHEL or EFG Turbien, CINK or Schimmer)

1.3.3 Materials

All materials used in the manufacture of the equipment supplied shall be selected as the best available for the purpose for which it is used, considering strength, resilience, durability and

other physical properties, as well as best engineering practice. They shall be new and of first class commercial quality, and free from defects and imperfections.

All materials, supplies and articles not manufactured by the Contractor shall be the products of recognized reputable manufacturers.

The material contemplated for incorporation in the equipment together with performance characteristics and other significant information pertaining to the materials shall be furnished to the Employer for approval. Materials installed or used without such approval shall be at the risk of subsequent rejection.

Material tests shall be conducted at the manufacturer's premises or at other places agreeable to the Employer, in accordance with the requirements of the ASTM-Standards or other agreed standards. The results of these tests shall be in such a form as to provide a means of determining compliance with the applicable specifications for the material tested.

Where the Contractor desires to use stock material not manufactured specifically for the works, satisfactory evidence that such material conforms to the requirements stated in the Contract shall be furnished to the Employer, in which case tests on these materials may be waived.

The Contractor shall be responsible for the standardization of all small mechanical and electrical equipment, materials and device for the works. He shall arrange and perform the necessary coordination work with his subcontractors for the purpose of such standardization, such equipment, devices, fittings, etc. shall comprise but not necessarily be restricted to the following:

- Valves
- Gauges
- Electrical instruments and meters
- Terminals and terminal blocks
- Primary, secondary and auxiliary relaying devices
- Contactors, fuses, miniature breakers and the like
- Control devices and control switches
- Lamps, bulbs, sockets, plugs, etc.
- Lubricants

1.3.4 Welding

a) Operation for Welding

Members and sections to be joined by welding shall be cut accurately to size, with their edges sheared, flame-cut or machined to suit the required type of welding and to allow full penetration.

The surfaces of members or sections to be welded shall be free from rust, grease and other foreign matters for a distance of at least 50 mm back from the edge of weld.

b) Welding Procedure

All welding shall be performed by the electric-arc method, by a process at least equal to that required by the latest edition of the "standard qualification procedure" of the American Welding Society, or the corresponding DIN Standards.

c) Qualification of Welders

The Contractor shall be responsible for the quality of the work performed by his welding organization. All welders and welding operators assigned to the work shall have passed a performance qualification test for welding operators at least equal to that specified in the latest edition of the "Standards Qualification Procedure" of the American Welding Society (or DIN 8560 and 8563). All expenses in connection with making the qualification tests for welding operators shall be borne by the Contractor. Operators welding certificates shall be furnished to the Employer, if requested by him.

d) **Welding Equipment**

All welding equipment, such as welding machines, transformers, cables, electrodes, etc. for welding at the Site shall be of reputable make and suitable for the purpose intended for.

Consumable material (electrodes etc.) shall be included in the price. Other materials and tools shall remain the property of the Contractor.

1.3.5 Bolts, Studs, Nuts and Screws

They shall have standard threads and be of high quality steel. All bolts, studs, nuts and screws (including their washers) shall be well protected against corrosion according to the site of their installation. Nuts and bolts heads shall be hexagonal in shape and truly faced. Nuts, bolts and screws which might become loose during operation shall be locked in fastened position by means approved by the Employer.

1.3.6 Pipes, Flanges and Joints

All piping, flanges and joints shall be designed for the highest pressure occurring in the respective system in service, including water-hammer where appropriate.

All piping under internal pressure exceeding 16 bar, whether water or oil, shall be seamless. Piping of 50 mm inside diameter and over shall be of steel unless otherwise specified.

All bends, tees and other fittings for steel piping shall be of steel.

All coupling and joining together of pipes, fittings and valves of 50 mm inside diameter and over shall, if not otherwise specified, be by means of flanged joints. All flanges shall be cutter-bossed or faced at their back so that bolt-heads, washers and nuts will be bed down appropriately, Site welding of flanges shall be subject to the approval of the Employer. Piping under 50 mm inside diameter may be joined together with threaded socket-fittings or approved vise-couplings.

All pipes shall be of uniform thickness, and the dimensions and drilling of the flanges shall, wherever applicable, be in accordance with the USA Standard B 16.5.

All flanged joints shall be made with jointing material being perfectly suitable for the size of flanges and operating conditions.

The jointing material shall be so proportioned that when the joint is tightened-up no part of the jointing ring protrudes into the pipe bore.

All pipes, before the joints are bolted together, shall be placed on or hung from their respective supports and lined-up so that the joints are in parallel. In making joints no springing of pipes into position shall be allowed, except where specifically approved for the purpose of relieving strains due to expansion.

All oil pipes shall be thoroughly cleaned and fitted with temporary blank flanges or plugs before being packed and dispatched.

All brackets, stays, frames, hangers and supports for carrying and steadying the pipes, including their fastenings, shall be included in the supply and completed by the Contractor at the Site. Pipes and fittings shall be supported at or near a flange wherever possible.

The supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others.

Large size piping crossing ceilings and supporting walls shall be provided with welded-on anchor collars for embedding in the concrete.

All piping carrying water shall be protected externally against sweating (condensation) by means of an approved anti-condensation wrapping or sheathing.

1.3.7 Valves

All valves over 50 mm bearing pressure exceeding 16 bar shall be of forged or cast steel. Valves for such pressures but of 50 mm bore or less may be of bronze. Valves for water over 50 mm bore shall be of the external rising spindle type. Valves for oil shall be of the non-rising spindle type.

All valves shall have screw able wearing parts of corrosion-resistant materials. Their seals and sheets shall be of ample proportions and of suitable materials to ensure that galling or overloading will not occur in any service condition including partial opening.

Isolating valves shall be suitable for opening and closing against full unbalanced pressure, including closure against free discharge. If necessary, by-passes are to be provided to meet these requirements.

All valves shall be provided with hand-wheels of ample size and, where necessary, extended spindles and/or gearing so that any valve may be easily and conveniently operated by one man under any service condition.

All valves shall close with a clockwise rotation of the hand-wheel which shall be marked to show the direction of closing.

Large size valves shall be provided with means for pad locking in any position.

All brackets, stays, frames, supports and hangers necessary for carrying and steadying valves shall be included in the supply and completed at the Site.

1.3.8 Electrical Equipment

- a) All the equipment shall be new, durable to withstand long time use, and shall satisfy all requirements which a complete product shall generally meet even if such are not expressly provided in the Specifications.
- b) All the equipment shall be of a convenient construction for disassembling inspection and erection.
- c) Induction motors shall be of the direct line starting-drip-proof type, and when operated, shall not develop trouble under the voltage fluctuation of $\pm 10\%$. Neither shall it show any trouble at the rise of voltage and frequency of power source, of 30% and 35% respectively, resulting from the full load rejection of the turbine generator.
- d) Magnetic contactors used in various switches shall be made of arc resistant metal and have a sufficient capacity against rush current, and the contact part shall be free from over-wearing and misconduct for a long period of service.
- e) Electrical contacts of dial type thermometers, thermal relays, oil level relays, etc. shall be able to safely break the current determined with the condition of control circuit connected to these contacts at any considerable power source condition.
- f) Conductors shall not be joined by soldering except for inevitable position.
- g) The Contractor shall furnish installation materials as specified.
- h) Cubicles and control boards shall be provided with a fluorescent light inside (220 V AC, 20 W, 50 Hz) for interior lighting and shall be provided with door switch. The cubicle and control box for the auxiliary equipment shall be provided with a moisture preventing heater (220 V AC, 50 Hz) with a switch and thermostat.
- i) The bushings and insulators used in the equipment shall have sufficient mechanical and electrical strength.
- j) Miscellaneous electrical work including wiring, conduit connections, plugs, etc. shall conform to the safety codes of IEC. All electrical wiring inside an element of the supply shall be furnished. All control and small section wiring and conduit for each component shall be brought to junction boxes or cabinet. Wiring shall terminate in molded type terminal blocks with terminal marking strips. Terminal blocks shall be easily accessible and suitably placed in the near surrounding of the supply. Conduit shall be galvanized,

rigid steel with threaded ends. Fittings shall be galvanized with threaded hubs and gasketed cover for tightness. Flexible conduit may be used where necessary for vibration or flexibility purposes; they should be tight with appropriate fittings.

- k) Two (2) phase AC wiring shall be color coded according to the used standards.
They shall be uniformed throughout the power-station.
- l) The contact surfaces (both male and female) for the transistor sheet (printed card) shall be considered where necessary.
- m) The ground terminal of the equipment shall be of the bolt-fastened type, suitable for minimum 50 mm² (equipment in the powerhouse) and 70 mm² (high voltage equipment in the powerhouse) hard drawn copper stranded conductor or equivalent.
- n) Low voltage power cable shall be stranded copper conductor, thermoplastic insulation with thermoplastic jacket overall, maximum ambient temperature 40°C. Low voltage control cable shall be dielectric strength: 2,000 V, copper conductors, thermoplastic insulation, with thermoplastic jacket overall maximum ambient temperature 40°C (if necessary flameproof and/or screened). The control cables shall have minimum section of 1.5 mm².

1.3.9 Name Plates

All major equipment shall be provided with a securely fastened nameplate showing the maker's name, model, serial number, year of manufacture, main characteristics data of the respective equipment and further relevant information specified in the applicable standards or necessary for the proper identification of the equipment involved.

The Contractor shall supply and install also all label plates and other labeling (of the screw type) on control boards, control desks, panels and other places where required for operational, functional and safety reasons.

The labeling, size of the plates and their location shall be subject to approval of the Employer. A sample label-plate (with indication of the material used) with lettering shall be submitted for this purpose. The number of sizes of the plates shall be minimum. The name plates shall be in English.

1.3.10 Corrosion Protection and Painting

a) General

The supply shall include the surface treatment, priming, corrosion protection and painting of the equipment furnished. Such work shall comprise the workshop -and at the Site coating up to and including the finish painting. Unless otherwise specified the coating and painting shall be carried out in accordance with the latest edition of DIN 55928 (Protective Coatings for Steel Structures Direction) ASTM Standards A 153, A 386, A 123 and A 120 or another equivalent approved standard.

All priming and painting material shall satisfactorily fulfill the requirements imposed by the Site conditions, as well as the stresses, to which the respective equipment is subjected during its operation. At the request of the Employer, painting samples for the different coats and colors shall be provided.

All furnished surfaces shall present a neat, pleasing appearance.

Each coat of primer and painting shall be compatible with the previous and subsequent coats. All pigmented primers and paints which will be used for priming and painting at the Site shall be delivered in sealed containers packed by the manufacturer.

The Contractor shall supply full details regarding the extent which sand-blasting, priming and painting will be carried out in his workshop (or his sub-contractor's, as the case may be) at the Site and after erection. A properly equipped paint-shop shall be set up at the Site using a specialist organization, experienced and skilled in the preparation and application of protective coatings at the conditions prevailing at the Site. Materials shall

be thoroughly mixed at the time of application.

It is essential that before any primer and coat of paint is applied, the surfaces are properly prepared. Such preparation shall include any cleaning, smoothing, drying and similar operation that may be required to ensure that the primer and/or paint is applied on suitable surfaces. Clean cloths and clean fluids shall be used to avoid having film or greasy residue on the surfaces being cleaned.

Each coat shall be free from runs, drops, pinholes, waves, laps, sags and unnecessary brush marks, and shall be allowed to dry or to harden before the following coat is applied.

Machinery-paint maybe thinned, if necessary, to permit satisfactorily application but the amount of thinner shall be kept to a minimum.

For removing rust and mill scale from structural steel, plate, sheet, piping and other steel surfaces, as well as from other parts suitable for blast-cleaning, sand-blasting shall amount to approximately 50 microns.

Parts which cannot be blast-cleaned shall be cleaned free from rust and scale by power-tool cleaning to the highest possible degree, according to the above standards or equivalent approved standards.

Blast-cleaned surfaces shall receive a quick-drying shop-coating immediately after blast cleaning. Hand or power-tool-cleaned parts shall be treated likewise immediately after cleaning.

All structural steel and pipes carrying water shall if provided for galvanizing-be heavily galvanized by the hot-deep process. Galvanizing shall be carried out in accordance with the ASTM Standards A 153, A 123 or VDE - Standard 0 210 and original blast-furnace raw zinc only shall be apply (ASTM 8.6). The thickness of the galvanizing coating shall be approx. 70 microns.

b) External Surfaces

All unfinished external surfaces of the equipment and related accessories shall be thoroughly sand-blasted until a clean metal surface has been obtained and then immediately after coating with at least 1 coat of priming two pack zinc rich epoxy primer and 1 coat two pack micaceous iron oxide epoxy paint as intermediate. Final coating shall be with 2 finishing coat of paint on high quality polyurethane basis. The total thickness of the 4 layers shall be min. 0.18 mm.

c) Embedded Surfaces

All such surfaces shall be protected by an application of cement mill added with bichromat of potassium. Surfaces in transition zones of the concrete to the external surfaces shall be threaded and painted in a similar way as stipulated above for external surface over width of approx. 300 mm.

d) Surfaces in Contact with Water

Surfaces of water passages, including the turbine runner, wicket gates, stay vanes and exposed parts, not of nonferrous, stainless steel or special noncorrosive material, shall be thoroughly sand-blasted and carefully cleaned from rust, film, scale and/or other impurities until a clean metal surface has been obtained. Porous areas, flaws, inclusions of sand, etc. shall be chipped or ground until sound metal has been reached. Repair and reconditioning of such areas shall then be carried out by electric welding with electrodes corresponding to the base material. All surfaces shall then be coated immediately with 2 coats of priming paint of two pack high zinc pigmented epoxy primer (thickness of the 2 layers 0.12 mm).

Prior to the application of 2 finishing coats on two pack epoxy coal tar basis, careful elimination of remainders of oil and grease from all surfaces by means of a diluents agent of turpentine substitute, and retouching of possibly damaged areas is required. The total thickness of the 4 layers shall be min. 0.320 mm.

e) Parts of Finished Surfaces to be Left Bright in Service

Same shall be protected against corrosion with one heavy coat of readily removable anticorrosive varnish.

f) Surfaces Wetted by Oil

Same shall be treated and painted as stipulated for surfaces in contact with water, except that for the 2 final coats, oil-resistant varnish shall be used. The primer shall be applied before the tightness test and the second coat be applied after assembly.

g) Pipe Work

1) Water carrying pipes

Pipes, valves and fittings, except for parts to be embedded in concrete, shall be shop-coated with priming paint. Interior surfaces shall be treated with coal tar. Exterior surfaces to be primed with one (1) layer of two (2) pack zinc rich epoxy primer. Two (2) finishing coats shall be applied at site. The paint needed for two (2) finishing coats shall be furnished together with the equipment. The total thickness of the 3 layers shall be 0.18 mm.

2) Oil Carrying Pipes

Careful cleaning of the external and pickling of the internal surfaces shall be required. External surfaces to be primed with one (1) layer two packed zinc rich epoxy primer basis, followed by two (2) finishing coats on polyurethane basis. The total thickness of the three (3) layers shall be 0.18 mm.

h) Control Boards, Panel Boards, Cubicles, Cabinets, etc.

Careful cleaning, if possible sand-blasting, two (2) coats of oil-resistant paint shall be required. Interior surfaces shall have at least one (1) priming and one (1) finishing coat of anti-corrosion paint. Exterior surfaces shall be adequately treated to be substantially corrosion-resistant with one prime coat, one filler coat and two finishing coats. Control cabinet shall be coated with non-glossy paint.

i) Chains, Rope, etc.

These shall be fully galvanized.

j) Linings, Cover Plates, Supports, Handrails, etc.

Similar treatment and painting as specified above for "surfaces in contact with water" and "Embedded surfaces".

k) Checks

The work of anti-corrosion protection will be checked by the Employer. The check work will include:

- Check of the cleanliness of the cleaned surfaces.
- Check of the thickness and adhesion of zinc and paint coatings.
- Check of quality of the materials applied.

The thickness of the zinc and paint coatings shall be checked at about ten (10) check points per square meter. For the acceptance, the guaranteed thickness of the coating shall be decisive and not the number of coats applied.

l) Execution of the Work

In principle the painting work shall be executed in the Contractor's shops except for the finishing coats. The priming coats and the first finishing coat respectively shall always be applied by means of a painting brush in order to obtain better adhesion.

Paintwork damaged during shipment, storage and/or erection shall be properly restored by the Contractor after thorough removal of the damaged coating. The repair coating and

painting shall be carried out as per the above Specifications and reach the minimum dry film thickness stipulated.

When executing the paint work the air humidity shall not exceed 60 % at the working place, and all necessary fans, air heaters, ventilation ducts and dust absorbers shall be provided by the Contractor.

The Contractor shall furnish a suitable quantity of each priming and finishing paint for touch-up work at the Site, after the end of the guarantee period.

m) Repair of Defects

The Contractor shall carefully repair all defects occurring to the surface protection during the guarantee period (cleaning of defective parts by sand-blasting if necessary, reapplication of the different protective coatings).

Special care shall be given to transition zones where new and original coatings come together. Should the defect be one for which the Contractor is liable, all related repair cost shall be borne by the Contractor.

n) Shades

The shades of the finishing coats, as well as the color code to which they shall correspond shall be settled after the award of contract.

1.4 Packing

All the equipment shall be carefully packed so as to withstand the long time transport by sea and land. The electrical equipment shall be completely protected against moisture.

The finished surface of the equipment and the portion embedded in concrete shall be protected by rust preventive means.

The spare parts shall be packed and crated firmly enough to withstand storage for a long time, and those in need of rust preventive treatment shall be so treated.

The spare parts shall be packed separately from other articles. Packages of spare parts shall carry notation which clearly indicates that the contents are spare parts and shall be accompanied by a list of contents which sets for the directions for storing.

1.5 Color Code for Cabling, Piping and Electrical/Mechanical Equipment

1. Cabling

Power and control cables

(a) 3-phase AC power cables

Phase 1-yellow

Phase 2-blue

Phase 3-red

Neutral-black

(b) DC power cables

Positive lead-red

Negative lead-black

(c) Control cables and wires

All control cables and wires are black with the code numbers at both ends.

(d) Protection wire yellow-green.

2. Piping and Electrical/Mechanical Equipment

Not only to paint the pipes and ducts but also to paint the relevant equipment such as

tanks, pumps, valves etc. Color according to System RAL norm

a) Fire fighting system (red) 3000

Including but not limited to fire extinguishers, cabinets, fire water tank and pumps, pipes, etc.

b) Oil pressure

Including but not limited to sump tank, pressure tanks, pumps, valves, pipes

Oil pressure (yellow) 1018

Oil drainage (brown) 1011

c) Water treatment and water distribution system

Including but not limited to water tanks, pumps, filters, boilers, valves, pipes for industrial water (green) 6017 for domestic cold water (blue) 5007 for domestic hot water (red) 3022 for cooling water (green) 6016 used water (drain and sewage) (gray) 7032

d) Heating and ventilation (white) 9010

Including but not limited to AC units, chillers, pipes for cooling water, chilled water, freon, pneumatic regulation etc.

e) Fuel system (orange) 2003

Including but not limited to diesel oil tanks, pumps, valves, pipes etc.

f) Emergency diesel generator (orange) 2002

g) Turbine inlet valves, penstock within (green) 6016 the building and connection to the hydraulic unit.

Including but not limited to valves etc.

h) Turbine/generator unit (blue) 5014 horizontal axis type

The unit shall be painted in two different colors according to the distinction between electrical part and water part

i) Plant control, monitoring and (shaded white) 1013 instrumentation equipment

Including but not limited to distribution panels, control boards, supervision consoles etc.

j) Cranes

Including Crane Bridge, travelling cab, operator's cabin, cladding, control panels etc. except hook (yellow) 1021, hook is striped (black/yellow) 1021

2. MAIN GENERATORS

2.1 Scope of Work

2.1.1 General

These specifications cover the design, manufacture, testing at the factory, transportation from factory to site, storage, erection, testing and commissioning, putting in successful operation and guarantee of two (2), 50 Hz, 650 kVA generators each to be driven by horizontal shaft Francis type hydraulic turbines all as specified in this specification.

2.1.2 Extent of Supply

The equipment to be furnished and installed shall include, two (2) generators complete with all parts and each including mainly:

a. Stator with frame laminations, bearings, sole plates, windings, etc.

- b. Rotor with poles, windings and damper windings.
- c. Combined Thrust and Guide Bearing or lithium-base grease lubricating antifriction bearing/oil lubricated sleeve bearing as per Manufacturer's design.
- d. Cooling water system for generator bearing lubricating oil system heat exchangers and shaft sleeve (if applicable).
- e. All windings, internal wiring and connections main and auxiliary terminals, terminal boxes, etc.
- f. All necessary anchorage's and handling accessories.
- g. Covering plates for holes and under floor ducts.
- h. Oil injection AC and DC pumps, automatic change-over, control device, air/oil accumulator, piping valves, etc for generator bearing lubrication system (if applicable).
- i. Brakes blocking device piping and accessories.
- j. Space heaters.
- k. Measuring devices and instrumentation as specified in the specification.
- l. All accessories and fittings for appropriate operation of the units.

Turbine manufactures will recommend the type of coupling to be used, either rigid or flexible although a flexible coupling that can tolerate certain misalignment is usually recommended.

2.1.3 Type and Rating

The generator shall be of the horizontal shaft, driven by a horizontal Francis type turbine, alternating current, synchronous type, salient-pole rotating field with brush less excitation and shall conform to the applicable standards as regards to rating, characteristics, tests, etc., unless otherwise specified herein. The rating of the generator shall be as follows:

Number Two (2) units

Operating duty Continuous overload of 10%

Rated capacity 650 kVA

Rated voltage 0.4 kV $\pm$ 10 %

Number of phases three (3)

Rated Power factor, lagging 0.80

Frequency 50 Hz

Rated speed 600 rpm

Direction of rotation counter-clock wise when viewed coupling side

Prime mover horizontally coupled to the Francis type hydraulic turbine

Excitation Brushless excitation

Short Circuit Ratio (SCR) 0.75 (Minimum)

Insulation class/Temperature rise F/B

Table 3: Technical Particulars of Generator

SN	Particulars	Rating and Quantity
1.	Type	Synchronous Generators with brushless excitation

SN	Particulars	Rating and Quantity
2.	Number of unit	Two (2)
3.	Output in kVA	650 kVA
4.	Continuous overload	10%
5.	Rated Voltage	0.4 kV
6.	Rated power factor	$\cos \phi = 0.80$ (lag)
7.	Rated frequency	50 Hz
8.	Rated speed	750 RPM
9.	Runaway speed	1500 RPM (Not exceeding 2 times rated speed)
10.	Moment of inertia	Natural (Preferred) or separately flywheel
11.	Insulation Class	Class 'F'
12.	Form of Protection	IP 23
13.	Incoming cooling water max. temperature	40°C
14.	Rise in temperature over cooling water/air at rated output	Stator Class B Temperature rise Rotor Class B Temperature rise
15.	Type of duty	Continuous
16.	Type of control	Manual / Auto
17.	Temperature rise limit of generator under rated output operating condition	Class 'B' insulation temperature rise limit of generator at rated output
18.	Range of voltage variation between phases for rated output	$\pm 20\%$
19.	Range of frequency variation	$\pm 5\%$
20.	Stator winding connection	Three (3) phase Y connected neutral brought out
21.	Short circuit ratio	0.75 Minimum
22.	First critical speed	Maximum Runaway Speed 1,200

SN	Particulars	Rating and Quantity
23.	Cooling	Self ventilated type through rotor mounted fans
24.	Excitation	Brushless
25.	Design conformation	Tropical temperature of 45°C
26.	External cable	For 1.1 kV; 3 x 1 CORE, XLPE copper for 1.1 kV
27.	Shaft orientation	Horizontal
28.	Direction of rotation	Clockwise when viewed from the generator side
29.	Standards applicable	IEC 34-1, IEC 34-2, IS-4722, IS – 4889, IS – 4029, IS-325, IS-1271, IS-4729, IS-4691
30.	Sound emission	< 90 dB (A)

2.1.4 Design Particulars

The generators shall be designed in accordance with the best modern practice with safety factors and shall be suitable for operation under abnormal conditions. Insulation shall be designed for long life with due consideration being given to the expansion of the coils under the varying conditions of operation.

Each generator shall be designed to assume its complete and proper coordination and satisfactory operation with associated turbine. It shall be connected electrically to common busbar of 0.4 kV as shown in the single line diagram.

Each generator will be able to withstand earthquake accelerations of 0.20 g horizontally. Generators will be capable of operating continuously at a overload capacity of 10 % of the rated load and $\cos\phi = 0.8$ without any trouble.

2.1.5 Voltage and Harmonics

It shall be capable of delivering the full rated kVA at rated power factor and frequency through a range of $\pm 10\%$ the rated voltage of 0.4 kV in balanced phase distribution.

The telephone harmonic factor of the line-to-line voltage as specified in the IEC Publication 34-1A shall not exceed 1.5%.

2.1.6 Temperature Rise

Generators shall be capable of operating continuously at rated load, rated voltage $\pm 10\%$, rated power factor and frequency with the temperature rise of the stator windings not exceeding 80°C (embedded temperature detector method) and of the rotor windings not exceeding 90°C (resistance method) with cooling air entering the generator at not more than 40°C.

The temperature of the stator windings shall be determined by means of embedded resistance type temperature detectors located in the stator windings. The temperature of the rotor windings shall be determined by the resistance method.

The temperature of the thrust bearing shall not exceed 75°C when the temperature of cooling water is 25°C.

Each generator shall be capable of delivering rated output continuously at any voltage and

frequency in the operating range at rated power factor without exceeding the following values of temperature rise over cooled air temperature not exceeding 40°C and cooling water temperature not exceeding 30°C as per IS: 4722 or equivalent International Standard.

- a) Stator winding - Class F temperature rise
- b) Rotor winding - Class F temperature rise

Even though insulation of Class F is specified and must be used, the generator temperature shall not exceed the limits specified for Class B insulation temperature rise limit when the generator is operating continuously at rated output and maximum continuous output of 110% and at any working voltages and any frequency range specified.

2.1.7 Speed Rise and Runaway Speed

Generators shall be designed to withstand without damage and without excessive vibration, every stress and wear caused by the maximum runaway speed of the turbine at the maximum operating head with wicket gates fully open. No dangerous over heating of the bearing will be permitted under these conditions. The maximum stresses in generator rotating parts at runaway speed shall not exceed 2/3 of the yield strength of the material used. Computations showing the maximum stresses shall be furnished to the Employer within three months after the Contract Award, certifying that the above requirement has been satisfied.

The first critical speed of the combined turbine generator unit shall be at least 30% higher than runaway speed.

2.1.8 Noise Level

The noise level shall not exceed 90 dB when measured at a distance of 1.0 m from any component of the generator. Any vibration caused by the machine should not be in resonance with any part of the equipment delivered. The frequency band shall be indicated by the manufacturer and high vent noise shall be avoided.

2.1.9 Flywheel Effect

The flywheel effect (GD^2) of the revolving parts of the unit shall be determined by Generator and Turbine Contractors. However, considering the design condition, if necessary, a flywheel shall be installed on the turbine shaft between the turbine and generator.

The flywheel shall be made of integral steel casting construction and designed and manufactured to safely withstand runaway condition stresses.

The flywheel could be also used as the brake ring when the breakers are put into operation.

The flywheel shall be covered with an approved guard fabricated from welded plate and structural steel.

2.1.10 Insulation

The insulation of the generator stator and rotor windings and all connections, parallel connection rings, main and neutral leads shall be such as to prevent injury from permanent exposure to humidity, to provide adequate corona shielding, to withstand temperature rises without injury and to prevent the entering of magnetic particles. The electrical, mechanical and chemical properties of the insulation shall have a long life under frequent and wide variations of load and temperature.

Dielectric strength of the windings shall be in accordance with IEC Publication 34-1.

2.1.11 Efficiency and Losses

The guaranteed efficiency shall be stated by the Contractor for each unit operating at p.f. 1.0, 0.80 at rated voltage at each load rating of 60, 70, 80 and 100 % of the rated load.

The weighted average efficiency of the generator shall be evaluated from the following formula:

$$\text{Weight Average Efficiency} = \frac{40A + 20B + 30C + 10D}{100}$$

Where A, B, C, D are the guaranteed efficiencies respectively without minus tolerances at load of 100%, 80%, 70% and 60% of rated output, rated voltage, frequency and rated power factor.

The guaranteed value of the weighted average efficiency shall be within the limits of 1% tolerances. If the calculated weighted average efficiency less than the guaranteed value, the penalty shall be applied for the difference between the measured value of the weighted average efficiency and the guaranteed value and the amount of penalty on account of shortfall in the weighted average efficiency shall be as specified in Section 9, Contract Forms, Clause 4.

No bonus will be given for exceeding the guaranteed values.

The segregated losses necessary to be known for the derivation of the above shall also be indicated by the Contractor as per distribution. The generator shall conform to the efficiency curves submitted with the Tender for the rated and unity power factors over the range from 40 to 100% rated output at the rated voltage.

The total losses shall be guaranteed without tolerance in plus. However, if any elementary loss in any machine exceeds the guaranteed value by more than 50%, the Employer will then be fully entitled to refuse the generator.

In computing the efficiencies, the thrust bearing losses shall not be included in the generator losses. They shall be indicated separately and guaranteed by the Contractor.

2.1.12 Rated Output

Even though insulation of Class F is specified and must be used the generator temperature shall not exceed the limits specified for Class B insulation temperature rise limit when the generator is operating continuously at rated output of 650 kVA and at any working voltage and any frequency range specified.

The guaranteed value of the rated output shall be within the limits of given tolerances. If the calculated output is less than the guaranteed value, the penalty shall be applied for the difference between the measured value of the output and the guaranteed value and the amount of penalty on account of shortfall in the output shall be as specified in Section 9, Contract Forms, Clause 4.

2.1.13 Connections

The generator shall be star-connected with three (3) terminals brought at the neutral side and three (3) terminals at line side of the stator winding. Both the line neutral terminals shall be insulated for full line voltage.

The neutral point of stator winding shall be grounded through a grounding transformer and grounding resistor as specified.

2.2 Design Requirements

2.2.1 General

All provisions of this specification are given for the guidance of the manufacturer to be considered as minimum requirements. Every part of the supply shall be designed to withstand any electrical and/or mechanical stresses and/or other stresses of effects which might be experienced in service including terminals and/or field short-circuit-faulty synchronizing, over speed, etc.

The design of the unit shall be such that it will have adequate mechanical stability to operate successfully under all over speed and fault conditions which may be experienced during operation.

No part shall be stressed beyond 2/3 of its yield point under full over-speed and any electrical

fault conditions that might occur.

The design of the unit, including the relative locations of the rotor, thrust and guide bearings, shall be such as to cause no abnormal vibration or resonance conditions.

Turbine and generator shall form a completely integrated unit installed with a horizontal shaft in the axial-flow water conduit and surrounded by the propelling water. The generator unit shall be located in a bulb-shaped casing with the stator frame forming an integral part of it. On the upstream side the generator shall be closed by a hemispherical bulb nose.

The excitation system shall be the brushless type equipped with rotating diodes.

The accessibility to the generator is allowed for a vertical access shaft on the top. This shaft also carries the generator leads, excitation cables and auxiliary leads. The top of the access shaft can be closed by means of a closing cover.

The torque forces and axial forces arising from generator and turbine are absorbed by the vertical supporting column and transmitted to the concrete structure.

The Contractor shall connect the stator frame, bearing bracket and generator lid, in two locations each, to bare copper from the powerhouse grounding system. Guards over or around energized or moving parts shall be provided by the Contractor.

The system proposed by the Contractor shall permit all major and minor maintenance, operations to be performed in reasonably simple manner and without undue time loss.

Provision shall be made for easy handling of all parts during assembly or disassembly of a unit.

2.2.2 Vibration

The Contractor shall guarantee that the level of vibrations of the turbine-generator units shall be in the "good" region of the table G of VDI Recommendation NO.2056, under all heads within the operational range, for all loads from 10/10 to 4/10 and for speed / no-load operation as well as for the rated speed.

If the values exceed these limits, the Contractor shall be obliged to take necessary measures without extra cost and to reduce the vibration to the above specified limits.

2.3 Construction Main Details

2.3.1 Stator

a) Stator Frame

The stator frame of the generators shall be of welded steel construction. The generator shall be provided with bolts and dowels for fastening the stator frame to the sole plates and preserving the alignment between the generator frame and sole plates. An adequate number of dowels shall be provided in order to prevent any undue movement of the stator frame or the sole plates when the generator is subject to stresses resulting from the short-circuit conditions.

The sole plates shall be designed to minimize the transmission of vibration to the foundation cooler piping and other associated equipment.

The design of the stator and its fastening to the bulb casing shall safely exclude vibrations and oscillations of rotor and shaft. Any forces transmitted to the turbine during operation or in case of failures of all kind (e.g. short-circuit, earth fault, momentary interruption, etc.), have to be communicated to the turbine manufacturer according to size, direction and chronological course.

The support cone of the thrust bearing transmits the generator guide bearing forces to the foundation.

It has to be equally provided for inspection openings on the upstream side between the braking jacks and fan guide plates.

b) Stator core

The stator core shall be built up of high grade, non-ageing and cold-rolled thin-laminated silicon steel with each lamination coated on both sides with insulating varnish or other material to minimize eddy current losses. The lamination shall be adequately keyed or dovetailed to the stator frame and securely held in place by clamping flanges at each end. To ensure uniform tightness of laminations, full and final clamping pressure shall be applied to necessary layers of laminations while being stacked.

There shall be no perceptible buzzing of laminations during operation. The core has to be designed in a way that repressing can be possible at any time.

The air ducts in stator core shall be provided with guides to provide gradually curving paths for cooling air as it leaves the air gaps and enters the ducts in the stator core, so as to make the flow of air smooth and quiet and minimize windage and friction losses. In order to ensure against shrinkage, the coil slot wedges shall be bakalized convass or approved equivalent material. The stator frames shall be provided with lifting lugs suitable for applying slings for lifting the complete stator by the overhead traveling crane.

The Contractor shall give in his proposal the particulars concerning the sheet steel used for laminations, the lamination process, and the method used for clamping laminations.

c) Stator Windings

The stator windings shall be made of electrolytic copper with conductivity not less than the value for annealed copper specified in the approved standard and shall be of double layer and insulated with full class "F" or equivalent insulation as defined in IEC No. 85. The stator windings shall be capable of withstanding successfully the dielectric tests in accordance with IEC No. 34-1.

The stator windings shall be so designed that the whole windings shall be easily removable type and be replaceable with the spare windings. Connection shall be made with silver or brass soldered.

The stator winding shall be star-connected. There shall be three phase terminals and at least three neutral terminals.

The main and neutral leads brought out to terminals arranged outside the generator frame at approved location. Current transformers for excitation shall be provided by the Contractor. The stator windings neutral ends shall be grounded through neutral grounding resistor.

The generators shall be capable of withstanding sudden short-circuit at their terminals without injury in the stator winding. The end portion of the coils and connections shall be rigidly supported and braced to prevent vibration and distortion.

The coil insulation shall be non-inflammable and shall be properly vacuum or pressure impregnated with high-grade insulating synthetic resin. The insulation shall become reasonably plastic by the application of the heat or shall otherwise be of such nature that the coil can be placed in or moved from slot without injury. The entire coil shall be able to withstand exposure to dampness without injury. The coil shall have adequate corona shielding with a semi-conducting compound and shall withstand specified continuous temperature without injury. The coil shall be from-wound and interchangeable. Each coil shall be properly transposed to avoid circulating current within the elements comprising them. All coil ends shall be capped with non-inflammable materials filled with suitable compound free from air pocket.

If it becomes necessary during erection to lift coils from the stator after their ends have been finally connected the agreement of the Employer shall be obtained. Such coils lifted may be replaced only once in the slots and those lifted more than once be replaced with new coils.

2.3.2 Rotor

a) Rim, Poles and Windings

The rotor shall be built in accordance with best practice and designed to withstand safely all overloads and stresses encountered during abnormal or runaway conditions.

The rotor shall be of the solid disc or segmental rim construction. The design of the rotor shall be such as to permit an easy removal and replacement of the field poles. Dimensions of the rotor shall be determined by taking into account all requirements not only for electrical design, but also for flywheel effect (GD^2) required by turbine. It shall also be designed mechanically for the maximum design torque delivering maximum output.

Adequate provisions shall be made both for static and dynamic balances of the rotor so as not to cause any vibration.

The poles shall be built up of thin laminations secured by rivet or bolts passing through supporting end plates and the pole faces provided with damper windings.

The pole pieces shall be attached to the rim of the rotor spider by means of accurately machined or die punched dovetails and secured by tapered keys. The poles shall be mounted in such a way that neither the loosening of the keys nor the dropping out of the poles and keys are possible, but it shall be possible to remove and replace the poles with minimum disturbance.

The rotor winding shall consist of bare flat copper coils wound on edge. The turn insulation shall be thoroughly cemented to the adjacent turns. Insulation collars shall be provided at the top and bottom of each field coil and the collar shall be adequately supported at all points. The design shall be such as to compensate for shrinkage in the insulation and to maintain adequate pressure on the field coil.

The winding shall be insulated with class "F" insulation as defined in the applicable standard to withstand a dielectric test at:

$$U_t = 10 U_f \text{ when } 150 \text{ V} < U_f < 500 \text{ V}$$

$$U_t = 1,500 \text{ V when } U_f < 150 \text{ V}$$

$$U_t = 2 U_f + 4,000 \text{ V when } U_f > 500 \text{ V}$$

U_f = rated load field voltage

Electrical connections between field coils shall be supported sufficiently to eliminate mechanical failure due to vibration, thermal expansion or stresses from centrifugal forces throughout the speed range of the generator, including maximum over-speed.

The rotor shall be provided with a brake-ring with a renewable wearing surface. Adequate provision shall be made for dissipation of the heat resulting from the application of the brakes and to take care of the expansion of the brake plate segments.

Rotating-rectifiers for AC brushless exciter shall be located along with the AC exciter and effectively insulated from the shaft and mounted in a manner to permit easy inspection and servicing.

Special care shall be taken to prevent the end turns from deforming or slipping due to the centrifugal stresses on the interconnections.

Effective cooling fans shall be mounted at both ends of rotor and suitable air guides shall be arranged for correct circulation of cooling air. Provision shall be made for balance adjustment weight on the rotor at site before installation.

b) Damper Winding

According to the rotor body and pole structure, a damper winding shall be provided. The damper winding shall secure an improved stability and to reduce higher harmonic voltages under conditions of unbalance fault. The winding shall be of low resistance and rigid construction.

2.3.3 Shaft

The generator shaft shall be made of forged, open-hearth carbon or alloy steel properly heat-treated. It shall be of ample size to operate at any speed up to the maximum runaway speed without detrimental vibration or distortion and to operate at maximum output without exceeding the design stresses.

The generator manufacturer shall be responsible for designing the shaft system so that the first critical speed is not less than 30% greater than the maximum runaway speed.

The turbine manufacturer will supply and fit the coupling bolts for which the generator manufacturer shall ensure that his flange is correctly drilled.

The shaft shall be adequately insulated against stray currents which may be set up by the field of the generator and which may cause injury to the generator or turbine bearings.

The turbine and generator manufacturer shall cooperate and jointly provide all the arrangements necessary to align the generator shafts and complete at site. Alignment of combined generator shafts will be checked by the Contractor according to NEMA Standard (Publ. No.MG 52-1972). The Contractor shall supply all the instruments required for this alignment check. Approval of the results of this check shall be given in writing by the Contractors to the Employer.

2.3.4 Bearings Pedestals

Each unit shall be equipped with two pedestal bearings. One guide bearing located upstream from the generator rotor (- NDE) and one combined thrust/guide bearing located between the generator rotor and turbine runner (- DE) shall be installed. Both bearings, common bearing oil cooling unit and all other related equipment are included in this supply.

The bearings shall be of a design meeting the best practice for such equipment, and shall be capable of withstanding all stresses incident to normal operation of the unit and to runaway speed, and to resist the forces due to unbalanced conditions without injury or loss of oil.

The bearings shall also be guaranteed for correct and safe functioning during start-up and shut-down of the unit set, even without generator brakes, oil circulation and oil injection (normally, application of the brakes will be taking place at 20% of the rated speed). For normal start/stop operations a high pressure oil pump shall inject oil to the bearings in radial and axial directions.

The bearing pedestals shall be of welded steel structure, stress relieved, supported on the sole plates embedded in the concrete structure of the machine hall. Together with the sole plates, all anchorage and leveling devices shall be furnished and installed by the Contractor.

The bearing housings shall be of the split design for easy access to the shells and pads during adjustment, dismantling or replacement of same. Perfect oil sealing shall be provided. Cover for visual inspection shall be furnished. Provision for future installation of the oil mist suction system (separator, piping, valves, etc) for both bearings shall be provided.

The bearings (guide and thrust/guide) shall be designed to be capable of being operated without injury:

- continuously at any speed from 50%-110% of rated speed, no-load condition
- for 15 minutes at any speed between rated speed and over-speed
- for 5 minutes at runaway speed
- for at least 15 minutes or for the time required for the unit to come to a complete standstill (wicket gates closed) from maximum speed occurring during operation after a full-load rejection, whichever is longer, without oil circulation, oil injection and cooling water.

Guide bearings shall be of the babbitt-metal lined type.

Each guide bearing shall permit axial movement of the shaft for adjusting the thrust bearing (latter combined with the drive-end guide bearing) and for uncoupling. Guide bearings shall be of the split shell construction, unless other constructions (e.g. segmental type) are

preferred by Contractor. The babbit metal shall be securely anchored or bonded to the shells and accurately grooved and bored for oil lubrication. The lining shall be completely machined to fit the shaft properly and to guarantee a smooth operation of the unit.

The guide bearing design shall be such that the temperature of the shells or segments does not exceed 70°C under the most severe load conditions.

The NDE guide bearing shall be equipped with the following instruments:

- Oil temperature indicator, one piece
- Oil level indicator, one piece
- Oil level switch with two contacts, one piece
- Bearing metal Pt 100 temperature detector for remote temperature indication, one pieces
- Oil thermostat with two contacts, one piece
- Bearing metal thermostat, with two contacts, two pieces
- Oil Pt 100 temperature detector for remote temperature indication, one piece.

The thrust bearing shall be of the double-acting type (i.e with a counter-thrust face) and shall incorporate bearing pads (segments) of the tilting type.

The whole shall be designed and constructed to support safely any axial thrust (in both directions) up to that occurring at the most severe and unfavorable condition during operation.

The thrust bearing rings shall be of steel or steel-plate lined and fixed securely to the shaft.

The active surfaces shall be carefully machined and ground to a fine finish. Bearing pads shall be babitt-metal lined; lining shall be firmly anchored to the pads and bonded on the entire surface. The base rings or plates supporting the pads shall be steel or special iron.

The temperature of the thrust bearing pads shall not exceed 75°C under the most severe load condition.

The DE thrust/guide bearing shall be equipped with the following instruments:

- Oil temperature indicator, one piece
- Oil thermostat with two contacts, one piece
- Oil level indicator, one piece
- Oil level switch with two contacts, one piece
- Guide bearing metal temperature indicator, two pieces
- Guide bearing metal thermostat with two contacts, two pieces
- Guide bearing metal Pt 100 temperature detector for remote temperature indication, one pieces
- Thrust bearing metal temperature indicator, two pieces
- Thrust bearing metal thermostat with two contacts, two pieces
- Thrust bearing metal Pt 100 temperature detector for remote temperature indication, one pieces
- Oil Pt 100 temperature detector for remote temperature indication, one piece

One bearing oil cooling and circulating unit common for guide and thrust/guide bearings of each main unit shall be installed in the related generator hall. The oil cooling unit shall contain the following main components:

Oil reservoir with oil level indicator, oil level switch (minimum and maximum), filling opening including filter, silicagel breather, manhole, drain valve, two oil circulation pumps including AC driving motors (one pump shall be in service only), one high pressure oil injection pump including DC driving motor, oil filter on return oil pipe with differential pressure switch, water/oil heat exchanger (10 bar design and 15 bar test pressure), reservoir supports and all other equipment necessary for trouble free service.

All oil pipe lines, circulating supply and return pipe and injection oil pipe line, from the cooling unit up to the bearings, including the following instrumentation:

- Temperature indicator on the common return oil pipe

- Oil flow switch on the return oil pipe from NDE bearing
- Oil flow switch on the return oil pipe from DE bearing
- Oil pressure indicators on the injection pipe lines to NDE bearing, DE guide and DE thrust bearing (total three switches)

2.3.5 Brakes

Each generator shall be equipped with automatically operated hydraulic braking system, whereby the period of slow running with brakes applied before stand-still shall be minimized. Adequate brakes shall be provided complete with all piping permanently attached to the generator.

The brake system shall be capable of bringing the unit from about 20% rated speed to rest without excessive heating and within braking time of 3 minutes with wicket gates closed. Brakes shall be automatically reset complete stop of the generator. Braking operation shall also be performed manually from turbine control board.

The brake shoes shall be provided with replaceable and metal friction wearing surfaces.

The brake shoe shall make contact with wearing surfaces on the generator rotor.

Oil pipes and valves for braking shall be supplied by the Contractor up to the turbine control board.

The devices in the turbine control board such as electromagnetic valve and piping will be supplied by the turbine supplier; however the Contractor shall furnish necessary data of the above devices for approval.

A position switch shall be provided for each brake shoe, arranged so that the contact is closed when brake shoe is raised from normally "OFF" position. In this position other contact of this switch will be open to prevent unit from starting unless all brakes will be in the "OFF" position. Each brake-shoe shall also be provided with an end switch for remote annunciation "brake worn out".

2.3.6 Cooling System (if required)

In order to carry off thermal losses, each generator shall be equipped with open circuit cooling system complete with air coolers.

All metal ducts and plate or other equipment necessary for the generator cooling equipment shall be furnished by the Contractor.

The air in the generator can be moved by fans attached to the rotor which forces the air through the pole gaps, the coil ends of the stator windings, and the bores in the casing wall into the rear of the core. Cooling ducts provide for equal distribution of the air. The air shall be circulated by means of fans located on the upstream side of the unit and the warmed air leave the other side of generator

Discharge of the warmed air shall be through a funnel and leading up the generator room exterior. The funnel end shall be provided with a louver. The louver shall be automatically opened and closed by electrical actuator. One set each of temperature detectors shall be furnished and installed for the inlet air and discharge or outlet air.

The Contractor should submit the calculation sheet and drawing for approval of the Employer.

2.3.7 Temperature Detectors and Devices

Temperature detectors shall be provided by the Contractor for each generator and will be installed on the local unit control board furnished by the turbine contractor. They shall be of the compensated resistance type with platinum element giving 100 ohms at 0°C complying with the applicable standards. The characteristics of the detectors shall remain subject to the approval of the Employer.

The quantity of the detectors shall be at least as follows:

Location

In stator winding, located in accordance with IEC-34-1

In stator core

Guide bearing DNE

Thrust Bearing NE

All wiring between the terminal cubicle and the individual temperature detectors shall be furnished and installed by the Contractor.

2.3.8 Space heater

Auxiliary contacts on the main AC supply circuits of the heater for indication and interlocking shall be furnished. The contractor shall furnish and install an adequate number of electric heaters located in the stator casing to prevent condensation of moisture or sweating under conditions of extreme humidity and temperature difference when generators are idle or during shut down periods.

The Contractor shall furnish and install a thermostat mounted in the control panel, for automatically turning the heaters on keeping a constant temperature difference between the inside and outside of the generator casing. The heater frames shall be adequately grounded and easily replaceable.

2.3.9 Generator Leads Connections, Terminal Boxes, Conduit and Wiring

All connecting bus bars and leads shall be conducted to the front bulb nose area and executed as follows:

The stator winding shall be executed in star-series connection which results in three winding ends on the grid side leading to the stator connections via fully insulated flat copper bars. The disposition of the neutral point is carried out basically with the same connections as on the grid side. The necessary supports and protecting cages shall be provided by the Contractor.

The generator leads starting from the stator connectors shall be executed as fully insulated cables with 11 kV insulation strength according to IEC in correspondence with generator capacity and short-circuit conditions.

The Contractor shall furnish and install a main terminal box, all internal wiring and conduits for auxiliary conduits for the generator. The location and adequacy of the main terminal box shall be subject to the approval of the Employer.

All internal wiring and conduits in the generator shall be furnished and installed by the Contractor.

2.3.10 Shaft Current Preventing Devices

Suitable treatment shall be taken to prevent over-heating of the bearings due to shaft currents. Adequate insulation shall be provided at the base of the supporting brackets.

The position of such insulation shall be clearly indicated in the approval drawings.

2.3.11 Generator Housing

The generator shall be furnished with a steel to cover the generator, provided with access to station, air coolers, instrument transformer etc. The red color-indicating lamp for distinguishing the operation of generation shall be mounted on the generator.

2.3.12 Neutral Grounding Cubicle

Neutral grounding resistor shall be provided separately for two individual generators to limit neutral grounding fault current. The neutral grounding resistor shall be rated to limit the ground fault current to a maximum of 900 amperes or 60 seconds and shall be installed in the barrier fabricated with punch holed steel plates. The rated voltage shall be 0.4 kV and the value of resistor shall be decided as per the site conditions as per the resistance of the ground.

The neutral grounding cubicle shall accommodate one current transformer of ratio 1000/1A and one isolator (0.4 kV, 400 A) and neutral grounding resistor as shown in single line diagram. The resistor shall be capable of withstanding over voltage of 0.5kV for 1 minute without exceeding a temperature rise of 75°C.

2.3.13 Fire Protection

An automatic carbon dioxide fire protection system (excluding CO₂ cylinders), ring headers, discharge nozzles, temperature detectors etc. shall be provided by the Bidder for each generator.

2.3.14 Bearing Lube Oil System

If considered necessary by the Supplier, suitable lubricating oil circulation system with main and stand by motor pump sets with auto start facility, coolers, strainers, pressure gauges, flow relays, gauge, piping, valves etc. shall be included in the scope of supply.

2.3.15 Spare Parts and Tools

Spare Parts

The following spare parts shall be the part of the supply as minimum requirements three (3) years operation of the units without any restricting.

- 1) One-third set of wound stator coils, with all supplies required for installation, plus ten (10) percent extra wedges and materials.
- 2) One (1) pair of generator field poles with coil and core, including necessary materials for installation.
- 3) Five (5) solenoid coils of each type.
- 4) One (1) indicating instrument of each type.
- 5) One (1) complete set of brake shoes for one unit.
- 6) Two complete sets of the segments of wearing brake plates.
- 7) One (1) brake cylinder assembly.
- 8) One (1) set of O rings, seal and wipers for the brake cylinders, composed of 100 % of each type used for one unit.
- 9) One (1) complete set of thrust bearing runner, springs and/or pivots and shoes.
- 10) One (1) complete set of guide bearing segment.
- 11) One (1) complete set of guide bearing segment.
- 12) One (1) set of lamps and fuses with a quantity of 100 % for one unit.
- 13) One (1) space heater

The spare parts shall be strictly identical in every detail, whether electrical or mechanical, to the part it is intended to replace. Each spare part shall be delivered properly packed and clearly marked, ready for long terms storage indoors. Each instrument relay, coil or similar device shall be furnished in its individual vapor tight, moisture-proof container.

Tools

The tools required for assembly, disassembly, maintenance or adjustment shall be part of the supply.

The sets of tools shall comprise at least the followings:

- 1) Complete set of alloy steel case hardened, single ended wrenches, spanners socket wrenches, etc. to fit all the nuts and bolts of the supply.
- 2) Complete set of tools for dealing with every component of the supply such as bearings, field poles, windings, coolers, etc.

- 3) The tools shall be furnished orderly stored on a suitable wrench board bearing the reference mark of each tool for a classified positioning and easy identification of same.

A complete list of the tools shall be attached to each proposal.

2.4 The Drawings and Similar Documents to be provided by the Contractor

2.4.1 General Requirements

The provisions specified as below are for specific minimum requirements in respect of preparation and furnishing of drawings and similar documents.

Design notes and similar documents shall be submitted with the related drawings.

- 1) List of drawings, diagrams, design notes and similar documents to be submitted for the execution of the Contract.
- 2) Complete and itemized detail list of all the components of the supply showing for each item the reference number which will be used in the drawings and other documents throughout.
- 3) Documents showing the basic data
 - a) Generator outline with indication of:
 - Weights and outline dimensions of the main parts,
 - Positioning of the critical elements such as couplings, terminals, sole plates, bearings, instruments, etc.
 - Floor loads including short-circuit conditions.
 - Fixing holes, cable passages, pipe passages.
 - All information as required for the dimensioning of the structures and the elaboration of the civil engineering drawings.
 - b) Detailed drawings of the sole plates.
 - c) Diagram of generator piping.
 - d) Drawings of the air and oil coolers with indication of the tube dimensions as well as the positioning of the connecting flanges.
- 4) Design notes
 - a) General dimensioning of the generator with capability curves.
 - b) Computing note for the predetermination of the reactances and investigation of stability.
 - c) Computing of the static and dynamic forces applied to the structures by the generator in every situation.
 - d) Determination of GD^2 value.
 - e) Design of the stator and rotor windings.
 - f) Computation of critical speed for shaft.
 - g) Determination of the oil coolers.
 - h) Determination of the bearings.
 - i) Description notes, catalogs, leaflets, etc. for each part of the equipment
 - j) Description of the process for shaft alignment at site.
 - k) Description of the recommended instruments and process for balancing the rotating assembly at site.
 - l) Determination of the breaking system.
 - m) Oil injection system.

- 5) Construction detail
 - a) Detailed drawing of stator.
 - b) Detailed drawing of rotor.
 - c) Thrust and guide bearing, assembly and detail.
 - d) Main shaft and shaft ends.
 - e) Temperature detectors positioning and connections.
 - f) High pressure injection sets assembly.
 - g) Instrument panels.
- 6) Electrical diagrams
 - a) Generator wiring diagram
 - b) Elementary wiring diagram and connection diagram of control, signaling and instrumentation.
 - c) Armature winding diagram.
 - d) Braking system elementary and connection diagram.
 - e) Field cubicle and control boards wiring and connection diagram.
 - f) High pressure injection oil control and piping elementary and connection diagrams.
- 7) Assembly details
 - a) Generator assembly and detail.
 - b) Field cubicle and control board assembly and detail.
 - c) High pressure oil injection system assembly and detail.
- 8) Program of shop tests.
- 9) Program of field tests.
- 10) Complete report for shop tests.
- 11) Complete report for field tests.
- 12) Technical instructions
 - a) Operation instruction
 - b) Maintenance instruction, hand book, etc.
- 13) Complete set of as-built drawings including field modifications.

3. EXCITATION SYSTEM

3.1 Scope of Work

The work to be done under this specification covers the design, manufacture, supply, delivery, installation, acceptance tests, putting into successful operation and guarantee of two (2) brushless excitation systems for 2 (two) generator units of Saniveri Utterganga Mini HPP. The excitation system shall be of the latest commercially approved design and of the fully brushless system.

All apparatus, appliances, material and labor, though not explicitly called for in this specification, but which are necessary for the proper and satisfactory operation of the excitation system shall be furnished by the Contractor.

The single phase excitation power transformers and the free standing totally enclosed type excitation/regulation cubicles for each unit shall also be provided.

3.2 Automatic Voltage Regulator

An automatic dual channel voltage regulator of approved type shall be provided with the generator, and full details of the equipment shall be given during the design phase, particularly as regards to rate of response to busbar voltage variations, VAR control and limitation, and field suppression.

The regulator shall be mounted in a sheet steel cubicle to form part of the machine control panel suite and shall include the necessary fuses, isolating links, terminals and ventilating equipment. The arrangement of the equipment shall ensure easy access for cleaning and replacement.

The regulator shall be capable of maintaining the generator terminal voltage within +1% of the controlled value for any change in output over the full load range of the Unit and shall be free from voltage drift and unaffected by frequency or temperature changes. Provision shall be made for field suppression in the event of machine over speed.

The automatic regulating equipment shall be so arranged that it can be isolated from the excitation system for maintenance while the machine is on load, leaving excitation under hand control. It shall be so arranged that the regulator can be left in service during the startup and shutting down of the machine on either manual or automatic control.

The regulator shall incorporate over-voltage protection devices for internal electronic equipment; low excitation limiter to prevent the regulator reducing the generator excitation below the stability limit of the alternator; and a switch for changing from hand to automatic operation. The range of the set value shall be 90 - 110% of the rated voltage. It shall at all times be possible to change from hand to automatic operation and vice versa without causing any alteration in machine terminal voltage, and equipment required to ensure this shall be included.

In case of a fault in the regulator, voltage control shall be immediately and automatically changed over from automatic to hand control, and an alarm circuit shall be provided to give warning when a fault in the regulator has caused a changeover from auto to hand operation.

Where a separate field regulating system is employed in conjunction with the automatic voltage regulator, means shall be provided for keeping the motor operated rheostat in step with the automatic voltage regulating system.

The regulator shall be designed to allow the alternator to operate in parallel with other machines in the Employer's system.

Current transformers and voltage transformer to operate the regulator shall be supplied under this Contract.

The electronic circuits shall consist of double-sided printed circuit cards with metalized holes. The regulator shall be equipped with the following components;

a) Reactive Droop Compensation

Reactive current dependent droop characteristics of the generator terminal voltage shall be provided for the parallel operation of the generator units.

b) Power System Stabilizer

The regulator shall have a power system stabilizer. The input quantity to the stabilizer shall be generator's active power output. Active power output signal shall be obtained through a three-phase measurement of the active power.

c) Limiters

The regulator shall have the following limiting regulations:

- Time-dependent exciting current limiting
- Time-dependent stator current limiting

- Under excitation limiting

d) Transfer Function

The overall regulator shall be designed to have a reliable transfer function which remains effective even in case of larger transient operational conditions and shall have a wide and simple range of adjustment of parameters.

3.2.1 Transducers

The following transducers with a range of 4-20 mA shall be provided.

- One (1) for excitation current
- One (1) for excitation voltage

3.3 Technical Characteristics and Documents

3.3.1 Performances of Automatic Voltage Regulator (AVR)

- Adjustment range of automatic channel set point: 90 to 110% U_n
- Adjustment range of the manual channel set point current: from 50% of current at no load to 110% of rated field current.
- Permanent limitation of rotor current set at: $1.1 I_n$
- Overexcitation ceiling set at approximately: $1.6 I_m$
- Accuracy at steady state: $\pm 0.5\%$
- Regulator response time: less than 30 ms
- Line drop compensation range: $\pm 20\%$
- Ceiling duration: 10sW`
- Permissible frequency range: 47-52 Hz

3.4 Data, Characteristics and Documents

3.4.1 Drawings, Design Notes and Instructions to be submitted by the Contractor

- a) The Contractor shall submit the following drawings, design notes and instruction to the Employer within the time stated hereunder. The Contractor shall be fully responsible for the correctness of all drawings, design notes, data and instruction submitted by him. The documents and information hereunder enumerated, are not limited by the followings, the Employer may require additional drawings, information and details deemed necessary.
- b) The documents and information stated under this paragraph shall contain the preliminary design fundamentals upon which the further design details are to be based and shall be submitted for the Employer's approval after the date of the commencement of the Contract.
 - 1) Block diagrams of the complete excitation system showing clearly the functional units such as limiters, power system stabilizer, reactive power regulator, power converter blocks, start-up and field discharging equipment, etc.
 - 2) Capability chart should be submitted by the Contractor.
 - 3) Schematic diagrams of the complete excitation system with a list of the graphical symbols used.
 - 4) Short descriptions and explanatory notes for the schematic diagrams.
 - 5) Design notes on the coordination of the ceiling voltage (by high ceiling voltage values) with the rotor insulation.
 - 6) Transfer functions of excitation system AVR and its bode plot diagram.
 - 7) Transfer functions of power system stabilizer and its bode plot diagram.

- 8) Technical characteristics and drawings of the excitation system components such as circuit breakers, contactors, diodes, thyristors instrument transformers, excitation transformer, field discharge resistors, cables, etc.
- 9) Complete transfer function of the excitation system.
- c) The following drawings and instructions shall be submitted after the final approval of the documents stated
 - 1) Wiring diagrams
 - 2) Erection instructions
 - 3) Operation instructions
 - 4) Instructions for maintenance and repairing
 - 5) Cable lists
- d) Contractors shall furnish complete as built drawings, covering all revisions within one (1) months after the preliminary acceptance tests at site.

3.4.2 Performance Data and Characteristics to be submitted by the Bidder

- a) Information to be included in Bids

The tenders shall contain sufficient information on the excitation system to enable the Employer to make a detailed comparison of Tenders. The following information shall be included and shall show the difference between any alternatives offered:

- 1) Each tenderer shall furnish the performance data and guaranteed characteristics and other technical data and information.
- 2) The tender shall contain detailed information on the operational principles and particularities of the equipment offered, in the form of block diagrams, typical drawings, pamphlets, sketches or photographs, explanatory notes, etc.
- 3) Technical drawings of the excitation cubicles arrangement with approximate dimensions.
- 4) Recommended spare parts and tools list tendered by the Bidder.

- b) Alternatives

The Employer wishes to make clear to all tenderers that, notwithstanding the accompanying specification, the Employer may give consideration to alternatives which the tenderer considers advisable by reason of his/her own manufacturing requirements and experience or by reason of Employer's interest, provided attention is clearly drawn to such alternatives in the tender and descriptive matter submitted, pointing out wherein the recommended arrangement or device is equal to, or superior to that required by the accompanying specification.

4. TESTS

4.1 Shop Tests

According to the practiced standards all conventional tests and quality controls shall be performed on materials as received from sub-contractors/manufacturers or produced in the Contractor's own factories as well as parts partially or completely assembled in order to ensure the proper matching of parts and materials during installation and their proper operation after complete assembly.

Test shall include material checks on main items such as shaft, steel plates, etc. as well as a magnetic test of the stator core. All stator and rotor coils for the generator shall be tested in the factory for grounds and short-circuit between turns. In testing the generator field coils for shorted turns, readings shall be taken of AC ampere volts and watts, preferably using the

same value of current for all coils.

The Employer reserves right to pick at random samples of stator winding coils out of the first run of coils being produced for these units and to conduct on them voltage endurance tests in an independent testing laboratory (if voltage endurance test certificates are not submitted). If the results of the said tests on the sample coils are not good enough, the manufacturer shall adequately review its production procedure and make necessary modifications to meet the specified requirements. However,

The following but not limited to shop tests on each generator shall be performed by the generator manufacturer. The test reports shall be prepared and sent to the Employer in three (3) copies.

1) Generator

- General inspection of the construction and the dimensions
- Measurement of machine constants
- Measurement of no-load saturation characteristics
- Short-circuit tests
- Measurement of losses
- Measurement of GD^2
- Measurement of insulation resistance
- Dielectric strength test (power frequency)
- Measurement of coil resistance of stator and rotor
- Measurement of wave form
- Calculation of short circuit ratio, voltage regulation and efficiency
- Measurement of temperature rise
- Measurement of noise level which shall not exceed 85 dB at 1 meter distance from the generator.
- Measurement of vibration level which shall remain in "Good" or "Excellent" areas according to VDI Recommendation No. 2056.
- Phase sequence test
- Measurement of dielectric loss angle and absorption current
- Over speed test
- Operation test of oil lifting device (if applicable)

2) Excitation system

The excitation system in combination with the generator shall be subjected to the following tests:

- General inspection of construction and dimension
- Measurement of insulation resistance
- Measurement of losses
- Temperature rise test
- Dielectric strength test
- Voltage build-up test
- Voltage control test
- Characteristics of various components
- Temperature rise test on the power converters (completely assembled with one converter block removed)
- Check the current repartition among parallel diodes of the rectifier bridges at maximum rated output (uniform current division)
- Short circuit test at reduced voltage and normal operating temperature to demonstrate its capability to self-protection.

4.2 Field Tests

The following tests shall be included in the installation works.

4.2.1 Tests during Installation

The generator and its appurtenant equipment's shall be subjected to the following tests during installation under the supervision of the Employer.

- Measuring of clearance

The clearance between shaft and guide bearings shall be measured.

- Measuring of insulation resistance for stator coil, field circuit and shaft circuit.

After completion of installation, the pressure piping system shall be tested for 24 hours at 1.2 times the maximum operating pressure in order to confirm there is no leakage.

- Check of shaft alignment

After coupling the generator shaft with turbine shaft, the shaft alignment shall be checked by dial-gauges at more than 3 positions around the main shafts, for example, at generator shaft, at couplings and turbine shaft, during low revolving speed of the shafts.

- Running test of bearing

After admitting water into the bulb case, the turbine-generator unit shall be started by manual governor control and shall be tested for the bearing temperature at low, intermediate and rated speeds.

4.2.2 Preliminary Tests

After the turbine generator unit and its appurtenant equipment's have been installed, and before placing the unit in service, the following preliminary tests shall be performed.

- Measurement of insulation resistance for stator coil, field circuit and shaft circuit.
- Dry-out run.

The turbine generator unit shall be started at rated speed under manual control and the generator voltage shall be adjusted so as to carry sufficient short-circuit current necessary for drying-out windings through the metal enclosed buses. The air cooler shall be used whenever possible to prevent sharp temperature rise of the windings.

Temperature of stator windings shall be maintained at about 80 °C by controlling circuit current. The insulation resistance of stator windings shall decline as the temperature rises, but will increase with lapse of time and gradually become saturated.

The dry run shall be continued until such saturation is attained.

- Three-phase short-circuit characteristics tests

After completion of dry out run, 3-phase short-circuits characteristics tests shall be successively performed in the same circuit as in the case of the dry-out run.

- Dielectric test

Upon completion of three-phase, short circuit characteristic test, the dielectric tests of stator and rotor windings shall be performed in accordance with ANSI Standards.

- No-load saturation characteristics test

After completion of dielectric tests, no-load saturation characteristics test shall be performed.

- Operation tests of braking device

When peripheral speed of brake ring of the generator decreases, the braking device shall be operated by adjusting under-speed relay.

- Excitation system voltage-time response test

Positive and negative step signals shall be applied to reference setting of the regulator with the generator operating under no-load, rated voltage. The responses of the excitation voltage shall be recorded to measure the positive and negative ceiling voltage and excitation system voltage ratio.

- On-load response test

Step signals shall be applied to the regulator with the generator operating at rated load and voltage. Power swings shall be recorded with and without power system stabilizer to illustrate the damping effect of power system stabilizer.

- The Contractor shall demonstrate that limiters and the reactive drop compensator operate as specified.
- Accuracy test

Generator terminal voltage shall be recorded for several hours under steady state load conditions with the generator at rated load and voltage.

Overall tests

The Contractor shall conduct the following tests in coordination with respective equipment manufacturers.

- Load rejection test
- Emergency stop test
- Quick stop test
- Continuous operation test

4.2.3 Final Acceptance Tests

The following final acceptance tests shall be performed.

- Load rejection test
- Emergency stop test
- Quick stop test
- Continuous operation test

D3. – Specification of Electric Equipment and Control System

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D3. – Specification of Electric Equipment and Control System

1. GENERAL

1.1 Scope of Work

The work to be performed under this contract consists of furnishing all the material and performing all the works of the electrical equipment and control systems in Saniveri Utterganga Mini HPP as specified in the specifications.

The Contractor shall design, supply, manufacture, install and test all items of equipment as defined in these specifications. The equipment including all machinery tools, accessories and the spare parts shall be of first class quality, free of all manufacturing defects or imperfections and shall be in accordance with the requirements of Bidding Documents.

The supply shall also include all the accessories required for the erection, dismantling, inspection and maintenance of the equipment such as tools, ladders, slings, lifting beams, gangways, etc. also any accessories and instrumentation required for the tests, with the exception specified in the specifications. Initial filling of oil and grease shall be included in the supply.

All works, material and services, though not expressly called for in these specifications but necessary for the complete and proper operation of the supplied equipment will be included in the present contract.

1.2 Project Description

a) General

The powerhouse is designed for two (2) horizontal Francis turbines each 590 kW operating under a gross head of 55 m at full flow of 2.4 m³/s (2 Units). The generators will have a rated capacity of 650 kVA. The generated energy will be evacuated through 11 kV overhead Transmission Line of 91 km and distributed locally at different village of Putha Utterganga Rural Municipality at voltage level of 0.4kV via 11/0.4kV distribution transformer. The power is generated at 0.4kV.

b) Hydraulic Turbines

Type: Horizontal Shaft Francis Turbine

Number: Two (2) sets

Design head (net): 51.7 m (as calculated)

Output at normal head: 590 kW

Discharge at normal head: 1.2 m³/s

Rated speed: 750 rpm

c) Generators

Type: Horizontal shaft, air cooled, three phase AC synchronous generator

Number: Two (2) sets, operating duty: continuous overload of 10%

Rated Capacity: 650 kVA, Voltage: 0.4 kV

Power factor: 0.80 (lag), Frequency: 50 Hz

Rated speed: 750 rpm

Excitation: Brushless excitation

Insulation Class (stator/rotor): F/F

1.2.1 Control Power Source

The power to be used for control shall be 110 V DC and shall be supplied by stationary batteries. The voltage may vary within the range +10 % and -15 %.

1.2.2 Station Service

The service power for use within the plant shall be supplied with 3-phase, 4-wire, 50 Hz, 380/220 V AC. The terminal voltage of auxiliary equipment shall be 380 V and 220 V for 3- ϕ and 1- ϕ respectively.

1.2.3 Service Conditions

All the equipment shall be designed and manufactured for satisfactory operation at an ambient temperature 55°C and -5°C.

1.3 Design, Materials and Workmanship

1.3.1 Design and Workmanship

All work shall be performed in accordance with the most advanced practice in engineering for each class of equipment and completed in a thorough workmanlike manner following the best modern practice in the manufacture of high grade equipment. All work shall be performed by mechanics skilled in their various trades.

Machining of renewable parts shall be accurate and to specific dimensions so that replacements made to drawing size may be readily installed. Like parts and spare parts shall be interchangeable.

The International Metric System of measurement shall be used for all work under the Contract and all units of measurement shall be expressed in that system.

1.3.2 Standards

Except as provided in the specifications, all materials, equipment, and fabrication and testing thereof shall conform to the latest applicable standards contained in the following list:

- International Electrotechnical Commission (IEC)
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS)
- American Society of Mechanical Engineers (ASME)
- National Electrical Manufacturers' Association (NEMA)
- Deutsche Industrie Normen (DIN)

It shall be understood that the latest revision or edition in effect at the time of the tender call shall apply.

If it is desired to use equivalent standards or to deviate from the above-cited standards, a corresponding application together with one copy of the respective standards shall be submitted to the Employer for approval.

Machine work tolerances and allowances for the limiting sizes of mating parts for any class of metal fit shall be in accordance with ISO "system for limits and fit" or with the American Standards for "Tolerances, Allowances, and Gauges for Metal Fits".

1.3.3 Materials

All materials used in the manufacture of the equipment supplied shall be selected as the best available for the purpose for which it is used, considering strength, resilience, durability and other physical properties, as well as best engineering practice. They shall be new and of first class commercial quality, and free from defects and imperfections.

All materials, supplies and articles not manufactured by the Contractor shall be the products of

recognized reputable manufacturers.

The material contemplated for incorporation in the equipment together with performance characteristics and other significant information pertaining to the materials shall be furnished to the Employer for approval. Materials installed or used without such approval shall be at the risk of subsequent rejection.

Material tests shall be conducted at the manufacturer's premises or at other places agreeable to the Employer, in accordance with the requirements of the ASTM-Standards or other agreed standards. The results of these tests shall be in such a form as to provide a means of determining compliance with the applicable specifications for the material tested. Where the Contractor desires to use stock material not manufactured specifically for the works, satisfactory evidence that such material conforms to the requirements stated in the Contract shall be furnished to the Employer, in which case tests on these materials may be waived.

The Contractor shall be responsible for the standardization of all small mechanical and electrical equipment, materials and device for the works. He shall arrange and perform the necessary coordination work with his subcontractors for the purpose of such standardization, such equipment, devices, fittings, etc. shall comprise but not necessarily be restricted to the following:

- Valves
- Gauges
- Electrical instruments and meters
- Terminals and terminal blocks
- Primary, secondary and auxiliary relaying devices
- Contactors, fuses, miniature breakers and the like
- Control devices and control switches
- Lamps, bulbs, sockets, plugs, etc.

1.3.4 Welding

a) Operation for Welding

Members and sections to be joined by welding shall be cut accurately to size, with their edges sheared, flame-cut or machined to suit the required type of welding and to allow full penetration.

The surfaces of members or sections to be welded shall be free from rust, grease and other foreign matters for a distance of at least 50 mm back from the edge of weld.

b) Welding Procedure

All welding shall be performed by the electric-arc method, by a process at least equal to that required by the latest edition of the "standard qualification procedure" of the American Welding Society, or the corresponding DIN Standards.

c) Qualification of Welders

The Contractor shall be responsible for the quality of the work performed by his welding organization. All welders and welding operators assigned to the work shall have passed a performance qualification test for welding operators at least equal to that specified in the latest edition of the "Standards Qualification Procedure" of the American Welding Society (or DIN 8560 and 8563). All expenses in connection with making the qualification tests for welding operators shall be borne by the Contractor. Operators welding certificates shall be furnished to the Employer, if requested by him.

d) Welding Equipment

All welding equipment, such as welding machines, transformers, cables, electrodes, etc. for welding at the Site shall be of reputable make and suitable for the purpose intended for.

Consumable material (electrodes etc.) shall be included in the price. Other materials and tools

shall remain the property of the Contractor.

1.3.5 Bolts, Studs, Nuts and Screws

They shall have standard threads and be of high quality steel.

All bolts, studs, nuts and screws (including their washers) shall be well protected against corrosion according to the site of their installation. Nuts and bolts heads shall be hexagonal in shape and truly faced.

Nuts, bolts and screws which might become loose during operation shall be locked in fastened position by means approved by the Employer.

1.3.6 Pipes, Flanges and Joints

All piping, flanges and joints shall be designed for the highest pressure occurring in the respective system in service, including water-hammer where appropriate.

All piping under internal pressure exceeding 16 bars, whether water or oil shall be seamless. Piping of 50 mm inside diameter and over shall be of steel unless otherwise specified.

All bends, tees and other fittings for steel piping shall be of steel.

All coupling and joining together of pipes, fittings and valves of 50 mm inside diameter and over shall, if not otherwise specified, be by means of flanged joints. All flanges shall be cutter-bossed or faced at their back so that bolt-heads, washers and nuts will be bed down appropriately, Site welding of flanges shall be subject to the approval of the Employer.

Piping under 50 mm inside diameter may be joined together with threaded socket-fittings or approved vise-couplings.

All pipes shall be of uniform thickness, and the dimensions and drilling of the flanges shall, wherever applicable, be in accordance with the USA Standard B 16.5.

All flanged joints shall be made with jointing material being perfectly suitable for the size of flanges and operating conditions.

The jointing material shall be so proportioned that when the joint is tightened-up no part of the jointing ring protrudes into the pipe bore.

All pipes, before the joints are bolted together, shall be placed on or hung from their respective supports and lined-up so that the joints are in parallel. In making joints no springing of pipes into position shall be allowed, except where specifically approved for the purpose of relieving strains due to expansion.

All oil pipes shall be thoroughly cleaned and fitted with temporary blank flanges or plugs before being packed and dispatched.

All brackets, stays, frames, hangers and supports for carrying and steadying the pipes, including their fastenings, shall be included in the supply and completed by the Contractor at the Site. Pipes and fittings shall be supported at or near a flange wherever possible.

The supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others.

Large size piping crossing ceilings and supporting walls shall be provided with welded-on anchor collars for embedding in the concrete.

All piping carrying water shall be protected externally against sweating (condensation) by means of an approved anti-condensation wrapping or sheathing.

1.3.7 Valves

All valves over 50 mm bore for pressure exceeding 16 bars shall be of forged or cast steel.

Valves for such pressures but of 50 mm bore or less may be of bronze. Valves for water over 50 mm bore shall be of the external rising spindle type. Valves for oil shall be of the non-rising spindle type.

All valves shall have screwable wearings parts of corrosion-resistant materials. Their seals and sheets shall be of ample proportions and of suitable materials to ensure that galling or overloading will not occur in any service condition including partial opening.

Isolating valves shall be suitable for opening and closing against full unbalanced pressure, including closure against free discharge. If necessary, by-passes are to be provided to meet these requirements.

All valves shall be provided with hand-wheels of ample size and, where necessary, extended spindles and/or gearing so that any valve may be easily and conveniently operated by one man under any service condition.

All valves shall close with a clockwise rotation of the hand-wheel which shall be marked to show the direction of closing.

Large size valves shall be provided with means for pad locking in any position.

All brackets, stays, frames, supports and hangers necessary for carrying and steadying valves shall be included in the supply and completed at the Site.

1.3.8 Electrical Equipment

- a) All the equipment shall be new, durable to withstand long time use, and shall satisfy all requirements which a complete product shall generally meet even if such are not expressly provided in the Specifications.
- b) All the equipment shall be of a convenient construction for disassembling inspection and erection.
- c) Induction motors shall be of the direct line starting-drip-proof type, and when operated, shall not develop trouble under the voltage fluctuation of $\pm 10\%$. Neither shall it show any trouble at the rise of voltage and frequency of power source, of 30% and 35% respectively, resulting from the full load rejection of the turbine generator.
- d) Magnetic contactors used in various switches shall be made of arc resistant metal and have a sufficient capacity against rush current, and the contact part shall be free from over-wearing and misconduct for a long period of service.
- e) Electrical contacts of dial type thermometers, thermal relays, oil level relays, etc. shall be able to safely break the current determined with the condition of control circuit connected to these contacts at any considerable power source condition.
- f) Conductors shall not be joined by soldering except for inevitable position.
- g) The Contractor shall furnish all suitable installation materials.
- h) Cubicles and control boards shall be provided with a fluorescent light inside (220 V AC, 20 W, 50 Hz) for interior lighting and shall be provided with door switch. The cubicle and control box for the auxiliary equipment shall be provided with a moisture preventing heater (220 V AC, 50 Hz) with a switch and thermostat.
- i) The bushings and insulators used in the equipment shall have sufficient mechanical and electrical strength.
- j) Miscellaneous electrical work including wiring, conduit connections, plugs, etc. shall conform to the safety codes of IEC. All electrical wiring inside an element of the supply shall be furnished. All control and small section wiring and conduit for each component shall be brought to junction boxes or cabinet.

Wiring shall terminate in molded type terminal blocks with terminal marking strips.

Terminal blocks shall be easily accessible and suitably placed in the near surrounding of the supply.

Conduit shall be galvanized, rigid steel with threaded ends.

Fittings shall be galvanized with threaded hubs and gasketed cover for tightness. Flexible conduit may be used where necessary for vibration or flexibility purposes; they should be tight with appropriate fittings.

- k) Two (2) phases AC wiring shall be color coded according to the used standards. They shall be uniformed throughout the power-station.
- l) The contact surfaces (both male and female) for the transistor sheet (printed card) shall be considered where necessary.
- m) The ground terminal of the equipment shall be of the bolt-fastened type, suitable for minimum 50 mm² (equipment in the powerhouse) and 70 mm² (high voltage equipment in the powerhouse) hard drawn copper stranded conductor or equivalent.
- n) Low voltage power cable shall be stranded copper conductor, thermoplastic insulation with thermoplastic jacket overall, maximum ambient temperature 40°C. Low voltage control cable shall be dielectric strength: 2,000V, copper conductors, thermoplastic insulation, with thermoplastic jacket overall maximum ambient temperature 40°C (If necessary flameproof and/or screened).

The control cables shall have minimum section of 1.5 mm².

1.3.9 Name Plates

All major equipment shall be provided with a securely fastened nameplate showing the maker's name, model, serial number, year of manufacture, main characteristics data of the respective equipment and further relevant information specified in the applicable standards or necessary for the proper identification of the equipment involved.

The Contractor shall supply and install also all label plates and other labeling (of the screw-on type) on control boards, control desks, panels and other places where required for operational, functional and safety reasons.

The labeling, size of the plates and their location shall be subject to approval of the Employer.

A sample label-plate (with indication of the material used) with lettering shall be submitted for this purpose. The number of sizes of the plates shall be of minimum. The name-plates shall be in English.

1.3.10 Corrosion Protection and Painting

a) General

The supply shall include the surface treatment, priming, corrosion protection and painting of the equipment furnished. Such work shall comprise the workshop -and at the Site-coating up to and including the finish painting. Unless otherwise specified the coating and painting shall be carried out in accordance with the latest edition of DIN 55928 (Protective Coatings for Steel Structures Direction) ASTM Standards A 153, A 386, A 123 and A 120 or another equivalent approved standard.

All priming and painting material shall satisfactorily fulfill the requirements imposed by the Site conditions, as well as the stresses, to which the respective equipment is subjected during its operation. At the request of the Employer, painting samples for the different coats and colors shall be provided.

All furnished surfaces shall present a neat, pleasing appearance.

Each coat of primer and painting shall be compatible with the previous and subsequent coats. All pigmented primers and paints which will be used for priming and painting at the Site shall be delivered in sealed containers packed by the manufacturer.

The Contractor shall supply full details regarding the extent which sand-blasting, priming and painting will be carried out in his workshop (or his sub-contractor's, as the case may be) at the Site and after erection. A properly equipped paint-shop shall be set up at the Site using a specialist organization, experienced and skilled in the preparation and application of protective coatings at the conditions prevailing at the Site.

Materials shall be thoroughly mixed at the time of application. It is essential that before any primer and coat of paint is applied, the surfaces are properly prepared. Such preparation shall include any cleaning, smoothing, drying and similar operation that may be required to ensure that the primer and/or paint is applied on suitable surfaces. Clean cloths and clean fluids shall be used to avoid having film or greasy residue on the surfaces being cleaned.

Each coat shall be free from runs, drops, pinholes, waves, laps, sags and unnecessary brush marks, and shall be allowed to dry or to harden before the following coat is applied.

Machinery-paint may be thinned, if necessary, to permit satisfactory application but the amount of thinner shall be kept to a minimum.

For removing rust and mill scale from structural steel, plate, sheet, piping and other steel surfaces, as well as from other parts suitable for blast-cleaning, sand-blasting shall amount to approximately 50 microns.

Parts which cannot be blast-cleaned shall be cleaned free from rust and scale by power-tool cleaning to the highest possible degree, according to the above standards or equivalent approved standards. Blast-cleaned surfaces shall receive a quick-drying shop-coating immediately after blast-cleaning. Hand or power-tool-cleaned parts shall be treated likewise immediately after cleaning. All structural steel and pipes carrying water shall if provided for galvanizing be heavily galvanized by the hot-deep process. Galvanizing shall be carried out in accordance with the ASTM Standards A 153, A 123 or VDE - Standard 0 210 and original blast-furnace raw zinc only shall be applied (ASTM 8.6). The thickness of the galvanizing coating shall be approx. 70 microns.

b) External Surfaces

All unfinished external surfaces of the equipment and related accessories shall be thoroughly sand-blasted until a clean metal surface has been obtained and then immediately after coating with at least 1 coat of priming two pack zinc rich epoxy primer and 1 coat two pack micaceous iron oxide epoxy paint as intermediate.

Final coating shall be with 2 finishing coat of paint on high quality polyurethane basis. The total thickness of the 4 layers shall be minimum 0.18 mm.

c) Embedded Surfaces

All such surfaces shall be protected by an application of cement mill added with bichromate of potassium. Surfaces in transition zones of the concrete to the external surfaces shall be threaded and painted in a similar way as stipulated above for external surface over width of approx. 300 mm.

d) Surfaces in Contact with Water

Surfaces of water passages, including the turbine runner, jet reflectors, stay vanes and exposed parts, not of nonferrous, stainless steel or special noncorrosive material, shall be thoroughly sand-blasted and carefully cleaned from rust, film, scale and/or other impurities until a clean metal surface has been obtained. Porous areas, flaws, inclusions of sand, etc. shall be chipped or ground until sound metal has been reached. Repair and reconditioning of such areas shall

then be carried out by electric welding with electrodes corresponding to the base material. All surfaces shall then be coated immediately with 2 coats of priming paint of two pack high zinc pigmented epoxy primer (minimum thickness of the 2 layers 0.12 mm).

Prior to the application of 2 finishing coats on two pack epoxy coal tar basis, careful elimination of remainders of oil and grease from all surfaces by means of a diluent agent of turpentine substitute, and retouching of possibly damaged areas is required.

The total thickness of the four (4) layers shall be minimum 0.320 mm.

e) Parts of finished Surfaces to be Left Bright in Service

Same shall be protected against corrosion with one heavy coat of readily removable anticorrosive varnish.

f) Surfaces wetted by Oil

Same shall be treated and painted as stipulated for surfaces in contact with water, except that for the 2 final coats, oil-resistant varnish shall be used. The primer shall be applied before the tightness test and the second coat be applied after assembly.

g) Pipe Work

1) Water carrying pipes

Pipes, valves and fittings, except for parts to be embedded in concrete, shall be shop-coated with priming paint. Interior surfaces shall be treated with coal tar. Exterior surfaces to be primed with 1 layer of two pack zinc rich epoxy primer. Two (2) finishing coats shall be applied at the site; the paint needed for two (2) finishing coats shall be furnished together with the equipment. The total thickness of the 3 layers shall be 0.18 mm.

2) Oil Carrying Pipes

Careful cleaning of the external and pickling of the internal surfaces shall be required. External surfaces to be primed with 1 layer two packed zinc rich epoxy primer basis, followed by 2 finishing coats on polyurethane basis. The total thickness of the 3 layers shall be 0.18 mm.

h) Control Boards, Panel Boards, Cubicles, Cabinets, etc.

Careful cleaning, if possible sand-blasting, 2 coats of oil-resistant paint shall be required. Interior surface shall have at least one priming and one finishing coat of anti-corrosion paint. Exterior surfaces shall be adequately treated to be substantially corrosion-resistant with one prime coat, one filler coat and two finishing coats. Control cabinet shall be coated with non-glossy paint.

i) Chains, Rope, etc.

These shall be fully galvanized.

j) Linings, Cover Plates, Supports, Handrails, etc.

Similar treatment and painting as specified above for "surfaces in contact with water" and "Embedded surfaces".

k) Checks

The work of anti-corrosion protection will be checked by the Employer.

The check work will include:

- Check of the cleanliness of the cleaned surfaces.
- Check of the thickness and adhesion of zinc and paint coatings.
- Check of quality of the materials applied.

The thickness of the zinc and paint coatings shall be checked at about 10 check points per

square meter. For the acceptance, the guaranteed thickness of the coating shall be decisive and not the number of coats applied.

l) Execution of the Work

In principle the painting work shall be executed in the Contractor's shops except for the finishing coats. The priming coats and the first finishing coat respectively shall always be applied by means of a painting brush in order to obtain better adhesion.

Paintwork damaged during shipment, storage and/or erection shall be properly restored by the Contractor after thorough removal of the damaged coating. The repair coating and painting shall be carried out as per the above Specifications and reach the minimum dry film thickness stipulated.

When executing the paint work the air humidity shall not exceed 60 % at the working place, and all necessary fans, air heaters, ventilation ducts and dust absorbers shall be provided by the Contractor.

The Contractor shall furnish a suitable quantity of each priming and finishing paint for touch-up work at the Site, after the end of the guarantee period.

m) Repair of Defects

The Contractor shall carefully repair all defects occurring to the surface protection during the guarantee period (cleaning of defective parts by sand-blasting if necessary, reapplication of the different protective coatings).

Special care shall be given to transition zones where new and original coatings come together. Should the defect be one for which the Contractor is liable, all related repair cost shall be borne by the Contractor.

n) Shades

The shades of the finishing coats, as well as the color code to which they shall correspond shall be settled after the contract award.

1.4 Packing

All the equipment shall be carefully packed so as to withstand the long time transport by sea and land. The electrical equipment shall be completely protected against moisture.

The finished surface of the equipment and the portion embedded in concrete shall be protected by rust preventive means.

The spare parts shall be packed and crated firmly enough to withstand storage for a long time, and those in need of rust preventive treatment shall be so treated.

The spare parts shall be packed separately from other articles. Packages of spare parts shall carry notation which clearly indicates that the contents are spare parts and shall be accompanied by a list of contents which sets for the directions for storing.

1.5 Color Code for Cabling, Piping and the Electrical/Mechanical Equipment

1. Cabling

Power and control cables

(a) 3-phase AC power cables

Phase 1-yellow

Phase 2-blue

Phase 3-red

Neutral-black

- (b) DC power cables

Positive lead-red

Negative lead-black

- (c) Control cables and wires

All control cables and wires are black with the code numbers at both ends.

- (d) Protection wire yellow-green.

2. Piping and Electrical/Mechanical Equipment

Not only to paint the pipes and ducts but also to paint the relevant equipment such as tanks, pumps, valves etc. Color according to System RAL norms:

- a) Fire fighting system (red) 3000

Including but not limited to fire extinguishers, cabinets, fire water tank and pumps, pipes, etc.

- b) Oil pressure

Including but not limited to sump tank, pressure tanks, pumps, valves, pipes etc.

Oil pressure (yellow) 1018

Oil drainage (brown) 1011

- c) Water treatment and water distribution system

Including but not limited to water tanks, pumps, filters, boilers, valves, pipes etc. for industrial water (green) 6017 for domestic cold water (blue) 5007 for domestic hot water (red) 3022 for cooling water (green) 6016 used water (drain and sewage) (gray) 7032

- d) Heating and ventilation (white) 9010

Including but not limited to AC units, chillers, pipes for cooling water, chilled water, freon, pneumatic regulation etc.

- e) Fuel system (orange) 2003

Including but not limited to diesel oil tanks, pumps, valves, pipes etc.

- f) Emergency diesel generator (orange) 2002

- g) Control, monitoring and protection equipment (shaded white) 1013

Including but not limited to distribution panels, control boards, supervision consoles etc.

2. GENERATOR LEADS, CUBICLES AND POWER CABLES

2.1 Scope of Work

The work to be done under this specification covers the design manufacture, testing, delivery, erection, commissioning and guarantee of:

- Three (3) generator phase terminal cubicles
- Three (3) generator neutral terminal cubicles
- Power cables between generator neutral terminals to neutral cubicles
- Power cables between generator phase terminals to 0.4 kV cubicles
- Power cables between OHTL and 0.4 kV cubicles

Generator phase side and neutral side cubicles shall contain PT's, CT's and accessories required for the controls of the speed governors and the excitation system.

2.2 Design Conditions

2.2.1 General

Every part of the supply shall be designed to withstand any and all electrical and/or mechanical stresses and/or other stresses of effects which might be experienced in service.

The equipment covered by this specification shall be suitable for indoor installation. However the power cables between OHTL and 0.4 kV cubicles may be installed partially outdoors in a cable channel.

General Technical Characteristics

Insulation class

- Nominal voltage: 0.4 kV
- Maximum System Voltage: 0.5 kV
- Frequency: 50 Hz

However, the actual current ratings shall be selected as per the thermal and dynamic stresses of the highest short-circuit current susceptible to appear in the 0.4 kV system. The highest short-circuit currents to be considered are:

In the main leads between generator and common busbar:

- Asymmetrical peak value for dynamic stresses
- One second equivalent rms value for thermal stresses

The system shall be able to withstand for at least 1 second, any fault current, short-circuit included, for a fault fed by generator at 0.4 kV+5%, and appearing outside the area covered by the differential protection of the generator.

2.2.2 Cubicles

The neutral and phase side cubicles shall be of the metal-enclosed dust-insect-and splash proof type. All equipment installed within the cubicles shall be fully accessible, for inspection and maintenance.

The cubicles shall be provided with hinged access doors with key locks. Frame, equipment supports and hinged doors shall be connected to grounding pads. The cubicles shall have ample strength to withstand, without damage, all stresses incidental to shipping, installation and short-circuit forces during operation (Degree of protection IP40/IP43).

Anchor bolts as well as all necessary nuts and bolts for assembling shall be supplied with the cubicles. Nuts and bolts shall be corrosion proof. The cubicles shall be delivered completely wired. Terminal blocks for low voltage wiring shall be located in a metal clad compartment separated from 0.4 kV equipment. Cables shall enter the cubicles from above/below according to the location. The generator leads and cubicles shall be provided with suitable bushings for connection to the power cables.

The cubicles shall be well ventilated throughout adequately screened openings. Special consideration shall be paid to the design of frames, support and barriers to avoid eddy currents and to limit stray losses therein.

2.2.4 Generator Neutral Grounding

The generator neutral shall be grounded through a resistor and voltage transformer. This combination shall supply a current sensitive relay through suitably rated current transformer for stator earth fault protection.

Dimensioning of the voltage transformer and resistor shall be done in coordination with the transformer and generator manufacturers and shall be subject to Employer's approval.

The ratings of the loading resistor shall be determined for one minute duty. The resistor shall be capable of withstanding over voltage of 0.5 kV for 1 minute without exceeding a temperature rise of 75°C.

Numbers required: 2

2.2.5 Power Cables

The conductor shall be covered with solid insulation XLPE and shall be of annealed copper stranded wire and shielded by annealed copper tape plated with tin, lead or an alloy of tin a lead. Single core standard cables shall be used.

Dimensioning of the cables shall be done in accordance to standard practice and shall be subject to Employer's approval.

2.2.6 Cable Rack

All cable racks with cleats for power cable shall be furnished where necessary. The cable racks shall be made of galvanized shaped steel.

The cable rack shall be complete with all supports, hangers, foundation bolts, nuts, connection bolts, nuts and other necessary items for supporting and fixing the cable racks.

The cable cleat made of hard wood shall be used for fixing the cables.

2.2.7 Grounding

A copper grounding grid and/or bar has been already installed in the power plant. The manufacturer of the equipment covered by the specification shall furnish and install the necessary grounding connection-to be all copper-to the existing grounding grid or bar.

2.2.8 Design Notes and Drawings

The contractor shall furnish complete assembly drawings, wiring diagram and design notes for the equipment and such detail drawings and diagram, necessary for installation, operation and maintenance.

Design Notes:

1. Calculation of the electrodynamics stresses resulting from the maximum value of short circuit currents.
2. Calculation of the temperature rises in the various parts of the bus-bars and cables.
3. Calculation of losses.

2.3 Tests

Shop Tests:

Routine tests shall be made on all current and voltage transformers, switches and bus-bars to IEC Recommendation or equivalent.

These routine tests shall comprise at least:

1. For current and voltage transformers
 - a) Power frequency voltage withstand test
 - b) Ratio test
 - c) Accuracy test
 - d) Verification of terminal markings and polarity
2. For bus-bars

- a) Power frequency voltage withstand test
- b) Temperature rise test
- 3. For lightning arrester
 - a) Power frequency spark-over test
- 4. For power cables
 - a) Conductor resistance test.
 - b) High voltage test
 - c) Power factor test.

Following type tests shall be performed on one of the each kind of supplied equipment. Instead of carrying out type tests, the Contractor may submit the certificates of type tests made in an approved laboratory performed on the equipment of the identical design. However, the Employer reserves the right of accepting these certificates or rejecting them partially or totally.

These tests shall comprise at least:

- 1. For one current and voltage transformers
 - a) Impulse voltage withstand test
 - b) Temperature rise test
 - c) Short time current carrying capacity test (for current transformers)
- 2. For three insulators and bushings of each type
 - a) Mechanical strength test
 - b) Power frequency spark over test.
 - c) Impulse spark over test

Field Tests:

The following tests shall be performed in the field during and after erection of the supply:

- a) Mechanical clearances, bare dimensions, levels and other measurements of equipment as erected.
- b) Functional checks of all auxiliaries and protective devices.
- c) Dielectric insulation tests as well as measurement of winding resistance and insulation resistances.

2.4 Data to be furnished by the Bidder

The manufacturer names and the technical specifications related with the manufacturer shall be submitted by the Contractor at the design stage for the approval of the Employer.

Current Transformers

Units Value Tolerance

- Manufacturer
- Type
- Rated voltage kV
- Maximum Permissible operating voltage kV
- Rated frequency Hz
- Primary current A
- Secondary current A
- Accuracy classes and burdens
- Core 1 accuracy class

Burden	VA
Core 2 accuracy class	VA
Burden	VA
Core 3 accuracy class	
Burden	VA
▪ Instrument security factor	
Measuring winding protective winding	
▪ Impulse insulation level	kV
▪ Primary windings power frequency dry and wt, 1 min. kV full wave impulse 1.2/50μs	kV
▪ Secondary windings power frequency dry and wet 1 min.	kV
▪ Minimum admissible over currents	
▪ Continuous permissible over currents	%
▪ Thermal short-time current (1 sec.)	XIn
▪ Dynamic current (peak)	XIn
▪ Weight net/gross	Kg/Kg
Voltage Transformers	Units Value Tolerance
▪ Manufacturer	
▪ Type	
▪ Standard	
Main Characteristics	
▪ Rated voltage	kV
▪ Maximum Permissible operating voltage	kV
▪ Accuracy class/burden	/VA
▪ Type of insulation	
▪ Insulation level	kV
▪ Impulse withstand voltage 1.2/50μs	kV
▪ HV power frequency test voltage wet/dry	kV/kV
▪ LV power frequency test voltage wet/dry	kV/kV
▪ Continuous permissible overload	%
▪ Weight net/gross	Kg/Kg
Insulators (Support Bushing)	Units Value Tolerance
▪ Manufacturer	
▪ Type reference	
▪ Standard	
Main Characteristics	
▪ Rated voltage	kV
▪ Flash-over voltage	
Dry	kVrms
Wet	kVrms
Impulse	kVpeak
▪ withstand test voltage	
Dry	kVrms

Wet		kVrms
Impulse		kVpeak
▪ Leakage distance		mm
▪ Dry arcing distance		mm
▪ Mechanical strength		
Axial	Kg	
Cantilever		Kg
▪ Weight net/gross		Kg
Bar Connections	Units	Value Tolerance
▪ Type		
▪ Standard		
▪ Rated current (continuous)		A
▪ Maximum current in short circuit		
▪ Dynamic		kApeak
▪ Short time 7 sec.		kArms
▪ Short time 8 sec.		kArms
▪ Conductor profile shape		
▪ Cross section		mm ²
▪ Distance between phase		mm
Power Cables	Units	Value Tolerance
▪ Manufacturer		
▪ Type		
▪ Standard		
▪ Rated voltage		kV
▪ Max. Rated current for cable installed in air, shafts and trays with 40°C ambient temperature		A
▪ Maximum Permissible temperature rise		°C
▪ Short circuit capacity (1 sec.)		A
▪ Low frequency test voltage (15 min.)		kV
▪ Power frequency test voltage (1 min.)		kV
▪ Maximum admissible continuous service voltage (Phase to earth)		kV
▪ Cross section of the conductor		mm ²
▪ Overall diameter of the cable		mm
▪ Material of the insulation		
▪ Material of the conductor		
▪ Material of the shielding		
▪ Type of armoring		
▪ Resistance per meter of conductor at 30°C		Ohm
▪ Capacitance per meter of cable		pF

3. 0.4 kV EQUIPMENT

3.1 Scope of Work

The work to be done under this specification covers, the design, manufacture, testing, delivery, erection, commissioning and guarantee 0.4 kV metal enclosed switchgear equipment complete for operation.

The switchgear system shall consist of:

- Single common bus system
- Two (2) generator unit bays

- One (1) line bay at power plant

3.2 Extent of Supply

The supply shall comprise all apparatus and required accessories, conductors, insulators, connection boxes, power cables (1.1 kV XLPE), power cable sealing ends, terminal blocks, supporting frames for the outside equipment (for lightning arrester, power cable sealing ends and coupling capacitor etc.). All necessary special tools for operation and maintenance shall also be included.

Voltmeters, voltmeter selector switch for outgoing feeders and multifunction numerical protection relays will be mounted on cubicle panels that can easily be seen by the operator.

One (1) tariff (kWh) and kVarh meter with numerical type, class 0.2S, double direction and four quadrant measurements will be mounted on generator cubicle panels and station service panel.

One (1) tariff (kWh) and kVarh meter in the outgoing cubicle at power plant.

The electrical output meters shall comply with the following requirements:

- a. They shall be microprocessor based equipment. The software shall be of modular construction and developed using structured design techniques. The software modules shall be permanently programmed into the on-board memory (EPROM) of the system
- b. They shall be three elements, solid state complying with IEC 687
- c. Their accuracy class shall be 0.2S
- d. They shall be capable of metering and registering bidirectional MW, MVar, MWh and MVarh in each of the four quadrants
- e. They shall be driven by current transformer and voltage transformers provided in the switchyard and shall be capable of compensating for current transformer and voltage transformer ratio and phase angle errors.
- f. They shall be capable of being linked to the Control Centre, via the network SCADA system, and the Control Room by means of digital and analogue signals, and of being sampled at least once every six seconds
- g. The design of equipment shall be such, as to ensure satisfactory operation in an electrically hostile environment typical of high voltage electrical installations. In order to prevent incorrect functioning or damage to the equipment when subjected to interference arising from power system switching, fault currents and lightning, all input and output circuits, and power supply circuits shall be provided with isolation and/ or immunity to electrical interference.

3.3 Design Conditions

3.3.1 General

Every part of the supply shall be designed to withstand any and all electrical and/or mechanical stresses and on other stresses or effects which might be experienced in service. The equipment covered by this specification shall be suitable for indoor installation. However, the power cable sealing ends, LA, for outgoing lines shall be installed at outdoor.

The switchgear cells shall be type-tested, factory built assemblies, with robust interlocks and pressure resistant front.

3.3.2 Types of Construction

The metal-enclosed panels shall be fitted with internal partitioning of insulated material to give a VCB withdrawable circuit-breaker chamber, a bus-bar chamber and a cable termination

chamber. Degree of Protection against coming into contact with live or moving parts and against external effects shall be in accordance with IEC 529 and the protection degree shall be IP 40/IP43.

3.3.3 Protective Earthing

A continuous protective earthing shall be provided by interconnecting the individual panels with a continuous earth bus. The earthing connector between the trucks and the cubicles shall be done by means of sliding contacts. When the truck is being withdrawn the earthing connection shall not be interrupted until the truck has moved past the isolated position.

3.3.4 Busbars, Mating Contacts, Arc Traps and Barriers

The busbars shall be made of bare flat copper and mounted on cast resin insulators.

The mating contacts shall be attached directly to busbars. The busbar arc traps and pressure switches shall be supplied if necessary.

All circuit-breaker panels shall be equipped with cable earthing switches. The position of the earthing switch shall be indicated by a mechanical indicator visible when the truck is in the isolated position.

3.3.5 Interchangeability of Switchgear Trucks

The generator switchgear trucks shall be interchangeable. The other switchgear trucks of same current rating shall also be interchangeable.

3.3.6 Constructional and Performance Requirements of Circuit Breakers

3.3.6.1 Type of Operating Control

Normal operation of the Circuit Breaker shall be electrical. Mechanically manual, local control means shall also be provided on the circuit breaker itself. Facilities for remote electrical control from the station control board, by means of turn-push or equivalent type with luminous discrepancy signal, shall be furnished by the supplier.

A selector switch with "local" and "remote" positions shall be provided within the circuit breaker cabinet. In the "local" position, the circuit breaker shall be controlled only locally, blocking any remote control signal including those to be received from protective relaying. In the "remote" position, local control of the circuit breaker shall not be possible.

In addition, all Circuit Breakers shall be equipped with:

- A front type manual mechanical control handle of the removable type for emergency purposes.
- Well visible position indicators.

3.3.6.2 Control and Driving Mechanisms

Bidders shall give a description of the control and driving (closing and opening) mechanisms offered. The control mechanism shall be of the stored energy and mechanically trip-free type.

Dependent operation can be allowed for maintenance and repairs only. Sufficient energy for an O-CO operating cycle shall be automatically stored when closing the breaker, without necessitating any additional operation.

The rated operating duty cycle shall be as follows:

0-0.3 sec-CO-3min-CO:

All Circuit Breakers shall be equipped with anti-pumping circuits.

Where AC is specified in the Bill of Materials, the Circuit Breakers will be equipped with 220 Volt

AC single phase motors, where DC is specified, the supply will be from 110 Volt DC motors.

3.3.6.3 Closing Coils

The circuit breakers will be equipped with 110 V DC shunt closing coils only.

The bidders shall indicate the consumption of these coils. All closing coils shall be included in the supply.

3.3.6.4 Trip Coils

The circuit-breakers shall be equipped with 110 Volt DC shunt trip coils. All trip coils shall be included in the supply. The maximum interrupting time of the Circuit Breaker shall be 80 milliseconds.

3.3.6.5 Position Signaling

All Circuit Breakers shall be equipped with well visible local position indicators and they shall also include contacts for remote position signaling by semaphore switches.

3.3.6.6 Heating

Circuit breakers and mechanism boxes shall, when necessary, be equipped with heating resistors the power consumption of which shall be determined by the Manufacturer so as to ensure that the satisfactory performance of the device is maintained at the lower limits of the ambient temperature specified here before, supply voltages for such resistors shall be 220 V AC.

Heating resistors shall be energized by thermostatic control.

3.3.6.7 Various Remarks

- i) All the breakers shall be designed for front position and control.
- ii) Installation

Circuit breakers intended for indoor use shall be mounted in conventional masonry cells and be mobile via rollers in the forward-backward direction according to the control cabinet.

Meanwhile CBs shall be equipped with braking mechanism to fix the CB.

CBs shall be mounted on wheels and placed on ground. The distance between the moving contact and ground shall not be less than 350 mm.

On the other hand, CBs shall be equipped with holes for single expansion shield with machine bolts, to be mounted on console.

- iii) Circuit-breakers and cabinet shall be equipped with appropriate heating resistors.

Supply voltage: 220 Volt AC.

- iv) Circuit breakers shall be provided with all the necessary safety and alarm devices such as gas leakage detectors, low pressure and motor failure indicators.
- v) Motors and their electrically operated ancillary equipment (for spring charging) shall operate satisfactorily at all supply voltages between 85% percent and 115 percent of the rated supply voltage.
- vi) Bidders shall attach with their tenders
 - A complete description of the operation of the proposed CBs, along with the drawings and diagrams of the control and driving circuits.
 - Outline drawings of the CBs.

At Least 1 month before each party of circuit breakers is ready to be delivered, the Supplier shall submit to Purchaser's approval manuals concerning the assembling, disassembling and maintenance of circuit breakers. These manuals shall include the following minimal information as well as the ones mentioned in IEC 54-6, Section Two.

- Any special tools and/or appliances that may be required for erection and maintenance.
- The number of operations after which different parts of the circuit breakers need be maintenance.
- Relationships between contacts wear and contact resistance.
- Cautions to be considered during installation and maintenance.
- All applicable drawings.

3.4 Accessories

The following accessories shall be supplied:

- Wheeling device

The wheeling device facilitates maneuvering of the switchboards trucks when removed from the cubicles.

- Voltage Detector

A voltage detector is used to check that an installation is dead or not.

3.5 Technical Characteristics

3.5.1 General

a) Insulation level

- Rated voltage 0.4 kV
- Maximum system voltage 0.5 kV

b) Short-circuit currents

The short-circuit currents of 0.4 kV equipment to be considered are;

- Asymmetrical peak value for dynamic stresses: 25 kA

The circuit breakers shall be equipped with motor spring operating mechanisms, trip free in any position and shall be suitable for remote electrical closing and tripping operations.

The arch interrupting contacts of the circuit breakers shall be made of arch-proof metal, and the main contacts shall be silver coated to have ample current carrying and interrupting capacities.

The power to be used for the control of the circuit-breakers shall be 110 volt DC and shall be supplied by storage batteries provided that the voltage may vary within the range 85% and 115% of rated voltage. Each circuit breaker shall be equipped with auxiliary switches of the number required plus three "NC" and "NO" spare contacts. Careful attention shall be paid in designing the circuit breaker in respect to selection of materials, vibration-proof method and fastening method of parts liable to be loosened after long time use.

Each breaker shall be so designed as to afford easy assembly, disassembly, and maintenance and to assure safety of inspecting personnel. Measures shall be taken to minimize noise due to breaking.

Each circuit breaker shall be furnished with all Standard accessories and special tools as required for assembly and maintenance.

3.5.3 Technical Characteristics for Disconnecting and Earth Switch

a) Number required

Disconnecting switch with high voltage fuse Two (3) (as shown in SLD)

b) Type

Outdoor, three phase, single throw, manual operating type

c) Rating

- Rated voltage : 0.4 kV
- Maximum system voltage : 0.5 kV
- Rated frequency: 50 Hz
- Rated continuous current :

Impulse withstands voltage:

- common value kVpeak

Power frequency withstands voltage (1 min):

- common value : kVrms
- Rated peak short-circuit current : 25 kApeak
- Fuse : 2-10 A

d) Requirements for Construction

The disconnecting switches shall be provided with manual operating mechanism and shall include earthing switch to facilitate earthing of lines. It shall be operated by using a manual-operating handle.

Each disconnecting switch shall be equipped with auxiliary switches of the number required plus one "NO" and "NC" spares contacts. The main contacts of the disconnecting switch shall be silver coated and smooth operation shall be required without applying lubricant to the contacts for a long time.

3.5.4 Technical Characteristics for Current Transformer

Description	Feeder	Station Service	Generator Incomer	Line
Type		Indoor dry	Indoor dry	Indoor
dry				
Number of phase:	Single-phase	Single-phase	Single-phase	
	Single-phase			
Number required	3	3 (phase)+3 (Neutral)		3
No. of Cores	2	2		2
Ratio	50/5-5 A	100 /5-5A		100/5-5A
Accuracy class				
i) Core-1 Cl	0.5, n<5	5 P 20		5 P
20				
ii) Core-2 Cl	5 P 20	Cl. 0.5, n<5		Cl.
0.5, n<5				
iii) Core-3 Cl		PS		
Rated voltage	0.4 kV	0.4 kV		0.4 kV
Maximum system voltage	0.5 kV	0.5 kV		0.5 kV

The thermal short time current and dynamic current ratings of the CT's shall be provided. The

current transformer shall comply with the requirements of IEC 60185.

3.5.5 Technical Characteristics for Voltage Transformer

The 0.4 kV Metal clad Switchgear shall include one [Voltage Transformers in each Generator incomer, line bay and common bus](#) as required by the Single Line Diagram as follows:

- i. Type: Epoxy-resin insulated, single pole with 7.3 A Primary side fuses
- ii. Basic Impulse Level: 75kV_{peak}
- iii. Rated Power Frequency Withstand Voltage: 28kV rms
- iv. Primary Voltage : $0.4/\sqrt{3}$ kV
- v. Secondary Circuit : $110/\sqrt{3}$ V
- vi. Rated burden: 100 VA
- vii. Accuracy classification: 0.5 / 3P Class (for Generator Incomer only)

The voltage transformers shall comply with the requirements of IEC 186. Accuracy class and burden shall be adequate to ensure the correct operation.

The voltage transformers and their fuses shall meet the specified insulation requirements and have a rated primary voltage of 0.4kV with knee of saturation curve not lower than 0.5kV and ratios per single line diagram.

The voltage transformer shall be provided with high rupturing capacity (HRC) fuses for primary and secondary circuits. The fuses shall be rated for the short circuit levels specified.

Each set of secondary windings shall be wired to suitable terminal blocks and earthed at the first control or relay panel to which they are connected.

Earth Fault Factor should not exceed 1.4 for effectively earthed system.

The equipment to be supplied shall be suitable for following service conditions

- Average value of relative humidity measured during 24 Hours: 95%
- The average value of water vapor pressure for 24 Hours: 2.2 kPa
- The average value of relative humidity for a period of month: 90%
- The average value of water vapor pressure for a period month: 1.8 kPa

Continuous Rated Voltage Factor should be 1.2 and for 8 hrs should be 1.5.

For hermitically sealed Potential Transformer the temperature rise of the oil at the top of the tank or housing shall not exceed 55°C.

Power Frequency withstand voltage for the earthed terminal: The terminal of the primary winding intended to be earthed shall, when insulated from the case or frame, be capable of withstanding the rated power frequency short-duration withstand voltage of 3 kV (r.m.s.)

The dielectric Dissipation Factor at $U_m/\sqrt{3}$ and ambient should not exceed 0.005.

The rated power frequency-withstand voltage for secondary winding insulation shall be 3 kV (r.m.s.).

The Voltage Transformer shall be designed and constructed to withstand without damage, when energized at rated voltage, the mechanical and thermal effects of an external short-circuit for the duration of 1 Sec.

The voltage transformers shall be tested in accordance with IEC 600186, and shall include the following routine tests:

- i. Verification of terminal markings.
- ii. High voltage power frequency withstand test on primary windings.
- iii. High voltage power frequency withstand test on secondary windings.
- iv. Partial Discharge Measurement.
- v. Power Frequency Tests between sections
- vi. Determination of Errors

Repeated Power Frequency Tests on Primary windings shall be performed at 80% of the specified test voltage.

Following Types are required to be submitted from the accredited test Laboratory

- i. Temperature Rise Test
- ii. Short Circuit Withstand Capability Test
- iii. Lightening Impulse Test
- iv. Switching Impulse Test.
- v. Wet Test for Outdoor Type Transformer (N/A)
- vi. Determination of Errors
- vii. Measurement of the Radio Interference Voltage

All the dielectric Type Test shall be carried out on the same Transformer, unless otherwise specified.

Following Special Tests are required to be done.

- (i) Measurement of Capacitance & Dielectric Dissipation Factor Test.

3.6 Generator Incoming Feeder

Two (1) incoming generator feeders shall be provided. Each incoming feeder shall mainly be equipped as follows:

- One (1) breaker
- One (1) earthing switch
- One (1) mimic diagram and marking
- Three(3) current transformers
- Three(3) voltage transformers
- One (1) Tariff metering
- One (1) programmable transducer
- Three(3) high voltage fuse
- One (1) 3-phase capacitive voltage indicator
- One (1) protection relay multifunctional
- One (1) measuring center
- Two (2) position indicator
- One (1) selector switch local/remote
- One (1) set of heater
- One (1) thermostat
- One (1) set of auxiliary relays
- One (1) set of lamps and push-button
- Others as required

3.7 Outgoing Line Feeder at Saniveri Utterganga Mini HPP

One (1) outgoing line feeder at Saniveri Utterganga Mini HPP shall mainly be equipped as

follows:

- One (1) breaker
- One (1) earthing switch
- Three (3) surge arrester (installed at line end towers)
- One (1) mimic diagram and marking
- Three (3) current transformers
- Three (3) voltage transformers
- One (1) Tariff metering
- Three (3) high voltage fuse
- One (1) 3-phase capacitive voltage indicator
- One (1) protection relay multifunctional
- One (1) measuring center
- One (1) position indicator
- One (1) selector switch local/remote
- One (1) ammeter with selector switch
- One (1) voltmeter with selector switch
- One (1) set of heater
- One (1) thermostat
- One (1) set of auxiliary relays
- One (1) set of lamps and push-button
- One (1) programmable transducer
- Others as required

3.8 Spare Parts

According to Spare Parts List (See Section VI H)

3.9 Shop Tests

3.11.1 Routine Tests

Routine tests shall be made on all current and voltage transformers, circuit breakers, disconnecting switches and lightning arresters according to IEC recommendations or equivalent. These routine tests shall comprise at least:

1. For circuit breakers:
 - a) Power frequency voltage dry tests on the main circuit.
 - b) Voltage tests on control and auxiliary circuits
 - c) Measurement of the resistance of the main circuit.
 - d) Mechanical operating tests.
2. For disconnecting switches:
 - a) Power frequency voltage dry tests on the main circuit,
 - b) Voltage tests on control and auxiliary circuit,
 - c) Measurement of the resistance of the main circuit,
 - d) Mechanical operating tests.
3. For current transformers:
 - a) Power frequency tests on primary and secondary windings,
 - b) Over voltage inter-turn tests,
 - c) Accuracy test,

- d) Polarity check,
 - e) Resistance measurement of windings.
4. For voltage transformers:
- a) Power frequency tests,
 - b) Verification of accuracy

3.11.2 Type Tests

The following type tests shall be performed on one of each kind of supplied equipment. These tests shall comprise at least:

1. For one circuit breaker:
 - a) Temperature rise test,
 - b) Checking of making capacity and duration,
 - c) Checking of rupturing capacity and of total duration of tripping of operation cycle,
 - d) Checking of short time current withstand,
 - e) Power frequency and impulse dielectric tests
2. For one disconnecting switch:
 - a) Temperature rise tests,
 - b) Power frequency withstand voltage test,
 - c) Short time withstand current and peak withstand current tests,
3. For one current and voltage transformer:
 - a) Temperature rise tests,
 - b) Short time current tests (for current transformer)
 - c) Impulse voltage tests,
4. For lightning arresters:
 - a) Power frequency spark over test,
 - b) Standard lightning voltage impulse spark over test,
 - c) Residual voltage test.

Instead of carrying out type tests, the Contractor may submit the certificates of type tests made in approved laboratory, performed on the equipment of identical design. However, the Employer reserves the right of accepting these certificates or rejecting them partially or totally.

3.10 Field Tests

The following tests shall be performed in the field during and after erection of the supply:

- a) Mechanical clearances, levels and other measurements of equipment as erected
- b) Functional checks of all auxiliaries and protective devices
- c) Dielectric tests as well as measurement of winding resistance and insulation resistances

3.11 Data to be furnished by the Bidder

The manufacturer names and the technical specs related with the Manufacturer shall be submitted by the Contractor at the design stage for the approval of the Employer.

Circuit Breakers Tolerances	Units/	Values/
Manufacturer and Type		
Rated current	A	
Rated rupturing capacity	MVA	
Rated short time thermal capacity (1 sec)	kArms	
Rated making capacity	MVA	
Rated opening time		
Maximum arcing time at the rated rupturing capacity	ms	
Rated breaking time at the rated rupturing capacity		
▪ Without reclosing system	ms	
▪ With reclosing system	ms	
Type of control mechanism		
Maximum charging time of control motor	s	
AC consumption	Watt	
DC consumption	Watt	
Number of operations without changing contacts		
At rated current times		
At 100% of rated rupturing capacity times		
At 80% of rated rupturing capacity times		
At 30% of rated rupturing capacity times		
Guaranteed number of operations with normal maintenance (at p.f. 0.7)		
Consumed current by the control circuit in case of:		
▪ Three phase tripping	A	
▪ Three phase reclosing	A	
Impulse withstand voltage (1.2/50μs) to earth	kVpk	
Across open breaker poles	kVpk	
One-minute power frequency withstands voltage dry and wet to earth	kVrms	
Across open breaker poles	kVrms	
Maximum temperature rise at rated current		
Main contact	°C	
Weight net/gross	Kg/Kg	
Disconnecting Switches (Normal/With Earthing Mechanism/With High)	Units/	Values/
Tolerances		
Voltage Fuse)		
Manufacturer		
Type (Indoor, three phase, manual operating)		
Rated service voltage	kV	

Maximum service voltage	kV		
Rated making current kA			
Rated short time withstand current (1sec)	kA		
Rated peak short circuit current	kV		
Operating mechanism	kV		
Surge voltage			
On insulation distance	A		
To earth and between poles	A		
Rupturing capacity	A		
Melting current of fuse	A		
Weight net/gross	Kg/Kg		
Load Break Switches and Fuses	Units/	Values/	
Tolerances			
Manufacturer			
Type (Indoor, three phase, manual operating)			
Rated service voltage	kV		
Maximum service voltage	kV		
Rated current	A		
Surge voltage			
On insulation distance	kV		
To earth and between poles	kV		
Power frequency withstand voltage			
On insulation distance	kV		
To earth and between poles	kV		
Rated peak short circuit current	kA		
Number of auxiliary contacts			
Make contacts			
Break contacts			
Weight (net/gross)	Kg/Kg		
Current Transformers (Incoming/Outgoing/Station Feeder)	Units/	Values/	
Tolerances			
Manufacturer and type			
Rated voltage	kV		
Maximum permissible operating voltage	kV		
Rated frequency	Hz		
Primary current	A		
Secondary current	A		

Accuracy classes and burdens

▪ Core 1	/VA
----------	-----

Accuracy class/Burden

▪ Core 2	/VA
----------	-----

Accuracy class/Burden

▪ Core 3	/VA
----------	-----

Instrument security factor

Measuring winding

Protective winding

Impulse insulation level

Primary windings

Power frequency (dry and wet 1 min)	kV
-------------------------------------	----

Full wave impulse (1.2/50μs)	kV
------------------------------	----

Secondary windings

Power frequency	kV
-----------------	----

Minimum admissible over currents

Continuous permissible over currents	%
--------------------------------------	---

Thermal short time current (1 sec)	x In
------------------------------------	------

Dynamic current (peak)	Ixn
------------------------	-----

Weight net/gross	Kg/Kg
------------------	-------

Voltage transformers (Incoming/Outgoing/Station Feeder)

Manufacturer

Type

Rated voltage	kV
---------------	----

Maximum Permissible operating voltage	kV
---------------------------------------	----

Ratio

Accuracy class/burden

Type of insulation class

Insulation level

Impulse withstand voltage (1.2/50μs)

HV Power frequency test voltage wet/dry	kV
---	----

LV Power frequency test voltage wet/dry	kV
---	----

Continuous permissible overload	%
---------------------------------	---

Weight net/gross	Kg/Kg
------------------	-------

Lightning Arresters (Line feeders)

Manufacturer

Type**Main characteristics**

Rated voltage	kV
Excitation voltage	kV
1.2/50µs spark over voltage	kVpk (100% spark)
50 cycle spark over voltage (min)	kVrms
Rated discharge current	kA
Limiting capacity	kA
Weight net/gross	Kg

**Busbars
Tolerance****Units/ Values/****Type****Standard**

Rated current (continuous)	A
Maximum current in short-circuit kA (1 sec.)	kV
Conductor profile	
Cross section	mm ²
Material	

4. POWER TRANSFORMER**4.1 General**

This specification covers the design, manufacture, assembly, shop test, supply, delivery, installation works and field test of the power transformers complete with all accessories, fittings and auxiliary equipment for efficient and trouble free operation as specified hereinafter.

The equipment specified in this Section of the Contract shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60076 Power transformer

IEC 60137 Insulating bushings for alternating voltages above 1 kV

IEC 60156 Insulating liquids - Determination of the breakdown voltage at power frequency – Test method

IEC 60296 Specification for unused mineral insulating oils for transformers and switchgear

IEC 60551 Determination of transformer and reactor sound levels IEC 60616 Terminal and tapping markings for power transformer

IEC 60722 Guide to the lightning impulse and switching impulse testing of power transformers and reactors

Manufacturer of power transformer shall hold valid ISO 9001 (including design) quality certificate.

Equipment to be furnished:

1.5 MVA Power Transformer.

The equipment to be furnished shall strictly be in accordance with the specifications and the Price Schedule.

4.2 Design Requirement

4.2.1 The Transformer shall be connected to Three Phase 50Hz system with Higher side Voltage being 11 kV.

4.2.2 The Transformers shall be installed Outdoor in the Hot and Humid atmosphere. The Transformer shall be Oil Immersed and designed for the cooling system as specified in the appendices.

4.2.3 The Transformer should be capable of operating continuously at its rated output without exceeding the temperature rise limits as specified in the appendices.

4.2.4 The Transformer winding shall be designed to withstand short circuit stresses at its terminal with full voltage maintained behind it for a period as per IEC-76.

4.2.5 The Transformer shall be capable of operation at the rated output under the following conditions:

The voltage varying $\pm$ 10% of rated Voltage.

The Frequency varying $\pm$ 5% of rated Frequency.

4.2.6 The Transformer shall be capable of delivering its rated output at any tap position.

4.2.7 The Transformer shall be free from annoying hum and Vibration when in Operation even at 10% over Voltage. The noise level should be as per respective IEC Standards.

4.2.8 The manufacturer of the transformer shall be the holder of valid ISO 9001 certificate (including design).

4.3 Construction Features

4.3.1 Tank:

The Tank should be suitable to house complete core, and maintain oil level up to the top of the core and windings even when the cover is open. The Tank shall be all welded Construction and fabricated from the sheet steel of adequate thickness. All seams shall be properly welded to withstand requisite impact during short circuit without distortion. All welding shall be stress relieved.

The Tank shall be reinforced by stiffener of structural steel for general rigidity. The Tank shall have sufficient strength to withstand stress without any deformation by mechanical shock during transportation and vacuum filling in the field.

The Transformer cover shall be bolted on to the tank with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops should be provided to prevent complete compression. Bushing turrets, cover of inspection holes and other devices shall be designed to prevent leakage of water into or oil from the tank during normal or abnormal conditions. The tank cover shall be provided with two numbers of grounding pads and connected separately to tank grounding pads.

The tank shall be provided with sets of bi-directional flanged wheels for rolling the Transformer parallel to either central lines on the rail.

All heavy removable parts shall be provided with mounting rails along with the eye bolt for ease of handling and necessary lugs and shackles shall be provided to enable the whole Transformer to be lifted by the Crane or other means. Manholes of sufficient size shall be provided for access to leads, windings, bottom terminal of bushing and taps.

There shall be the provisions for the opening of the part of the Tank cover for cleaning of the Cores and Coils with Hot oil during overhauling.

4.3.2 Core & Windings:

The Transformer shall be of Core type. The Core shall be constructed with interleaved grade non-aging, low loss, non-ageing, high permeability, grain oriented, and cold rolled silicon steel lamination, properly treated after being sheared, to remove any burr and shall be re-annealed to remove any residual stresses.

All Steel sections used for the support of the core shall be thoroughly sand blasted after cutting, drilling and welding.

All lamination shall be properly insulated with the materials that will not deteriorate due to pressure and hot oil.

The core shall be rigidly clamped to ensure adequate mechanical strength. Core and Coil Assembly shall be capable of withstanding the vibrations and shock during transportation, Installation, service and adequate provision shall be made to prevent movement of core & coil assembly relative to the tank during these conditions.

The bidder shall submit following documents, as applicable, as a proof towards use of PRIME CORE MATERIALS before manufacturing a Transformer.

- i. Invoice of the supplier.
- ii. Mill's Test Certificates
- iii. Packing List.
- iv. Bill of Lading
- v. Bill of Entry certificate by the Customs.

Core Materials shall be directly purchased either from the manufacturer or through their accredited marketing organization of repute and not through any agent.

The core shall be provided with lifting lugs suitable for lifting complete core and Coil assembly of transformer.

The Coils shall be manufactured from electrolytic copper of suitable grade as per relevant IS. The maximum current density for design of the transformers shall not exceed 320 A/Sq.cm. They should be properly insulated and stacked. All Insulating materials shall be of proven design. Coils shall be so insulated that impulse and Power Frequency Voltage stresses are minimum.

4.3.3 Tapping

No Load Tap as specified in the appendices shall be provided on the high voltage winding of the Transformers.

The Transformer shall be capable of operation at rated output at any tap position provided the primary does not vary by more than $\pm 10\%$ of the rated voltage corresponding to the normal tap.

The winding including the tapping arrangement shall be designed to maintain the electromagnetic balance between H.V. and L.V. winding at all voltage ratios.

4.4 Transformer Oil

The Transformer Oil shall conform to the latest revision of IEC Publication 296, properly inhibited for preventing of sludging.

The necessary first filling of oil shall be supplied for the Transformer in non-returnable container suitable for outdoor storing. Ten percent (10%) excess oil shall also be provided to take wastage into account.

4.5 Oil Preservation System

Oil preservation system shall be by means of Conservator Tank.

4.5.1 Conservator Tank System

The Conservator Tank shall be mounted on a bracket fixed on the Tank

The Conservator Tank shall be provided without compartment, for the main Transformer Tank.

The Conservator Tank shall be connected with the Main Transformer tank by pipes through double float Bucholz relay (Gas Operated Relay) with valves at both ends.

Contact of the Oil in the compartment for the Main Tank with atmosphere shall be prohibited by using a flexible urethane air cell. The cell shall be vented into the atmosphere through a silicagel breather and shall inflate or deflate as Oil volume changes.

The Conservator Tank shall be provided with its own breather, filler cap and drain plug.

The Conservator Tank shall be provided with dial type Level Indicator visible from the ground level and fitted with low oil level alarm Contact and Plain oil level gauge.

4.6 Temperature Indicator

One set of Winding Temperature Indicator shall be supplied and fitted locally so as to be readable at a standing height from ground level. Necessary Current Transformer and Heating Coil for obtaining thermal images of winding temperatures and detector elements shall be furnished and wired or fitted inside the transformer marshaling box.

The above Winding Temperature Indicator shall be provided with necessary contacts to take care of the following:

- i. Starting cooling units in stages with the rise of Temperature.
- ii. Alarm on High Temperature.
- iii. Trip on Higher Temperature.

4.7 Bucholz Relay (Gas Operated Relay – For Conservator Type of Oil Preservation)

The Bucholz relay shall be provided with two floats and two pairs of electrically separate contacts – One pair for Alarm & other pair for Tripping function.

The Bucholz relay shall be provided with the facility for testing by Injection of air by hand pump and with cock for draining and venting of air.

A Sudden Gas Pressure relay shall be furnished and mounted on top of the Tank in the region of the Gas Space. The Relay shall respond to sudden increase in the internal Gas Pressure in the Transformer due to internal arcing. The Relay shall be provided with trip contact. The above relay shall be stable during change in Oil or Gas pressure due to change in ambient temperature and / or loading.

4.8 Transformer Bushings

All Bushings shall confirm to the requirements of the latest revisions of IEC Publication 137.

The Bushings shall be located so as to provide adequate electrical clearances between phases and also between phase and ground as per relevant standards.

All Bushings shall be porcelain type and shall be furnished complete with terminal connectors of adequate capacity. The porcelain used in bushings shall be Homogenous, Nonporous, Uniformly glazed to Brown colour and free from Blisters, Burns and other defects.

Stresses due to expansion and contraction in any parts of the Bushings shall not lead to

deterioration.

Liquid / Oil filled Bushings for 36kV and above shall be equipped with Liquid Oil level Indicators and means for sampling and draining of liquid. The angle of inclination to vertical shall not exceed 30°.

Oil in oil filled Bushings shall meet the requirement of the Transformer Oil standards specified.

4.9 Marshaling Box

A Sheet metal weatherproof marshaling box of IP-55W construction shall be provided. The box shall contain all the auxiliary devices except those which must be located directly on the Transformer. All terminal blocks for external cable connections shall be located in this box.

The Marshaling Box shall have the following but not limited to them

4.9.1 Load disconnect Switch for Incoming Power Supply for Auxiliaries.

4.9.2 Cooler Fan and Pump Motor starters.

4.9.3 FAN START STOP Control Switches for ONAF type only.

4.9.4 AUTO-MANUAL Switches.

4.9.5 Wiring and Termination individually of the following alarm contacts for remote pre trip alarm

- Bucholz relay alarm from Main Tank.
- Winding Temperature High Alarm.
- Oil Temperature High Alarm.
- Tank Oil Level Low Alarm.
- Tap Change incomplete alarm.

4.9.6 Wiring and Termination individually of the following Trip Contacts for remote trip and trip alarm.

- Winding Temperature High Trip
- Oil temperature High Trip
- Bucholz Relay Trip or Sudden Oil Pressure Relay Trip
- Pressure Relief Device.

Cubicle Illumination Lamp with door switch and space heater with thermostat and ON-OFF switch shall be provide.

4.10 Wiring

Wiring shall be done as specified.

4.11 Cable Termination

Marshaling box shall be designed to facilitate cable entry from bottom. Removable plates shall be furnished with compression type cable glands to make entry dust proof and no weight is transferred to the terminal. The glands shall be suitable for terminating Cable Armor.

Sufficient space shall be provided to avoid sharp bending and for easy connection. A minimum space of 200mm from the gland plate to the nearest terminal block should be provided.

4.12 Terminal Blocks

Terminal Blocks shall be as specified

4.13 Painting Works

All painting works shall be done as specified

4.14 Auxiliary Supply

All indication, alarm and trip contacts provided shall be suitable for separation on a nominal 110V DC system.

4.15 Current Transformer

The Bidders are required to propose the detail scheme of ac circuit after making a Site visit and studying the existing ac system of the Transformer Protection and Metering. The existing data are enclosed. The details about the Current Transformer will be finalized after the approval of the scheme or as instructed by the Owner.

4.16 Tests

4.16.1 Routine Tests

During Manufacturing and on Completion, the Transformer shall be subjected to the following Routine Tests but not limited to as laid down in the latest revision of the IEC Publication 76.

Applied Voltage Tests

Induced Voltage Tests

No-Load and Excitation Current Test

Impedance Voltage and Load Loss Test.

Resistance Measurement

Ratio Test

Polarity and Phase Relation Test

Leakage Test.

Insulation Resistance Test

Insulation Power Factor Test

4.16.2 Special Tests

The Following tests shall be performed.

Zero Phase Sequence Impedance measurement.

After fabrication, the tank fitted with all Valves, Covers, Conservator Tank etc shall be completely filled with Transformer Oil and subjected to a pressure of 25% over the Normal pressure of the Oil. This pressure shall be maintained for 12Hours during which time there should be no leakage of oil nor there shall be permanent set when pressure is released. If

any leakage or permanent set occurs, the test shall be conducted again after rectification of the defects.

The Transformer Tank shall be subjected to full Vacuum as far as possible for 12Hours.

After assembly, each core shall be pressure tested for 1 minute at 2kV ac between all bolts, side bolts, structural steel works and core.

Excitation loss and current measurement shall be made at 90%, 100% and 110% of rated Voltage.

4.16.3 Design Tests

Following design Test shall be performed on the Transformer in accordance with latest revision of IEC Publication 76, if such tests have not yet performed by the Manufacturer earlier in size commensurate with the Tendered Transformer. However, if such had been performed earlier, then the design tests can be submitted. If the submitted design tests in the opinion of the Owner, cannot be approved, then such tests have to be conducted.

Temperature Rise Test

Impulse Voltage Withstand Test

Short Circuit Test

4.16.4 Tests of Miscellaneous Components

The various components of the Transformer such as insulating oil, Bushings, Current Transformers etc. shall be tested with the relevant Standards.

The bodies of all valves and pipe works shall withstand a hydraulic pressure of 20psig for 15 minutes. The Testing medium shall be insulating oil as per IEC Publication 296.

4.16.5 Test Certificates

Test Certificates should be submitted in required number of copies for approval.

The Routine, Special and Design Test Certificates of the Transformer shall be furnished for approval before the delivery of the Equipment from the Factory.

The Routine and Type test Certificates of miscellaneous components shall be furnished for approval.

4.16.6 Field Tests

After Installation at Site, the Transformer shall be subjected but not limited to the following field tests

Construction Inspection & Completeness inspection

Insulating Oil Test

Insulation Resistance Measurement

Ratio Test

Tap Changer Operation Test

Magnetic Balance Tests

Short Circuit Test

Magnetizing Current Test

Vector Group Test

Winding Resistance Test

Calibration of WTI & OTI.

Setting of Alarm/Trip And cooler Controls and operation Check.

4.17 Tender Evaluation

4.17.1 Capitalization of Transformer Losses

When evaluating the individual bid received from various Bidders, the transformer shall be evaluated for the cost of losses based on the following relation

$$P_E = P_b + K_L \times L_L + K_{NL} \times L_{NL}$$

P_E = Evaluated Price

P_b = Bid Price

K_L = Value of Load Loss

L_L = Guaranteed load losses at rated current (Maximum MVA base)

K_{NL} = Value of no load Loss

L_{NL} = Guaranteed no load losses

The transformer losses shall be capitalized as follows:

Value of No Load Loss = US\$ 4684.00 per KW

Value of Load Loss = US\$ 1180.00 per KW

4.17.2 The Bidder shall furnish guaranteed no load and full load loss data at rated load with the bid for all rating of transformers contained herein. The supplier shall furnish a test certificate for each transformer supplied, which shall show the actual no load and full load losses of the transformer at rated load. For the purpose of evaluation, the higher values of no-load and load losses shall be considered from the values guaranteed by the Bidder and the values given in the test reports.

4.17.3 If the actual no load and full load losses of any transformer exceed the guaranteed values then the contract price for that transformer shall be reduced by the following calculated amounts for the losses in excess of the guaranteed values:

No Load Loss = US\$ 4684.00 per KW

Load Loss = US\$ 1180.00 per KW

Any transformer shall be rejected if losses exceed the guaranteed value by an amount in excess of the following

Total losses: 10%

Component losses: 15% (unless the total loss exceeds 10 %)

4.18 Performance Guarantee

The Performance figures quoted on the Technical data shall be guaranteed within the tolerances permitted by relevant standards listed below, and will be a part of the successful Tenderer's Contract.

4.19 Drawings, Data & Manuals

4.19.1 Submission

Submission of Drawings, Data & Manuals by the Tenderer along with the Tender Document and that after the Award of Contract for approval shall be as follows:

4.19.1.1 Drawings and Details to be submitted with the Tender

Tenderer's Proposed typical general arrangement drawing showing Constructional Features of Tank including Conservator, level Gauge etc..

Bushing Configuration Arrangement

Cable Termination Arrangement

Wheel Base Dimension and Detail

Head Clearance required for De-tanking of Coil Assembly.

Routine and Type Test Certificates of Similar Transformer as quoted

Technical Manuals on Accessories such as Bucholz Relay, Sudden Gas Pressure / Oil Pressure Relay

Temperature Indicators

High and Low Voltage Bushings

4.19.1.2 After Award of Contract

After Award of Contract, the successful Bidder shall submit the required numbers of copies of following data for approval :

- Outline Detail Drawing showing the general arrangement, indicating the space required for:
- Cable Termination Arrangement
- Wheel base Dimension & Details
- Head Clearance required for De-tanking of Core and Coil Assembly
- Foundation Plans and Loading
- Transport/Shipping details with net weight and weights of various parts.
- Final calculation of the Impedance for Each Transformer.
- Schematic flow diagram of cooling System showing the number of Cooling Units.
- Technical details along with Control Schematic and Wiring Diagram for Marshaling box, Remote Tap Changer Control Panel.

Any other relevant Data, Drawings and information necessary for the review of the items under Clause 1.17.3 of this section whether specifically mentioned or not, shall be furnished along with these information.

4.19.3 The General Arrangement Drawing,

The Schematic Wiring Diagram showing the Control Scheme, Cable Termination Arrangement, Location of Terminal Blocks, etc. shall be furnished for comment / approval in compliance with the **Clause 4.17.3 of this Section**. The Employer / Owner will return those drawings after their review with the comments and / or and the Configuration and the arrangement of the accessories fitted on the Transformer. The Contractor on receipt of their returned drawings, with comments from the Owner, shall prepare final schematic drawing, and coordinate the terminal markings of their final wiring diagram. The outgoing terminals of the wiring diagram shall be specially indicated for different functions, such as closing, tripping, alarm, indication etc. The responsibility for correctness of the wiring diagram shall lie with the Contractor.

The Owner will only check the final schematic diagram after submission. If any modification, addition or alteration is considered necessary thereon to comply with the Owner approved

schematic drawing stated hereinabove, the said modification, addition, or alteration shall be carried out by the Contractor either at works if it is before delivery or at site after delivery at no cost to the Owner.

4.20 NAME PLATE

Each Transformer shall be provided with a nameplate of weather resistant material fitted in a visible portion showing but not limited to the following items.

- ☐ Kind of Transformer.
- ☐ Number of the Specification.
- ☐ Manufacturer's Name
- ☐ Year of Manufacture.
- ☐ Manufacturer's Serial Number
- ☐ Number of phases and Frequency.
- ☐ Rated Power
- ☐ Rated Voltages and Currents
- ☐ Connection Symbol.
- ☐ Impedance Voltage at Rated Current.
- ☐ Type of Cooling
- ☐ Total Weight
- ☐ Insulating Oil Weight
- ☐ Class of Insulation
- ☐ Temperature Rise
- ☐ Connection Diagram
- ☐ Insulation Levels
- ☐ Weight of Transportation and untanking.
- ☐ Details regarding Tapping.
- ☐ No-Load losses
- ☐ Load Losses

4.21 TRANSPORTATION

The Core and Coils shall be completely dried before shipment and Assembled with Tank and with Oil or Dry Nitrogen depending upon the size of the Transformers. In order to facilitate Handling and shipping, as many external accessories as practical, including bushing shall be removed and replaced by special shipping covers.

Bushings, Radiators and other accessories which may be affected by moisture shall be packed in moisture proof containers.

4.22 TECHNICAL PARTICULARS

The Technical Details of the Transformer shall be as per Appendices enclosed with this specification.

4.23 TRANSFORMER ACCESSORIES

4.23.1 The Technical Particulars of Power Transformer and Accessories are:

Description	Technical Specifications
Rated Capacity	1.5 MVA
Quantity Required	1
Type	Out Door Oil Immersed
Type of Cooling	ONAN
Temperature Rise above 45° Ambient Temperature	
In Oil by Thermometer	50°C
In Winding by Resistance	55°C
Number of Phases	3
Maximum Voltage (Phase to Phase)	
Primary, kV	0.5
Secondary, kV	12
Rated Voltage(Phase to Phase)	
Primary, kV	0.4
Secondary, kV	11
Insulation Level of Winding	
Basic Impulse Level as per IEC 76	
Primary, kV	
Secondary, kV	
Connections	
Primary	Star
Secondary	Star
Vector Group Reference	
Primary-Secondary	Dyn11
Tap Changer	
Type of Tapchanger	No-Load

Range of Taps	±10%, Step 2.5%
Number of Taps	9
Method of Tap Change Control	
Mechanical Load	Yes
Percentage Impedance Voltage At Rated MVA and 75° C	
System Grounding	
Primary	Ungrounded
Secondary	Solidly Grounded
Neutral Terminals	
Primary	No
Secondary	Yes

4.23.2 Transformers furnished under this Specification shall be equipped with:

- i. Oil Conservator with one component with filler caps and drain plugs.
- ii. Two sets of Silica Gel Breather with Connecting Pipes and Oil Seals.
- iii. Air Release Plugs.
- iv. Double float Bucholz Relay with Electrically Separate Trip and Alarm Contacts for Transformer Tank.
- v. Two Nos of Shut-Off vales at both sides of each Bucholz.
- vi. Sudden Gas Pressure relay with Trip Contact.
- vii. Mechanically Operated Self Resetting type Pressure relief Device with visible Operation Indicator and Trip Contact.
- viii. 150mm Dial Magnetic Level Gauge with Low Oil Level alarm.
- ix. Direct reading Plan Oil Level Gauge.
- x. 150mm dial Oil Temperature Indicator with Maximum Reading pointer and individually adjustable Separate Sets of Contract for Alarm and Trip.
- xi. 150mm Dial Winding Temperature Indicator with individually adjust electrically separate sets of Contracts for two stage cooler control. Alarm and Trip with detector element complete with Heating coil, Ct's etc.
- xii. Drain Valve with Threaded Adapter.
- xiii. Sample Valve (Top and Bottom).
- xiv. Filter Valve with Threaded Adapter (Top and Bottom)
- xv. Cover Lifting Eyes
- xvi. Jacking Pads, Hauling and Lifting Lugs.
- xvii. Bi-directional Wheels.
- xviii. Rails.
- xix. Clamping Device with Nuts & Bolts for clamping the Transformer on Foundation rails.

- xx. Ladder with Safety device for access to the Transformer top and Bucholz relay.
- xxi. Grounding Pads each with 2 nos tapped holes, bolts and washer for Tank, Radiator and Cable end box Grounding.
- xxii. Rating Plates and Terminal marking plate.
- xxiii. Marshaling Box for housing Cooler Control Equipment and Terminal Connections.
- xxiv. Any other Accessories.

5. 11 kV CIRCUIT BREAKER

5.1 General

This specification covers the design, manufacture, assembly, shop test, supply, delivery, installation works and field test of 11kV vacuum circuit breakers complete with all accessories for efficient and trouble-free operation as specified here in under.

Circuit breakers shall be offered from reputed makes like **ABB/Siemens/CG/SCHNEIDER/GE /Fuji / Siemens or equivalent.**

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60056	High-voltage alternating switchgear
IEC 62271	High-voltage alternating switchgear and control gear
IEC 60376	Specification and acceptance of new sulphur hexafluoride
IEC 60529	Degree of protection provided by enclosures
IEC 60694	Common specifications for high-voltage switchgear and control gear standards

Manufacturer of 11 kV Circuit Breaker shall hold valid ISO 9001 quality certificate (including design).

5.2 Equipment to be furnished

- 5.2.1 The equipment to be furnished shall strictly be in accordance with the specifications and the Price Schedule.

5.3 Design Requirements

- 5.3.1 The circuit breakers shall be suitable for 3 phase, 50Hz in 11 kV system.
- 5.3.2 Circuit breaker shall be installed outdoor in a hot and humid climate. All equipment and accessories shall be provided with tropical finish to prevent fungus growth.
- 5.3.3 The maximum temperature rise in any part of the equipment at specified rating shall not exceed the permissible limit as stipulated in relevant standards. The de-rating of the equipment shall be made taking 45 deg. C as an ambient temperature of the site, if it is designed for any lower ambient temperature.
- 5.3.4 The rated peak short circuit current or the rated short time current carried by the equipment shall not cause:
 - Mechanical damage to any part of the equipment.
 - Separation of contacts.
 - Insulation damage of "Current Carrying Part".
- 5.3.5 Technical particulars of the circuit breaker shall be as per Appendix 5.5.1.
- 5.3.6 All auxiliary equipment shall be suitable for 3 phase 4 wire, 50Hz, 400 V.

5.4 Construction Features

5.4.1 This circuit breaker shall be outdoor, three phase, single throw, pneumatically or spring charged motor operated, vacuum type, trip free in any position, complete with operating mechanism and supporting structure.

5.4.2 Bushing or tanks shall be accurately aligned and assembled with the operating mechanism as a complete rigidly mounted unit on a structural steel base or frame at the factory, to permit shipment and installation as an assembled unit.

5.4.3 Contacts

The contacts shall be designed to have adequate thermal and current carrying capacity for carrying full-rated current without exceeding the allowable temperature rise as specified by IEC standards. They shall be designed to have long life so that frequent replacement or maintenance will be unnecessary. The surfaces of both moving and stationary arcing contacts, which are exposed directly to the arc, shall be faced with suitable arc resisting material.

5.4.4 Local test switch

Each mechanism shall be equipped with a local test switch for electrically testing the closing and tripping operations of the circuit breaker. A separate manually operated cutout device to disconnect the circuits to remote closing, re-closing and tripping devices shall be provided on each circuit breaker. A warning nameplate requiring operation of this device before operation of the local test switch shall be mounted adjacent to the local test switch.

5.4.5 Emergency trip

Each circuit breaker shall be provided with an emergency hand trip device. This device shall be provided with mechanically interlocked contacts to disconnect circuits from remote closing and re-closing devices.

5.4.6 Position indicator

The circuit breaker shall be equipped with mechanical position indicator. The indicator shall be provided for each pole.

5.4.7 Operating mechanism

The operating mechanism of the circuit breakers shall be spring charged by 110V D.C. motor and with mechanical charging.

The tripping circuit mechanism and the closing control circuit mechanism shall each have a nominal voltage rating of 110 volts DC. The tripping circuit shall operate satisfactorily for a tripping operation over a voltage range of 70-110%. The closing control circuit shall operate satisfactorily over a voltage range of 85-110%.

5.4.8 Operation Counter

There shall be the counter to read the number of operations of VCB.

5.4.9 Accessories

The Contractor shall furnish following accessories as an integral part of the circuit breaker:

- Padlocks and duplicate keys
- Operation counter
- Earthing terminals
- Nameplate
- Other necessary accessories
- Operating handle

5.4.10 Spare parts

Following spare parts shall be provided in required quantities as listed in Price Schedule.

5.5 Tests

5.5.1 Routine tests

One circuit breaker of each type ordered under the Contract shall be fully assembled at the manufacturer's works and subjected to routine tests in accordance with IEC 56 and shall comprise but not limited to the following.

- Construction inspection
- Leakage test
- Operating speed check
- Dielectric test
- Pressure test
- Control and secondary wiring check test
- Mechanical operation test
- Operating mechanism system check

5.5.2 Design tests

The Bidder shall submit the Type Test Report for identical circuit breaker with the following test, but not limited to;

- Bushing tests
- Dielectric withstand test
- Current carrying test
- Normal current switching test
- Short circuit switching test
- Mechanical operation life test

If a circuit breaker has been used for design tests, the test breaker will not be accepted unless the following minimum maintenance are completed, including any other provisions not included herein, but required to render the breaker equivalent of a new breaker:

- Replace all latches and pins
- Replace all major parts which are subject to fatigue, including, but not restricted to, contacts, movable cross-heads, spring and linkages.

5.5.3 Field tests

After installation at Site, the circuit breaker shall be subjected but not limited to the following field tests:

- Construction inspection
- Measurement of insulation resistance
- Operating speed check
- Mechanical operation test
- Operating mechanism system check

5.6 Performance Guarantee

The performance guarantee figures quoted on the schedule of technical data shall be guaranteed within the tolerances permitted by relevant standard and will become a part of successful Tender's Contract.

5.7 Drawings, Data and Manuals

5.7.1 The following drawings and data shall be furnished along with the Tender.

General equipment layout

Outline drawings of the breaker and control cubicle with accessories

5.7.2 After award of Contract the successful Bidder shall submit the required number of copies of the following drawings and data for approval of the Employer/Employer's Representative.

General equipment layout

Outline drawing of the breaker and control cubical with accessories.

Loading data and foundation detail.

Elementary control wiring diagram.

Internal wiring diagram.

External connection diagrams, showing terminal boards and other external connection points for each assembly and the required interconnecting wiring.

Drawing showing typical cross-section of the operating mechanism and breaker mechanism.

Drawing showing typical cross-section and assembly of interrupting device.

Drawing showing assembly of principal component parts and accessories.

Drawing showing details of bushing or porcelain supporting columns, including dimension details of flanges and outline dimensions.

Drawing to show details at all points where adjustments may be made to operating dimension mechanism, breaker mechanisms and contacts.

Any other drawings and data required for design and installation of circuit breaker.

Instruction manual for storage, installation, operation and maintenance of circuit breaker and operating mechanism.

5.8 Nameplate

Each circuit breaker shall be provided with nameplate of weather resistant material fitted in a visible position showing the following items as a minimum.

Manufacturer's name

Manufacturer's serial number and type designation

Year of manufacture

Rated voltage, kV

Rated insulation level, kV

Rated frequency, Hz

Rated normal current, A

Rated short-circuit breaking current, kA

Rated interrupting time cycles

Weight of circuit breaker, kg

5.9 Special Tools

In addition to the tools, which are regularly furnished with such breakers, the Contractor shall also supply all necessary special tools or equipment for assembling and disassembling the breaker. The Contractor shall submit an itemized list of such equipment.

APPENDIX 5.5.1

TECHNICAL PARTICULARS OF 11 kV CIRCUIT BREAKER

1.	Type	Vacuum, outdoor type
2.	Quantity required	As per Price Schedule
Voltage rating		
(a)	Nominal system voltage	11kV
(b)	Rated maximum voltage	12kV
Insulation level		
(a)	Impulse withstand voltage	170 kV
(b)	Power frequency withstand voltage (1 min)	75 kV
5.	Frequency	50Hz
Current rating		
(a)	Rated continuous current at 45 deg. C ambient	800A
(b)	Rated interrupting current	25 kA
7.	Re-closing duty cycle (Rated operating sequence)	0-0.3 sec-CO-3 min.-CO
Auxiliary supply		
(a)	Control circuit	DC 110V
(b)	Space heater and auxiliary equipment	AC, 3Ph-4W, 400V, 50Hz
9.	Total maximum break time	ms
	First pole to clear factor	1.5
	Additional Auxiliary Contacts	NO, 8 NC

Maximum make time	ms
Spring charging motor	V DC

6. 11 Kv DISCONNECTING SWITCH

6.1 General

This specification covers the design, manufacture, assembly, shop test, supply, delivery, installation works and field test of disconnecting switches complete with all accessories for efficient and trouble-free operation as specified herein under.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60129 High-voltage alternating current disconnectors and earthing switches

IEC 60529 Degree of protection provided by enclosures

Manufacturer of Disconnecting Switch shall hold valid ISO 9001 quality certificate (including design).

6.2 Equipment to be furnished

- 6.2.1 The equipment to be furnished shall strictly be in accordance with the specifications and the Price Schedule.

6.3 Design Requirements

- 6.3.1 The disconnecting switches shall be used for the 11 kV. 50Hz, 3 phase system.
- 6.3.2 The equipment shall be installed outdoor in a hot, humid climate. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- 6.3.3 The maximum temperature rise in any part of the equipment at specified rating shall not exceed the permissible limits as stipulated in relevant standards. The de-rating of the equipment shall be made taking 45 deg. C as an ambient temperature of the site, if it is designed for any lower ambient temperature.
- 6.3.4 The rated peak short circuit current or the rated short time current carried by the equipment shall not cause:
- Mechanical damage to any part of the equipment
 - Separation of Contacts
 - Insulation damage of "Current Carrying Part."
- 6.3.5 The grounding switch shall be capable of making to a dead short circuit without damage of the equipment or endangering operator.

The disconnecting switches shall be rotating post type with contact blades moving through horizontal plane.

- 6.3.6 The rating, the accessories to be furnished and the schedule of equipment are detailed in Appendices.
- 6.3.7 The disconnecting switches shall be able to carry the rated current continuously and rated short time current for three seconds without exceeding the temperature limit specified in the relevant standard.
- 6.3.8 The disconnecting switches shall be capable of withstanding the dynamic and thermal effects of maximum possible short circuit current at the point of its installation.

6.4 Construction Features

- 6.4.1 The 3-pole disconnecting switches shall be gang operated type so that all the poles make and break simultaneously.
- 6.4.2 The disconnecting switches shall be designed for upright mounting on steel structure.
- 6.4.3 The disconnecting switches shall have padlocking arrangement in both "open" and "closed" positions.
- 6.4.4 All current carrying parts shall be non-ferrous metal or alloy. All live parts shall be designed to avoid sharp points and edges.
- 6.4.5 All metal parts shall be of such material and treated in such a way as to avoid rust, corrosion and deterioration due to atmospheric conditions. Ferrous parts shall be hot-dip galvanized.
- 6.4.6 Bolt nuts, pins, etc. shall be provided with appropriate locking arrangement such as locknuts, spring washers, key etc.
- 6.4.7 Bearing housing shall be weatherproof with provision for lubrication. The design, however, shall be such as not to require frequent lubrication.
- 6.4.8 All bearings in the current path shall be shorted by flexible copper conductor of adequate size (minimum-70sqmm) to allow the specified fault current through it without injury.
- 6.4.9 Main contacts
 - The main contacts shall be of silver-plated copper alloy and controlled by powerful springs designed for floating and pressure point contact.

The contacts shall have sufficient area and pressure to withstand the electromagnetic stresses developed during short circuit without excessive heating liable to pitting or welding.

Contacts shall be adjustable to allow for wear, shall be easily replaceable and shall have minimum movable parts and adjustments.

The blade shall be made of electrolytic copper tube or aluminum tube of liberal section. Rotating feature of the blade at the end of tube travel for contact wiping shall be provided.

Arcing horns shall be provided to divert the arc from main contacts to the separating horns after the main contacts have opened. Arcing horns shall be renewable type.

6.4.10 Insulators and terminals

Insulators shall be post type; brown glazed and composed of stacked units.

The porcelain used for insulators shall be manufactured by wet process and shall be homogeneous and free from cavities and other flaws.

Caps and pins shall be of the highest quality malleable iron or forged steel and smoothly galvanized.

Arcing horn as required shall be furnished.

All insulators of identical ratings shall be interchangeable.

The terminals of the disconnecting switch shall be provided with terminal connectors.

6.5 Operating Mechanism

6.5.1 Disconnecting switches for 11 kV.

The operating mechanism for 11 kV shall be manually operated.

The manual operating mechanism shall be of torsion type suitable for operation in the horizontal

plane. The operating handle shall be equipped with each switch and shall be arranged for mounting on the steel base supporting structures. Means shall be provided on each switch for taking up loose motion in the operating mechanism and for adjusting the travel of each blade independently. The Contractor shall furnish all supplemental members required to secure the installation of the complete switch mechanism to the supporting structures.

All switches shall be self-locking in the open and closed positions independent of the control shaft restraint. Each mechanism shall be provided with an indicator showing direction of rotation for opening or closing, and shall be provided for grounding and for padlocking in the open and closed positions.

Each operating mechanism shall be furnished complete with all necessary operating pipes, inter phase shafts, pipe couplings, guide bearings, ground braids, mounting brackets, mounting bolts, operating handle, auxiliary switches and offsets required for operation from the ground. All operating rods and levers shall be cut to length and all machining operations and threading shall be complete in the factory.

The manually operated disconnecting switches shall also be provided with a minimum four (4) normally closed and four (4) normally open auxiliary contacts for remote indications.

6.6 Assembly

Each disconnecting switches along with its base frame and operating mechanism shall be completely assembled and checked at manufacturer's works for correct alignment and operation prior to dispatch.

All parts and accessories shall have appropriate match marks and part number for identification at site.

6.7 Tests

6.7.1 Type and routine tests on the equipment and components shall be in accordance with latest revision of IEC Standards or equivalent standards.

Each switch shall include but not limited to the following tests:

Routine tests

- Power frequency voltage dry test
- Measurement of resistance of main circuit
- Control and secondary wiring check test
- Mechanical operation test

Design tests

- Insulator test
- Dielectric test, including impulse withstand test
- Radio influence test
- Short-time current test
- Voltage drop test the voltage drop across one complete phase of a switch shall be measured when carrying rated current.
- Temperature Rise Test

If type tests have been previously conducted on identical disconnecting switch, the Contractor may furnish the certified copies of such previous reports instead of performing tests. The Bidder shall submit copy of design test report from accredited testing laboratory for the disconnecting switch of the offered model along with the bid.

6.7.3 Field tests

After installation at Site, the disconnecting switches shall be subjected but not limited to the following field tests:

- Construction inspection
- Measurement of insulation resistance
- Mechanical operation test

6.8 Drawings, Data and Manuals

6.8.1 The following drawings and data shall be furnished with the Tender.

General arrangement drawing with different sections showing constructional features.

Technical leaflets on disconnecting switches offered explaining the function of various parts, principle of operation and special features (if any).

Typical type test results on identical equipment offered in the Tender.

6.8.2 The various drawings, data and manuals shall be submitted for approval and afterwards for final distribution in quantities and in procedures as set-up elsewhere.
The various drawings and data to be furnished shall include:

Outline dimensional drawings of the equipment showing general arrangement and location of fittings.

Transport/shipping dimensions with weights.

Foundation and anchor bolt details including loading condition.

Assembly drawing for erection at site with part numbers and schedule of materials.

Electrical schematic and wiring diagram.

Any other relevant drawings and data necessary for erection, operation and maintenance.

Instruction manual and data sheets.

Any other relevant data, drawing and information necessary for review of the items stated above.

APPENDIX A-1
TECHNICAL PARTICULARS OF 11 kV DISCONNECTING SWITCH
(WITH GROUNDING SWITCH)

1.	Type	3-pole, single throw, outdoor	
2.	Quantity required	As per Price Schedule	
Voltage ratings			
(a)	Nominal system voltage	11 kV	
(b)	Rated maximum voltage	12 kV	
4.	Frequency	50 Hz	
Insulation levels			
(a)	Basic impulse level (BIL)	170 kV	
	Power frequency withstand voltage (1 min.)	75 kV	
Current ratings			
(a)	Continuous current	800 A	
(b)	Short time current (1 seconds)	25 kA	
(c)	Peak short time current	32 kA	
(d)	Making current of grounding switch	32 kA	
7.	Operating mechanism	manually operated	gang

APPENDIX A-2
TECHNICAL PARTICULARS OF 33kV DISCONNECTING SWITCH
(WITHOUT GROUNDING SWITCH)

1.	Type	3-pole, single throw, outdoor
2.	Quantity required	As per Price Schedule
Voltage ratings		
(a)	Nominal system voltage	11 kV
(b)	Rated maximum voltage	12 kV
4.	Frequency	50 Hz
Insulation levels		
(a)	Basic impulse level (BIL)	170 kV
	Power frequency withstand voltage (1 min.)	75 kV
Current ratings		
(a)	Continuous current	800 A
(b)	Short time current (1 seconds)	25 kA
(c)	Peak short time current	32 kA
7.	Operating mechanism	manually operated gang

7. INSTRUMENT TRANSFORMER

7.1 General

This specification covers the design, manufacture, assembly, shop test, supply, delivery, and installation works and field test of instrument transformers as specified herein under.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60044 Voltage transformers

IEC 60044 Instrument transformers

IEC 60529 Degree of protection provided by enclosures

Manufacturer of instrument transformer shall hold valid ISO 9001(including design) quality certificate.

7.2 Equipment to be furnished

The Following Equipment shall be furnished, if seemed necessary, after the approval of Schematic Diagram submitted by the Bidders or as Instructed by the Owner. The Schematic

diagram should be prepared and submitted by the Bidders with Technical Proposal, after studying the existing Protection and Metering System, such as to provide necessary and adequate Protection to the Transformer Bay as a Whole. The Bidders are required to make the Site visit and access necessary Data and Drawings from the respective Substation. Similarly, the details about the Ratio / Burden / Class will be finalized after the approval of the Schematic Diagram or as Instructed by the Owner.

11 kV Current Transformer for Measurement & Protection

11kV / 110V Potential Transformer for measurement & Protection

7.3 Design Requirements

- 7.3.1 Instrument transformers shall be suitable 11 kV 50Hz. 3 Phase with neutral solidly grounded system.
- 7.3.2 Instrument transformers shall be installed outdoor in a hot, humid climate. All equipment and accessories shall be provided with tropical finish to prevent fungus growth.

Burden of the instrument transformers stated herein is the minimum value required. Where higher burden is required to suit the designs, the Contractor shall supply the same without additional cost.

7.4 Construction Features

- 7.4.1 The instrument transformers shall be oil-filled construction and shall be designed for outdoor service and suitable for vertical mounting.
- 7.4.2 The core and coils of current transformer shall be mounted in a steel tank on the top of the unit with the primary coil leads extending through insulated bushings for series or multiple connections. A steel base shall support the high voltage bushing and tank. The high voltage bushing shall be sealed to the tank and the base with oil-tight joints.
- 7.4.3 The primary terminals of instruments shall include provisions for externally connecting the primary winding. The secondary terminals shall be enclosed in a weatherproof terminal box.
- 7.4.4 Porcelain bushings shall have adequate mechanical and electrical strength. The color of porcelain shall be brown.

7.4.5 Junction boxes

Junction boxes shall be rigid weatherproof type complete with terminal blocks suitable for cable size having the range up to 2x6 sq. mm for termination of the secondary connections (such as delta or wye connection). They shall be made of metal, which will resist corrosion on both inside and outside surfaces; otherwise they shall be suitably protected by galvanizing. Cover of the junction box shall be of hinge door type complete with door handle. Two drainage holes shall be provided at the bottom of the junction box. In case the junction boxes are steel sheet, the thickness of such steel sheet shall be at least 1.2mm. Junction boxes shall be sized and arranged to provide easy access for external cables and adequate space for internal wiring and installed equipment. Enclosure protection class of the junction boxes shall be IP55W

The terminal blocks used should be provided with shorting links on the top of the unit with the primary coil leads extending through insulated bushing for series or multiple connections. A steel base shall support the high voltage bushing and tank. The bushings shall be sealed to the tank and the base with oil tight joints.

7.4.7 Termination

Current transformers

All current transformer secondary winding terminals shall be connected to terminals on terminal located in the junction boxes. In addition, a short -circuit type terminal block shall be provided for each maximum ratio of each core at the terminal blocks in both the secondary terminal box and junction box.

Potential transformer

All PT's secondary terminals shall be connected to terminals on terminal blocks located in the junction boxes.

7.4.8 Protective devices

The secondary phase wire for external connection shall be equipped on all potential transformers with switch and fuse. Fuses shall be rated to provide external short-circuit protection and shall be high rupturing capacity non-deteriorating type. Switches shall be rated not less than 250V AC 50Hz. Switches and fuses shall be contained within the junction box provided for termination. Supply fuse failure supervision shall be provided.

7.4.9 Accessories

The following items shall be provided for each instrument transformer:

- Nameplate
- Oil level gauge
- Oil valves or plugs
- Power factor test terminals
- Necessary terminal connections
- Grounding terminals
- Other necessary accessories

7.5 Tests

Tests shall be performed as specified hereunder.

7.5.1 Current transformer

Routine tests

Each current transformer shall be subjected to the following tests.

- Applied potential test
- Induced potential test
- Accuracy tests (including excitation curve for relaying class)
- Polarity check
- Winding resistance measurement for each ratio

Design tests

Bidder shall submit Type Test Report per IEC and/or other recognized international standards.

7.5.2 Potential transformer**Routine tests**

Each capacitor voltage transformer shall be subjected but not limited to the following tests:

Power frequency withstand voltage (dry) test.

Dielectric tests for electromagnetic unit

Accuracy tests

Polarity check

Ratio test

Design tests

Bidder shall submit Type Test Report per IEC and/or other recognized international standards.

7.5.3 Field tests

After installation at Site, all instrument transformers shall be subjected but not limited to the following tests:

Constructions inspection

Polarity check

Ratio test

Measurement of insulation resistance

7.6 Drawings, Data and Manuals

7.6.1 The following drawings and data shall be furnished with the Tender.

Outline dimensional drawings of the equipment

Characteristics and performance data

Type test certificates of similar equipment

7.6.2 After award of Contract the successful Bidder shall submit the required number of copies of the following drawings for approval of the Employer/Employer's Representative.

Outline dimensional drawings of the equipment

Transport/shipping dimensions with weights

Foundation and anchor bolt details

Characteristic and performance data including ratings, ratio and phase angle curves, accuracy for standard burdens, and thermal burden ratings.

Instruction books including complete information for installation, testing, operation and maintenance with renewal parts data.

Any other relevant drawings and data necessary for review of the items stated above.

APPENDIX A-1

TECHNICAL PARTICULARS OF 11 kV CURRENT TRANSFORMER

1.	Type	Outdoor, oil immersed for protection and metering
2.	Quantity required	As per Price Schedule
3.	Rated primary voltage	11 kV
4.	Max. System voltage	12 kV
5.	Impulse withstand voltage	170 kV
6.	Rated frequency	50 Hz
7.	Number of cores	2
8.	Current Ratio	400-200-100/5A for Transformer
9.	Rated Burden	50 VA
10.	Accuracy	5P20 and 0.5 for metering
11.	Power Factor	0.85
12.	Over voltage factor	1.1 Continuous 1.5 For 30 sec
13.	No of secondary windings	as required
14.	Over load factor	200%
15.	Short time thermal rating	25 kA

APPENDIX A-2

TECHNICAL PARTICULARS OF 11kV POTENTIAL TRANSFORMER

1.	Type	Outdoor, oil immersed
2.	Quantity required	As per Price Schedule
3.	Rated primary voltage	11/ $\sqrt{3}$ kV
4.	Max. System voltage	12kV
5.	Impulse withstand voltage	170kV
6.	Rated frequency	50Hz
7.	Connection	Line to ground
8.	Number of secondary winding	2
9.	Voltage ratio	11,000/ $\sqrt{3}$ /110/ $\sqrt{3}$ V
10.	Rated burden for each winding	100 VA
11.	Accuracy	5P and 0.5 for metering
12.	Power factor	0.85
13.	Rated voltage factor	1.1 continuous, 1.5 for 30 sec

Note: The CT Ratio given above are tentative one, the final decision shall be taken prior to the approval of Drawings.

The CT and PT shall be offered from reputed makes like ABB, SIEMENS, CG, SCHNEIDER, GE, FUJI OR Equivalent.

8. LIGHTING ARRESTOR

8.1 General

This specification covers the design, manufacture, factory test, delivery, field test and installation of lightning arresters, complete with all accessories.

The equipment specified in this Section shall conform to the latest edition of the appropriate IEC specifications and/or other recognized international standards. In particular:

IEC 60099-4 Metal-oxide Surge arrester without gap for ac system

IEC 60099-5 Surge arrester - Selection and application recommendations

IEC 60529 Degree of protection provided by enclosures

Manufacturer of Lightning Arrestor shall hold valid ISO 9001(including design) quality certificate.

8.2 Equipment to be furnished

- 8.2.1 The equipment to be furnished shall strictly be in accordance with the specifications and the Price Schedule.

8.3 Design Requirements

- 8.3.1 The lightning arresters shall be station type, single pole, gap less type rated voltage 9 kV for 11kV system. The nominal discharge current shall not be less than 10kA.
- 8.3.2 The active part of the lightning arresters shall be accommodated in porcelain insulators which are suitably reinforced to prevent explosion of an arrester.
- 8.3.3 Pressure relief device shall be provided for the safe discharge of internal pressure.
- 8.3.4 The lightning arresters shall be mounted on galvanized steel structure. Terminal connectors for both line and ground terminals shall be furnished.
- 8.3.5 Surge monitoring device consisting of surge counter, etc., along with insulating bases for mounting at the bottom of the arrester, shall be furnished.

8.4 Test

- 8.4.1 All routine tests shall be performed on each piece of arrester as per IEC. In addition, the following tests shall be carried out.

Construction test

Insulation resistance test and leak current test

- 8.4.2 Type Test certificates on similar equipment shall be submitted by the bidder as per IEC specifications and/or other recognized international standards and routine test certificate carried out for following tests shall be furnished for approval of the Employer/Employer's Representative.

Voltage withstand test

Impulse voltage characteristic test

Discharge voltage characteristic test

Discharge current withstand test

Duty cycle test

Pressure relief test

Contamination test

8.5 Drawings and Data

- 8.5.1 The following documents shall be furnished along with the Tender.

Standard catalog identifying the models and ratings being furnished.

Outline drawings including dimensions

- 8.5.2 The following drawings and data shall be furnished in required number of copies after award of contract for approval of Employer/Employer's Representative.

All updated documents furnished with the Tender.

Outline drawings including dimensions

Foundation and anchor details including dead load

Transport/shipping dimensions with weight

Any other relevant data, drawings and information

8.6 Nameplate

Each lightning arrester shall be provided with a nameplate of weather resistant material fitted in a visible position showing the following items as a minimum.

Manufacturer's name

Manufacturer's serial number and type designation

Year of manufacture

Rated voltage

Nominal discharge current

APPENDIX A-1

TECHNICAL PARTICULARS OF 9 kV LIGHTNING ARRESTER

1.	Type	Outdoor, station type
2.	Quantity required	As per Price Schedule
3.	Mounting	Pedestal
4.	Rated frequency	50 Hz
5.	System voltage	11 kV
6.	Rated voltage	9 kV
7.	Impulse withstand voltage (BIL)	170 kV
8.	Power frequency withstand voltage	70 kV
9.	Nominal discharge current	10 kA
10	Surge Counter	shall be the ISO 9001 holding Company

9. GROUNDING SYSTEM AND LIGHTNING PROTECTION

9.1 General

This specification covers the design, supply, delivery, installation and testing of the complete Grounding System as described herein.

9.2 Codes and Standards

The complete station grounding work shall be in accordance with the recommendation in the "Guide for Safety in Substation Grounding" IEEE No. 80 and the requirements of this section.

9.3 Equipment to be furnished

Complete installation of the ground grid, test link chamber, grounding of all equipment located in the substation as specified herein but not be limited to the supply of grounding conductors, jointing materials and all accessories to complete this grounding installation shall be covered under this specification.

9.4 Grounding Installation Features

- 9.4.1 The installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a first class neat workmanlike manner. Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during laying and installation. All exposed ground conductor runs shall be taken in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly. All connections to the grounding grid shall be made with the bare copper stranded cable.
- 9.4.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean contact surfaces. Grounding conductor connection to all electrical equipment, switchgear, transformers, motors, panels, conduit systems, equipment enclosures, cable trays, distribution boards, equipment frames, bases, steel structure, etc., shall be by pressure type or bolting type connectors.
- 9.4.3 All lap, cross and tee connections between two grounding conductors both below and above grade shall be made by thermo welding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer/Employer's Representative.
- 9.4.4 Grounding conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 500 mm below the bottom elevation of such trenches/pipes.

9.5 Grounding Conductor

9.5.1 Main ground grid

The main ground system shall consist of a grounding grid buried minimum one meter below grade level. The grounding grid shall consist of one no. 100 sq. mm (min) stranded bare copper conductor cable.

9.5.2 Ground electrodes

The ground electrodes shall be 16 mm diameter and 1.5-meter long (min.) copper clad steel. These shall be driven into ground and connected to the main ground grid.

9.5.3 Risers

The risers shall consist of stranded bare copper conductor or connected at one end to the main ground mat and at the other end to the equipment.

9.6 Design Requirement

9.6.1 The Contractor shall measure the soil resistivity and calculate the total length of buried ground conductor, number of grounding electrode and their depth and spacing to achieve a grounding system resistance of not more than 1.0 ohm.

9.6.2 The Contractor shall calculate the cross-section considering the maximum fault level.

9.7 Tests

On completion of the installation, either wholly or in sections, it shall be tested in compliance with relevant code by the Contractor in the presence of the Employer/Employer's Representative. The cost of any test including labor, material and equipment charges shall be borne by the contractor. The ground grid resistance to remote earth shall be 1.0 ohm or less. If this low resistance cannot be obtained as per his design, then additional grounding conductors shall be buried in the earth, or if necessary, buried in treated soil to obtain the required low ground resistance.

9.8 Lightning Protection

The outdoor equipment of the substation and the substation building shall be protected against lightning. The lightning protection shall be achieved by one or more lightning masts or horizontal lightning conductors above the protected equipment. The design of the lightning protection system shall be subject to the approval of the Employer/Employer's Representative.

9.9 Drawings

After award of the Contract, the Contractor shall furnish the grounding layout drawing with dimensions showing the location of grounding grids, electrodes, test link chambers and risers backed up by necessary calculations for Employer/Employer's Representative approval. The work shall have to be started at site only after getting approval from the Engineer. If alternation is required for any work done before getting Employer/Employer's Representative approval, the same shall have to be done by the Contractor at no extra cost to the Employer.

10.12 kV SWITCHGEAR

10.1 Scope of work:

10.1.1 All the works/material as specified in Bill of Quantity and the scope of work shall be the integral part of the job and all the cost reoccurred in this respect and shall be included in the bid price. So the bidder is requested to visit the site and contact the Owner in case of any items/ works not understood before the bid submitted.

10.1.2 12kV cubicle type Indoor Switchgear Panel shall be an air insulated metal clad switchgear with withdrawal vacuum circuit breaker with the fault interrupting capacity of at least 25 kA at 11kV solidly grounded system. The switchgear shall be arranged in single bus bar. The cubicle shall be of modular design provided with space heaters, with the following modules integrated neatly to form dead front type switchgear capable of extension on the both side, forming a single row, single bus bar switchgear panels.

Breaker Compartment.

Bus bar Compartment

Cable, C.T. and P.T. Compartment

Instrument and Relay Compartment (LV Compartment)

10.1.3 All Switchgear operation shall be performed behind a close door. Additionally it shall even be possible to perform all preparations for work inside the cubicle with full degree of protection.

10.1.4 The use of insulation material shall be reduced to minimum, only ripped insulators

with high-anti-tracking characteristics shall be used for necessary conductor supports.

- 10.1.5 Cubicle front shall be covered by a door with inspection windows for mechanical indication for CB ON/OFF position, spring charged and counter indication of CB operation.
- 10.1.6 The cubicle shall be of modular design consisting of separate modules for busbar, circuit breaker, cable and low voltage compartment, and instrument component. Each compartment shall have its own pressure relief flap. The fixed contact shall be mounted in bushing moved by circuit breaker carriage.
- 10.1.7 Earthing to cable feeder and bus bar shall be done via earthing switch manually operated from panel front.
- 10.1.8 Fixed contacts shall have flat silver plating and contact pressure of male and female contacts during connected position according to the International Standard.
- 10.1.9 Bus bars and Jumpers shall have made of flat electrolytic bare copper contact with special heat shrinkable sleeves which provide effective insulation between phases or phase to earth, even if bridged by vermin or other conducting body and suitable for rated current not less than 2000 A. Bus bar shall be latched per panel and easy to replace by standard normal material. Flexible insulation shrouds shall cover the bus bar to Jumper Joints and jumper to stationary contact joints.
- 10.1.10 Bottom of the cubicle shall be covered with a bottom mica plate through which cables are passed into the panel through the appropriate cable glands.
- 10.1.11 The proposed switchgear panel shall be extendible.
- 10.1.12 The proposed switchgear panel shall be suitable for mounting of standard Current and Voltage Transformer according to IEC standard.
- 10.1.13 It is observed that most of the fault and damages inside the CB is due to the short circuit condition carrier out by crawling animals like rat , lizards etc. So, special attention shall be given during design and fabrication, for preventing them to enter into the chamber.
- 10.1.14 Panel shall be of enclosure protection of class IP54

10.2 WITHDRAWABLE PART (CARRIAGE)

- 10.2.1 The chassis shall be made of sheet-steel section and shall carry the switching device, moving mechanism, 4 rolling contact bearings for movement and interlocking mechanism. Movement for carriage shall be done manually and shall be independent from switch room floor.
- 10.2.2 Moving contacts shall be double flat contact with silver plated contact pieces. The flexible fixing shall allow high tolerance and avoiding overheating.
- 10.2.3 Connection of auxiliary supply to the fixed part shall be verified via multi-pole plug which shall be included in the interlocking system. For the easy and assured insert of the plug the hose should come from the fixed part and the plug shall be on the withdrawable part.
- 10.2.4 CB and Isolating Switch Carriage shall have the provision to operate mechanically behind the closed door in Operating and Test Position.
- 10.2.5 Carriage of the same rating shall be exchangeable. It shall be possible to insert CB with higher current in lower rated cubicle but not vice versa.

10.3 11 KV METALCLAD SWITCHGEAR:

10.3.1 Main Equipment Characteristics

10.3.1.1 Insulation:

- i. 12kV primary equipment shall be insulated to meet or exceed the following criteria:

Rated Lightning Impulse Withstand Voltage (kVp): 75

Rated Power Frequency Withstand Voltage (kVrms): 28

- ii. 12kV cubicles shall be designed to provide phase segregation within the enclosures.

10.3.1.2 Clearances:

12kV Primary Equipment clearances between phases and phase to earth shall not be less than as in BS162 or in this specification, whichever is greater.

The layout of the equipment shall provide for safe access for operation and maintenance whilst the remaining sections equipment are alive.

Minimum clearances in air for the 12kV 'Indoor' Primary Equipment shall not be less than:

Phase to Phase (mm): 127

Phase to Earth (mm): 76.2

The busbars shall be insulated by High Grade Phase Insulation. Busbars partitioning shall be done by means of a bushing plate with Cast-Resin Insulators and Cubicles shall be partitioning with earthed sheet metal barriers.

10.3.2.3 Current Carrying Capacity:

Switchgear 12 kV Busbars and Connections thereto shall be designed to carry current corresponding to Maximum Permissible Overload of the connected equipment without exceeding temperature rise specified in the Relevant Standards.

Switchgear 12kV buswork shall be designed to safely withstand with an appropriate margin of the Mechanical and Thermal Effects corresponding to at least the following short circuit currents:

Symmetrical three-phase

(Is) (kA)rms: 25

Peak making Current (kA)p : 63

10.3.2 Circuit Breakers:

10.3.2.1 General

The 12 kV Circuit Breakers shall be Vacuum type, easily withdrawable and housed in a cubicle. It shall consist of three Vacuum Interrupter, three Supports and Operating Mechanism. The Operating Mechanism shall have Motor Charged Spring Operated with provision of hand operated mechanism. With the breaker in close state, spring energy shall be for a "Trip/Close/Trip" Cycle.

10.3.2.2 Main Data:

Type: Metal enclosed, Indoor switch type: Metal enclosed, Outdoor switchgear cubicle type with vacuum interrupters.

Nominal Service Voltage (kV) : 11

Rated Voltage (kV) : 12

Rated Frequency (Hz) : 50

Rated Nominal Current (A) :-

Breaker for Bus Coupling	: 2000A
Feeder Breaker	: 800A
Incomer for Main Power Transformer	: 1250A
Rated Short-Time Breaking Current (asymmetrical) at Rated Voltage, kArms	: 25
Rated Short-Time Making Current at Rated Voltage (KA)p	: 62.5
Rated Operating Mechanism	: Motor-spring operated .
Provision for Manual Operation	:Yes
Bus Bar Rating	2000 A.

Circuit Breaker shall be offered from reputed makes like ABB, SIEMENS, CG, SCHNEIDER, GE, FUJI OR Equivalent.

10.3.2.3 Technical Requirements:

The Circuit Breakers shall meet requirements of BS 5311 and IEC 56.

Vacuum Interrupter: The Arcing chamber with the two stem connected contacts shall be located between two ceramic insulators. One contact shall be fixed to the housing and the moving contact shall be connected to the housing via vacuum tight bellows. The metal bellows shall enable the moving contact to carry out its strokes. The metal bellows must be able to withstand the movement corresponding to 30,000 make / break operation without failing. The insulators shall be made of metallized aluminum oxide ceramic which permits them to be brazed to metal so that there is no need to use conventional seals. The Vacuum Interrupter shall remain vacuum tight throughout its working life.

The Transformer CB shall be capable of interrupting the corresponding 11kV distribution lines in the event of failure of the respective feeder breakers.

The Operating Mechanism shall have two Trip Coils and be electrically Trip-Free and Antipumping.

The Spring Charging Motor, the Closing Coil, the Tripping Coils and all other control devices of all circuit Breakers shall be suitable for 110V d.c Operation.

A Manually Operated Mechanism for closing and tripping shall be provided in the breaker cubicle for Maintenance and Emergency Operation. This device shall be so interlocked that while it is operative, the breaker cannot be operated remotely.

Each Circuit Breakers shall be equipped with an Operation Counter (to register tripping operations) and position indicator, on the cubicle front.

Provision shall be made for Remote alarm/indication of the following status through a pair of NC+NO contacts:

- Circuit Breaker "Open".
- Circuit Breaker "Closed".
- Circuit Breaker "Trip".
- Circuit Breaker "Device Mechanism Faulty".
- Trip Circuit Healthy.
- Circuit Breaker "Failure"

The circuit breaker shall be equipped with a local control switch and local remote selector switch auxiliary contacts for remote indication. All contacts shall be wired to terminal block in the breaker cubicle.

Each of the circuit breakers shall be housed in a free standing indoor type cubicle. This cubicle (and others comprised in the 11kV metal clad switchgear) shall be of standard construction and shall be suitable for attachment of cable connection as described in relevant cubicles. These cubicles shall be equipped with copper earthing busbars of not less than 200Sq.mm.

Plugging contact apertures shall be fitted with fully automatic metal safety shutters to close the apertures and prevent access to live part when truck partition is withdrawn and to open when the truck partition is being plugged in. The shutters shall form reasonable dust, drip, fire and insect proof enclosures over the apertures. The respective sets of shutters shall be clearly, boldly and permanently marked 'Busbars' and 'Feeders' respectively.

Auxiliary Switches shall be provided as required for Indication, Control, Protection and Interlocking. In addition, a minimum of two Normally Open and two Normally Closed Auxiliary Contacts shall be provided as spare contacts. All available contacts of Auxiliary Switch Assembly shall be wired to the Terminal Blocks on the fixed portion of the equipment of the switches and terminals shall be such as to facilitate future extension.

All auxiliary switches shall have contacts with strong wiping action. the switches shall be located in an accessible position and adequate physical protection shall be provided.

The Circuit Breakers shall be tested in accordance with BS5311 and IEC56 and IEC60 and shall include the following routine tests:

Mechanical operating tests

Power Frequency Voltage withstand tests.

Tests on auxiliary and control circuits

The quality assurance of the equipments and their auxiliary shall be based on ISO9001 Standard.

The Minimum Operating Cycle (without maintenance) of Interrupters and Operating Mechanisms shall be suitable for operation over 10Years or 10,000 operations with rated current or 100 operation with rated short circuit current and overall life shall be more than 30,000 operating cycles.

The Vacuum Circuit Breaker installed in the Switchgear shall move into following position in the Circuit Breaker Components:

Running Position (Run)

Main Circuit and Control Circuit connected to all circuits.

Test Position (Test)

Main circuit separated from the circuit and only Control Circuits are Connected.

Disconnected Position

As a Control Circuit Connector that would be plugged by hand during the test position both Main and Control circuit are disconnected from the Circuit.

10.4 EARTHING SWITCHES

The Earthing Switch is operated by means of detachable lever from outside the cable compartment. It shall be mechanically interlocked with the CB so that the earthing switch in close position in section of CB truck into the service position is not possible. The operation of the Earthing Switch shall not be possible as long as the CB is not in isolated position.

10.4.1 The 11kV metalclad switchgear shall include earthing switches to facilitate earthing of each cubicle as specified.

10.4.2 Main Data

Rated Voltage kV 12

Rated Current A 1250

Short Circuit Current withstand capability (as specified above)

Bus Bar Rating A = 2000

Short Circuit Current withstand capability (as specified above)

Bus Bar Rating A = 2000

10.4.3 Technical Requirements:

- a. The Earthing Switches shall meet the requirements of BS 5253 and IEC 129. Auxiliary Switches shall be provided as specified for the Circuit Breakers. Provision shall be made for padlocking in the Open and Closed position.
- b. Manual control of the switches and position indicator external to the cubicle shall be provided.
- c. The Earthing Switch shall be interlocked manually with transformer circuit breakers.

10.5 INTERLOCKING

The following operation shall be taken place only when the under stated interlocking conditions are fulfilled to ensure Personal and Operational Safety.

10.5.1 Transferring the withdrawable part from the Disconnecting Position to the Service Position:

Control Circuit Plug Inserted

High Voltage Compartment Door closed.

Circuit Breaker in OPEN Position.

Earthing Switch in OPEN Position

10.5.2 Transferring the Withdrawable part from the Service Position to the Disconnected Position.

Circuit Breaker in OPEN Position.

10.5.3 Operating the Circuit breaker

Position (Service or Disconnecting position)

10.5.4 Operating the Earth Switch Withdrawable part in the Interlocked Final Withdrawable part in the interlocked disconnected position. windows shall be provided to allow visual inspection.

The Switches shall be tested in accordance with BS5253, IEC129 and IEC265 and shall include the following routine tests:

Operating and Mechanical tests

Measurements of the resistance of the main circuit.

10.5.5 Safety Device

Individual explosion vents should be provided for breaker / busbar / cable chambers on the top of the panel to let out the gases under pressure generated during an unlikely event of fault.

Cubical with the front plate is pressure tested for the internal arc fault as per PHELA recommendations.

Circuit breaker and the sheet metal enclosures are fully earthed.

10.6 12kV VOLTAGE COMPARTMENT:

The Low Voltage Compartment of the Switchgear shall be located on the top front of the Panel and shall be accessible with a separate door and partitioned against high voltage part. Connection of control and Metering cable is by means of a multiple plug to the withdrawable part possibly at front face of the breaker. Low voltage devices metering and protection equipment shall be mounted flush in the door or on the mounting plate inside.

Wiring inside the cubicle shall be done by 2.5 Sq.mm insulated stranded copper wires for current circuits and 1.5 Sq.mm for voltage circuits.

The following equipment's shall be mounted in the low voltage compartment.

1 No. Ammeter, Digital Type of class C designation, with selector switch. (for incoming and outgoing circuit breaker)

1 No Voltmeter, Digital type, with Voltage Selector switch (for incoming and outgoing circuit breaker)

1 No kVA meter, Digital type of class designation (for incoming and outgoing circuit breaker)

1 No Energy meter 3Phase 4 wire, 3Element, as specified (for incoming and outgoing circuit breakers)

1 No Power Factor Meter Digital type 3Ph, 4Wire, 3Element. (for incoming and outgoing circuit breaker)

Nos Overcurrent Relay Static Type 5A secondary current with (for incoming and outgoing bus coupler circuit breaker)

Setting range 5-250% in step of 1% for Overcurrent element

have a time multiplier range of 0.025-1 in step of 0.001 for phase fault

Setting range 50-3000% in step of 50% for High Set Element

1 Earth fault Relay, Static Type, with Secondary Current 5A and with Instantaneous tripping setting range 5-250% (For incoming and outgoing circuit breaker).

Setting range 5-250% in step of 1 for Earth fault element have a time multiplier range of 0.025-1 in step of 0.001 for earth fault

Setting range 50-3000% in step of 50% for High Set Element

Auxiliary relay and coupling relay if required Anti-condensation heater (for incoming and outgoing circuit breaker)

10.7 CURRENT TRANSFORMERS:

10.7.1. The 12kV Metalclad Switchgear shall include protection and metering Current Transformers as specified. The Current Transformers shall be Epoxy Resin insulated block type Current Transformers as follows:

10.7.2 The current transformer shall comply with the requirements of BS 3938 and IEC 185 shall confirm to the specified insulation requirements and shall withstand without damage the applicable short-circuit current specified. Primary ratio taps shall not be

accepted. The ratio given above is tentative one, the final decision shall be taken prior approval of the drawing.

- 10.7.3 The manufacturer of current transformer shall be the holder of valid ISO 9001 certificate.
- 12.7.4 Maximum temperature rise at rated primary current shall not exceed 50 degree centigrade.
- 10.7.5 Accuracy classes for the protection and metering shall not be less than 5P20 and 0.5 respectively. Burden and accuracy class shall be adequate to ensure correct operation of associated protective devices and instruments. Saturation curves shall be provided with C.T. Characteristics.
- 10.7.6 Each set of secondary windings shall be wired to suitable terminal blocks and earthed at the first control or relay panel to which they are connected. Differential Protection Circuits (involving more than one set. of CT's) shall be earthed at one location only.
- 10.7.7 The Current Transformers shall be tested in accordance with BS 3938 and IEC 185 and shall include the following Routine Tests:

Verification of terminal markings polarity etc.

Power frequency tests on primary windings.

(iii) Power frequency tests on secondary windings.

(iv) Overvoltage inter-turn tests.

Determination of ratio error and phase displacement.

The CT and PT shall be offered from reputed makes like ABB, SIEMENS, CG, SCHNEIDER, GE, FUJI OR Equivalent.

10.8 VOLTAGE TRANSFORMERS

- 10.8.1. The 11kV Metalclad Switchgear shall include Voltage Transformers in incomer as required by the Single Line Diagram as follows:

Type : Epoxy-resin insulated, single pole with 7.3A Primary side fuses	
Basic Impulse Level : 75kV	
Primary Voltage :	11/ $\sqrt{3}$ kV
Secondary Circuit :	110/ $\sqrt{3}$ V
Rated burden :	20 VA
Accuracy classification : 0.5 Class	

- 10.8.2. The voltage transformers shall comply with the requirements of BS 3941 and IEC 186. Accuracy class for the metering case shall be 0.5 Bidder shall insure whether 100VA is sufficient for the smooth operation.

10.8.3 The voltage transformers and their fuses shall meet the specified insulation requirements and have a rated primary voltage of 11kV with knee of saturation curve not lower than 12kV and ratios per single line diagram.

10.8.4 The voltage transformer shall be provided with high rupturing capacity (HRC) fuses for primary and secondary circuits. The fuses shall be rated for the short circuit levels specified.

10.8.5 The voltage transformers shall be tested in accordance with BS 3941 and IEC 186, and shall include the following routine tests:

Verification of terminal markings.

High voltage power frequency withstand test on primary windings.

High voltage power frequency withstand test on secondary windings.

Tests for accuracy.

10.8.6 The voltage transformer shall be installed at the suitable place in the incoming circuit breaker.

10.9 CONTROL PROTECTION AND INSTRUMENTATION:

10.9.1 This covers the detailed requirements 11kV switchgear panel cubicles, and design, manufacture, transport, installation and commissioning of new 12kV Metal clad VCB switchgear.

10.9.2 The substation will normally be attended and operation will be semi-automatic.

Normally closing of circuit breakers shall be manual operation and operation of earthing switches will be manual if it is not mentioned.

10.9.3 Local control facilities adjacent to the equipment shall be provided for maintenance, inspection and emergency operation.

10.9.4 The control system shall be designed to permit the following operating modes:

10.9.4.1 Automatic start/stop operation refers to spring-charged motor for operating mechanism of 11kV VCB.

10.9.4.2 Automatic tripping of 11kV VCB, LV MCB if faults occur in protected lines equipment's or circuits.

10.9.5 The control system shall be arranged in such way that it is possible to change between local automatic and local manual control any time.

10.9.6 Solid state modular equipment shall be used wherever possible.

10.9.7 The designs shall be in general conformity with the single line diagrams and layout drawings accompanying this specification.

10.9.8 Under manual control the individual operations shall each be subject to safety interlocks being satisfied.

10.9.9 The control scheme shall be operationally simple, safe, easy to maintain and functionally consistent. Each module shall have sufficient test points to facilitate fault finding. Control circuits shall be brought out to isolating terminals to permit efficient trouble shooting.

10.9.11 Each cubicle shall be provided with a sufficient point annunciator to identify an alarm condition, including audible alarm, test, acknowledge and reset push buttons.

10.9.12 Control switches for circuit breakers shall be of the discrepancy type. Two independent movements shall be required to initiate an operation. The position of manually operated disconnectors shall be indicated by means of discrepancy indicators.

10.9.13 The design shall be such that as to avoid nuisance alarms and shall block those devices which assume alarm conditions when the equipment is under shutdown. Annunciator

windows shall be engraved with identification of the alarm condition.

10.9.14.1 Annunciators shall have the following sequence :

Condition	Lamp	Alarm
Normal	Off	Off
Alarm Flashing	On	On
Acknowledge	On	Off
Reset after return		
Normal	Off	Off
Lamp test	On	Off

10.9.14.2 Required signals or alarm systems:

CB Off/On position by green/red lamp

Flag or lamp indication of faults for:

Overcurrent Protection, E/F Protection, DC Supply Failure, CB Failure, MCB tripped, AC supply failure, interlocking system disturbed, CB driving faults.

10.9.15 The annunciator shall be of solid state type and suitable for operation at 110 V dc and shall be able to withstand IEC 255 class 3 tests without malfunctioning.

10.16 Protection required:

For incoming & outgoing -**O/C and E/F protection with instantaneous tripping**

For bus coupler panel **O/C protection.**

10.9.17 Transformer Protection:

Following protection shall be provided for the step-down power transformers in incomer feeders:

10.9.17.1 Transformer Differential

Differential relay shall be provided for the protection of 0.4/11kV,250kVA & 0.4/33,1500 kVA transformer.

10.9.17.2 Overcurrent (if applicable)

Backup protection shall be provided in the form of inverse time overcurrent relay connected into the transformer LV neutral connected current transformer.

10.10 FACTORY TESTS:

Factory tests shall include inspection and routine testing of all relays and devices as per BS and IEC publications. Continuity and insulation testing of all devices and wiring and complete control sequences testing shall be performed to the extent feasible in the plant.

All electronic equipment items and the subsystem shall be operated continuously for a minimum of two hundred (200) hrs. prior to shipment in accordance with the approved testing procedures to ensure the operational integrity of each component and of the total system.

Type test reports for each protective relay shall be provided.

Each component of protective equipment shall be tested at the Manufacturer's work or at site to establish its performance characteristics.

10.11 MINIMUM REQUIREMENT FOR SWITCHGEAR

10.11.1 All 11kV feeder and bus coupler cubicles shall house single circuit breaker per pond. Each circuit and feeder shall be equipped with the following devices and equipment Withdrawable module with:

☐ Hand operated drive mechanism	1 Set
☐ Auxiliary block with 4NO+ 4NC contacts for position indication	1 No
☐ Multiple pole lug for control signals	1 No.
☐ Motor operated spring charging mechanism	1 No.
☐ Close/trip buttons	1No.
☐ Trip coil	1No.
☐ Closing coil	1No.
☐ Counter indicating number of switching operation	1No.
☐ Auxiliary block with 11NO + 11NC 1Wi (alarm contact)	1No.
☐ Auxiliary switch for spring charged indication	1 No.
☐ Service track for removing of withdraw able module	1 No
☐ Breaker carriage (if applicable)	2No

Bus Coupler (if applicable)

☐ Copper busbars, rating shall be 2000A	1 Set
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Epoxy resin insulated block type current transformer as mentioned above in clause 13.7.

1st Core : 0.5 class 30 VA (for measurement) 2 Nos

2nd Core : 5P20 30 VA (for protection)

☐ Breaker Carriage.	1No.
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10.11.2 Trunking (Adaptor) Chamber:

Trunking Chamber should have the voltage rating 12 kV and the current rating of bus bar shall not be not less than 2000A. Contractor must verify the overall dimension by inspection at the site for accurate fitting.

10.11.3 Specification of Meter to be installed

Please refer above in the Energy Meter

11. STATION SERVICES

11.1 Scope of Work

This specification covers the requirements for the design, manufacture, erection, commissioning and guarantee of station service equipment for Saniveri Utterganga Mini HPP.

The station service equipment to be provided by the Contractor shall consist of mainly:

- One (1) AC main and distribution switchboard
- One (1) DC main and distribution switchboard
- One (1) 110 V stationary battery set
- One battery charge system with redundant rectifiers (110 V DC Converter)

The Contractor shall provide the distribution circuitry along with the equipment.

The Contractor shall also provide the power distribution circuits from the power centers up to the panel of the equipment.

11.2 AC-Station Service System

AC-Station service main power - center is divided into two sub-centers +SDP1 and +SDP2 which are normally connected together and supplied by the 50 kVA, 11/0.4-0.23 kV station service transformer. Such a division of the main power center is foreseen, in order to eliminate some loads easily in cases of emergency conditions.

The circuit breakers connecting the station service transformer and the diesel generator set to and the circuit breaker connecting the two sub-centers shall be remotely controlled from the control room of the power station.

The necessary interlocking among the circuit-breakers switching the station service transformer and the diesel generator unit on the bus bars of the power center +SDP1, +SDP2 and the circuit breaker between +SDP1 and +SDP2 shall be provided by the Contractor for a proper and secure operation.

The AC power supply system shall be 50 Hz, 3-phase, 400/230 V plus and minus 10%, 4 wire with neutral solidly grounded at power transformer and diesel generator.

11.3 DC-Station Service System

11.3.1 General

DC-services will be available at all times and will not be affected by any fault on a high or medium voltage circuit or by a possible shut down of the main AC-power supply. They will maintain the continuous feeding and operation of the following elements of the power plant.

- General monitoring of the power plant
- Control, signaling and protection circuits
- Solenoid valve
- Emergency lighting recording instruments
- 0.4 kV switchgear equipment
- Emergency pumps (if any)

DC-services feed the above consumers directly with direct current generating by a rectifier battery set.

11.3.2 DC-Station Service Power Center

DC-station service power center DCB shall basically consist of 110 DC stationary battery and two AC-DC rectifiers. Normal coupling will be with the battery and the main rectifier connected to the main DC bars (floating battery).

When necessary, the following couplings will be possible also:

- Only the battery connected to the bus bars
- Spare rectifier connected only to the battery and isolated from main bars, main rectifier connected to the main bars.
- Battery disconnected, one rectifier feeding the main DC bars.

These couplings shall be realized through hand operated disconnecting switches. Rated voltage of the DC system shall be 110 V DC plus 15 and minus 10.

11.3.3 Batteries

The batteries shall be Nickel Cadmium (NiCd) and it shall be able to supply the normal continuous current and the peak current at the rated voltage range (110 V DC $\pm 10\%$) during

the discharge period of 5 hours.

The battery shall be assembled in heat resisting, shock absorbing plastic containers with airtight and leak proof covers.

Sufficient sediment space shall be provided so that the battery shall not have to be cleaned during their normal life under most severe cycle service.

A suitable rack or cubicle shall be furnished for the battery.

The battery shall have sufficient reserve to enable continuous floating operation for 3 months.

Battery Specifications:

Number of set: One (1)

Rated voltage: 110 V

Number of cells: as required including spares

Capacity (10 hours): 200 Ah,

Discharge time: 5 hours

11.3.4 Rectifiers

Both rectifiers, main and spare, shall be static type with silicon or selenium elements. The rectifiers shall have high efficiency and shall be durable under long term duty. The temperature rise of the rectifier elements shall not be more than 30°C above the ambient temperature.

The regulation of the rectifier shall meet the following requirements:

For supplied current between 0 and rated value and for maximum AC voltage variation. DC voltage shall be kept at the rated voltage $\pm 1\%$.

The rectifiers shall be equipped with a limiting device, so that, beyond the rated current capacity, the voltage shall decrease very quickly.

An alarm shall be provided to the control room for the minimum/maximum values.

The rectifiers shall be completely automatic and self regulating and shall be supplied with adequate overload and short circuit protection by ultrafast fuses fitted with melting indicators, the contact of which shall be connected to a general alarm to be transmitted to the control room.

The rectifiers shall be equipped with Ammeter and Voltmeter for DC System Voltage and current

11.3.5 Technical Requirement

Battery charger shall consist of following components

Number of set: one (1)

Type: self-cooled, silicon controlled rectifier (thyristor)

Rating: AC side 3-Phase 400 V, 50 Hz

DC side 50 A (continuous)

Accuracy: Output DC voltage: within $\pm 1\%$ to 0-100% load

Power transformer: 1 phase dry-type

Voltage regulator: Automatic voltage regulator

11.4 Performances

11.4.1 Voltage

The rated service voltage shall be:

- 400/230 V, 50 c/s, 4 wire system for the AC supply system
- 110 V and 24 VDC for the DC supply system

All equipment shall be suitable for continuous operation at every voltage in the full range of:

- 400/230 V +10% and - 10% for AC equipment
- 110 V and 24 V + 15% and -20% for DC equipment

11.4.2 Operating Temperature

Temperature range:

Indoor equipment: 0°C to 55°C

Outdoor equipment: -5°C to 55°C

Maximum temperature rise of the buses and insulating materials: 45°C and 65°C respectively (above ambient temp)

Maximum temperature rise of the air in the cubicles: 25°C (above ambient temp.)

Maximum temperature rise of the instrument transformer windings: 55°C (above ambient temp.)

11.4.3 Current and Short-Circuit Ratings

All equipment shall have the capability of supporting a continuous load at least equal to the highest possible setting of the thermal relays selected as per selectivity chart. Short circuit duty rating of the equipment shall be equivalent at least to the highest symmetrical and asymmetrical short circuit current of the relevant circuitry. Size and the rated capacity of the equipment shall be subject to the Owner's approval.

11.4.4 Protection

A good selectivity of the protection shall be provided from end to end of the AC and DC system, including on overloads and short-circuit currents as well. This shall be carried out by application of the coordinated graded time principle.

11.4.5 Guarantees

The manufacturer shall guarantee the performance, quality, etc. of his/her supply to be in conformity with all specific requirements, and in particular with the following:

- Equipment, chiefly the protection system, to incorporate the highest degree of selectivity, in view of a perfect service to be rendered in association with the equipment as described.
- Design of the equipment to be supported by studies, computing notes, selectivity charts in the full extent as necessary for evidencing its capability to meet properly with the requirements.
- Equipment to incorporate at short-circuits withstanding capability.

11.5 Construction Main Details

11.5.1 Switchboard Arrangements

The switchboards shall be of the metal enclosed type. Main AC and DC switchboards shall be equipped with draw-out and or fixed circuit breakers. Other switchboards shall be equipped with fixed equipment.

Motors shall be supplied by the fuse, contactor, and thermal relay combination. The switchboards or switchboard sections shall have ample strength to withstand, without damage, all stresses incidental to shipping, installation and short-circuit forces during operation.

The arrangement of equipment shall be such as to ensure satisfactory performance and shall allow sufficient space for maintenance within the structures. Ventilation openings shall be provided on all totally enclosed switchboard and cubicles:

- On indoor installed switchboards they shall be so arranged and located as to prevent

damage to or malfunction of equipment and wiring components from water dripping or splashing.

- In outdoor installed switchboards they shall be so arranged and located as to ensure a waterproof construction. All ventilation openings shall be screened so as to be insect proof.

Heating resistances shall be provided within the outdoor switchboards with a rating sufficient to maintain the temperature inside the board about 5°C above the ambient air temperature to avoid water condensation due to temperature variations. The heater circuits shall comprise protective miniature breakers and hand control.

Any material entering into the construction of the switchboard components shall be reasonably fireproof:

- Circuit breakers shall be of oil less type
- Instrument transformer, bars, cables and wires shall be self extinguishing plastic insulated.

11.5.2 Metal Structures

The switchboards shall be made of sheet steel framed as required so to obtain self-supporting free-standing structures.

Access to the interior shall be by front and rear doors of 2 mm thick sheet steel panels.

The sheet panels shall be free from flows and stiffened as required so as to prevent any deflection.

The frame-work shall be suitable for support of any equipment and conduits runs which must be installed behind the face of the board.

Channels base 150 mm high, slotted to receive floor anchor bolts shall be set back 50 mm from the face of the boards:

Switchboard sections shall be designed so as to permit fastening together.

All necessary nuts and bolts for assembling sections shall be supplied with the boards as well as floor anchor bolts.

Nuts and bolts shall be corrosion-proof.

Each switchboard shall be provided with facilities for any easy extension at both ends.

11.5.3 Bus-bars

Bus-bars shall be insulated by insulated screening around and between the main bus-bars in the main boards.

Bar support and bar insulation shall retain substantially undiminished mechanical and dielectric strength for the service life of the equipment.

Bus-bars and tap conductors shall be supported to withstand stresses resulting from short-circuit currents as specified.

Neutral bars shall be insulated from the switchboard frame and sheet steel, but connected to the ground bar, at two places, by means of removable links.

Grounding bars shall not be insulated.

Bar and tap joints shall be bolted and each connection shall be made with not less than two bolts.

Grounding connections shall be bolted, brazed or welded.

11.5.4 Wiring and Terminals

Connections internal to panels and boards shall be made with copper wires of adequate cross section, with non-flammable plastic insulation. Moreover each wire shall be capable of withstanding without excessive overheating the most severe combination of intensity and

duration of fault current susceptible to appear in the circuit.

The wirings shall be adequately supported to prevent breakage caused by sagging or vibration.

Terminals shall be in sufficient number: Only one conductor of the incoming or outgoing cable shall be connected to any one terminal. Internal wiring shall not have more than one wire connected to any one terminal point, except two wires maximum at apparatus and on condition that the terminal be properly sized and arranged. Each terminal block shall have 10 spare terminals, with a minimum of two. Full depth insulating barriers shall be provided between the terminal rows of the various categories of voltage and/or functions.

Terminals for connection of secondary windings of current transformers shall be provided with adequate devices for easy short-circuiting and for insertion of a test instrument, with plugging type connector.

Terminals for connection of secondary windings of voltage transformers shall be designed for easy connection (plug type) of a test instrument.

Each terminal, cable and wiring shall bear a reference mark clearly visible and unalterable.

11.5.5 Breakers

AC-breakers shall be three-pole air break type, 500 V minimum. Wherever the neutral has to be connected to the incoming or outgoing, cable connection shall be through a removable link so as to allow for a complete separation of the distribution switchboard or equipment when necessary.

DC breakers shall be two-pole air break type 250 V minimum.

The operating mechanism of the breakers shall be trip free. Contacts shall be quick make and quick break and shall be made of non-welding materials.

A mechanical indicator shall be provided to indicate the open and closed positions. The circuit protection shall include thermal and magnetic elements for over current and short-circuit protection breakers shall be equipped with an auxiliary contact to give an alarm signal when they are tripped by their incorporated thermal and/or magnetic device. Each breaker, equipped with a trip signaling contact, shall be provided with a small switch for alarm circuit disconnection when the breaker is open and out of service.

Auxiliary tripping contacts of the breakers in one same switchboard shall be connected in parallel to give one common alarm through a local luminous indication duplicated in the control room.

Breakers shall be provided with all the auxiliary contacts required for control, indication and interlock functions. Control shall incorporate pumping prevention as well as sealing-in of the control circuit for securing of operation as soon as started.

Draw-out type breakers shall be able to be put into three positions:

Disconnect position: main and control circuits disconnected.

- Test position: main circuit disconnected local electrical operation of the breaker shall be possible.
- Connect position: -The breaker shall be mechanically interlocked for positively holding in place under all operating conditions.
- All contacts must be full and complete engagement before the breaker can be locked in connects position.
- Grounding of the circuit breaker base shall be so arranged as to apply before power contacts are made and shall be maintained until the power contacts have been separated by a safe distance.

11.5.6 Instrument Transformers

Instrument transformers shall be so provided as indicated on the accompanying drawings and

wherever necessary.

Voltage transformers shall be equipped with primary fuses of the current limiting type with an interrupting capacity not less than the rated interrupting capacity of the upstream breakers.

Voltage transformer neutrals and current transformer common leads shall be grounded at the transformers. No further grounding shall be made at the terminal blocks of the control boards for said circuits. The rated output of instrument transformers shall be adjusted to meet the rated burden requirements of instruments and protective relays to be connected thereto.

11.5.7 Instruments

Instruments, unless otherwise specified, shall be approximately 96 mm square for ammeters and voltmeters. They shall have a 90 degrees scale and zero point adjustment and shall be mounted flush in front of panel with flange.

Dials shall be white with black numerals and lettering and shall be parallax free types. Current and voltage circuits of instruments as well as of protective relays shall be rated in accordance with the characteristics of the current and voltage transformers to which they are connected:

- Secondary windings of voltage transformers will be rated 100 V between phases.
- Secondary windings of current transformers will be rated 5A

11.5.8 Tools and Spare Parts

The special tools as required for assembly, dismantling, maintenance or adjustment are part of supply. The sets shall comprise at least:

Complete set of alloy steel, case hardened, (single ended wrenches, spanners, socket wrenches) etc. to fit will all nuts and bolts of the supply.

Complete sets of the special tools for dealing with every component of the supply (as per list to be included in the proposals).

11.6 Tests

11.6.1 Shop Tests

Factory tests shall be run on all equipment being furnished and in accordance with applicable standards:

The tests shall include at least:

- Dielectric tests
- Operating tests to demonstrate that the equipment can work correctly.
- Check on the control, indicating and interlocking circuits to verify the correctness of the circuits.
- Check on interchangeability of all parts.
- Temperature tests to be run on one breaker of each rating, unless previous satisfactory tests on identical model have been completed and certified test reports are available.
- Physical fit and clearance shall be checked between stationary and movable parts of draw-out and plug in type equipment.
- Inspection of grounding connections

11.6.2 Field Tests

Field tests shall include at least:

- Check on physical fit and clearances
- Measurement of the insulation resistance of each switchboard.
- Check on each set of protection relay for correct adjustment and operation, and readjustment if necessary, feeder by feeder, for the actual load conditions.
- Operation check on each feeder in actual service.
- Check on the grounding connection, measurement of resistance included.

11.7 Data, Characteristics and Documents

11.7.1 Drawings, Design Notes to be submitted by the Contractor

Drawings, design notes to be given to the Employer shall comprise the followings:

- List of drawings: mentioning the drawings, diagrams, computing notes, etc. which will constitute the document set to be submitted during the course of construction.
- Complete and itemized detailed list of all the components of the supply, showing for each item whether main or accessory and whether electrical or mechanical, the reference number which will be used in the drawings and documents throughout.

Switchboard outline with indication of:

- Weights and outline dimensions of the main parts, positioning of the original elements (terminals, instruments).
- Floor loads etc.
- Fixing holes, cable passages etc.
- All information as required for the dimensioning of the structures and the elaboration of the civil engineering drawings.
- Computing note regarding the dimensioning and withstanding of the switchboards busbars.
- Recommendation, computing notes and selectively charts for all the protective systems of the supply, setting adjustment included.
- Detailed drawings of the switchboards.
- Complete wiring diagrams.
- Complete connection and interconnection diagrams.
- Complete lists of the necessary interconnection cables with indication of the sizes.

11.7.2 Information to be Included in Tenders

The technical information to be present in each proposal shall contain at least the followings:

- Tables of the guaranteed value, ratings and construction basic data must be given
- List of spare parts
- List of tools

Drawings and similar documents:

- Photographs of material similar to that proposed.
- Descriptive leaflets, papers and similar,
- List of reference equipment and installations with their commissioning date.
- Copies of the latest issue of each official standard specification, code and similar documentation referred to.
- Charts, diagrams, etc. with curves, parameters and complete information regarding the quality and operation characteristics of the proposed equipment.
- Time schedule of equipment delivery and erection.

12. CONTROL, MONITORING AND PROTECTION SYSTEM

12.1 Scope of Work

The work to be done under this specification consists of design, manufacture, factory tests, delivery and supervision of the complete erection works, field tests, commissioning and guarantee of the operation and control equipment of the power plant switchgear family (0.4 kV, 11 kV) including mainly:

- Local control boards
- Remote control computer station
- Auxiliary equipment and material

The control and operation system shall cover all the equipment at the plant which is implicated either directly or indirectly in the generation and transfer of energy into the interconnected system.

1. For Headworks
 - Intake gates
 - Water level measuring
2. For each unit:
 - Inlet valve
 - Turbine and speed governor
 - Generator and excitation system
 - Pressure Oil & Water cooling system (if any) etc.
3. For the general service of the power plant
 - Station service system
 - Emergency power unit
4. For switchgear equipment
 - Two (2) 0.4 kV incoming feeders for generators
 - One (1) 11 kV village distribution feeder

All the required instruments, control switches, indicating instruments indicating lamps (if any), alarm and control sequence monitoring facias, materials and equipment such as protection relays to be mounted in the local control board and wiring between the apparatus and the local control board shall be furnished by the contractor.

The Contractor shall coordinate with turbine and generator manufacturers and both manufacturers/suppliers shall be responsible for the design of the automatic and manual control schemes.

12.2 Description of the System

The control, monitoring and protection system mentioned above shall employ a Programmable Logic Controller (PLC) and it shall provide control, protection, metering and annunciation requirements of the power plant. This system shall consist of two (2) Local Control Boards and a Remote Control Computer Station. The exterior of the Local Control Boards shall consist of an operator touch screen, power metering pilot devices and protective relays for each unit. The interior of the Local Control Boards shall contain a Programmable Logic Controller (PLC), transducers, CT and PT test switches, interposing relays along with miscellaneous fuses and terminal blocks for each unit. The two (2) operator touch screens located in the local Control Boards, each shall communicate with the individual unit PLC's. This equipment shall provide the means for monitoring and controlling each unit. Data acquisition and alarm handling shall also be accomplished through the operator interface. The operator touch screens shall eliminate the need for most hardwired panel devices such as indicating meters, switches, push buttons and annunciators; panel space will therefore be reduced. All operator interaction shall be done at one central location through the touch screen. The menu driven software shall be presented in a logical, user friendly, easy to understand format. The following screens shall be provided for each of the local operator touch screens:

- Main Menu
- Unit Control
- Unit Parameters
- Unit Alarm Parameters
- Alarm Annunciation

The scope of supply for the plant areas shall include the following:

Quantity CONTROL ROOM EQUIPMENT

1 Operator stations

1 x Operator station (WINDOWS NT based), each one including:

2 x High resolution color screens 17"

1 x Operator Keyboard and Trackball

1 Engineering Station

1 x Engineering Station (WINDOWS NT based)

1 x High resolution color screen 17"

Common equipment for Operators Workplace

1 x B/W Laser - Diagram/Report printer

1 x Color Ink Jet - Alarm/Event printers

1 x Optical Disk data Storage facility

1 x GPS Master Clock

Associated equipment

1 x Control room desk, chairs and associated furniture

1 BUS COMMUNICATION SYSTEM

Redundant Power Plant Bus IEEE 802.3 Ethernet, including coupler and accessories, interconnecting the Control System.

2 UNIT CONTROL

Automation equipment for each unit

1 x Process Controller

Quantity CONTROL ROOM EQUIPMENT

Multifunctional numerical protection relay

Set of I/O boards, Interface devices Power Supply and accessories, as required

2 GOVERNER CONTROL

Human Machine Interface (HMI) with touch screen technology

1 x $\cos\phi$ / I / U / P / Q / f Electrical Measurement Transducers

1 x Multifunctional Digital Indicator (all indication can be displayed permanently at the same time)

1 x Manual Synchronizing equipment

Required quantity of cabinets, interface devices and accessories

Required quantity of cubicles, interface devices and accessories

AUXILIARY PLANT CONTROL / SYNCHRONIZING EQUIPMENT

1 Auxiliary Plant Automation equipment

Set of I/O boards, Interface devices Power Supply and accessories, as required

1 x Automatic Synchronizing equipment

In place of Control Desk, Remote Control Computer Station shall be provided. The Remote Control Computer Station shall include the Remote Color Graphic Operator Interface and an Alarm Printer. The Remote Color Graphic Operator Interface shall communicate with the individual PLC's for each unit, thus the units shall be remotely monitored and controlled through the operator interface. The printer shall be available to print out alarms, events and reports.

The mimic diagram function shall be accomplished on the Local Control Boards and in the Remote Control Computer Station via color graphic operator interface screen.

The following screens shall be provided with the Remote Color Graphic Operator Interface:

- Main Menu
- Plant Overview
- Unit Control
- Unit parameters
- Unit Alarm Parameters
- Unit Sequencing
- PLC Diagnostics
- Alarm Annunciation
- Alarm Summary
- Trending
- Report Generation

The system shall be so designed that the manual operation can be realized without any interruption in case of the Remote Control Computer Station is out of service.

12.3 Services to be provided by the Contractor

The following services, but not limited to, shall be provided by the Contractor:

- Elementary Drawings
- Panel Layout Drawings with approx. dimensions and weights
- Panel Bill of Material
- PLC Program Flowchart
- PLC Programming and Documentation
- Supervisory Computer Programming
- Installation Specifications (Electrical and Mechanical)
- Installation to/from Wiring Interconnections
- Operation and Maintenance Manuals
- Factory Tests Prior to Shipment
- Calculation of Protective and Control Device Set points
- Supervision during installation
- System check-out and site tests
- Commissioning
- Personnel Training at Site

The following instrumentation which is required to provide information to the Control, Monitoring and Protection Systems shall be supplied:

- Turbine Bearing RTD's
- Generator Bearing RTD's
- Speed increaser RTD's
- Generator Stator RTD's
- Speed Sensing System
- Governor Servomotor Position Transducers
- Vibration Switches
- Generator CT's and PT's
- Bus CT's and PT's
- Any Additional Field Devices Related with the Intake Gates, Turbines, Generators, Governors, Excitation System, Generator Phase Side Cubicle, Generator Neutral Side Cubicle, Switchgear and Station Service Power Systems.

12.4 Operation and Control System

12.4.1 General

The operation and control system of the units shall be unit one-man control system which is capable of supervising and controlling the operation of the turbines, generators and other equipment from the operator station at the control room.

The control and protective equipment shall be so designed that the safe operation shall be performed under every operation condition without any damage and/or energy limitation on the units.

The unit operation including starting and stopping with the necessary interlocking, signaling and protection shall be controlled either manually or automatically, as per operator's choice. Selection between manual operation and automatic operation shall be made by means of a main selector switch "AUTOMATIC – MANUAL" installed on the local control board and a Remote Control Computer Station located in the control room. Switching from one operational method to another shall be possible only when the unit is "stopped" or "loaded".

12.4.2 Automatic Operation

The turbine and generator shall be automatically controlled in the following order and sequence provided by the Remote Control Computer Station in the control room.

- 1) STOP
- 2) START
- 3) EXCITE
- 4) PARALLEL-IN
- 5) LOAD

Even when the Remote Control Computer Station is set at any optional position the turbine-generator shall be controlled passing through the sequential order as indicated by the positions of the computer until the operation of the set point is achieved.

An irregularity in the automatic sequence which does not permit further execution shall be indicated as a fault and the automatic control shall be returned automatically back to the beginning of the program step which is alarmed as faulty. It shall be then possible to changeover to the manual mode to perform the operation sequences manually which could not be achieved by automatic control. Further steps shall be performed either manually or automatically depending upon operator's choice.

After the unit is started up to the rated speed and excited up to the rated voltage automatically by the computer, the unit shall be synchronized to the system either by manually or automatically with the computer by the operator, using the manual or automatic synchronizer. After the synchronization of the unit, the active and reactive power loading of the units shall be done either by the operator manually or automatically via computer in the control room.

12.4.3 Loading Control

When no speed regulation is needed (utility network, grid is driving the generator's frequency), the operator can use following loading control:

One (1) is automatic procedures

One (1) is on manual procedure. PLC assisted

The operation mode will be defined by the Employer before studies.

1- Water level loading control

The operator sets a target water level. The automatism controls this target level through a PLC build PID and drive the turbine inflow in order to maintain this fixed water level.

Water level sensor: Type piezoelectric ultrasonic 3-20 mA signal

2- Automatic regulation for 1 unit

The Unit No. 1 is named leading unit. When the leading unit (Unit No. 1) gets the full power, the Unit No. 2 starts automatically.

Then according to water availability the Unit No. 1 will stop when getting to a low efficiency values defined during the studies.

The operator controls the turbine inflow by means of the touch in screen or switches. The automatism drives the turbine inflow following the operator's commands.

12.4.4 Manual Operation

Although the operation of this power plant shall be mainly performed automatically from the remote control computer station, for trial operation or other necessary cases, manual operation of the turbine and the brakes of the generator shall be possible by selecting the "manual" position on the computer and manually operating the electromagnetic valves mounted on the unit local control board.

After opening the intake gate and starting the unit up to the rated speed manually from the unit local control board, exciting, synchronizing and loading of the unit shall be possible manually by the operator in the control room.

The following functions shall be designed to be controlled from the remote control computer station manually;

- Governor Starting/Stopping
- Governor speed setting
- Gate opening and blade position limiter settings
- Excitation system automatic-manual selection
- Excitation system voltage setting
- Excitation system - excitation current setting (manual mode of excitation)
- Automatic synchronizing starting
- Circuit-breaker closing/opening

12.4.5 Starting of the Unit

Prior to the starting of the unit, the pit liner shall be filled by opening the intake gate. The intake gate which is at the beginning of the pit liner shall be opened and closed locally.

The positions of the intake gate shall be monitored by the computer. The Contractor shall provide the relevant connection cables between the remote control computer station and the intake gate.

After pit liner is filled up, the spiral case shall be filled by opening the by-pass valve of inlet valve, after spiral case is filled up, the inlet valve is opened.

Finally, the working of jet reflectors and running of the unit up to the rated speed shall be possible either from the local control board of each unit step by step manually or from the remote control computer station automatically in the control room. Exciting and the synchronization of the unit manually or automatically shall be possible from the remote control computer station. The loading of the unit shall be only possible via the remote control computer station either automatically or manually by the operator.

12.4.6 Stopping of the Unit

The following stopping facilities for the unit shall be provided;

- Normal stop
- Quick stop
- Emergency stop

According to the operation sequence and the tripping schedule the above stopping conditions shall be provided with the coordination of the turbine and generator manufacturers.

a) Normal Stop

By giving the "stop" command to the computer, the unit shall automatically stop in the following sequence:

- The active power and the reactive power of the generator shall be gradually decreased (automatically) to nearly zero and then, the unit circuit-breaker shall be tripped
- The field circuit breaker shall be opened, and the Automatic Voltage Regulator (AVR) shall go out of operation after exciter voltage is reduced
- Guide Vanes closed
- The braking device shall be operated automatically and when the turbine is stopped, the brake shall be automatically released. The braking device shall be operable at any time by manually turning the control switch.

b) Quick Stop

By giving the "quick stop" command to the computer or operation of the relays for quick stop (for failures of mechanical nature) the unit shall be stopped in the following sequence automatically.

- Guide Vanes closed
- On the conditions that the guide vanes closed, the unit circuit breaker shall be tripped, the field circuit breaker shall be opened.
- The braking device shall operate in the same manner as for normal stop.

c) Emergency Stop

By giving the "emergency stop" command to the computer in the control room or by operation of the relays for emergency stop the unit shall be stopped in the following sequence automatically.

- The unit circuit-breaker shall be immediately tripped; the guide vanes shall simultaneously be closed.
- Simultaneously with tripping of the unit circuit breaker, the field circuit breaker shall be opened.
- The braking device shall operate in the same manner as for normal stop.

12.4.7 Safe Shut-Down System

Should the unit controller fail the unit shall be shut down in an orderly fashion by a safe shutdown system that functions independently from the unit controller.

This system shall have the highest priority and can also receive activation signals from other protection devices.

Manual Interventions

1 push-button (with protective covers) is foreseen for the quick and emergency stops for each unit. A emergency trip push button shall also be provided on the operator screen in software form and on the touch screen panel.

12.4.8 Automatic Synchronizing Device

An automatic speed matcher, automatic voltage balancer and parallel switch-in relays shall be furnished for the automatic synchronizer board.

The device shall be of the type having reliable operation characteristics without hunting. It shall be possible to perform the following adjustments.

In case that the synchronizer in "auto-position", the generator voltage build up near to the rated voltage and the automatic voltage regulator (AVR) is in operation, the voltage balancer shall minimize the voltage difference between the generator and power system by controlling intermittently the AVR. And the speed matcher shall match the generator speed to the power system frequency.

If the difference of voltages and frequency between the system and the generator are within

certain allowable band, the generator circuit breaker shall be automatically closed by the parallel-in equipment. In this case, however the circuit breaker shall also be operable by manually operating the control switch of the circuit -breaker. In "manual" position sequential matching is to be directed and handed over manually through the matching needle type synchroscope.

12.4.9 Items to be specified in the Proposal

The following items shall be specified in the proposal specification.

- 1) Explanation and block diagram of the control system
- 2) Names and numbers of indicating instruments
- 3) Names and numbers of control switches
- 4) Drawing and schematic diagrams
- 5) Detailed control cable list including size, type, length, route, etc.

12.4.10 Interlocking Circuit

For the sequences of the unit one-man control system, the necessary interlocking circuit shall be provided, the details of which shall be as instructed in the approval drawings.

The closing circuit of the unit circuit breaker shall pass through the contacts of the electrical trip-free relay and through the contacts of the synchronizing switch.

A necessary interlocking circuit shall be applied between related disconnecting switches and circuit breakers.

12.4.11 Operation Indication

Each stage of sequential operation of the turbine and the generator manually and/or

Automatically shall be indicated on the Remote Control Computer Station in the control room.

12.5 Electrical Protection

12.5.1 General

An integrated protection solution shall be provided with comprehensive protection against phase and ground faults and abnormal voltage, frequency, power, field failure and over fluxing conditions.

The protection system shall provide a flexible and reliable integration of protection, control, monitoring and measurement functions.

The Protection System shall be of numerical type installed in cubicles.

Unless otherwise specified the system shall be for operation from instrument transformers having a nominal output of 5/1 Ampere, 110/ $\sqrt{3}$ V or 110/3 V secondary. Protective relays shall be equipped with externally reset, operation indicators and include self contained quick check facilities.

Furthermore protective relays shall include continuous self-diagnosis and supervision. All the necessary protection scheme calculations related to the system (Generator, Busbar, Line) for the Tinau power plant, shall be a part of the scope of work under these specifications.

12.5.2 Protective Relays

Protection system, consisting of multifunctional numerical generator protection systems, mounted in one relay cubicle for each unit.

Unit protections

- 1) Generator over current: 50/51
- 2) Generator thermal image: 49
- 3) Generator Negative phase sequence current relay: 46

- 4) Zero sequence current (4 protections): 51N/51
- 5) Generator Reverse power relay: 32
- 6) Generator Under/ over voltage relay: 27 /59
- 7) Stator earth fault relay: 64S
- 8) Over speed relay: 12
- 9) Maxi and mini frequency (1 protection of each): 81
- 10) Lost of excitation (maxi of reactive power): 40
- 11) Synchronizing (or synchronism check) device: 25
- 12) Generator neutral protection: 51N
- 13) Rotor earth fault relay: 64R
- 14) Temperatures module: 8 channels
- 15) Generator Differential Protection (87G)

For 11 kV feeder protections

- 1) Maxi phase and ground current: 51/51N
- 2) Under voltage: 27
- 3) Over voltage: 59
- 4) Maxi and mini frequency (1 protection of each): 81

For 0.4 Station service bus bar

- 1) Maxi phase and ground current: 51/51N
- 2) Under voltage relay: 27

12.5.3 For Studies and Design

Collecting the final characteristics of all electrical equipment related to the protection system.

- Protection calculations (short circuit and relay settings calculations).
- General and detailed design of protective relaying providing adequate protection of all sections. Protective relaying co-ordination, choice of equipment, etc.

12.5.4 For Drawings and Documents

- Draw-up of principle diagrams for the protection system.
- Draw-up wiring diagrams, cabling diagrams, list of cables with complete identification of cables and connections.
- Draw-up of complete cubical assembly drawings showing front and rear elevations, typical section views, equipment arrangement, etc.

12.5.5 For Tests and Commissioning**Factory Tests**

This includes factory test of equipment in accordance with IEC Standards including routine and type tests.

Site Tests/Commissioning

Functional test at site to demonstrate that protection system operates satisfactorily.

- Secondary injection to verify relay settings
- Relay tripping together with control system

Draw-up of documents necessary for commissioning and for the instruction of Maintenance Personnel (i.e. test reports, drawings, list of material, maintenance requirements, operation manuals, etc.).

Place at Employer's disposal the personnel responsible for the supervision of the installation, for the instruction of Operating Personnel, for trouble-shooting, and for maintenance, for a period of time to be agreed.

12.5.6 Mimic Diagrams

Mimic diagrams shall be provided on the local control board only. Mimic bars shall be of smooth edged material and arranged on the accompanying drawings. Symbols of transformers, rectifiers, etc. shall be of a shape and line size fitting with the other lines of the diagram.

Mimic bars and symbols shall be fixed to panel faces by means of screws or bolts or by other means approved by the Employer.

12.6 Circuit Protection and Wiring

12.6.1 Circuit Protection

Voltage circuits for instrumentation (indicators, recorders and meters) shall be protected by 6 Amps MCB's located near to the terminal blocks to which the incoming voltage circuits will be connected. Each MCB shall have a signal contact. The tests of MCB's shall be fully identified as to circuit and polarity and shall be easily and safely accessible.

DC auxiliary power feeders shall be protected by MCB's according to the accompanying DC single line diagram.

The circuit breaker shall be located inside of the relevant section of main panel and each breaker shall be fully identified. All auxiliary bus bars shall be fully insulated over their whole length.

12.6.2 Wiring and Terminals

a) This specification covers the design, supervision of the installation and test of the all control cables for complete control of power plant, and 31.5 kV switching building, excluding only the cables for telephone system, lighting distribution and 400/230 V, AC power distribution.

b) Connections external to the panels shall be made with cables, internal connections with individual wires; cables and wires shall be self extinguishing plastic insulated.

Secondary connections of CT'S secondary connections of PT's and control cables shall be individual cables, wiring internal to the panels shall be with copper conductors, 1.5 mm², minimum (secondary circuit of CT's: 4 mm² minimum) with single layer of nonflammable plastic insulation, 0.6/1 kV class. Moreover, each wire shall be capable of withstanding without excessive overheating the most severe combination of intensity and duration of fault current susceptible to appear in the circuits.

c) The wiring shall be adequately supported to prevent breakage caused by sagging or vibration. Terminals shall be in sufficient number, only one conductor (of the incoming or outgoing cable) will be connected to any one terminal

Internal wiring shall not have more than one wire connected to any one terminal point (except two wires maximum at apparatus and on condition that the terminal be properly sized and arranged.

d) Each terminal block shall have 10% spare terminals, with a minimum of two.

e) Full depth insulation barriers shall be provided between the terminal rows of the various categories of voltage and/or function.

f) Terminals for connection of secondary windings of current transformer shall be provided with adequate devices door easy short-circuiting and for insertion of a test instrument, with plug-in type connector.

g) Terminals for connection of secondary windings of voltage transformers shall be designed for easy connection (plug type) of a test instrument.

- h) Each terminal, cable and wiring shall bear a reference mark clearly visible and unalterable.
- i) The circuiting shall be with complete separation between the various functions as follows:
1) Protection, 2) Control, 3) Signaling, 4) Measuring and Metering, 5) Auxiliary Power.
That applies to the circuits throughout, thus covering for the primary contacts, auxiliary contacts, wiring, etc. and distribution of auxiliary power feeders.
- j) The wires having similar functions shall be formed into groups clearly separated from each other. Wire trunking shall be made of PVC and provided with removable covers. It shall be possible for the wires to leave trunking everywhere and on either side.
- k) The cable route and cable installation shall be determined by the Contractor by using ducts, trenches, under floor ways, etc. provided and shown on civil drawings and on the basis of wiring and cabling diagrams and cable list which will be prepared by the Contractor.
- l) All cable ends and connections shall be identified as follows:
 - Cable ends shall be identified with tags.
 - Connection shall be identified with a plastic sleeve sheathing the connected conductor.
 - Tags and sleeves type as well as identifying codes (color and writing) shall be submitted to Employer for approval.

12.6.3 Grounding

A copper grounding grid and/or bar will be installed by another manufacture, as per another specification.

The manufacturer of the equipment covered by this specification shall furnish and install the necessary grounding connections-to be all copper - from same equipment to have above mentioned grounding grid to bar.

The above is for application chiefly to:

- The structures of the desk and panels, and every metal housing of instrument switch, lamps, etc.
- The star points of the secondary winding of the current transformers and potential transformers shall be grounded at the transformers. No further grounding shall be made at the terminal blocks of the control boards.
- Any other element of the supply to be grounded as per diagram.

12.6.4 Operator Training

Operators shall be trained during the commissioning phase of the project. The training shall take the form of theoretical session of at least 60 man x days, describing the system and operating philosophy. After which practical experience will be gained during commissioning. The main goal of this training procedure is to allow the operators to gain experience and knowledge of the following tasks:

- Familiarization of the control system hardware.
- Familiarization of the control system software.
- Selecting screens.
- Performing controls.
- Analyzing the information on the display pictures.
- Analyzing the information on the alarm and event lists.
- Analyzing the information on the event printers.
- Remote & Local control.

Operator training shall take place at site during the commissioning phase of the various units. As a final part of the training, the Employer's personnel shall participate with the Contractor in

the commissioning of all equipment.

12.7 Water Level Measuring Devices

12.7.1 Forebay Water Level Measuring Device

One (1) set of water level measuring device shall be furnished for measuring of the forebay water level.

- a) Number required: One (1) set
- b) Type: piezoelectric ore ultrasonic detector digital Indicating type
- c) Composition

The device shall include all equipment required to indicate the water level of the forebay at the remote control computer station in the control room. The device shall consist of the following components but not limited to;

- (1) Transducer (ultrasonic signal - electric signal)
- (2) Control equipment
- (3) Wave guide pipe
- (4) Heating device with automatic temp. control device
- (5) Protective guard frame for wave guide pipe
- (6) Fitting material
- (7) Transmitter
- (8) Receiver (Control room side)
- (9) Cables and conduit pipes
- (10) Other necessary devices
- d) Construction and Characteristics
 - 1) A transducer shall be equipped at the top of the wave guide pipe and shall be of outdoor type. The transducer shall include an oscillator and receiver for ultrasonic signal.
 - 2) Control device for ultrasonic wave, automatic control device for air inside the wave guide pipe and transmitter for sending signals to the control room shall be mounted on indoor type metal enclosed cubicle and the cubicle shall be installed inside a cabin near the intake structure.
 - 3) Wave guide pipe shall be of stainless steel pipe and shall be installed on a sloping surface of intake structure.
 - 4) Electrical heater shall be provided around the wave guide pipe in order to prevent freezing and to keep the air temperature inside the pipe within a certain value. An extra heater for stand-by use shall also be equipped.
 - 5) Insulation shall be provided around the wave guide pipe and the heaters. Cover plate shall also be provided on the outside of the insulation.
 - 6) Protective guard frame shall be provided to prevent damage to the pipe from foreign materials.
 - 7) One (1) set of indicator shall be furnished to be mounted on the cubicle at the site. Indicator shall indicate digital numerals with plus or minus sign. The water level shall be indicated in four (4) digits and last two (2) digits shall indicate centimeters.
 - 8) Power source will be 3-phase, 1-wire, 380 V or 110 V DC

12.8 Spare Parts and Tools

According to the Spare Parts and Tools List (Section VI H)

12.9 Tests

12.9.1 Shop Tests

Test on elementary elements.

The manufacturer shall furnish:

- a) Origin and quality certificates for each kind of material used, e.g. for:
 - Steel sheets and profiles
 - Paint
 - Copper bars and wires (whether bare or insulated)
 - Insulating material
- b) For each unit of the supply, e.g. protection relay instruments, meters, etc.:
 - 1) Carrying out routine tests on each unit
 - 2) Complete tests on one unit of the series
- c) Each main assembly (remote control computer, main panel, main of relay racks) shall be completely assembled and fully equipped in manufacturer's shop of inspection. The latter shall consist of at least:
 - 1) Visual check as to conformity with the specific requirements, such as:
 - Assembly content, in respect of quantities, types, ratings, etc.
 - Arrangement of various components,
 - Mutual fittings of all parts,
 - Overall and detail dimensions, levels, clearance and tolerances,
 - Paint coating,
 - Weights of assemblies,
 - Interchangeability of the components
 - 2) Visual and electrical check on the circuitry, including;
 - Insulation tests, circuit to circuit and circuit to earth (test shall be applied with all lamps, relays and similar)
 - Measurement of insulation ohmic resistance, using 1000 V Megger tester,
 - Check as to conformity of the circuits with the diagrams.
 - Check as to conformity of the reference marking of each element (wires, terminals, relays, etc.).
 - 3) All assemblies of the supply shall be interconnected and an operation check shall be run as follows:
 - Operational check on each circuit; at rated voltage are current with all internal elements in service with simulating devices playing the role of the elements external to panel: voltage sources, current sources, contacts, controlled equipment, etc.

The check shall be run following an operation schedule (step by step check list) prepared by the manufacturer and reflecting the step by step detail of all kinds of operations and functions to be fulfilled by the equipment, with indication of which terminals are to be energized and which devices are operated on the panel and out of panel.

In the check list, the designations of the various parts involved (devices, apparatus, wires and terminals) shall reflect exactly the tag numbers of same as per the electrical diagrams.

All defects or discrepancies or errors of any kind possibly detected in the course of

the shop tests shall be corrected and the equipment checked again for full conformity, before shipment. Furthermore, immediately after the tests, the diagrams shall be brought up to date with any improvement or correction which might appear to be necessary or recommended as per the results of the operation check and as the case may be, as per Employer advice.

12.9.2 Field Tests

1) Test during and after erection:

The following tests shall be performed in the field during and after erection of supply:

- a) Mechanical clearances, bare dimensions, levels, alignments and other measurements of equipment as erected.
- b) Checks on the wiring of the interconnections:
 - Between the various parts of the supply,
 - Between said and other works, for conformity with the wire connection and referencing schedules.
- c) Dielectric tests as well as measurement of insulation resistance of each circuit and comparison of the results with those of the shop test.
- d) Check and the ratings, etc. of all equipment involved including for that pertaining to other works, for conformity with the data of specific diagrams and schedule.
- e) Functional checks of all instruments, protective relays, auxiliary relays, switches, etc. including for calibration of all gauges and instruments and relay settings.
- f) Functional check runs of the systems of local control and automatic control, interlocking and annunciation, etc. in operation with the actual equipment to be protected and/or controlled.
- g) Final adjustment of the voltage, current and time setting to make the them fitting with the requirements of the actual equipment to be serviced, in view of a first class operation and protection of same as per plant requirements.

2) Commissioning tests:

The tests on the main units shall consist of runs in various conditions of load, voltage, speed, switching on and off, starting-up shutting down, etc. with local control and automatic control.

An unrestricted operation between manufacturers shall be mutually granted by each of them, for a rapid coordinated and efficacious execution of the work.

Unless otherwise agreed on by Employer, all tests made at site shall be performed by manufacturer under the supervision of Employer's representatives. Manufacturer shall arrange with Employer as to the test processing details and time schedule, aiming for the tests being carried expeditiously in conformity with the operating conditions of the station.

Manufacturer shall secure that all necessary precautions are taken to guard against accident or damage to persons or property in performing the tests. He shall arrange with Employer for the supply and erection of all necessary barriers, guards and warning.

3) Other Tests

The above enumeration covers minimum requirements only. The tests run may include any inspection, check or test required to verify the equipment conformity with the characteristics guaranteed by the manufacturer.

12.10 Data to be furnished by the Bidder

The following data sheets shall be filled by the Bidder for each kind of protective relay, auxiliary relay, switch, indicating instrument if any, and for auto synchronizer. The manufacturer names and the technical specifications related with the manufacturer shall be submitted by the Contractor at the design state for the approval of the Employer.

12.10.1 Guaranteed Characteristics and Performance Data for Protective Relay (for each type)

DESIGNATION	UNITS	VALUES
Description of relay		
Manufacturer		
Type		
Standards		
Rated voltage	V	
Rated current	A	
Rated frequency	Hz	
Setting range		
Current	A	
Voltage	V	
Time s		
Overall accuracy in percent of setting		
Operating time (without time delay)	s	
Burden per CT		
At rated current	VA	
At setting current	VA	
At 10x rated current	VA	
Burden per PT		
At rated voltage	VA	
At lower setting	VA	
Auxiliary voltage supply (DC)	V	
Dynamic, thermal withstanding of relay in amperes		
Instantaneous, peak	A	
Short time, rms 1 sec	A	
Continuous, rms	A	
Insulation level	kV	
Highest permissible voltage (30 minutes)	V	
Auxiliary contacts		
Number		
Capacity		
Continuous at 110 V D.C. +15%, -20%	A	
Breaking	A	
Resetting (built-in push button)		
Operation signaling (built-in flag-contact)		
Facilities for connection of testing set		

Built-in connector

Separate plug set

Test switch

Dimensions mm x mm

Weight kg

12.10.2 Guaranteed Characteristics and Performance Data for Auxiliary Relays**DESIGNATION****UNITS/VALUES**

Manufacturer

Type

Standards

Coil rating

Rated voltage

V

Min. pick-up voltage

V

Maximum drop-out voltage

V

Number of contacts

Make contacts

Break contacts

Contacts rating

Voltage, D.C.

V

Current, continuous

A

Current, breaking

A

Operating time by energizing

Make contact ms

Break contact ms

Operating time by de-energizing

Make contact ms

Break contact ms

Burden

On starting

W

Continuous

W

Dimensions mm x mm

Weight

kg

12.10.3 Guaranteed Characteristics and Performance Data for Switches**DESIGNATION****UNITS /VALUES**

Manufacturer

Type

Standards

Number of contacts

Signaling contacts make break

Control Contacts make break

Contact rating Voltage, A.C. V

Current, continuous A

Current, breaking A

Indication lamp

Consumption W

Rated voltage V

Mechanism (turns and push or turn and turn)

Dimensions mm x mm

Weight kg

12.10.4 Guaranteed Characteristics and Performance Data for Indicating

Instruments

DESIGNATION	UNITS /VALUES
--------------------	----------------------

Manufacturer	
--------------	--

Type	
------	--

Standards	
-----------	--

Rated voltage (phase to phase)	V
--------------------------------	---

Rated current	A
---------------	---

CT ratio	A/A
----------	-----

PT ratio	V/V
----------	-----

Accuracy class (percent error of full scale deflection)	
---	--

Scale graduation	
------------------	--

Range of measurement (at defined	
----------------------------------	--

CT and PT ratio)	
------------------	--

Consumption at full scale deflection	
--------------------------------------	--

Current circuit	VA
-----------------	----

Voltage circuit	VA
-----------------	----

Overcurrent withstanding, permissible highest value	
---	--

Continuous Temporary, 1 sec	A
-----------------------------	---

Instantaneous, peak	A
---------------------	---

Overvoltage withstanding, permissible overvoltage	
---	--

Continuous	V
------------	---

Temporary, 1 sec.	V
-------------------	---

Instantaneous, peak	V
---------------------	---

Dimensions	mm x mm
------------	---------

Weight	kg
--------	----

12.10.5 Guaranteed Characteristics and Performance Data for Auto-Synchronizer

DESIGNATION	UNITS/ VALUES	
Manufacturer		
Type		
Standards		
Input values		
Voltage	V	
Maximum difference between voltages		%
Frequency	Hz	
Power consumption		
Supply	VA	
Measuring	VA	
Setting		
Maximum slip	Hz	
Breaker time	s	
Frequency matching pulse time		s
Output values		
Contact loading for frequency matching pulses and paralleling order		VA
Dimensions		mm x mm
Weight	kg	

12.10.6 Guaranteed Characteristics and Performance Data for Recorders and Converters

DESIGNATION	UNITS/ VALUES	
a) Recorder		
Manufacturer		
Type		
Standards		
Measuring range		
Accuracy class		
Indication	%	
Recording	%	
Scale graduation		
Chart speed		
Chart graduation		
Input impedance		Ohm
Input signal		
Recording width		mm
Marking system (Preferably inkless)		

Electric drive	
Rated voltage (220 V)	V
Consumption	VA
Length of chart in each rolls	m
Marked paper storage	
Dimensions	mm x mm
Weight	kg
b) Converter	
Manufacturer	
Type	
Standards	
Inputs	
Voltage	V
Current	A
Output (volt or ampere)	
Accuracy	%
Dimensions	mm x mm

12.10.7 Guaranteed Characteristics and Performance Data for Miscellaneous Equipment

DESIGNATION	UNITS/VALUES
a) Indicating lamps	
Manufacturer	
Type	
Fitting	
Bulb	
Bulb consumption	W
Rated voltage	V
b) Annunciator	
Manufacturer	
Type	
Bib consumption	W
Rated bulb voltage (DC)	V
Rated coil voltage, D.C.	V
c) Terminals	
Manufacturer	
Type	
For wires up to mm ²	

Test voltage	V
d) Wiring	
Manufacturer	
Type	
Insulation	
Type	
Thickness	
Sizes	
CT circuits	mm ²
PT circuits mm ²	
Control circuits mm ²	
Maximum operational voltage	V
Test voltage	V

12.10.8 Guaranteed Characteristics and Performance Data for Operator Station

DESIGNATION

Specification

Manufacturer of Processor

Type and capacity of memory

Hard disk storage

Back-up storage

Power supply

Input range

Maximum Power

High resolution colour screen

Size

Resolution

Refresh rate

Key board

Trackball

Protection class

Operating temperature

Operating humidity

13.AUTOMATIC CONTROL AND SCADA SYSTEMS

13.1 Scheme and Structure of Control System

At this hydropower plant, the automation control system shall adopt layered arrangements as per its structure, mainly consisting of the Central Computer System (CCS) and the Local Control Unit (LCU). The CCS mainly performs the automatic operation and administration of the whole plant, recording, filing, retrieving and sheet-compiling the old data, recording operation, alarming, displaying pictures, as well as integrated to the dispatching automation

system. The LCU consists of the unit automatic control, protection, measurement etc. and the microcomputer protection, measurement and control and so on for the main transformer (if any) and the lines. Each unit and the main transformer (if any) shall be controlled with the corresponding LCU. The control system of the unit is new digital automation system in which new control and protection system integrating the control, protection and measuring devices together, and can realize the unmanned automatic operation with simple maintenance.

The automatic control system of the whole station is arranged as follows:

1. The Central Computer System (CCS)

- Computer: P-III 800, one pieces of 500GB hard disks, and the memory capacity of 256M
- Printer: A3 color printer
- Colorful display: 19" LED Monitor
- SCADA communication module

2. The automatic control & protection of turbine and generator unit

- The control module for turbine/generator
- The displaying module for local operation
 - The module for generator standby protection and the electrical measurement (including 20-channel temperature measurement)
- Optocom line
- Auxiliary relay
- LCM-10-01 guide-vane measuring transmitter
- ACC-007 electronic velocity-measuring transmitter

3. The supervision & measurement unit for the public device in plant

- PLC section
- Input/output card

4. The protection & control unit for the generator-transformer block

5. The protection & control unit for transmission outline

6. The synchronizing device at 0.4 kV circuit breaker of transmission line

7. A set of UPS power source

8. Working platform

9. Systematic software

13.2 The Function of Control system

13.2.1 The Central Computer System (CCS)

The CCS mainly performs the automatic operation & administration of the whole plant, recording, filing, retrieving & sheet-compiling the old data, recording operation, alarming, displaying pictures as well as integrated to the dispatching automation system. It consists of the following:

1) Data Logging and Management

- The electrical parameters of unit such as voltage, current, frequency, active power, non-active power and kilowatt hour etc.
- The switching data of unit such as the conditions of circuit breaker, Turbine control and the protection signal etc.

- Temperatures of unit
 - Water level at the forebay
 - The protection signal of main transformer
 - Switchover of unit working condition
- 2) The control functions of the unit and the main transformer
- To control the unit start/stop
 - To adjust the unit load
- 3) Data display and printing
- To print the consumer-compiled sheet in the preset duration
 - To recall and print the historic sheet
 - To recall & print the time-being sheet
 - To manually set the printing time for sheet
- 4) Faults & accidents alarm
- Alarm on the temperature of unit
 - Alarm on the protecting action of generator
 - Alarm on Turbine control failure
 - Alarm on the failure from the main transformer
 - Recording & printing the failure and accident signal
- 5) Communication inside plant and outside
- Communication with the unit control section
 - Communication with the plant public section
 - Communication with the control & protection device of the main transformer
 - Communication with the remote dispatching

13.2.2 Unit Control & Protection Section

The unit control & protection section consists of the optional modules, and the customers can select the modules according to their demands. Therefore, much less cost can be invested for providing special flexible control functions. The operation control system shall extend from the protection control to the standby protection, and each of the modules includes a high-speed microprocessor and an error-tolerable safety circuit, in which the necessary software is adopted to perform a certain operating function. The control module for each turbine-generator unit shall be fixed in a standard control cubicle, and there are terminals for each module for simple connection and easy maintenance. Furthermore, a display module shall be fixed at the facing panel of the control cubicle, and also communicated with all the modules inside, so that the digits for operation, protection and measured parameters can be displayed. Once all the modules are normally connected and the parameters are selected, the system can be put into operation.

13.2.2.1 The turbine-generator control module

The turbine-generator control module shall perform functions such as, the unit automatic start/stop, synchronous integration into power grid, switchover of operating working condition, unit stopping in emergency and other logic operation, as well as signal alarm, and measurement & local display of the guide-vane open gauge and speed.

13.2.2.2 The generator-turbine protection module and the electrical measurement module

The generator-turbine protection module will timely shows the failure of the input signal. When a certain parameter exceeds the setting value which is selected by the operator, GPM is required to quickly or delayed send out the signal or trip.

The protection functions include:

- Differential protection
- Over-voltage/low-voltage
- Over-current/low-current
- The imbalance of interval voltage
- Over-frequency/low-frequency
- 20-channel temperature RTD checking
- De-pressure of hydraulic system or low hydraulic level
- Time-delay alarming of any one of the inputs (0.1 second)

The electrical measurement functions include: timely measuring & displaying three-phase voltage, three-phase current, active power, non-active power, frequency, power factor, active kilowatt hour, non-active kilowatt and other parameters, which can be transmitted to the local or remote supervision devices. The measuring module can timely measure the electrical parameters and the status of generator.

13.2.2.3 The supervision & control module inside plant

The OPTOCOM line shall perform the communications inside the station, and meanwhile, it can provide the supervision & control system (SCADA) for the turbine-generator unit inside the plant.

13.2.2.4 Local operation & display module

The local operation & display module is fixed at the panel of the control cubicle, which shall receive all the timely information from the modules. Through a simple order and the corresponding number of the module, the digit or parameter can be timely displayed and the control on the unit can be realized.

13.2.2.5 The public control section at the station

The public control section of the station shall perform the control on all the public devices and the concerned data measurement and logging.

13.2.2.5 Microcomputer-based protection & control section for generator-transformer block

At this station, there are three generators –transformer blocks, totally 3 control sections. The microcomputer-based complete protection, measuring & control device are composed of the main protection section, standby protection section and the measuring, supervision & control section. The function of each section shall be performed by the concerned CPU solely, and the hardware shall apply the unit-type complete-sealing anti-interference structure. The large-screen liquid-crystal display shall be adopted, on which the character parameters such as measured value, status and the protection value shall be directly indicated and measured. The protection functions of generator-transformer block consist of:

- Differential quick shutoff
- Compound-voltage over current
- Light/heavy gas
- Oil over-temperature

The electrical measurement functions include: timely measuring & displaying three-phase voltage, three-phase current, active power, non-active power, frequency, power factor, active

kilowatt hour, non-active kilowatt and other parameters, which can be transmitted to the local or remote supervision devices.

13.2.2.6 Microcomputer-based protection & control section for transmission line

At this station, there is 11 kV transmission line. The microcomputer-based power line complete protection, measuring & control device shall compose of main protection section, standby protection section and the measuring, supervision & control section. The function of each section shall be performed by the concerned CPU solely, and the hardware shall apply the unit-type complete-sealing anti-interference structure. The large-screen liquid-crystal display shall be adopted, on which the character parameters such as measured value, status and the protection value shall be directly indicated and measured.

The power line protection functions include:

- Distance protection with three distance zones
- Compound-voltage over current
- Earth fault protection
- Auto reclosing function

The electrical measurement functions include: timely measuring & displaying three-phase voltage, three-phase current, active power, non-active power, frequency, power factor, active kilowatt hour, non-active kilowatt and other parameters, which can be transmitted to the local or remote supervision devices.

13.3 Control Mode of Plant

At the plant site, these functions can be performed such as manual operation, automatic start/stop, changeover of the working condition, unit stopping in emergency, load adjustment, automatic alarm in case of failure or accidental signal etc.. Concerning the remote control, the unit start/stop, unit stopping in emergency and load adjustment etc. can be realized, as well as timely displaying & recording the operating parameters of station, accident recording and failure alarming etc.

13.4 Tests

13.4.1 Workshop Tests

The Contractor shall have established a comprehensive and effective quality control (QC) system applicable to all groups of companies for engineering, design, manufacturing and installation in close relation to QC standard ISO 9001, representing the highest level of quality control system. The Bidder shall confirm the application of a certified QC system.

The SCADA system shall be assembled and tested in the workshop in compliance with the certified QC plan and the relevant Standards. The Bidder shall prepare for Employer approval a detailed test processing and inspection plan/programme.

The Factory Acceptance Tests (FAT) shall be carried out to verify the system performance close to the final configuration, but with an agreed limited number controllers and workstation.

System and application software functions shall be fully verified. Communication links to related systems shall be verified.

Necessary protocol converter hard- and software requirements shall be clarified with the related suppliers before the start of the FAT. The protocol conversion and adaptations to interlinked systems/equipment shall be an integral part of the FAT.

The specific test requirements for the factory testing shall be as defined under clause 10.1 of the IEEE Std. 1249-1996 and as per the requirements given below.

The factory acceptance tests shall be performed prior to shipment of the equipment and field test should be performed after the equipment is installed at site. The factory tests should demonstrate the proper operation of all furnished hardware and software. A test procedure

shall be prepared by the manufacturer and approved by Employer prior to commencement of the factory tests. Specific requirements for the factory tests should include but not limited to the following.

- a) Surge protection testing
- b) Application of appropriate signals to each input points to verify their operation
- c) Running of programmes to test the proper operations of each output points
- d) Demonstration of major features of system components
- e) Demonstration that the data base sized for ultimate system and implemented for all variable
- f) Demonstration of system performance while running all applications
- g) Software during simulated worst case conditions
- h) Demonstration of automatic failover process
- i) Demonstration of operator interface software
- j) Demonstration of each applications software routine

13.4.2 Site Tests

(a) Pre-Commissioning Tests

The field test should confirm that no degradation has occurred during shipment and installation. It should also be used as design verifications. A test procedure shall be prepared by the supplier/manufacturer and approved by the Employer prior to commencement of the field tests.

i. The following tests shall be performed during and after erection of the complete systems:

- Inspection of the installed equipment;
- Checks of the wiring of the interconnections;
- Measurement of insulation resistance of each circuit;
- Functional checks of all instruments, protection relays, auxiliary relays, switches, etc. including the calibration of all gauges and instruments and relay settings;
- Functional check runs of the systems for local control and automatic control, interlocking and annunciation, etc. in operation with the actual equipment to be protected and / or controlled;
- Final adjustment of the voltage and current settings.

ii. Tests of components / equipment shall be according to the Contractor's QC plans, which shall be subject to approval by the Employer.

(b) Commissioning Tests

i. Tests of components / equipment shall be according to the Contractor's QC plans, which shall be subject to approval by the Employer.

ii. After installation at site and after finishing all cabling works, the Contractor shall verify all process signals and process interface. All control commands shall be executed and real process contacts and variables shall be checked.

iii. The total system performance shall be verified testing all main- and sub-routines, algorithms and control functions.

iv. The tests of the generating unit shall include the operation in various loads, voltage and speed conditions, switching on and off, starting-up, shutting-down, etc. with local manual / automat and automatic control.

- v. All tests shall be performed by Contractor under the supervision of Employer. The Contractor shall arrange with the Employer the test processing details and time schedule, aiming for the tests being carried efficiently and in conformity with the operating conditions of the power plant and network.
- vi. Password of Customer Application programs:
Following passwords shall be provided as and when specified below:
 - 1. First level - Monitoring of the display values - At the end of commissioning of plant.
 - 2. Second level - Monitoring of the process variables and modification of peripheral parameters or settings - At the end of Warranty period or after Acceptance certificate.
- vii. Unless otherwise agreed on by the Employer all tests made at Site shall be performed by the Contractor under the supervision of the Employer. The Contractor shall arrange with the Employer the test processing details and time schedule, aiming for the tests being carried expeditiously in conformity with the operating conditions of the station.

(c) Training of the Employer's Staff

- i. The Contractor shall plan for the Employer's staffs' participation, either continuously or on a regularly recurring basis, in the commissioning work and:
- ii. Allow the Employer staff to become familiar with the operating and maintenance aspects of the new equipment.
- iii. Maintain a continuing assessment with the Employer of the precautions required in, or possible consequences of, initial energization of equipment.
- iv. Allow for the above two necessary objectives in the preparation of schedules.
- v. The Contractor shall station at site at least one technical expert for a minimum of one week after commissioning to rectify any problems as well as train the Employer's attending staffs. If required the length of his stay shall be extended as per requirement depending upon the seriousness of the problem encountered, which shall be at the Employer's discretion.
- vi. A Special Training class at site for three days shall be conducted by the Contractor for giving in detail of the Equipment in view of maintenance purpose. The refreshment during training for above Engineers/Technical personnel shall be on the account of the Contractor.

13.5 Equipment List of Control System

Central computer & its accessories	Computer system • P-III 800, one pieces of 500 G hard disks, and the internal capacity of 256M. • Printer: A3 color printer • Colorful display: 19" • SCADA communication module	Set	1
Automatic control & protection section	Turbine control unit	Set	2
Generator-transformer (if any) block control & protection section	Generator control & protection module	Set	2

Transmission line control & protection section	Line protection module	Set	1
Control system for the public device	Auxiliary control system PLC control	Set	1
Synchronizing device		Set	1
Power source	UPS	Set	1
Systematic software	SCADA software and software of auxiliary system control	Set	1

14. POWER AND CONTROL CABLES

14.1 Operating Conditions

This section of specifications covers the supply and lying of all 11 kV and low voltage power, control and measuring, shielded and tele-transmission cables related to the station services and control & monitoring systems of the Saniveri Utterganga Mini HPP including all related accessories as described hereafter.

The supply and installation of cables related to miscellaneous systems such as (telephone, lighting, HVAC, domestic water, industrial water, drainage and dewatering, etc.) shall also be done by the Contractor.

In the drawings, diagrams and the specifications, some cable cross sections (for 0.4 kV, 11 kV and the bigger sections of 33 kV cables) and the main cable routes/trays are indicated for information only. The Contractor shall still make the detailed calculations for final selection of the cables sections and determination of the cable routes. The Contractor's works shall proceed as follows:

- Collection of the necessary cable data (length, power to be carried, allowed voltage drop, type of cable, terminal points, etc.)
- Selection of the cable cross-sections and types followed by the related calculations
- Determination of cable routes and cable – way types and preparation of civil info drawings with all requirements for the civil contractor such as position and size of openings for cable passages, etc.
- Preparation of cable lay-out drawings/plans
- Preparation of detailed drawings for closing the cable passages (fire-proof, weatherproof and air-tight) with submission of the relevant data about material to be used
- Preparation of drawings for installation of the cable tray, supports, fixations, etc.

After approval by the Employer of all above mentioned documentation the Contractor shall proceed with the work as follows:

- Manufacturing of cables and accessories
- Factory tests
- Packing, shipment and transport to site including storage at site
- Installation of cable trays and supports
- Laying of cables and installation of related accessories
- Installation of cable identification tags and labels
- Closure of the cables passages
- Final adjustment and energizing of cables.

14.2 Scope of Supply

This specification covers the supply of material, transport, storage at site, erection and testing

of the 0.4 kV, 11kV voltage power and control cables and their related accessories for Saniveri Utterganga HPP.

The main components of the supply are as follows:

- a) 15 kV, YE3SV cables, connecting 11 kV switchgear to generator phase terminals and generator neutral terminal to neutral grounding transformer including:
 - Indoor cable terminations (11 kV)
 - Cable connections to the 11 kV switchgear and neutral grounding transformer
- b) 15 kV, YE3SV cables, connecting 11 kV switchgear to the tower of the over head line including:
 - Indoor and outdoor cable terminations (11 kV)
 - Cable connections to the 11 kV switchgear
 - Connection to the disconnecting switch installed on the tower including cable shoes with adequate section.
- b) 15 kV (11 kV) XLPE cable, connecting 11 kV switchgear to the 50 kVA station service transformer including:
 - Indoor cable ends on both cable sides (15 kV)
 - Cable connections to the switchgear and transformers bushings
- f) 0.6/1 kV, NYY cable connecting the 50 kVA station service transformer to the LV main distribution panel including:
 - Cable connections to the transformers
 - Cable connections to the distribution
- g) 0.6/1 kV, NYY cable connecting the 50 kVA emergency diesel generator set to LV main distribution panel including:
 - Cable connections to the generator
- Cable connections to the main distribution panel
- h) All 0.6 / 1 kV, 50 Hz feeding cables, connecting the LV distribution panel to all LV consumers and systems including cable connections on both sides.
- i) All 110 V DC (0.6 kV) power cables, all as described here above in item h.
- j) All control, monitoring, metering, protection and measurement cables (0.6 kV), connecting the main control and monitoring system (described in section 6) to all other systems in the power plant.
- k) All necessary cable trays, supports, fixations, protection sleeves and other appurtenances required for laying and installation of all cables and related accessories furnished within the scope of this specification. All steel structures shall be hot-dip galvanized for protection against corrosion with a zinc layer of minimum 70 microns.
- l) The cable passages through the walls, floors and ceilings shall be closed after installation of the cables, as follows:
 - All cable passages for cables going out of the building shall be weather – and fire proof (fire resistant for 30 minutes).
 - All cable passages in the service building through the floors shall be fire proof (fire resistant for 30 minutes).
 - All other cable passages shall be air-tight closed.

The Bidder has to submit all technical details with the Bid; the same is valid for those cable passages which also have to be weather-proof.

- m) One (1) set of standard and special tools required for installation and connection of the cables provided in this scope of supply.

- n) One (1) set of spare parts, self-sufficient for a service period of two (2) years, including but not limited to the following:
- One cable terminations of each type used
 - Cable trays, 5 % of each type used
 - Cable drums for storage of the above mentioned spare cables.

The Contractor shall submit a detailed list of tools and spare parts for approval of the Employer. The list shall have unit prices for each element.

14.3 Technical Requirements

In addition to the "General" mentioned in 1 above:

- All cables are to be from one piece, without any intermediate junction boxes.
- All cables and tests covered with this specification shall be in accordance with the applicable international standards (especially IEC recommendations and VDE standards) and where applicable with IEC standards.
- All power and control cables leaving the building (outdoor) shall be provided with metal armouring.
- All material shall be of the highest grade, free from defects and imperfections, free from tool traces, shielding or insulation scratches, and of recent manufacture.
- The chosen material shall be fully adapted to the specified ambient conditions.

Material shall be chosen and when required shall be surface-treated in order to avoid corrosion.

- All power cables shall be so sized as to allow a maximum voltage drop of 0.5 % under maximum load and maximum ambient temperature (design ambient temperature for cables shall be 40°C).
- In order to use a minimum number of cable types, the cables shall be standardized as much as possible with respect to sections, number of cores, marking of cores, etc.

14.3.1 1.1 kV Cables (system voltage class 0.4 kV):

Single-core/ three 1.1 kV cables, stranded copper conductor, polyethylene insulation (XLPE or equivalent), shielded with copper tape (electrostatic screen), metal armored with thermoplastic jacket overall, for 0.4 kV cabling to the generator and main transformers. Design ambient temperature 40°C.

14.3.2 Low voltage Power Cables:

- Standard copper conductors, thermoplastic insulation, metal sheathed with thermoplastic jacket overall, design ambient temperature 40°C, for all indoor cabling. (These cables shall not be directly exposed to the sun).
- Stranded copper conductors, thermoplastic insulation with thermoplastic jacket overall, design ambient temperature 40°C, for all indoor cabling.

All low voltage power cables shall be selected with the following characteristics:

- voltage rating : 600 V
- rated voltage : 440/231 V
- operating voltage : 380/220 V
- current rating : according to IEC
- design ambient temperature : 40°C
- maximum voltage drop : 3%
- minimum copper conductor section : 2.5 mm²
- 4 core cables shall be used only.

Control and measurement cables:

- Copper conductors, thermoplastic insulation, metal sheathed with thermoplastic jacket overall, design ambient temperature 40°C, for all outdoor cabling. (These cables shall not be directly exposed to the sun).

- Copper conductors, thermoplastic insulation, with thermoplastic jacket overall, design ambient temperature 40°C, for all indoor cabling.
- Voltage rating of all control and measuring cables shall be 600 V.
- Unstranded copper conductors are accepted up to 1.5 mm² cross section.
- All control and measurement cables shall be shielded for protection against external EM interferences.
- The voltage drop and highest current of the control, measuring and special cables shall be determined in each individual case, in order to assure a correct service of all connected apparatuses and instruments even under the most severe variations of the power sources.

14.3.3 Tele transmission Cables:

- Single and multipair cables: Thin stranded copper conductors, thermoplastic insulation screened twisted pairs, thermoplastic jacket overall, suitable for indoor cabling for electronic circuits.
- Multipair, telephone cables: Copper conductor, thermoplastic or paper insulation, wired in screened double twisted pairs, metal armored with thermoplastic jacket overall, for outdoor cabling. (This includes two independent cables for transmission between switchgear room and powerhouse, to satisfy the requirement to use fully independent duplication of safety signals.)
- 50 Hz, f min. test voltages required for LV and telecommunication cables 4,000 V and 2,000 V respectively.
- All the signals, data transfer and communication cables shall be supplied and installed by the contractor of the related equipment.

14.3.4 Basic

- The cables routes for cable installation shall be determined by the Contractor, by using cable trays, trenches, channels, shafts, etc., indicated on the appropriate drawings.

By designing the cable routes, the following principles are to be considered:

- gathering of cables of the same voltage level.
- simplicity and clarity of cable routes enabling the shortest possible lengths
- adequate and approved separation of HV cables running in the same cable trench or on the same cable trays.

It shall be avoided:

- the parallel routing of power and control cables.
- the parallel routing of medium and low voltage cables.
- laying of cables in stops where they can be exposed to incidental damage due to handling, erection, maintenance works, liquids, heat, exhaust gases, etc.
- Cables shall be neatly arranged in order to make any cable easily traceable along the whole route.

14.3.5 Laying of Cables

The type of lying and fixing of cables shall be chased according to the following principles:

- Wherever possible, cables shall be laid on cable racks or cable trays attached to the ceiling or the walls.
- Where the quantity of cables does not justify the installation of cable racks or cable trays, the cables shall be pulled through cable conduits fixed to the ceiling or to the wall.
- Short connections can be pulled through conduits buried in the floors.
- In vertical routes, cables shafts, etc., the cables shall be fixed to the supporting structure with sleeves.
- The cable supporting structures are to be attached to the walls by means of special screws. There will be no auxiliary steel profiles available in the concrete building structures.
- Connectors shall be provided for all entrances of cables in boxes, junction boxes, panel

boards, etc.

- The above description is of general character and does not include those cases where specially adapted supports are to be used.

14.3.6 Connection of Cables and Identification

- Cables and wires shall be properly stripped, cable jacket overall shall be left as close as possible to the connection.
- The copper sheath or armor of the cables shall be earthen at both ends.
- 11 kV cables shall be provided with a cable sealing end.
- Low-voltage power and control cables connections shall be made either on terminals provided with cleats, or by means of terminal lugs.
- Control cables connections will be made by welding or clamping.
- Identification, labeling, cable colour codes, etc. shall be done according to Part 1 of this Volume.

14.3.7 Performance Data and Guaranteed Characteristics

The Bidder shall furnish together with his Bid all required cable data and characteristics by fully completing the forms enclosed in the next pages. This shall be done for each supplied type of cable and also for each cable cross-section.

Item Description Unit Quantity

Cable capacitance per km

Insulation resistance per km of conductor, at 30°C

Charging current per km of conductor at rated voltage

Maximum admissible continuous service voltage (phase to earth)

Power frequency test voltage (phase to earth)

Maximum conductor permanent temperature

Applicable standard specifications

Catalogues

15. POWERHOUSE TRAVELLING CRANE

15.1 Scope of Work

One (1) overhead traveling crane shall be of electrical operated, cabin controlled type, suitable for three-phase 220/380V-50 Hz power supply and shall be equipped with a single trolley having only main hoist.

The crane shall be complete with bridge girder, cabin, main hoists, shaft, gear box and complete electrical equipment including motors, control gear, power collecting gear, electrical equipment for trolley, hoisting ropes, blocks and hooks, ladders, platforms, guards and handrails, spares, tools and other necessary accessories for its proper and efficient operation.

The runway crane rails shall be supplied and installed by the Contractor on such concrete beam girder as show on approved drawings, including end-stop dampers, anchor bolts, splices, base plates, liners, joint plates and other necessary material to complete the work.

Embedded details (such as steel plates, joint plates recesses, etc. for fixed embedded parts of the equipment) shall be supplied by Contractor to be installed into concrete.

Contractor shall show measures of installation in the Bid.

15.2 Design Standards

Design standards for the crane shall be in accordance with national entrepreneur standards and FEM norms or equivalent standards.

15.3 General Requirements

The design of crane shall be such that all movements take place smoothly and positively. No nipping or creeping of the loads shall occur at any time.

The crane shall be designed for continuous operation cycle equivalent to 25% ED, starting with cold motors and brakes.

Safety factor used in the design shall be not less than 5, unless otherwise specified.

Under the rated loading conditions, momentary operation of the control shall not permit movements in excess of the following standards or limits or shall be as proposed by the manufacturer:

Main hoist hook, vertical movement:	2 mm
Trolley travel:	8.6 mm
Bridge travel:	8.6 mm

Special care shall be taken to guard against oil or grease dripping from the crane, and where necessary, easily removable catch pans shall be provided.

15.3.1 Lifting Capacity

The lifting capacity of the main hoist shall tentatively be 5-ton (according to partial weight of generator) and the crane shall be capable of traveling with its full load suspended in any position.

The lifting capacity of main hoist may be changed by Employer based on the actual heaviest equipment to be handled during the erection and maintenance. Such change in lifting capacity of main hoist will be adjusted at the price per ton.

15.3.2 Runaway Crane Rails

The runaway crane rails provided under this Contract shall have adequate length for traveling of crane and it is necessary to take care of rail connections. The length of the rail shall be 23.0 m (shall be verified at site). End stop dampers and accessories shall also be provided.

15.3.3 Dimensions and Distances

The crane distances in the machinery hall are shown in the drawing. The span of the rail shall be 13.8 m (distance between two rail centers and bidders shall verify at site).

The trolley shall be so designed that in the extreme position of its traverse the main hook can still reach close to the rail. Minimum distance of each crane hook from centerline of rail at each end shall be stated in the Bid.

15.3.4 Speed

Speed of the crane shall not be less than following values under full load condition or as proposed by the manufacturer:

Bridge longitudinal traveling:

High speed	: 10.0 m/minute
Low speed	: 0.5 m/minute
Trolley cross traversing	
High speed	: 10.0 m/minute
Low speed	: 0.5 m/minute
Main hoist	
High speed	: 2.0 m/minute
Low speed	: 0.2 m/minute

15.4 Construction

The design of crane shall be take into account the lateral stresses due to starting and stopping the crane suddenly when carrying the rated load.

The main bridge girders of the crane shall be constructed as box type girder. Temporary deflection of the girders with full load on the main hoist in any position shall not exceed permitted value.

Bridge girders shall be mounted on traveling trucks with buffers.

All rails of the trolleys and crane shall be equipped with rail brushers.

Rails, with wheel stops of adequate height, shall be provided on the main bridge girders for the trolley travel. Rails shall be secured to the bridge girders and shall have provision to prevent creep-age.

15.4.1 Wheels and Axles

Wheel axles shall be equipped with bearings and shall have construction for easy maintenance and removal of wheels. Axles shall be made from alloy steel heat treated, accurately machined to receive high smooth.

Wheels shall be cast, forged or rolled steel double flanged of appropriate contour to suit the runaway travel and bridge rails. Wheels are to be accurately machined to receive the specified smooth.

15.4.2 Bridge and Trolley Driving Machinery

One pair of wheels in each end of bridge shall be driven by an electrical motor driving a cross shaft through a helical spur, or herring bone gear speed reduced unit mounted near the center of the bridge or by two electrical motors without cross shaft and individual speed reduced units at each end. The motors shall be coupled to the reducer by a flexible coupling.

The cross shaft shall be supported on self-aligning bearings along the bridge. Final driven pinions shall be mounted on shaft section of shaft coupled to the main cross shaft for convenience in assembly and replacement of parts.

The motor, speed reducer unit and brake shall be mounted on a common structural steel base, supported from the bridge drive-side girder.

The trolley drives shall be generally as described for the bridge drive except that crane motors may be provided with direct drive to the wheel shafts.

All gearing, other than final drive gears at the wheels shall be enclosed in oil tight gear cases designed for splash lubrication of the gears and bearings. Adequate inspection window with transparent cover shall be provided in each case together with an oil filter plug, drain cock and dipstick.

15.4.3 Hoist Drums

Hoist drums shall be mounted on the trolley and located so that the hoisted load will at all times be transmitted equally to the crane girders. Each drum shall be dimensioned so as to receive the required amount of hoisting rope in one layer plus 1-3 turns to spare on each half of the drum with the hook in the maximum raised position, and when hook is in the lowest position at least three full wraps of rope shall remain unwound on each half of the drum. Hoist drums shall be fabricated or cast with adequate stiffening ribs to prevent deformation and to minimize deflection under all operating conditions. Drum diameters and rope grooves shall be in accordance with the recommendations of the rope manufacturer. All surfaces to come in contact with the rope shall be machined true to approved tolerances and surface finished to minimize wear and prevent permanent deformation of the rope.

15.4.4 Sheaves

Sheaves shall be of cast steel or cast iron properly dimensioned to suit the recommendations of the rope manufacturer. All surfaces to come in contact with the rope shall be machined true

to approved tolerances and surface finished. Sheaves shall be mounted on axles and axle bearings.

All sheaves shall be provided with guard plates to retain slackened rope within the grooves. Ample means for lubricating the bearings shall be provided in easily accessible locations.

Alignment of the upper and lower sheaves and the drum shall be such that the fleet angles of the ropes do not exceed 3-1/2 degrees on live sheaves and 4-1/2 degrees on equalizer sheaves.

15.4.5 Hook Blocks

The main hook shall be of single type, and bored for a horizontal lifting pin of a size sufficient to lift the maximum rated load. Hooks shall be of forged steel properly annealed after forging. Hooks shall be swiveled and designed to turn easily on bearings. The main hook block shall be shaped at the bottom to permit the block to rest in an upright position on a horizontal plate without support to facilitate reeling of the hoisting rope and greasing of bearings.

15.4.6 Hoisting Rope

Hoisting rope shall be of preformed, regular lay extra flexible improved plow steel, and shall be designed so that the maximum working load including hook block does not exceed one-fifth of the breaking strength of the rope. Hoisting ropes shall be grease impregnated during manufacture.

15.4.7 Lubrication

All bearings requiring grease shall be fitted with grease fittings of approved type, easily accessible from the crane walkway.

The Contractor shall advise the Employer in writing as to the recommended type make of grease and other lubricating oils to be used. In addition, the Contractor shall state a lubricating cycle in the instruction manual to guide the operators of Employer in their maintenance work. The Contractor shall provide the initial lubrication for all the equipment, including the hoisting ropes.

15.4.8 Brakes

Each hoisting motion of the crane shall be provided with a separate spring-actuated A.C solenoid released brake capable of rapidly decelerating the trolley to rest from full speed with full load. Each brake shall be so arranged as to become automatically applied when power is cut off and shall also be arranged to release automatically upon application of power to the drive motor.

Each brake shall consist of a pair of shoes normally pressed against steel or cast iron drums of ample diameter and width by adjustable helical springs in compression. Each brake shoe shall have an ample thickness of replaceable friction lining. Brake drums shall preferably be on the input shaft of the gearbox but where brake drums are on the motor shaft, they shall be so placed that they can be readily removed to change a rotor and so as not to interfere with proper access to the brushes and bearings.

The main hoist shall be provided with:

- a. An electro-hydraulic thruster brake for lowering speed control in slow operation. The electro-hydraulic thruster brake shall be capable of necessary intermittent operation at any step of speed control without overheating. An over-speed safety device shall be incorporated in the hoist control to interrupt the power supply and operate the spring-actuated solenoid released brake to stop the hoist if over-speeding occurs;
- b. A multiple-disk, self-adjusting mechanical load brake, capable of sustaining the load in the event of power failure and failure of the hoist electro-hydraulic brake.

The bridge shall be provided with a friction brake controlled by a foot pedal in the operator's cabin and of sufficient capacity to bring the crane quickly to rest from full speed with rated load.

15.4.9 Cabin

The cabin for accommodating the control gear and operator shall be constructed of steel sections fixed under to one side of main girders. It shall have ample dimensions, be well ventilated, neat and have liberal open areas to give the operator a clear view of the hoist hooks. It shall also have a comfortable chair. A warning ring shall be fitted to indicate movement of the crane.

15.4.10 Electric Motor

Electric power supply to the crane shall be derived from low voltage switchgear cubicle with 220/380V-50Hz three-phase current. The longitudinal travel drive, the cross traverse drive, the main hoist and traverse drives shall be operated by independent electric motors each of the wound rotor, reversible, totally enclosed type with suitable insulation class and suitably impregnated to be non-hygroscopic. Motors shall be rated for 25% ED.

15.4.11 Controllers

A separate reversing drum controller shall be provided for each motor. Each controller shall be fitted with replaceable contact on the drum. Each controller shall be provided with arc shields of incombustible non- hygroscopic material. When in the "OFF" position, the controller shall isolate the motor on all three phases. Each controller shall be provided with a "Dead man's" button or spring return to "OFF" position. Emergency stop buttons convenient to controllers shall be provided. Not less than five steps of speed control shall be provided to allow a gradual speed increase from standstill to the maximum.

The controllers shall be mounted in the operator's cabin so as to permit unobstructed view of the work area below the crane for the driver when seated.

15.4.12 Control Panel

A metal-enclosed panel with access doors, suitable for working with six controllers shall be provided with and mounted in the operator's cabin.

The panel shall be provided with circuit breakers, contactors, protective relays, indicating instruments, transformers, fuses and other necessary apparatus.

A main circuit breaker shall be provided to cut off all power to the crane and to lock in the open position. Independent over current and over voltage protection shall be provided.

All controls, switches and components shall be adequately labeled and numbered for easy maintenance. A lighting and convenience outlet control shall be included on the panel.

15.4.13 Safety Limit Switches

The crane shall be designed to prevent over-winding of hoists, unreeling of cables from drums and overrunning of travel and traverse drives by means of limit switches arranged for quick make and brake of the motor circuits. The upper main line limit switches shall be arranged to open by the rising hook blocks without coming in contact with the rotating sheaves on the hoisting cables.

15.4.14 Lighting and Outlets

Adequate illumination shall be provided and wired in the cabin, so located as to prevent any direct or reflected glare from the operator's seat.

Four (4) lighting fixtures complete with 1kW reflector lamps, fittings and wiring shall be suitably mounted on the crane to illuminate the work area.

Two (2) outlets rated for 250V-15A shall be provided in the cabin at a convenient location for connecting temporary load during a period of maintenance.

15.4.15 Wiring

- a. The Contractor shall supply all necessary wiring, cabling and conduit on the crane taking the supply from low voltage cubicle. The main runaway contact wires and trolley duct

conductors according to relevant standards shall be of approved design and shall be supplied by the Contractor, located on the outside on the bridge girders to prevent interference with hoist loads.

- b. All current collectors shall be supplied by the Contractor and shall be of substantial construction with ample capacity to ensure continuous contact and designed to eliminate all sparking and flashing. The wearing parts shall be easily replaceable.
- c. Suitable guards or screens shall be provided to comply with the safety requirements.
- d. The minimum size of conductor shall be 2.5 mm².
- e. All wires connected to resistors or other subject to abnormal temperatures shall have 600-volt thermo-resistive insulation.
- f. All conduits shall be of rigid steel galvanized and shall be arranged to prevent ingress of moisture.

15.5 Accessories

1. Tools

All tools necessary for maintenance of crane shall be properly supplied.

2. Spare parts

The Contractor shall supply sufficient spare parts as follows:

- One (1) brake drum of each type;
- One (1) wrapped friction lining of each size and type;
- One (1) sets of suspension hooks with isolated plates;
- One (1) set of flexible joints and collection rings of each type;
- One (1) spare wiring and one (1) set of contactor;
- One (1) set of collector;
- 20% of lubricant and oil;
- 100% of fuses, indicating lamps and lighting lamps; and
- One (1) relay, button and limit switch.

15.6 Tests

The crane shall be completely assembled at the manufacturer's workshop and the following tests shall be carried out and the results shall be certified before shipment:

1. No load tests

The following items shall be object to test during the testing period:

- Accuracy and efficiency of the brake and limit switches;
- The distance of horizontal, vertical moving shall be measured approximately;
- Operation speed;
- Characteristics of manual and remote control;
- Painting check;

2. Load tests

a. Loading tests

Under the rated load, the equivalent items shall be tested as in case of non-load tests. However, the brake system shall be checked for operation of lifting equipment at its stipulated speed with the max sliding and ensure that the loading shall be on fixed position without any sliding; bearings, gears and other mechanic parts shall be overheating checked.

b. Static tests

Static tests shall be carried out for one hour. The loading shall be lowered slowly. The structural deformations shall be measured. No defect and deformation are remained after unloading.

c. Move tests

- The accuracy of lifting devices during its operation: the bridge girder system shall be quarter to runaway crane rails and no any case given the certifications on defects or deformation.
- Accuracy and efficiency of the brake and limit switches;
- Adjustment of control system and initial operation of the crane, driving adjustment of starting and braking.

d. Final tests

Final tests shall be carried out after non-load tests and maintenance, repairing, painting for the crane.

- The accuracy of lifting devices during its operation: the bridge girder system shall be quarter to runaway crane rails and no any case given the certifications on defects or deformation.
- Accuracy and efficiency of the brake and limit switches;
- Adjustment of control system and initial operation of the crane, driving adjustment of starting and braking.

After complete assembly the crane, the Contractor shall completely carry out an operating adjust and test including the brake system test. Then the Contractor shall sign on the minutes of allowance for stipulated operation of the crane.

15.7 Specifications of overhead traveling crane

No	Description	Technical Specifications	Unit	Qty	Note
1	Overhead traveling crane	Lifting capacity: 15T, Rail span: 7.2 m	Set	1	Expectation
2	Runaway crane rails	Length: 19.5 m	Set	1	
3	Testing devices (anchor, hydraulic dynamometer)	According to the crane	Set	1	
4	Electrical wiring	400V cable	Set	1	

15.8 Main parameters

- | | |
|------------------------------------|--|
| (i) Name | : Overhead traveling crane with two beams |
| (ii) Load | : 15 Ton for main hook |
| (iii) Aperture between rail center | : 8.6.0 m |
| (iv) Working grad | : A4-A5 |
| (v) Crane rail | : 43 kg/m |
| (vi) Operation type | : Control cabinet |
| (vii) Power source | : 380V/220V, 50 Hz |
| (viii) Speed of Crane | : 50 m/min |
| (ix) Speed of main hook | : 2 m/min or as proposed by the Manufacturer |
| Length of the rail-crane | : 19.5 m (Bidder shall verify at site) |

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D4– Inspection, Testing and Commissioning

1. Scope of work

The whole of the Works supplied under the Contract shall be subject to inspections and tests by the Employer or their Representatives during manufacturing, erection and after completion. The inspections and tests shall include, but not be limited to, the requirements of this section of the Specifications.

The Contractor shall provide all costs, appliances, apparatus, supervision, labor and services necessary to carry out all tests, unless specifically stated otherwise.

The Contractor shall furnish the detailed schedule of his commissioning plan at least one month prior to the scheduled date. The schedule shall include the commissioning procedures, testing sequences and details of special testing equipment, tests and commissioning record formats, information about relevant standards etc.

The scope of the commissioning program includes the field/site testing and putting into successful operation of all the equipment supplied under the Contract. Testing of energy meters and certification of their accuracy shall also be included.

2. Objectives

The objectives of commissioning work, prior to the successful energization of Plant at full voltage and connection to the system, are the following:

- Confirm the integrity (correctness) of installation.
- Confirm the integrity of insulation, connections and phasing.
- Ensure proof of equipment characteristics.
- Review workmanship.
- Confirm the correct implementation of the design.
- Check equipment ratings.
- Check settings and operation of protective relays.
- Check operation of emergency shutdown.
- Check and measure resistivity of earthing grid and earthing system.
- Confirm the proper functioning of PLC and SCADA system.

3. QUALITY ASSURANCE, INSPECTION AND TESTING

To assure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his subcontractor's premises or at the Site or at any other place of work, are in accordance with the Specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such program shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions before the award of the Contract. A quality assurance program of the Contractor shall generally cover, but not be limited to the following:

- (a) His organization structure for the management and implementation of the proposed quality assurance program.
- (b) Documentation control system.
- (c) Qualification data for bidder's key personnel.
- (d) The procedure for purchases of materials, parts, components, and selection of sub-contractors' services including vendor analysis, source inspection, incoming raw materials inspection, and verification of materials purchases.
- (e) System for shop manufacturing including process controls and fabrication and assembly controls.

- (f) Control of non-conforming items and system for corrective actions.
- (g) Control of calibration and testing of measuring and testing equipment.
- (h) Inspection and test procedure for manufacture.
- (i) System for indication and appraisal of inspection status.
- (j) System for quality audits.
- (k) System for authorizing release of manufactured products to the Employer.
- (l) System for maintenance of records.
- (m) System for handling storage and delivery.
- (n) A quality plan detailing out the specific quality control procedure adopting for controlling the quality characteristics relevant to each item of supply.

The quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

- Quality Assurance Documents

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of material/equipment.

The Employer, through his duly authorized representatives, reserves the right to carry out Quality Audit and Quality Surveillance of the systems and the procedures of the Contractor's and the subcontractor's Quality Management and Control Activities.

- Inspection, Testing and Inspection Certificates

The provisions of the clauses on Test and Inspection of the General Conditions of Contract and Special Conditions of Contract shall be applicable to the supply and erection portions of the Works. The Employer shall have the right to re-inspect at his expenses, any material though it would have been previously inspected and approved by him at the Contractor's works before, and if, after the same are inspected at Site following the latter, material is found defective, then the Contractor shall bear the cost of this inspection and reinstatement according to specification.

4. Tests at Manufacturers Works

4.1 General

Where no specific test is specified, then the various items of materials and equipment shall be tested in accordance with the relevant British, IEC, or American Standards. Where no appropriate standard is available, tests shall be carried out in accordance with the maker's standard practice, which shall be subject to the Employer's approval.

At least fourteen days' prior notice, in writing or by tele-fax, shall be given to the Employer of the readiness of the plant for test or inspection and every facility shall be provided by the Contractor and sub-Contractor (s) to enable the Employer or their Representative to carry out the inspections and witness the tests. This includes progress, test rig and packing inspections also.

Inspection of equipment will not be carried out unless the Employer has approved copies of the relevant sub-orders, drawings and test procedures. No equipment shall be packed, prepared for shipment, or dismantled for the purpose of packing for shipment, unless it has been satisfactorily inspected, or inspection has been waived by the Employer.

Functional electrical and mechanical tests shall be carried out on the completed plant after assembly in the Works. The extent and method of recording the results shall be agreed by the Employer in sufficient time to enable the tests to be satisfactorily witnessed or to make any changes to the proposed program of tests. All instruments and apparatus used in the performance of the tests shall be subject to the approval of the Employer and, if required by the Employer, shall be calibrated to an agreed standard at a laboratory of national standing to be nominated by the Contractor and approved by the Employer. The costs of carrying out such

calibration shall be borne by the Contractor in all cases.

The costs of making/performing any test shall be borne by the Contractor. This shall apply to tests performed at the site or elsewhere.

4.2 Test Certificates

Within 30 days of the completion of any test, triplicate sets of all principal test records, test certificates and performance curves shall be supplied to the Employer.

These test records, certificates and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer or his representative. The information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificate refers and should also bear the Contract reference title. Specified requirements shall be shown on each certificate for comparison with actual test results.

When all equipment has been tested, test certificates of all factory and site tests shall be compiled by the Contractor into volumes and bound in an approved form complete with index. Two copies of each volume shall be supplied to the Consultant and five copies to the Employer.

4.3 Type Tests

Type tests are required to prove the general design of the equipment and the Contractor may submit certificates of such design tests, which have been carried out on identical equipment. Notwithstanding any provision in BS, IEC or ANSI Standards, the Employer shall have the right to accept such certificates in lieu of the specified type tests or to reject them.

The type tests prescribed shall be carried out at the Contractor's cost in all cases, where either such certificates are not available or are rejected by the Employer.

5. Responsibilities

To ensure that the test jurisdiction and transfer of responsibilities is regulated by strict safety and handover procedures, the Contractor agrees the interface with the Employer to establish and implement handover procedures consistent with the terms of these Specifications.

The Employer shall retain full jurisdiction over all commissioning activities, which may affect the operation of the existing system. In these circumstances and when so requested, shall provide technical advices and assistances.

The Contractor shall be responsible for technical guidance and assistance in establishing the scope and method of tests, witnessing of the testing, assessment of results, and re-negotiation of the changes in test schedules which may be necessary as a result of other circumstances, such as delays in the delivery, possible equipment failures.

6. Safety Procedures

The Contractor shall share the responsibility for safety procedures with the Employer. The Contractor shall establish and implement a work permit and tagging system and associated safety procedures (subject to the review of the Employer) for all equipment, systems and areas not covered by the Employer's safety procedures.

The Employer will assume responsibility for the establishment and implementation of tagging, safety and work permit procedures for the protection of personnel and equipment, as soon as equipment and systems are connected to or are energizeable from the existing system.

7. Training of the EMPLOYER'S Staff

The Contractor shall plan for the Employer's staffs' participation, either continuously or on a regularly recurring basis, in the commissioning work and:

Allow the Employer's staffs to become familiar with the operating and maintenance aspects of the new equipment supplied by him,

Maintain a continuing assessment with the Employer of the precautions required in or

possible consequences of, initial energization of equipment, Allow for the above two necessary objectives in the preparation of schedules.

The Contractor shall station at site, at least, one technical expert for a minimum of six months continuously after commissioning to rectify any problems, as well as train the Employer's attending staffs. If required, the length of his stay shall be extended as per requirement, which shall be at the Employer's discretion.

8. Commissioning Staff

The Contractor shall provide commissioning personnel including skilled and unskilled labor as required. Submit a list with names, experience and proposed duration of the stay of key personnel on site, consistent with the construction schedule, along with the commissioning program.

Ensure that only staffs assigned to commissioning fulfills that duty for the duration of the assignment.

Ensure that commissioning staffs have authorization, and the competence, to undertake minor repairs or to make temporary redesigns and to reconnect systems to meet the specified system performance to preclude delays in energization and putting into commercial service of any part of the works.

9. Test Equipment

The Contractor shall ensure that all instruments, tools and other equipment required for testing and commissioning are available on site, ensure that the test equipment is of satisfactory quality and condition and, where necessary, is calibrated by an approved authority or standard.

Make arrangements for the provision of power supplies for testing with necessary vector configuration, voltage and current rating.

10. COMMISSIONING PROGRAM

Prepare a commissioning program for approval by the Employer and for incorporation into the Project master construction program. Allocate adequate time in this program to permit full commissioning of all components.

Carry out all testing during normal working hours as far as practicable. Tests, which involve existing apparatus and system outages, may be carried out outside normal working hours. Give the Employer sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing program.

Note that no tests listed in the agreed program will be waived except upon the instructions or consent of the Employer in writing.

10.1 Test Procedures

The following basic tests, in addition to others, shall be carried out:

- Measurement of insulation resistance.

10.2 Requirements for Field Tests

The field tests shall be carried out in presence of Employer under the following conditions:

AC withstand test voltages for conductors and outdoor equipment shall be normal operation voltage of the transmission line and, withstand voltage test shall be carried out for ten (10) minutes by the normal voltage mentioned above. The field tests shall be carried out by the Contractor after adjustment of all the equipment have been completed.

Expandable and lead wires and other materials required for the field tests shall be arranged by the Contractor. The Contractor shall be responsible for providing all measuring instruments, test equipment and tools required for the tests.

Preparation of the test record sheets and test reports shall be the responsibility of the Contractor and the results of the field tests shall be submitted by the Contractor for Employer's approval.

Measurement of insulation resistance of the equipment shall be performed by at least 1000 V megger.

After completion of the measurement of insulation resistance mentioned above, ac withstand voltage test shall be performed by the normal operation voltage of the existing power system in accordance with the following procedure:

Main Circuit: The circuit breakers and disconnecting switches, except for circuit breakers receiving power for the test from the existing power system through a transmission line, shall be closed, succeeding, normal operation voltage shall be charged on the equipment and bus conductors for ten (10) minutes for ac withstand voltage test. The indication value of meters mounted on the board during the ac withstand voltage test shall be recorded on the test record sheets prepared by the Contractor.

Submit test procedures, consisting of detailed test methods and samples of the related test record forms, for all equipment to be tested, to the Employer for approval along with the commissioning program. Strictly adhere to these procedures for the commissioning tests.

10.3 Records

Maintain an up-to-date record of all commissioning activities on site.

Record the results of the tests clearly on forms and formats approved by the Employer and with clear references to the equipment and items tested, so that the record can be used as the basis for maintenance tests, in future. Submit the required number of site test records to the Employer as soon as possible after completion of the tests.

Record the details of the test equipment and instruments used in the test sheets, in those cases where the instrument or equipment characteristics can have a bearing on the test results

10.4 "As-Built" Drawings

Keep an ongoing record of all changes on a master set of drawings. Produce and supply a minimum of five complete sets of marked-up "As Constructed/As-Built" drawings before leaving the Site. Correct and re-issue the original drawings as soon as possible as per this specification.

10.5 Test Methods

Carry out all necessary tests for commissioning the power plant. The following clauses detail the tests which are considered to represent the minimum required in addition to those specified under the appropriate IEC Publications, other approved standards and the manufacturer's instructions for each item of equipment.

Strictly adhere to the methods of testing approved by the Employer. The tests for each item shall be coordinated with the tests for other main items like turbines, governors, shut-off valve, generators and other equipment.

A) Site and Commissioning Tests for Main and Auxiliary Equipment

i. General Checks:

Make a general check of all main and auxiliary equipment. Include a check of the completeness, correctness and condition of ground connections, labeling, arcing ring, paint surfaces, cables, wiring, pipe-work, valves, blanking plates and all other auxiliary and ancillary items.

Check for oil and water leaks and that equipments are clean and free from external damage. Check that loose items, which are to be handed over to the Employer, e.g., blanking plates,

tools, spares, etc. are in order and are correctly stored or handed over.

ii. Hydraulic Turbines

Carry out pressure tests on all oil and water pressure systems, alignment and run-out check, dry functional tests, initial run, checking run-outs, vibrations and balance, bearing run and other mechanical checks, start-up, load rejection and load acceptance tests and make all tests as per commissioning tests specified under the appropriate IEC Publications, other approved standards, called for in the Manufacturers' instructions manual and/or specified in the specifications.

Record and submit to Employer in a hardcover binder, all test data obtained.

iii. Main Inlet Valves

Carry out 100% ultrasonic inspection of welds between inlet valve, penstock and spiral case, check tightness test of all pressure piping, check of cable connections, check of surface protection and painting and measure closing and opening times of the inlet and by-pass valves.

Record and submit to Employer in a hardcover binder, all test data obtained.

iv. Synchronous Generators

Measure clearance between shaft and guide bearings, measure insulation resistance for stator coil, field circuit and shaft circuit, test pressure pipe system, check shaft alignment, running test of bearings and make all tests as per commissioning tests specified under the appropriate IEC Publications, other approved standards, called for in the Manufacturers' instructions manual and/or specified in the specifications.

Record and submit to Employer in a hardcover binder, all test data obtained.

v. Governor System

Make all tests as per commissioning tests specified under the appropriate IEC Publications, other approved standards, called for in the Manufacturers' instructions manual and/or specified in the specifications.

Record and submit to Employer in a hardcover binder, all test data obtained.

vi. Excitation System

Carry out excitation system voltage-time response test, on-load response test and check if limiters and the reactive drop compensator operate as desired.

Record and submit to Employer in a hardcover binder, all test data obtained.

vii. Service Power Transformer

Make all tests as per commissioning tests called for in the Manufacturers' instructions manual.

Record and submit to Employer in a hardcover binder, all test data obtained.

viii. Circuit Breaker Tests

Check and set pressure switches settings when required. Also test mechanical operating systems.

Test local and remote trip/close operation and perform circuit breaker and auxiliary contact timing tests on all circuit breakers.

ix. PLC and SCADA System, Control/ Relay Panels, energy meters and Switchboards

Carry out general testing and inspection, as referred to above. The Contractor shall also carry following tests: a) Carrier signal testing b) protective relay testing c) Instrument transformers testing c) Phase correcting testing. Functionally test and perform the timing tests on circuit breakers and AC and DC circuits, associated with stand-by auxiliary supplies and stand-by generating sets, particularly where automatic operation is defined.

Carry out insulation measurement tests of secondary circuits with a 1,000 V DC megger before and after high voltage testing.

Check shutters, interlocking, earth procedures and the inter-changeability of components.

Carry out a high voltage 50 Hz dielectric test on each bus at 75% of the specified value for the equivalent factory test.

x. Disconnecting Switch and Earth Switches

Test all disconnecting switch and earth switches operationally to confirm contact pressures, contact resistance, simultaneous-operation of all phases and the ease of operation.

Check the local and remote indications and the operation of auxiliary contacts. Check the earthing mat at the operating positions and check the availability of connecting points for maintenance earthing arrangements.

Test the earth switches and maintenance earthing devices to confirm the opening and closing sequences and check the ground mat connections, indications and manual locking devices.

xi. Lightning Arresters

Inspect and verify the condition and satisfactory mounting of the arresters and their earth connections, electrodes and operation counters. Note the counter readings.

xii. Busbars and Connections

Test flexible busbars and connections to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental conditions and loads without stress to other equipment. If dynamometers are used to check the sags and tensions, check them before and after use.

Check rigid busbars and connections to ensure that the busbars will not cause overloading of the supporting insulators under load conditions and under the range of climatic variations applicable to the Site. Ensure that expansion and contraction of the equipment is fully accommodated by flexible connections.

xiii. Test conductivity on selected connections and joints.

Perform high voltage DC tests on all HV cables and isolated phase busbars at 75% of the specified value for the equivalent factory test. Carry out with at least 1000 V DC megger the insulation measurement test, before and after high voltage tests.

xiv. Batteries and Battery Charging Equipment

Test the insulation to earth of the complete DC system. Test the batteries and chargers to confirm the charger ratings, adjustment, alarm systems and battery capacity for the specified length of time at maximum expected loading. Record the specific gravity and cell voltages of the batteries during the initial charge and when fully charged and maintain proper regular records until the battery is taken over by the Employer.

Interlocking: Check all interlocking arrangements, both electrical and mechanical.

B) Earthing System

Carry out the tests and measurements in accordance with IEEE Standard 80. Test the effectiveness of the bonding and earthing and make conductivity tests on selected joints on the main earthing system and at the connections to equipment and structures. Check the precautions taken to avoid corrosion attack on the earthing system.

Measure the resistance of the earthing system to the remote earth indicating method and equipment used. Separate test probes of minimum 300 to 600 meters length to effectively test the earthing system. Perform earthing resistance measurements with the transmission line earth wires disconnected from the grounding grid.

C) Area Lighting

Check all lighting circuits including the operation of relevant photoelectric cells and remote/local commands. Measure the lighting levels throughout the substation on horizontal surface 800 mm above ground level and on all vertical surfaces of transformers, marshaling kiosks, etc. Measure the lighting levels in the area surrounding the substation up to 20 m from the fence.

D) Particular Constraints and Special Tests

The Contractor shall be prepared to cooperate with any special tests requested by the Employer.

D5 –Technical Data Sheets

The Bidders shall demonstrate their understanding of the Employer's Requirements and their Bid prices shall indicate the basis and reliability by providing proposed plant particulars in the tables below.

Where stated; indicative details may be tendered that are similar to existing work that the Bidder has previously designed and supplied; these shall be identified as "Indicative".

Details tendered are not binding; the Contractor shall amend and update the tendered particulars as necessary for the Employers approval of the detailed design. Notwithstanding the tendered details the Contractor shall be responsible for all requirements to achieve the intent of the Employers concept design.

TECHNICAL DATA SHEET (To Be Completed By the Tenderer)					
Table 1: Mechanical					
1. TURBINE					
Output, efficiency and turbine discharge at net head of 51.70 m					
REF	DESCRIPTION	EMPLOYER		BIDDER	
	Discharge (%)	Turbine efficiency (%)	Turbine output (kW)	Turbine efficiency (%)	Turbine output (kW)
	100	89.2	590		
	80	87.4	424		
	60	83.9	305		
	40	78.6	190		

The figure showing the curves for output, efficiency and turbine discharge at the respective heads shall also be submitted with the proposed specifications.

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REF	DESIGNATION		UNIT	EMPLOYER	BIDDER
	Manufacturer and Country of Origin				
	Year of manufacturing experience		Years	15	
	Manufacturing's Designation as per submitted catalogue				
	Applicable standard				
	Type			Horizontal Francis Turbine	
	Direction of rotation (Viewed from generator side)			C.W.	
	Rated speed		rpm	750	
	Runaway speed		rpm	1500	
	Specific speed (at optimum point)				

	Maximum speed variation and maximum pressure variation				
	Output (maximum)		kW	590	
	Turbine discharge		m ³ /s	1.2	
	Effective net head		m	51.7	
	Maximum speed variation		%	40	
	Maximum pressure variation		%	50	
	Maximum pressure		mpa		
	Starting time in turbine at maximum power of:				
	Stand still to no load running		s		
	Load take-up		s		
	Servomotor				
	Number of servomotors		sets	1	
	Minimum operating oil pressure		bar		
	Runner				
	Discharge diameter		mm		
	Number of Runner Vanes		pcs		
	Shaft seal				
	Type				
	Turbine guide bearing (if any)				
	Type				
	Type of lubrication				
	Cooling water flow (if required)		m ³ /s		
	Temperature of bearing metal not higher than		°C		
	Material of major parts				
	Runner			ZG0Cr13Ni5Mo	
	Housing			Q235-B	
	Distributor pipe			ZG230-450	
	Servomotor			Cast Steel	
	Casing				
	Needle Valve				
	Shaft				
	Moments of Inertia				

	GD ² required by turbine	t-m ²		
	GD ² of generator	t-m ²		
	Weight of turbine			
	Turbine total	kg		
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements and reasons for such deviations:

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As representative for.....

Address.....

Date.....

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
2. TURBINE GOVERNOR				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years		
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard		IEC	
	Type of governor		PLC-based digital with PID controller	
	Power supply		AC 230, 50 Hz DC110V	
	Rating	Kg-m		
	Guaranteed Sensitivity (minimum speed range to which governor will respond)	%	≤1	
	Speed signal		Tooth wheel type speed signalizer	
	Operating characteristics			
	Range of adjustment of permanent speed drop	%	0 to 10	
	Range of adjustment in speed setting	%	0 to 100	
	Total opening time of load limiter		Programmable	
	Total opening time of wicket gates			
	Total closing time of wicket gates			
	Adjustment range in governor opening and closing time	s	1 to 99	
	Maximum over speed			
	100% load rejection	%	3	
	50% load rejection	%	3	
	25% load rejection	%	3	
	Dead time equal or less than (IEC Rules)	s	0.15	
	Dead band	%	0.02	
	Regulating parameters			
	Temporary speed drop	s		
	Derivative time constant, T _n	s	12	

	Description and method of operation		Closed loop	
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
3. HYDRAULIC UNIT				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years		
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard			
	Oil pump			
	Type	Screw type		
	Delivery pressure	bar		
	Delivery rate	l/min	As required	
	Type and Capacity of Motor	kW	AC driven screw type as required	
	Number	No	2 (one main + one stand by)	
	Nitrogen Accumulator			
	Number per unit	No	1	
	Total capacity	liter	To suit the system requirement	
	Oil Pressure	bar		
	Maximum operating oil pressure	bar		
	Minimum operating oil pressure	bar		
	Oil sump tank			
	Effective capacity	liter	As required	
	Dimension of oil sump tank	mm		
	Weight (including oil)	kg		
	Grade of oil recommended		VG 68	
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		

	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
4. COOLING WATER SYSTEM				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years		
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard			
	Source- penstock tapping or tailrace pumping		As per site condition	
	Cooling water pumps			
	Type			
	Delivery rate	m ³ /min		
	Delivery head	m		
	Automatic washing strainer			
	Type			
	Material of filter			
	Maximum admissible differential pressure for filter element			
	Design pressure of filter housing			
	Flow meters			
	Type			
	Range of indication			
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements and reasons for such deviations:

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
5. INLET VALVE				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years		
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard			
	Type		Pressure oil operated butterfly type counter weight closing	
	Operating method			
	Nominal diameter	mm.	As required	
	Length of valve (flange to flange)	mm.	As required	
	Weight	kg		
	Head loss with $Q=0.5 \text{ m}^3/\text{sec}$	m.w.c.		
	Maximum leakage through closed valve	l/min		
	Bypass valve			
	Type			
	Diameter	mm.	As required	
	Valve seal			
	Type		Metal seal	
	Material of seat ring		Carbon casting steel	
	Material of seal ring		Stainless steel	
	Time required for operation			
	Main valve			
	Opening time	sec.	60-120	
	Closing time	sec.	60-120	
	Bypass valve			
	Opening time	sec.	60-120	
	Closing time	sec.	60-120	
	Oil pressure			
	Rated pressure	bar		

	Minimum oil pressure to hold the valve at closed position	bar		
	Maximum force acting on			
	Valve supports	ton		
	Servomotor supports	ton		
	Materials			
	Valve body		Carbon casting steel	
	Valve disc		Carbon casting steel	
	Valve shaft		Carbon steel	
	Dismantling joint		Carbon steel	
	Upstream pipe			
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements and reasons for such deviations:

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
6. DEWATERING AND DRAINAGE SYSTM				
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years		
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard			
	Draft tube Dewatering			
	No. of pumps		2	
	Capacity of each pump		To suit system requirement	
	Dewatering and Drainage System			
	No. of pumps		2	
	Type		Centrifugal mono block	
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
Table 2: Electrical				
1. GENERATOR				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years	15	
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard		IEC	
	Type		Horizontal Synchronous AC Generators	
	Rated Output	kVA	650	
	Continuous over load capacity	%	10	
	Rated power factor		0.80	
	Rated frequency	Hz	50	
	Rated voltage (phase to phase)	kV	0.4	
	Voltage variation range	%	5	
	Rated current	A	900	
	No. of Phases	No	3	
	Connection		Star	
	No. of terminals	No	6	
	Rated speed	rpm	750	
	Runaway speed	rpm	1500	
	Runaway speed durability	min	5 min	
	Insulation class			
	Stator winding (Class F)	class	F	
	Rotor winding (Class F)	class	F	
	Insulation level			
	Stator winding (incl. neutral)	V		
	Rotor winding	V		

	Maximum service voltage			
	Stator winding	V		
	Rotor winding	V		
	Maximum temperature			
	Stator winding	°C	145	
	Rotor winding	°C	150	
	Thrust bearing	°C	90	
	Guide bearing	°C	85	
	Cooling methods			
	Generator		IC01	
	Bearing		Water cooling or as proposed by Manufacturer	
	Voltage rise in case of sudden load rejection at rated speed with AVR acting			
	At p.f. 0.80	%		
	At p.f. 1.0	%		
	Wave form deviation factor	%	5	
	Short circuit ratio		0.75 (Minimum)	
	Vibration maximum, half amplitude of rotor	micron		
	Surge impedance of generator			
	One phase	ohm		
	Comprehensive value for three phases	ohm		
	Rated current			
	Stator windings	A		
	Rotor windings	A		
	Dimensions of generator			
	Weights of generator	ton		
	Characteristic curve			
	Power chart			

	No-load saturation and three-phase short-circuit curve			
	VEE curve sheet			
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements and reasons for such deviations:

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
Output & Efficiency				
The outputs and efficiencies at load of 100%, 80%, 70%, 60% under the rated voltage, frequency and 0.80 (lag) power factors respectively shall be guaranteed by the Contractor.				
DESCRIPTION	EMPLOYER		BIDDER	
Percentage of Load	Efficiency	Output (kVA)	Efficiency	Output (kVA)
100%	94.27	650		
80%	94.04	508		
70%	93.85	444		
60%	93.85	381		

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
2. BRUSHLESS EXCITATION SYSTEM				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years		
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard		IEC	
	Type		Brushless	
	Exciter			
	Rating	kVA	As required	
	Winding temperature rise	°C	<40	
	Max. one hour power requirement			
	Total rated losses			
	Rated voltage	V		
	Excitation rectifiers			
	Max. continuous current rating	A		
	Ceiling voltage rating	V		
	Ceiling current	A		
	Number of parallel connected rectifier circuits	No	3	
	Number of serial connection diodes	No	6	
	Peak reverse voltage rating of diodes	V		
	Repetitive peak reverse voltage of diodes	V		
	Max. range current rating of diodes			
	Max. operating temperature of diodes	°C	75	
	Total rectifier losses at rated output	kW		
	Quantity of requested cooling air	m ³ /min		
	Operating temp. at rated load	°C	<60	
	Voltage regulating equipment			

	Voltage setting range manual adjustment, minus, plus or rated voltage	%	30-130	
	Voltage setting range of automatic regulator, minus, plus or rated voltage	%	70-110	
	Limiters			
	Limits of frequency for which the excitation equipment is suitable	cps	47.5-52.5	
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements and reasons for such deviations:

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
3. HV XLPE POWER CABLE				
S. No	Description	Unit	EMPLOYER	To be filled by the Bidder
1	Manufacturer and country of origin			
2	Manufacturer's type designation			
3	Type			
4	Applicable Standards		IEC	
5	Voltage ratings			
	Suitable for max. system voltage	kV	1.1	
	Rated voltage between each conductor and screen	kV	1.1	
	Type of system earthing		Solidly grounded	
6	Conductor material		copper	
	Cross section of wires	sq.mm		
	Nos & dia of wires of each conductor			
	Insulating material and thickness		XL Polyethylene	
	Overall jacket material/thickness		PVC	
	Overall cable diameter			
7	Continuous current	mm		
	in ground	A		
	in duct	A		
8	Electrical parameters			
	Resistance	ohm		
	Reactance	ohm		
9	net weight of the cable	kg/m		
10	Technical literature submitted	yes/no	yes	
11	Type test certificate submitted	yes/no	yes	
12	Delivery of equipment in months following award of contract	months		

Deviations from technical requirements and reasons for such deviations:

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
4. LV CONTROL CABLES				
S. No	Description	Unit	EMPLOYER	BIDDER
1	Manufacturer and country of origin			
2	Manufacturer's type designation			
3	Type			
4	Applicable Standards		IEC	
5	Voltage ratings			
	Suitable for max. system voltage	V	1000	
	Voltage grade of the cables	V	600	
	Rated voltage between each conductor and screen	V		
	Rated voltage between two conductors	V		
6	Conductor material		copper	
7	Conductor			
	Cross section of wires	sq.mm		
	Nos & dia of each core in cable			
	Overall jacket of thickness			
8	Insulating material		Polyethylene	
9	Overall jacket material		PVC	
10	Net weight of the cable	kg/m		
11	Standard drum length	m		
12	Continuous current at 45 deg C			
	in ground			
	in duct			
13	Electrical parameters			
	Resistance	ohm		
	Reactance	ohm		
14	Technical literature submitted	yes/no	yes	
15	Type test certificate submitted	yes/no	yes	
16	Delivery of equipment in months following award of contract	months		

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
5. DC Power Source				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and country of origin			
	Year of manufacturing experience	Years		
	Manufacturer's designation as per submitted catalogue			
	Applicable standard	IEC		
	Rated voltage	V		
	Type of Cell		NiCd	
	Rated discharge capacity of 10 h rate to end-point voltage /cell	Ah	200	
	Acid density of full charged battery Charging current Initial Final	Kg/dm ³ A A		
	Number of cells Output capacities at different values of discharge rate and final voltage	no. –	Curve	
	Cell weight without electrolyte	kg		
	Electrolyte volume	dm ³		
	Cell dimensions	mm x mm x mm		
	Internal resistance of cell Quantity of air to be changed in the battery room	Mohm m ³ /min		
	Rated current of battery fuse	A		
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No		
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

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TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

6. BATTERY CHARGER GUARANTEED DATA

REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and country of origin			
	Year of manufacturing experience	Years		
	Manufacturer's designation as per submitted catalogue			
	Applicable standard	IEC		
	-A.C. input voltage and no. of phases	V/No		
	-Allowable A.C voltage variation	%		
	-Maximum A.C supply current	A		
	-Frequency variation	%		
	-D.C output at constant voltage • float charging • equalize charge	V V		
	-Max. D.C output voltage automatic control manual control	V V		
	-Max. load current via voltage dropping diodes	A		
	-Output voltage ripple with battery connected	mV		
	-Boost charging current	A		
	-Duty class as per IEC 146 clause 463.2	—		
	-Rated current of A.C supply fuse	A		
	-Rated current of D.C supply fuse	A		
	-Selection of charging characteristic: • Manually • Automatically • with electronic timer	— — —		
	-Protection class	IP		
	-Weight	kg		
	-Dimensions	mm x mm x mm		
	-Max. charging time of completely discharged battery	h		
	-RFI suppression grade	—		

	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No		
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No	Yes	

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
7. UPS				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	INPUT • Voltage • Voltage range without battery contribution • Voltage tolerance • Input frequency • Power factor • Input phases	V V V Hz %	%100 load, 50% load	
	BYPASS • Voltage tolerance • Frequency tolerance	V %		
	OUTPUT • Rated power • Active power • Phases number • Wave form • Rated voltage • Voltage distortion with distorting load • Voltage distortion with linear load • Frequency • Crest factor (I _{peak} /I _{rms}) • Output phases	kVA W V Hz	< <	
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
	Is manufacturer is ISO 9001 holder?	Yes/No		
	Has manufacturer exported units?	Yes/No		
	Technical literature/drawings submitted?	Yes/No		

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
8. STATION TRAVELLING CRANE				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	Manufacturer and Country of Origin			
	Manufacturer's type designation			
	Type of Crane		EOT	
	Applicable standard			
	Type of Hoist			
	Hoisting Capacity	MT	15	
	Electric Motor			
	Braking System			
	Limit Switch			
	Maximum Lift	m	To be determined by Bidder as per site conditions	
	Hoisting Speed (Operating Speed)	m/min	To be determined by Bidder	
	Equivalent Running Time	Hrs/day	To be determined by Bidder	
	Operation		Operator Cabin/Pendant Control Device	
	Electric Power Supply i) Main Power Supply: ii) Control Supply: iii) Power Consumption		380 V/ 50 Hz /3-phase 230 V/ 50 Hz /1-Phase 110 V DC	
	Material			
	Wheel		To be determined by Bidder	
	Shaft		To be determined by Bidder	
	Gear		To be determined by Bidder	
	Pinion		To be determined by Bidder	
	Portal, Bogie, Deck etc		To be determined by Bidder	

	Bridge Structure			
	Lifting Capacity	MT	15	
	Span	mm	To be determined by Bidder as per site conditions	
	Wheel Base		To be determined by Bidder	
	Total Length of Travel		To be determined by Bidder	
	Class		To be determined by Bidder	
	Travelling Equipment		To be determined by Bidder	
	Crane Travelling Speed (fast/slow)		To be determined by Bidder	
	Crane Travel		To be determined by Bidder	
	No. of Wheels	No	To be determined by Bidder	
	Rail Size		To be determined by Bidder	
	Limit Switch		Extreme position as well as for centre of each bay	
	No. of wheel boogies		Four hinged to end carriage in which two are driving units and two are idle type	
	Drive System		VSD	
	Power Supply		Main Power Supply: 315-480 V/50-60 Hz/3-phase Control Supply 110-230 V/50-60 Hz/ 1-Phase 110 V DC	
	Rail Gauge	Meter	To be determined by Bidder	
	Wheel Gauge	Meter	To be	

			determined by Bidder	
	End Buffers		To be determined by Bidder	
	Type		Spring Loaded Type	
	Outer Static Housing			
	Movable spring housing			
	Parking			
	Parking Arrangement		Anchoring to prevent movement from parking position and interlocking to prevent over travel during parking and anchoring	
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	Month		
	Is manufacturer is ISO 9001 holder?		Yes	
	Type test certificate submitted?		Wherever required	
	User's certificate submitted?		Required	

Deviations from technical requirements and reasons for such deviations:

Signed.....

As representative for.....

Address.....

Date.....

TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
9. AUTOMATIC CONTROL AND SCADA SYSTEM				
REF	DESIGNATION	UNIT	EMPLOYER	BIDDER
	PLC SYSTEM			
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years	10	
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard		IEC	
	Electromagnetic Compatibility according to IEC	Yes/No	Yes	
	Type			
	Communication protocol type		IEC 60870-5	
	Reliability class according to IEC 60870-4 (MTBF)		R1 > 8760 h	
	Time change in PLC input to change in diagram		< 2 s	
	Time executing command diagram change output PLC		< 2 s	
	Processing module microprocessor type			
	Max. possible number of process stations on the bus			
	Max. ambient temperature (continuous operation)			
	Max. relative humidity (continuous operation)			
	Bus system cable kind/ type			
	Max. number of clients			
	Resolution time tagged event and alarms in PLC		10 ms	
	Resolution time tagged event alarms protection relays		2 ms	
	Total number of data points			
	Total No. of Analog Inputs	Nos.		
	Total No. of Analog Outputs	Nos.		
	Total No. of Digital Inputs	Nos.		
	No. of Digital Outputs	Nos.		
	Standard cubicle:			
	- protection class	IP		
	- thickness of sheet steel	mm		
	- dimensions			
	height	mm		
	depth	mm		

	width	mm		
	Auxiliary power supply			
	- AC source	V AC		
	- DC source	V DC		
	- internal power supply	V		
	- type of back-up power supply			
	Permissible ambient conditions			
	- operating temperature range	°C		
	- relative humidity range	%		
	Overvoltage protection incorporated	Yes/No	Yes	
	Power Supply Voltage	V		
	Processor			
	Memory			
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	Month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	ISO 9001 certificate submitted?	Yes/No	Yes	
	Type test certificate submitted?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No	Yes	
	User's certificate submitted?	Yes/No	Yes	
	Technical literature/drawings submitted?	Yes/No	Yes	
	INSTRUMENTATION DEVICES			
	Manufacturer and Country of Origin			
	Year of manufacturing experience	Years		
	Manufacturing's Designation as per submitted catalogue			
	Applicable standard			
	Type			
	Current Output	mA	4..20	
	Overvoltage protection incorporated	Yes/No	As specified	
	Power Supply Voltage	V		
	Accuracy	%	Up to 0.02% of measuring range	
	Measurement Range		As required	
	Operating temperature range	°C	-25...+60°C	
	Protection Class		IP67	

	Vibration resistance (IEC 68-2-6)			
	Shock resistance (IEC 68-2-27)			
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	Month		
	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
	ISO 9001 certificate submitted?	Yes/No	Yes	
	Type test certificate submitted?	Yes/No	Yes	
	Has manufacturer exported units?	Yes/No	Yes	
	User's certificate submitted?	Yes/No	Yes	
	Technical literature/drawings submitted?	Yes/No	Yes	
	Certification			
	SERVER HARDWARE			
	Manufacturer and Country of Origin			
	Manufacturer's type designation			
	Processor Type		Intel Xeon, Quad-Core	
	Applicable standard		IEC	
	Processor frequency	GHz	3.10	
	Hard Disk Storage	TB	2	
	PC Hard disk Controller		SATA	
	PC Standard Drives		SATA16xDVD+/-RW Super Multi SATA Drive	
	Monitor		24" LED	
	Floppy Drive		No	
	Size of graphics card	GB	1	
	Size of RAM	GB	4	
	Technical literature submitted	Yes/No		
	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	Month		
	Is manufacturer is ISO 9001 holder?		Yes	

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
10. POWER TRANSFORMER				
S.N	DESCRIPTION	UNIT	EMPLOYER	BIDDER
1	Manufacturer and Country of Origin			
2	Year of manufacturing experience			
3	Applicable Standard		IEC	
4	Type		Out door, oil immersed, core type	
5	Winding/Phase		Two/1 Phase	
6	Cooling		ONAN	
7	Rating			
7.1	Rated MVA			
7.1.1	ONAN	MVA	1.5	
7.1.2	ONAF	MVA	1.5	
7.2	Rated Voltage			
7.2.1	Primary	kV	0.4	
7.2.2	Secondary	kV	11	
7.3	Maximum Voltage			
7.3.1	Primary	kV	0.5	
7.3.2	Secondary	kV	12	
8	Number of Phases		Three	
9	Rated Frequency	Hz	50	
10	Noise Level			
	On ONAN Rating	db	As per IEC	
	On ONAF Rating	db		
11	Temperature Rise			
11.1	Temperature rise above 45 deg C ambient			
	In Oil by thermometer	deg C	50	
	In winding by resistance	deg C	55	
	Manufacturer for winding temperature indicator		AB Khilsrom, Sweden or Equivalent	
11.2	Hottest spot temperature in winding limited to		AB Khilsrom, Sweden or Equivalent	
12	Connection			
12.1	High Voltage		Delta	

12.2	Low Voltage		Star	
13	Vector Group		Dyn11	
14	Taps			
14.1	Type of Tap Changer		OLTC	
14.2	Tap Steps		1.25%	
14.3	Tap Range		±10%	
14.4	No of Tap		17	
15	Cooling System			
15.1	Number Connected	Nos		
15.2	Numbers Standby	Nos		
15.3	Rated Voltage	Volts	110	
15.4	Adjusted Control Gear			
16	OLTC Gear			
	Manufacturer		Maschinenfabrik Reinhausen (MR) Germany or Equivalent	
16.1	Rating			
16.1.1	Rated Voltage	Volts	110	
16.1.2	Rated Current	A		
16.1.3	Step Voltage	Volts		
16.1.4	Number of Steps	No		
16.2	Control Suitable For			
	Remote/Local Operation	Yes/No	Yes	
	Auto manual Operation	Yes/No	Yes	
	Parallel Operation	Yes/No	Yes	
	Master Slave Operation	Yes/No	Yes	
16.3	Rated Voltage of Drive Motor	V	110	
17	Guaranteed Loss			
17.1	No load losses at rated voltage and frequency on max MVA base			
17.2	Load losses at rated current and at 75 deg C on max MVA base			
17.3	Cooler losses for full load operation on max MVA base			
18	Impedance volt at rated current and frequency at 75 deg C Winding Temp on ONAN, MVA base.	%	As per IEC	
18.1	Positive Sequence Impedance at name plate Normal Tap.			
18.2	Positive Sequence at maximum			

	voltage tap.			
18.3	Positive Sequence at minimum voltage tap.			
18.4	Zero sequence at Name plate tap			
19	Reactance at rated current and frequency at 75deg C on maximum MVA base at a nameplate tap.			
20	Efficiency at 75deg C winding temperature.			
20.1	At 100% Load			
20.2	At 75% Load			
20.3	At 50% Load			
21	Load in Percentage of full load and Power Factor at which maximum efficiency occurs.			
22	Regulation at full load and 75 deg C			
22.1	At unity power factor			
22.2	At 0.85 Power Factor Lagging.			
23	No Load Current in percentage of rated current referred to HV and 50 Hz.			
23.1	At 90% rated voltage	A		
23.2	At 100% rated voltage	A		
23.3	At 110% rated Voltage	A		
24	Clearances			
24.1	Minimum clearance in air HV/LV	Mm		
24.2	Between phases	Mm		
	Between phases and ground	mm		
25	Insulation level			
25.1	Power Frequency withstand voltage(1 min rms)			
25.1.1	Primary	kV		
25.1.2	Secondary	kV		
25.2	Impulse withstand voltage			
25.2.1	Primary	kV peak		
25.2.2	Secondary	kv peak		
26	Details of Oil Preservation system			
26.1	Type		Conservator Type	
26.2	If conservator type, urethane air cell provided	yes/no	yes	
26.3	Volume of conservator			

26.4	Volume of oil between the highest and lowest levels			
27	Pressure relief device min pressure settings			
28	Details of bushing HV/LV/Neutral Manufacturer/Type			
28.1	Voltage Class			
28.2	Creep Distance	mm		
28.3	Weight of Bushing	kg		
28.4	Standard reference			
28.5	Dry flash over voltage	kV		
28.6	Wet flash over voltage	Kv		
28.7	Impulse withstand voltage	Kv		
29	Insulating Oil			
29.1	Approx volume of oil	Liters		
29.2	First filled of oil with 10% excess provided	Yes/no	Yes	
30	Bushing Current transformer			
30.1	Type and voltage class			
30.2	Number of Cores			
	HV	Nos	1/phase	
	LV	nos	1/phase	
30.3	Accuracy class and Burden			
	Accuracy		PS	
	Burden	VA	15	
30.4	Max resistance of secondary winding	ohm		
31	OLTC control panel with AVR			
	Make			
32	Type of Core Material			
33	Approximate overall dimension			
34	Approximate weight	Kg		
34.1	Core	Kg		
34.2	Coil	Kg		
34.3	Tank and fitting	Kg		
34.4	Oil	Kg		
34.5	Total Weight	Kg		
35	ISO 9001 holder	Yes/no	Yes	
36	ISO 9001 certified submitted	Yes/no	Yes	

37	Type test certificate submitted	Yes/no	Yes	
38	User's certificate submitted	Yes/no	Yes	
39	Has exported to third country	Yes/no	Yes	

Deviations from technical requirements and reasons for such deviations:

Signed.....

As representative for.....

Address.....

Date.....

TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
11. 11 kV VACUUM CIRCUIT BREAKER				
S. No	Description	Unit	EMPLOYER	To be filled by Bidder
1	Manufacturer and country of origin			
	Model No.			
2	Year of manufacturing experience	Years	15	
3	Manufacturer's designation as per submitted catalogue			
	Applicable standard		IEC	
4	Type		3 Phase , Outdoor	
5	Poles		Three Pole	
6	Pole breaking		Three	
7	Rated Voltage			
7.1	Nominal	kV	11	
7.2	Maximum	kV	12	
8	Rated Current			
8.1	Continuous at 45 degree ambient	A	800	
8.2	Rated interrupting current	KA	20	
8.3	Momentary	KA		
9	Frequency	Hz	50	
10	Temperature rise above 45 deg C ambient		As per IEC	
10.1	Contacts	Deg C		
10.2	Terminal	Deg C		
11	Rated short circuit breaking current			
12	Rated short circuit making current			
13.1	Peak	kA		
13.2	RMS symmetrical	kA		
14	Interrupting time at 100% capacity			
14.1	Maximum Opening time	ms	60	
14.2	Total interrupting time	ms	60	
15	Closing time	ms		
16	Make time	ms		
17	Maximum current breaking capacity (rms)	A		
18	Insulation level			
18.1	Impulse withstand voltage (peak)	kV	170	
18.2	Power frequency withstand voltage	kV	70	
19	Operating Mechanism			
19.1	Type		Spring Loaded	
19.2	Number of mechanism per breaker			
19.3	Single/Three phase auto-reclouser		Not required	

19.4	Operating voltage of closing and tripping coil.	VDC	110	
19.5	Operating voltage range	% of rated voltage		
	Closing time		85-110%	
	Tripping		70-110%	
19.6	Closing and tripping current	A		
19.7	Spring charging motor rating			
	Capacity	kW		
	Rated voltage	V	110 DC	
19.8	Time required by motor to charge the spring completely	sec	<30	
19.9	Space heater and auxiliary equipment	Yes/no	yes	
19.10	Push bottom for local operation	yes/no	yes	
19.11	Selection switch for local and remote control.			
20	Operating counter provide	Yes/no	Yes	
21	Thickness of sheet steel of cubical	Mm	2	
22	Number of auxiliary contacts	No	6NO,6NC,6MBB	
23	Operating duty cycle		0-0.3sec-CO-3min-CO	
24	Number of possible operation without maintenance under.			
	Rated short circuit breaking current	No		
	Rated normal Current	No		
25	Porcelain insulator			
25.1	Manufacturer			
25.2	Creepage distance	Mm	900	
26	Pad locking provision for local cubicle	Yes/no	Yes	
27	Total weight of the cubicle	Kg		
28	Mechanical dimension (L x W x H)			

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Signed..... As representative for.....

Address..... Date.....

The Switchgears must be from **(ABB, Siemens, CG, SCHNEIDER, GE, Fuji or equivalent)**

TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
12. CURRENT TRANSFORMER (11kV)				
S. No	Description	Unit	EMPLOYER	To be filled by Bidder
1	Manufacturer and Country of Origin			
	Model No.			
2	Year of manufacturing experience	Years		
3	Applicable Standards		IEC	
4	Type		One phase outdoor, oil immersed.	
5	Number of phases	Nos	1	
6	Number of core in each CT	Nos	1	
7	Frequency	Hz	50	
8	Rated primary voltage			
8.1	Nominal	kV	11	
8.2	Maximum	kV	12	
9	Temperature rise above 45 deg C ambient at normal rated current	Deg C		
10	Insulation Level			
10.1	Impulse withstand voltage	kV	170	
10.2	Power frequency withstand voltage (1min rms)	kV	75	
11	Creepage distance			
12	Short time thermal rating	kA		
13	Current ratings	A		
14	Rated VA burden	VA		
15	Accuracy class		5p20 for protection and 0.5 for metering	
16	Rated thermal VA burden	VA		
17	Overload factor	%	20	
18	Dimension	Cu mm		
19	Weight	Kg		
20	ISO 9001 holder	Yes/no	Yes	
21	ISO 9001 certified submitted	Yes/no	Yes	
22	Type test certified submitted	Yes/no	Yes	

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Date.....

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
13. POTENTIAL TRANSFORMER (11kV)				
S. No	Description	Unit	EMPLOYER	To be filled by Bidder
1	Manufacturer and Country of Origin			
	Model No.			
2	Year of manufacturing experience	Years		
3	Applicable Standards		IEC	
4	Type		One phase outdoor, oil immersed.	
5	Number of phases	Nos	1	
6	Frequency	Hz	50	
7	Rated primary voltage			
7.1	Nominal	kV	11/ $\sqrt{3}$	
7.2	Maximum	kV	12/ $\sqrt{3}$	
8	Temperature rise above 45 deg C ambient at normal rated current	Deg C		
8.1	With 1.1 times rated primary voltage continuously			
8.2	With 1.5 times rated voltage for 30 seconds			
9	Insulation Level			
9.1	Impulse withstand voltage(peak)	kV	170	
9.2	Power frequency withstand voltage (1min rms)	kV	75	
10	Creepage distance			
11	Open circuit intermediate voltage			
12	Ratings			
12.1	Voltage ratio	kV	11/ $\sqrt{3}$:0.11/ $\sqrt{3}$	
12.2	Rated burden	VA	100	
12.3	Accuracy class		5p and 0.5	
12.4	Over Voltage factor			
12.4.1	30 seconds		1.1	
12.4.2	Continuous		1.5	
12.5	Connection			
12.6	Secondary fuse			
	Manufacturer			
	Amp. Ratings	A		
12.7	By pass device for protection provided	Yes/no	Yes	
12.8	Knife switch and fuse on secondary provided	Yes/no		

13	No of secondary windings	No	2	
14	Dimension	M		
15	Weight	Kg		
16	ISO 9001 holder	Yes/no	Yes	
17	ISO 9001 certified submitted	Yes/no	Yes	
18	Type test certified submitted	Yes/no	Yes	

Deviations from technical requirements and reasons for such deviations:

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Date.....

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
14. LIGHTING ARRESTOR(9kV)				
S. No	Description	Unit	EMPLOYER	To be filled by Bidder
1	Manufacturer and Country of Origin			
	Model No.			
2	Year of manufacturing experience	Years		
3	Applicable Standards		IEC	
4	Type		Outdoor, gapless, zinc-oxide	
5	Voltage rating of LA	kV	9	
6	Nominal Discharge Current	kA	10	
7	Surge counter with insulating base furnished	Yes/no	Yes	
8	Minimum power frequency spark over voltage	kV		
9	Maximum 1/50 impulse spark over voltage	kV		
10	Maximum front wave spark over voltage	kV		
11	Maximum switch surge spark over voltage	kV		
12	Number of section per pole			
13	Insulation level			
13.1	Impulse withstand voltage(peak)	kV		
13.2	Power frequency withstand voltage (1 min rms)	kV		
14	Creepage distance	Mm		
15	Earth terminal and accessories provide	Yes/no	Yes	
16	Surge Counter	Yes/no	Yes	
17	ISO 9001 holder	Yes/no	Yes	
18	ISO 9001 certificate submitted	Yes/no	Yes	
19	Type test certificate submitted	Yes/no	Yes	

Deviations from technical requirements and reasons for such deviations:

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TECHNICAL DATA SHEET (To Be Completed By the Tenderer)				
15. 11kV DISCONNECTING SWITCH				
S. No	Description	Unit	EMPLOYER	To be filled by Bidder
1	Manufacturer and country of origin			
2	Year of manufacturing experience	Years		
3	Applicable Standard		IEC	
4	Type		3 pole, single throw, outdoor, center rotating.	
5	Frequency	Hz	50	
6	Rated Voltage			
	Nominal	kV	11	
	Maximum	kV	12	
7	Rated Current			
7.1	Continuous at 45 de C ambient	A	800	
7.2	Short time for 3 sec max Kv	kA	20	
7.3	Peak short time current	kA		
8	Temperature rise above 45 deg C ambient at normal rated current			
8.1	Contacts	deg C		
8.2	Current Carrying parts	Deg C		
9	Maximum current the switch can safely interrupt			
9.1	Bus/Line charging current	A		
9.2	Potential transformer magnetizing current	A		
10	Clearance			
10.1	Between live parts and ground	Mm		
10.2	Between fixed contact and blade in open position	Mm		
11	Insulation Level			
11.1	Impulse withstand voltage(peak)	kV		
11.2	Power frequency withstand voltage (1 min, rms)	kV		
12	Main contacts			
	Material of fixed contact		Copper alloy	
	Coating of fixed contact		Copper alloy	
	Material of moving		Copper alloy	

	contacts			
	Coating of moving contacts		Copper alloy	
	Materials of the contacts of the earthing switch.		Copper alloy	
	Coating of the contacts of the earthing switch		Copper alloy	
13	Material of Terminals			
13.1	Coating of terminals			
14	Operating mechanism		Manual operation	
15	Auxiliary Contacts			
15.1	Type	Convertible or fixed	Convertible	
15.2	Continuous current at 110V DC	A		
15.3	Material		Copper	
15.4	Contacts silver plated	Yes/no	Yes	
16	No of operation switch can withstand without deterioration of contact	No		
17	Type of interlock furnished		Electrical and mechanical	
18	Are the disconnecter and the earthing switch mechanically interlocked to each other.	Yes/no	Yes	
19	Insulator			
19.1	Manufacturer			
19.2	Type			
19.3	Ref Standard			
19.4	No of units per stack			
19.5	Power frequency withstand voltage			
	Dry	kV		
	Wet	kV		
19.6	Impulse withstand voltage(1min)			
19.7	Creepage distance in Air	Mm		
19.8	Tensile strength			
19.9	Cantilever strength			
19.10	Compression strength			
19.11	Torsional strength			
20	Enclosure protection		IP-55W	
21	Operating mechanism		Manual gang operated	
22	Type of interlock furnished		Manual	
23	Weight of Insulator	Kg		
24	ISO 9001 holder	Yes/no	Yes	
25	ISO 9001 certified submitted	Yes/no	Yes	
26	Type test certificate	Yes/no	Yes	

D6. Spare Parts

List of Mandatory Components for Saniveri Utarganga Mini Hydro Subproject

S. No.	Description	Qty.
1)	Turbine	
1.1	Turbine Runner	1 No
1.2	Guide vane bushes (upper, middle, lower)	1/2 of used
1.3	Guide vane seal rings	4 No
1.4	Guide vane half diversion key	1/3 of used
1.5	Guide vane shear pin	1/2 Set
1.6	Guide vane stopping bearing piece	1/2 of used
1.7	Main shaft working seals	1 Set
1.8	Main shaft maintenance seals	1 Set
1.9	Head cover & bottom ring anti-wear plates	1 Set
1.10	Guide vane lever shaft bush	1/4 of used
1.11	Washers and fillers for all turbine connection	1 Set
1.12	Turbine facing plates	2 Set
1.13	Resistance temperature detectors of each type	1 Lot
1.14	Flow indicators of each type	1 Lot
1.15	Oil level indicators complete with switches	1 Set
1.16	Indicating instrument of each type	1 Lot
2)	Governing Equipment	
2.1	Frequency measurement card in PLC for governor	1 No
2.2	Sensor for position indicator in governor	2 No
2.3	Relay Board	1 No
2.4	Signal Board	1 No
2.5	Safety Tube	4 No
2.6	Indicator Light	1 No
2.7	Seal	1 Set
2.8	Power Supply Card	2 No
2.9	Push Button	4 No
2.10	Filter	4 No
3)	Oil Pressure Unit & Cooling Water System	
3.1	Oil pump for pressure oil supply (only gear pump)	1 No
3.2	Seals/Pickings	1 No
3.3	Filter element	2 No
3.4	Solenoid/Coil	1 No
3.5	Oil level switch	1 No
3.6	Pressure switch	1 No
3.7	Safety relief valve	1 No
3.8	Valve of each type for Cooling Water System	1 Lot
4)	Main Inlet Valve	
4.1	Seal of each type	1 Lot
5)	Station EOT Crane	
5.1	Brake drum of each type	1 No
5.2	Wrapped friction lining of each size and type	1 No

5.3	Suspension hook with isolated plates	1 Set
5.4	Flexible joints and collection rings of each type	1 No
5.5	Contactor	1 Set
5.6	Collector	1 Set
5.7	Fuses, indicating lamps and lighting lamps (100% of used)	1 Lot
5.8	Relay, button and limit switch	1 No
6)	Generator	
6.1	RTD's (Resistance Temperature detector)	2 No
6.2	Bearing pad	1 No
6.3	Oil level indicators complete with switches	1 Set
6.4	Indicating instrument of each type	1 Lot
7)	Brushless Excitation System	
7.1	SCRs	1 Set
7.2	Indicating Lamps, Push Button & Fuses (50% used)	1 Lot
7.3	Current meter, Voltmeter, kw/kVA meter (100% used)	1 Lot
7.4	Power Supply Card	2 Nos
7.5	Auxiliary Relays (50% used)	1 Lot
7.6	Transformers	1 No of each type
8)	Control & Instrumentation, Monitoring & Protection System	
8.1	Generator Protection Relay	1 No
8.2	Indicating Lamps, Push Button & Fuses (100% used)	1 Lot
8.3	Power Supply Card (100% used)	1 Lot
8.4	CPU	1 No
8.5	I/O Card (1/3 of installed)	1 Lot
8.6	Communication Module	1 No
8.7	Frequency Transducer (50 % of installed)	1 Lot
8.8	CPU internal battery	2 Nos
8.9	Indicating lamps (100% of used)	1 Lot
8.10	Flash Card (if any)	1 No
8.11	Bulbs / Fuses (Annunciation Window)	1 No.
8.12	Lockout Relay (Master trip relay)	1 No.
8.13	Relay terminal blocks	1 No.
9)	Generator Voltage Equipment	
9.1	Current Transformer	3 Nos
9.2	Vacuum Interrupter	2 Nos
9.3	Tripping & Closing Coils	2 Nos. each
9.4	Spring Charging Motor	1 Nos
9.5	Ammeter	2 Nos
9.6	Voltmeter	2 Nos
9.7	kVA meter	1 No
9.8	Indicating Lamps & Fuses (100% used)	1 Lot
9.9	Operating Handle	1 No
10)	DC & UPS System	
10.1	Indicating lamp, push button, fuses of each type (100% of used)	1 Lot
10.2	One of each type of switch, relay and other special	1 Lot

	devices	
10.3	Ammeter	1 No
10.4	Voltmeter	1 No
10.5	One of each type of control cards (PCBs)	1 Lot
10.6	NiCd Cell	5 Nos.
11)	12 kV Switchgear Equipment	
11.1	Current Transformer	3 Nos
11.2	Voltage Transformer	3 Nos
11.3	Vacuum Interrupter	2 Nos
11.4	Tripping & Closing Coils	4 Nos. each
11.5	Spring Charging Motor	1 Nos
11.6	3- ϕ , O/C relay with ground fault	1 No
11.7	Ammeter	2 No
11.8	Voltmeter	2 No
11.9	kVA meter	2 No
11.10	Indicating Lamps & Fuses (100% used)	1 Lot
11.11	Operating Handle	1 No
11.12	12 kV Indoor/Outdoor Heat Shrinkable Cable Termination Kit of required size	3 Nos each
13)	Power Transformer (0.4/11kV)	
13.1	H.V. Bushings	1 No.
13.2	Neutral Bushings	1 No.
13.3	L.V. Bushings	1 No.
13.4	Gaskets	1 No.
13.5	Magnetic oil level gauge	1 No.
13.6	Buchholz relay	1 No.
13.7	Oil and winding temperature indicator	1 No. each

OTHER MISCELLANEOUS COMPONENTS

S. No.	Description	Quantity
14.1	500 V, 100 Mega ohm hand driven generator type megger with leather case	1 No. each.
14.2	DIGITAL Tong tester 0-600 V, 0-300 A clip on volt – meter and Ammeter with leather case	1 No.
14.3	Digital multimeter	1 No.
14.4	Hand held type phase sequence meter 50 to 500 V	1 No.
14.5	Blower	1 No.
14.6	Soldering iron	1 No.
14.7	Hand held speedometer	1 No.
14.8	Vernier Caliper 300 mm	1 No.
14.9	Dial gauge with magnetic base 0 – 0.1 mm accuracy	1 set
14.10	Inside & outside calipers 150 mm, 200 mm, 250 mm and 300 mm	1 No. each
14.11	Master level 0.02 mm / M accuracy	1 No.
14.12	Ring spanners 5 mm to 36 mm set 36 x 41 and 46 x 51 mm size	1 set each
14.13	Single end open Jaw spanners 46, 50, 51, and 55 mm	1 No. each
14.14	Box spanners 10 to 50 mm with accessories	1 set
14.15	Circlip opener (inside & outside) 6"	1 No. each
14.16	Hammers – Ball peen 1 kg and straight – 5 kg & 10 kg	1 No. each
14.17	Pistol drilling machine (Black & Décor)	1 No.
14.18	Shim cutter 12" size	1 No.
14.19	Pipe wrench 18", 24"	1 No. each
14.20	Screw wrench 18", 24"	1 No. each
14.21	Allen keys 5 mm to 24 mm	1 set
14.22	1 Cutting pliers 6" & 8" size	1 No. each
14.23	Nose pliers 6" 8" size	1 No. each
14.24	Hacksaw frame 12" with 12 nos. blade	1 no.
14.25	Rough & Smooth flat, round, half round and triangular file 12" size	1 No. each
14.26	Centre punch & letter punch	1 No. each
14.27	Chisels 12 mm and 20 mm width	1 No. each
14.28	Bench vice 12" size	1 No. each
14.29	Screw drivers 6", 9" 16"	1 No. each
14.30	Grease gun 12"	1 No.
14.31	Tap set with wrench M10, 12, 16, 18, 20, 24	1 set
14.32	Feeler gauge 0.05 mm to 1 mm size 6", 18"	1 set each
14.33	Torque wrench 0-675 NM	1 No.
14.34	5 kg ABC Stored pressured type Fire Extinguisher	5 Nos

Part II- SECTION I, Part E - Training Requirement for Operation and Maintenance

The Contractor shall provide training to the Employer's personnel (Manager-1, Operator-3, and Electrician-5, Lines man for T&D line) to establish a well-trained operation and maintenance crew. The training shall be based on Operation and Maintenance Manual for the project which will be prepared by the Contractor.

If the specifications and/or drawings of these Bidding Documents do not contain particulars of materials or works which are obviously necessary for the proper and safe completion, operation and maintenance of the equipment in question, all such materials and works shall be deemed to be included in the supply.

Part II- SECTION I, Part F - Requirement for Operation and Maintenance

The Contractor shall provide all personnel (Manager-1, Operator-3, Office Assistant (1 no.) and Peon (1 no)), equipment and materials for proper operation and Maintenance of the whole system for 1 year. For the first one year the Contractor shall be fully responsible for any kind of operation and maintenance jobs required to the subproject. The contractor will depute all personnel (Manager-1, Operator-3, Office Assistant (1 no.) and Peon (1 no)), tools and consumables for operation of mini Hydro subproject from the date of commissioning. The Manager shall have minimum academic qualification of Diploma in Electrical /mechanical with 5 years' experience or Bachelors in Electrical/Mechanical/Industrial Engineering. The Operator shall have minimum academic qualification of Technical SLC/SEE in Electrical/Mechanical Engineering or equivalent. The Office Assistant shall have minimum qualification of 10+ 2 or equivalent. The Peon shall have minimum 8 class passed.

A quarterly site visit must be done by the contractor's engineer to make sure the preventative maintenance and assure that all the system components are fully functional. The quarterly site visit report shall be submitted to AEPC and project developer or Rural Municipality Office within a week of each visit.

The Contractor shall prepare operation and maintenance manual based on Operation and Maintenance for Small Hydro Power Plants Manual, April 2003 prepared by Small Hydro Power Promotion Project, GTZ which is attached as Annex VI of Bid document for reference.

Part II- SECTION I, Part G - Specification of General Items

Specification of General Items:

1. Site Office space/Residence and laboratories facilities to the Employer
The Contractor shall construct Site office/Residence as per indicated in drawings with separate bathroom and toilet, fully furnished to accommodate construction site supervision team for use as office cum residence.

The specification of the Site Office space/Residence and laboratories facilities to the Employer will be as follows:

- Construction of Site Office space/Residence and laboratories facilities in stone masonry (wall thickness: 350mm) of size 13.60m (L) x 6.65 m (B) x 3m(H)
- DPC band must be 350mm x 230mm with 6 nos of 12mm dia bar with 8mm dia Stirrups at 150mm center to center with concrete ration 1:2:4
- Sill and Lintel Band must be 100mm thick with 2 nos. of 12mm dai Bar with 8mm dia Stirrups at 150mm center to center with concrete ration 1:2:4
- Cement sand ratio 1:6 for wall, Cement sand ratio 1:4 for plaster
- Floor: PCC (1:2:4) flooring of 75mm thickness with punning 1:3 cement mortar
- Roofing: 24 SWG color corrugated GI sheet with Truss and Purlin. The truss must be of Howe King Post type and made of Tubular Black Pipe with at least 50mm dai. section medium type to be put at the interval of 3000mm center to center. The purlin must be at least 38mm dia section medium type at the interval of 500mm center to center. All the black pipes and purlins must be coated with a single coat of primer and 2 coat of Enamel Paint
- Foundation: 1050 mm width and 1500 mm depth
- Main wooden door double panel with frame (1500mm*2300mm) of SAL WOOD, 1 number
- Inner wooden door single panel with frame (1000mm*2150mm) of SAL WOOD, 3 Number
- Inner wooden door single panel with frame (750mm*2150mm) of SAL WOOD, 1 Number
- Window (glaze 5mm thick): 5 numbers of wooden window with frame (1500mm*1500mm) of SAL WOOD and 1 number of ventilations with frame (750mm*1000mm) of SAL WOOD
- All door, windows and ventilation shutter size shall be of size 75mm*100mm
- 20mm thick plaster at 1:4 cement sand ratio in inside the powerhouse and pointing works in 1:4 cement sand ratio at outside of power house
- The minimum masonry height of site office/residence should be 3000 mm
- Painting
 - o All wood works shall be painted with one coat wood primer and two coats of enamel paint
 - o External face of site office wall shall be painted with one coat of cement primer and two coats of black enamel on the stone masonry pointing surface only

- o Internal plastered surface shall be painted with one coat of cement primer and two coats of white distemper
- Supplying and fixing of 12.5mm thick Gypsum Board False Ceiling, including wooden frame with all complete set
- Toilet shall be furnished with Toilet Pan with Flushing System, Wash Basin with Tap, HDPE Pipes, Fittings, 500 Liters Water Tank with Accessories and other necessary accessories with all complete set
- The Septic Tank of Size 2200mm *2200mm*1500mm with 350mm thick stone masonry and slab cover 125mm thick with 10mm dia bar at 150mm c/c both ways. The Soak pit of size 600mm dia Circular Pit should be connected with 150mm dia HDPE Pipe to Septic Tank

2. Laptop Specification:

1 TB HDD 1.86 GHZ 17.3 Inches Full HD LED Notebook

Hardware Interface:	SATA
RAM Frequency:	1600 MHZ
Memory Slots:	1
Cache:	4MB
Processor Brand:	Intel
Processor Type:	Intel core i7
Usage:	Gaming
Laptop Type:	Notebook
Dimension(WxDxH)mm :	0
Weight:	3.2 Kg
Warranty:	1 year
Features:	Back lit English Keyboard
Storage Type:	HDD
Operating System:	Windows 10
Clock Speed:	1.86 GHZ
Peripherhals:	Keyboard, Speakers
Processor Speed:	1.86 GHZ
RAM:	16 GB
RAM Expandable Memory:	Upto 16 GB
RAM Type:	DDR3
Resolution:	1920x1080
Screen Sizes(Inches):	17.3
Touchscreen:	Yes
Graphics Solution:	Nvidia GT750M
Screen Type:	LED

Display Type:	Full HD
Storage Capacity:	1 TB
Power Supply:	65 W AC
Ethernet:	10/100
Bluetooth:	v4.0
Wireless LAN:	802.11 b/g/n
USB Port:	4x USB 3.0
Variant:	4500U

3. A3 Printer Specification:

Canon iR2004N A3 laser highly efficient black-and-white copying, network printing scanning

4. 500 W Solar power system with all accessories:

- PV module 24 V minimum 300 Wp x 2 numbers.: IEC 61215: 2005 and IEC 61730 certified from RETs
- Battery : 12 V 70 Ah@ C/10 x 4 numbers, Flooded Tubular Battery and certified from RETs
- Charge Controller : 48 V, 20A MPPT type and certified from RETs
- Inverter : 48V, 3.5 KVA pure sine wave off grid inverter and certified from RETs
- Accessories as per requirements for installation with all complete.

5. Laboratory facilities

The Contractor shall provide Laboratory facilities minimum 1 room with size at least 4.0m x 3.5m to accommodate Laboratory Equipment for:

- Sieve shaker with sieve sets
 - Coarse series – 80 mm to 4.75mm
 - Fine series – 4.75 mm to 0.75mm
- Slump test
- Cube Mold 15x15x15cm
- Compression Testing Machine 25Ton (M25 upto)
- Hydrometer
- Weighing Machine Digital
- 2 nos. Table and 12 nos. of Chairs

SANIVERI UTARGANGA MINI HYDRO PROJECT, 998 kW, PUTHA UTARGANGA RURAL MUNICIPLAITY, RUKUM, PROVINCE NO-5 SUPPLEMENTARY INFORMATION

Description of the Project Area, Location and Characteristics.

Saniveri Uttarganga Mini Hydropower Project (SUMHP) is located in former Taksera VDC (Now Putha Uttarganga Rural Municipality ward no-10) of Rukum district. The project is a run of river type project being developed by Rukumeli Sahid Smriti Gramin Jalbidhut Cooperative Ltd formed by local people in coordination and support from Rural Municipality office. Gap funding is being provided by AEPC as Subsidy. The 997kW capacity plant plans to electrify Putha Utarganga Rural Municipality (Ward no 1 to Ward no 10) with total number 5586 households.

Geographically, the project area is located in between latitudes 28°34' 30" to 28°35'10"N and longitudes 82°48'50" to 82°49'20" E

The basin is characterized by steep gradient and surrounding mountains are characterized by steep sloped landscape, alluvial terrace varies with elevation. The temperate coniferous forests and mixed forests are found around the project area. The snowfall is experienced seasonally in higher mountains.

The Saniveri Khola is a snow fed Perennial River, a tributary to the Bheri River, one of major tributary of the Karnali river system, one of Nepal's Largest river basin system of Nepal. The catchment is located in Rukum district of Province no. 5

The Saniveri Khola has its upper reaches high mountains within Rukum district. The maximum elevation within the catchment is 4500 m and the minimum elevation is 2100 m. The upper part of the catchment is thickly vegetated with tropical forest. However, there are few cultivated land within the upper reach of the catchment. Catchment area of Saniveri River computed at the proposed intake site is shown below. (Figure 1)

Annual maximum and minimum temperature in the project area is 300 C in June and 50 C in December respectively.

Precipitation in the catchment area is in the form of rain and snow. Higher altitude areas receives snow. The average annual precipitation over the catchment area is estimated as 1972.15 mm by Thiessen polygon method. As in other parts of the country, monsoon brings in plenty of rainfall in the project area. Heavy rainfall occurs over the basin during the month of June, July, August and September.

The total catchment area at intake site is 420.5 km². The project utilizes flow of Saniveri Khola and the head created by headrace canal and penstock between headworks and powerhouse site to generate power. The project has an installed capacity of 997 kW with a gross head of 55.0 m between the weir crest level at an operation elevation of 2171 m and

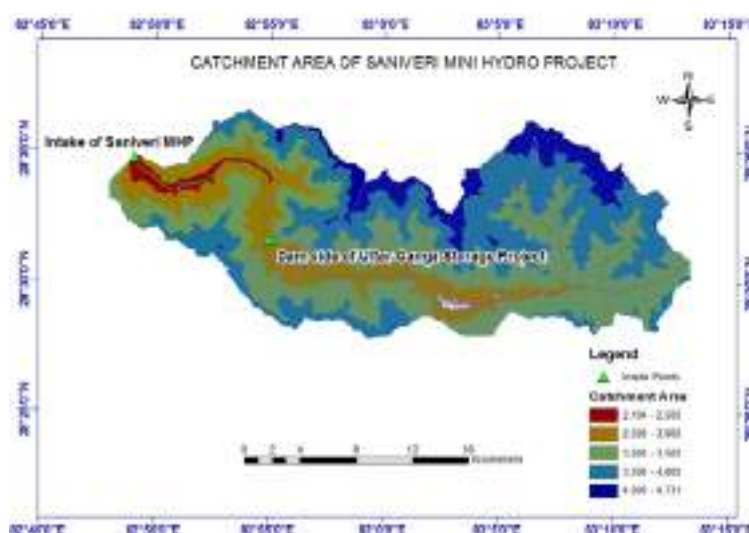


Figure 1: Catchment of Saniveri Khola at
Proposed Intake Site

the turbine tail water level at 2116 m. The design discharge is 2.4 m³/s corresponding to 80 percentile exceedance of flow. The net head of the project is 51.70 m and estimated annual energy generation is 7.916 GWh of which 2.996 Gwh is dry season energy and 4.204 GWh is wet season energy.

The project components constitute of 30m long concrete gravity weir, orifice type two intake, one single chambered 35 m long settling basin, 492 m long (size 1.5 m width x 1.5 m high RCC) headrace canal, a forebay of size 13m x 6m X 3.5m, 292.53m long (1100 mm diameter) penstock pipe powerhouse size (19.9 m x 9.0 m x 7.25 m). The water is discharged back to the Saniveri Khola through tailrace culvert. The surface powerhouse will be located on the left bank of the Saniveri Khola. It will have double unit Horizontal Shaft Francis Turbine having each plant installed capacity of 590 KW mechanical output. The transformer and accessories will be out door just in the side of powerhouse.

Accessibility

The project is accessible by Kathmandu-Dang- Rukum (Musikot) which is Black Topped Road and gravel road from Musikot – Tak upto the project site. Alternatively the project can also be accessible through Mid Hilly Highway from Kathmandu to Baglung and Baglung to Kakri Village of Rukum District. Then from Kakri there is earthen road which is about 20 km distance till the project site.

Communication facilities

Though seems remote area in the geological map, every modes of communications are available in this project area from headworks to power house area. NTC CDMA phones can be used for site communication purpose. Besides, NTC and NCELL cell phones are also widely used in the overall transmission and distribution area. So, communication won't be a great problem in this site unlike other site in our country.

Electricity Availability, Transmission and Distribution Networks

The electricity generated will be utilized mostly for powering the household uses along with some end uses in the Putha Utarganga Rural Municipality. Altogether more than 5583 households from the settlement will be benefitted from the scheme. The power is generated at low voltage (0.4kV) and transmitted over the distance 91.93 km long 11kV transmission line which also include the composite line (11kV and 0.4kV) of 15.72km .

The proposed project electrifies 5586 households of Putha Utterganga RM Ward no 1-14 of East Rukum district. There will be 29 distribution transformers proposed with different size from 15kVA to 250 kVA, 11/0.4kV. The power is distributed in Sera, Tak Gaon, Bachhi Gaon, Birgung, Pipal Tung, Okhama, Dimurghaira, Arjal Gaon, Gunma Gaon and Kada Gaon (Former VDC- Garli, Chuma, Karbang, Kol, Rankshi, Taksera, Hukam, Mikot, Tupa, Damchan, Tatu, Gumlibang and Jang).

A Switchyard is a part of an electrical generation system. Switchyard transform voltage from low to high voltage and also the power is evacuated from the Switchyard. Between the generating station and consumer, electric power may flow through several substations at different voltage levels. A switchyard includes transformers to change voltage levels between generation, power evacuation and distribution voltage. In Saniveri Utterganga Mini Hydropower Project there is 1500KVA Transformer to step up the generating voltage from 0.4kV to 11kV.

Household energy consuming activities

The main sources of energy in the load centre is from Kerosine, Wood. The power from these source is extensively costly. Activities like cooking and heating are mostly carried out with firewood. Lighting is another important activity performed in the household though some of them are using solar home system. After the Mini hydro installation they can get good light at cheaper price. Lighting hours per day in rural areas are about six. Other time could be used for Product End use activities.

Environmental Consideration

The existing environmental status of the project area at the site was gathered during this feasibility study and Detailed Engineering Design Study. The main objective of this study is to provide environmental assessments of existing physical, biological and socio-economic environments during construction and operational phase of Saniveri Khola Mini Hydropower project. Since most of the people mainly depend on i) inadequate existing projects for lighting and, ii) fire wood for cooking, deforestation is rapidly wide spreading. Therefore, it is believed that after installation of a Mini-hydro power project, deforestation would be controlled and would have the significant positive impacts in the environment also. From the project infrastructure development point of view, there will not be any trees cutting and no blasting works will be required. And neither heavy constructional works will be done. It is believed that some few trees could be cut during installation of Transmission and distribution line. Therefore, there won't be any adverse environmental effects in the project area.

After project

- Electricity will be an alternative source of energy for lighting, which helps to conserve local forest and improve women's health.
- High quality, clear and safe lighting will available in all houses which improves quality of life and helps children's health and education.
- Moreover, it is possible to make people aware environmentally and socially by the help of radio, TV etc. Programs. And NGO's, INGO's and governmental agencies also will have easy excess in the area which will uplift the people's status.
- Electricity will open the door for the improvement of the social Status & the environmental condition of the locality.

End-use

Since the power production of the project is 998kW, the end use will be utilized for various purposes like bakery, Cold store, medium scale factories for processing of medicine, production of wine from local apple etc. which will have immense contribution on project's revenue generation.