NEPAL ELECTRICITY AUTHORITY
(A Government of Nepal Undertaking)
Generation Directorate
Medium Generation Operation and Maintenance Department

TINAU HYDROPOWER PLANT REHABILITATION PROJECT

Electricity Transmission Expansion and Supply Improvement Project
SUNDARIJAL HYDROPOWER PLANT REHABILITATION PROJECT

BIDDING DOCUMENT
FOR
Procurement of Plant for Tinau Hydropower Plant Rehabilitation Project
(Design, Supply and Install)

Single-Stage, Two-Envelope
Bidding Procedure

Issued on:
Invitation for Bids No.: ICB-THPPRP–072/73-01
ICB No.: ICB-THPPRP–072/73-01
Employer: Nepal Electricity Authority
Country: Nepal

VOLUME –II OF III

September 2015

Tinau Hydropower Plant Rehabilitation Project
Generation Directorate
Durbar Marg, Kathmandu, Nepal
Telephone: +977-1-4153070, 4153032
Fax: +977-1-4153016

The information in this Document is for reference only. The Bidders shall base their bids on the Document to be purchased from the Project Office.
# Table of Contents

**SECTION VI**  TECHNICAL SPECIFICATIONS AND DRAWING

<table>
<thead>
<tr>
<th>VI A – Rehabilitation Concept</th>
<th>VI A</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI B – Specifications of Turbines and Inlet Valves</td>
<td>VI B</td>
</tr>
<tr>
<td>VI C – Specifications of AC Generator and Excitation System</td>
<td>VI C</td>
</tr>
<tr>
<td>VI D – Specification of Electric Equipment and Control System</td>
<td>VI D</td>
</tr>
<tr>
<td>VI E – Specification of Civil Works</td>
<td>VI E</td>
</tr>
<tr>
<td>VI F – Inspection, Testing and Commissioning</td>
<td>VI F</td>
</tr>
<tr>
<td>VI G – Technical Data Sheets</td>
<td>VI G</td>
</tr>
<tr>
<td>VI H – Spare Parts</td>
<td>VI H</td>
</tr>
<tr>
<td>VI I – Drawings and Details of Existing Equipment</td>
<td>VI I</td>
</tr>
</tbody>
</table>
Tinau Hydropower Plant Rehabilitation Project

VI A. Rehabilitation Concept
Table of Contents
1. Background ................................................................................................................ 1
2. Objective/Purpose of the Project ............................................................................... 3
3. Project Components .................................................................................................. 3
4. Scope of Works .......................................................................................................... 5
5. Power and Energy Analysis ....................................................................................... 8
6. Preliminary implementation schedule ........................................................................ 9
7. Basic Project Features ............................................................................................... 9
8. Financial Analysis ...................................................................................................... 9
9. Assumptions and Important Notes ............................................................................ 9

Tables
Table 1: Main Description of the Project.......................................................................... 1
Table 2: Structure of Shareholders .................................................................................. 1
Table 3: Salient Features of the Existing Power Plant .................................................... 2
Table 4: Summary of Monthly Flow of Tinau River ......................................................... 9
Table 5: Basic Proposed Project Features ........................................................................ 9
Table 6: Highlights of Financial Analysis ......................................................................... 9
1. **Background**

1.1 In a joint initiative between erstwhile the Ministry for Water and Power/ His Majesty’s Government and the United Mission to Nepal (UMN) with objectives of electrifying Butwal-Khasauli as well as facilitating industrial development in the area, it was decided to generate electricity utilizing power potential available in Tinau River. This led to the setup of Butwal Power Company on 14 Poush, 2022 (29 December, 1965), which carried out the construction works of Tinau Hydropower Project. The total construction period was approximately 11 years.

1.2 The construction works of the Project commenced in the year 2023 B.S. (1966/67 A.D) Under the first stage, a 400 meters long tunnel was constructed, and installation of a generator set was completed in Poush, 2027 (December/January, 1970) supplying 50 kW electric power to then Butwal-Khasauli Nagar Panchayat area.

1.3 Under the second stage, additional 1,200 meters long tunnel was constructed, construction of an underground power house building and installation of two generator sets were completed in Ashad, 2032 (June/Jully, 1975). The capacity of the hydro electric power supply was thus, increased to 500 kW.

1.4 Under the third and final stage, additional 800 meters long tunnel was constructed, and installation of one generator set and construction of dam were completed in Chaitra, 2034 (March/April, 1978), and the aim to obtain 1,000 kW hydropower was achieved.

1.5 The basic project features is shown in the following table:

<table>
<thead>
<tr>
<th>Table 1: Main Description of the Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height of the dam</td>
</tr>
<tr>
<td>Type of dam</td>
</tr>
<tr>
<td>Length of the tunnel</td>
</tr>
<tr>
<td>Diameter of the tunnel</td>
</tr>
<tr>
<td>Capacity of Electric Power Production</td>
</tr>
<tr>
<td>Cost of the project</td>
</tr>
</tbody>
</table>

The shareholdings for investment of the Project were as follows:

<table>
<thead>
<tr>
<th>Table 2: Structure of Shareholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shareholders</td>
</tr>
<tr>
<td>His Majesty’s Government Ministry of Water and Power</td>
</tr>
<tr>
<td>Nepal Industrial Development Corporation</td>
</tr>
<tr>
<td>United Mission to Nepal</td>
</tr>
<tr>
<td>Nepal Electricity Corporation</td>
</tr>
<tr>
<td>Total Share Investment</td>
</tr>
<tr>
<td>Nepal Industrial Development Corporation</td>
</tr>
</tbody>
</table>

1.6 Tinau Powerhouse is an underground powerhouse and is the first of its kind in Nepal. It is a run of the river type power plant located at Dovan VDC-6 in Palpa District. The energy generated from the power plant is evacuated through 3.3/33 kV, 1,000 kVA power
transformer at Rajmarga Chauraha Substation connected via 3.3 kV distribution line. The salient features of the power plant are listed here under.

**Table 3: Salient Features of the Existing Power Plant**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed Capacity</td>
<td>1,000 kW</td>
</tr>
<tr>
<td>Design discharge</td>
<td>2.5 m³/sec</td>
</tr>
<tr>
<td>Gross head</td>
<td>50 m</td>
</tr>
<tr>
<td>Minimum Flow</td>
<td>2.4 m³/sec</td>
</tr>
<tr>
<td>Maximum flow</td>
<td>54 m³/sec</td>
</tr>
<tr>
<td>Average rainfall of Butwal</td>
<td>3,700 ml</td>
</tr>
<tr>
<td>Total length of tunnel (including approach tunnel)</td>
<td>2,462 m</td>
</tr>
<tr>
<td>Length of penstock</td>
<td>50 m</td>
</tr>
<tr>
<td>Diameter of penstock</td>
<td>1.275 m</td>
</tr>
<tr>
<td>Number of turbines</td>
<td>3</td>
</tr>
<tr>
<td>Type of turbine</td>
<td>Francis</td>
</tr>
<tr>
<td>Number of generators</td>
<td>3</td>
</tr>
<tr>
<td>Configuration</td>
<td>Horizontal</td>
</tr>
<tr>
<td>Type of generator</td>
<td>Synchronous, 3 phase, 3.3 kV</td>
</tr>
<tr>
<td>Distribution line</td>
<td>approximately 4 km at 3.3 kV level</td>
</tr>
</tbody>
</table>

1.7 A brief description of major components of the power plant is given below.

a. Dam: Dam is stone masonry and RCC type having dimensions of 65 m (L) x 4 m (B) x 8 m (H). It also has a side gravel trap facility.

b. Intake: Main intake is 150 m long with a cross section area of 2.4 m². A trashrack present at the intake allows silt sizes up to 10 cm inside tunnel.

c. Desilting Chamber: 2 (two) nos. of desilting chambers having dimension of 8 m (L) x 4 m (B) x 2 m (D) are present with a facility of flushing the silt sizes up to 2.5 cm.

d. Headrace Tunnel: There is 1.266 km long headrace tunnel with a cross section area of 2.1 m² and more than five audits on its way.

e. Radial Gates: 2 (two) nos. of manually operated radial gates are installed on the top of the intake tower to flush silt and pebbles deposited on trashrack (grill) installed at intake. They are operated with winch. Apart from this, 1 (one) manually operated radial gate is present on the top of the flushing tower to flush out silt deposited on the flushing chamber.

f. Penstock: Penstock is 50 m in length and is placed in an inclination of 450 to the horizon. It is a diameter of 1.275 m and has a thickness of 5 mm. There is a surge tube on the top of the penstock.

g. Powerhouse: Powerhouse is of underground type. It is about 88 m long and about 3.5-4.5 m wide.

h. Tailrace: The cross section of tailrace is 3.85 m² and is 752 m long.

i. Heating, Ventilation and Air Conditioning: There is no proper arrangement of heating, ventilation and air conditioning system installed inside the powerhouse. Only available natural cooling in the powerhouse is from air passing from the tailrace access tunnel.

1.8 The Government of Nepal (GoN) has received financing from the Asian Development Bank (ADB) in the form of a loan, Loan No.: 2808-NEP (SF), towards the cost of Electricity
Transmission Expansion and Supply Improvement Project (ETESIP) and the Nepal Electricity Authority, an implementing agency, intends to apply a portion of the proceeds of this loan to eligible payments under Part C: Rehabilitation of Tinau HPP.

2. **Objective/Purpose of the Project**

The key objectives/purposes of rehabilitation project are as follows:
- Increase/re-establish the effectiveness of original functionalities of headworks
- Renovate and modernize the electromechanical system
- Effective power evacuation through distribution lines and substation reinforcements
- Capacity building and training to NEA staff through training courses and on-the-job training
- Improve gender equity and community participation by promoting small–scale gender-sensitive infrastructure development

3. **Project Components**

**Component A: Civil and Hydromechanical Works** will address all items related to civil and hydromechanical works in headworks and powerhouse and will consist of the following sub-components:
- **Sub-Component A1: Headworks Repair and Maintenance.** Under this sub-component, weir repair, trashrack installation, stop-log installation on sluice way, gravel flushing gate and associated repair maintenance will be carried out.
- **Sub-Component A2: Power House Repair and Maintenance.** Under this sub-component, machine foundation works, tailrace repair work, painting works of powerhouse, vertical ladder erection and associated adjustments and modifications will be carried out.
- **Sub-Component A3: Power House Access Road.** Under this sub-component, widening of access road with slope protection using gabions and construction of drain from Siddhartha Highway to Power House courtyard will be constructed.

**Component B: Electromechanical Works** will address all items related to electrical and mechanical works of the power plant and will consist of the following sub-components:
- **Sub-Component B1: Mechanical Works.** Under this sub-component, existing mechanical equipments of the power plant will be dismantled and replaced by new modern equipments. This consists of design; supply and installation of Horizontal Shaft Francis Turbines, Main inlet butterfly valve and Digital type Speed Governor having PID function consisting of controller and hydraulic servo system. The Cooling Water System for bearings, Drainage and Dewatering System for leakage water, Lubricating and Pressure Oil as well as Compressed Air System as required will also be installed for proper functioning of hydraulic system. The Ancillary Equipments will mainly be Station Fire Extinguishing System and Power house Electric Over Head Travelling Crane complete with hoisting elements, bridge girders, and single trolley having hoist capacity of 5 Ton.
- **Sub-Component B2: Electrical Works.** Under this sub-component, existing electrical equipments of the power plant will be dismantled and replaced by Horizontal Synchronous salient-pole Generator and Excitation System Brushless Type consisting of rotating rectifier diodes, exciter and regulation device with digital AVR. The plant
automation will be realized through deployment of PLC & SCADA System equipped in Unit Turbine, Generator and Auxiliary Equipments Automatic Elements cubicles. The Unit Generators having separate electrical protection, control and instrumentation system will be synchronized to a common bus with Vacuum Circuit Breakers including instrument transformers. This sub-component also includes station auxiliary system like revamping of underground Power Plant Ventilation System, installation of indoor, Station Service Transformer, Low Voltage Station AC and DC Distribution Cubicles with secondary selective system considering DG set, DC Power Source 110V, 200 Ah Ni Cd Batteries with Charger System having redundant rectifier units and Emergency Diesel Generator of 50 kVA, 400 Volt including arrangement of exhaust system. The indoor Type Vacuum CBs having instrument transformers and instrumentation including C&R Panel is required for station supply and outgoing power evacuation feeder. Outdoor HTXLPE Armoured Copper Cable and LT Control Cables including termination/jointing kits accessories, earthing, Lighting and Small Power System Power and Light Current Cables are also included in this sub-component.

Component C: Distribution Line and Substation Reinforcement Works Under this sub-component, reinforcement of existing 3.3kV distribution line as well as 33 kV substations will be included with following sub-components:

- **Sub-Component C1: Distribution Line Reinforcement.** Under this sub-component, dismantling and restringing of 0.1 sq inch ACSR conductor in designated sections from Tinau HPP to Rajmarga Chauraha Substation, double circuiting in approximately 2.5 km sections of the existing 11 kV distribution line, replacement of different sized distribution transformers connected to the existing 3.3 kV distribution line will be included.

- **Sub-Component C2: Substation Reinforcement Works.** Under this sub-component, replacement of existing 1,000 kVA, 3.3/33 kV power transformer with new 6/8 MVA, 11/33 kV power transformer and its integration to existing switchgear, control and protection system along with necessary extension of 11 kV switchgear with C&R system will be carried out.

Component D: GENDER AND SOCIAL INCLUSION PLAN- This component represents small-scale gender-sensitive infrastructure construction to improve gender equity and community participation having following sub-components:

- **Sub-Component D1: Construction of male/female public toilet facilities along penstock road of Sundarijal HPP in Sundarijal VDC and Tinau HPP area.** Total of 6 (six) numbers of male/female public toilet will be constructed under this sub-component at Tinau power house and at Sundarijal Hydropower Plant power headworks as well as on the appropriate location of pedestrian route between power house and headworks along the way of penstock pipe of Sundarijal VDC. The toilet will be constructed as per the given specification having water and electricity supply from the nearest available source/connection.

- **Sub-Component D2: Erection of Short Suspension Trail Bridge.** This sub-component involves design, fabrication and erection of short suspension trail bridges of following sizes at given location to enhance the accessibility and safety used primarily by NEA staffs and local women for livelihoods in the neighboring areas.

\(^1\) Component will be covered separately.
The 3 (three) short suspension trail bridges to be deployed at 3 (three) locations of the HPP premises are described hereunder:

(i) Suspension Trail Bridge of length approx. 61 m and walkway width of 1.1 m erected across Tinau River just down the Siddhartha Highway towards South at Tinau Power House

(ii) Suspension Trail Bridge of length approx. 80 m and walkway width of 1.1 m erected across Tinau River at Tinau Power Plant Headworks Area down the Siddhartha Highway towards South

(iii) Suspension Trail Bridge of length approx. 32 m and walkway width of 1.1 m located near archaeological site near on way to sediment flushing chamber opposite to Siddhartha Highway towards South.

This component also includes complete dismantling of existing suspension bridge at those locations and transportation to designated warehouse.

4. Scope of Works

Component A: Civil and Hydro-mechanical Works

- **Sub-Component A1: Headworks Repair and Maintenance**
  The scope of works includes construction of coffer dam for weir repair with high strength concrete and protective steel lining and repair of weir with masonry along d/s face. The other major works include design, supply, fabrication, and installation of a vertical sliding gate at sluiceway with hoisting mechanism, trashrack panel at intake, inclined gate with hoisting mechanism at intake, gravel flushing gate, sediment flushing gate with hoisting mechanism, trashrack at intake of tunnel d/s of desander.

- **Sub-Component A2: Power House Repair and Maintenance**
  The scope of the works mainly includes dismantling works to remove existing machines and equipment and transporting the old machines and equipments at designed site, new concreting works for machine foundation, replacement of penstock pipe with accessories so suit new turbine installation, supply and installation of vertical steel ladder at powerhouse access shaft, maintenance of tailrace tunnel near exit. It includes minor repair works like maintenance of ventilation duct, repair of surge tank, installation of new Iron Gate at powerhouse cavern, aluminum partition, and painting works.

- **Sub-Component A3: Power House Access Road**
  The scope includes survey design and preparation of construction drawings for the construction of graveled access road up to the power house from Siddhartha Highway to transport heavy equipments to and from the powerhouse safely for a season. The scope mainly includes widening of road through excavation, slope protection using gabion/masonry works, road sub base preparation, river crossing using RCC Hume pipes, and drain construction along the hillside.

Component B: Electromechanical Works

- **Sub-Component B1: Mechanical Works.** The scope of works under this sub-component consists of complete design, supply, install, test and commissioning
and all other associated works of all mechanical equipments as identified in the price schedule as well as other items as and when necessary to complete the given scope of works. The scope also includes dismantling of existing mechanical equipments of the power plant and storing in the designated location by the Employer. The main mechanical items includes Horizontal Shaft Francis Turbines, Main inlet butterfly valve and Digital type Speed Governor having PID function consisting of controller and hydraulic servo system. The Cooling Water System for bearings, Drainage and Dewatering System for leakage water, Lubricating and Pressure Oil as well as Compressed Air System required will also be installed for proper functioning of hydraulic equipments of the power plant. The Station Fire Extinguishing System and 5 Ton hoist capacity Power house Electric Over Head Travelling Crane complete with hoisting elements, bridge girders, and single trolley will also be installed as ancillary equipments. The detail scope of works is included in Section VI B. Specification of Turbine and Inlet Valve and Section VI D. Specification of Electric Equipment

- **Sub-Component B2: Electrical Works.** The scope of works under this sub-component consists of complete design, supply, install, test, commissioning and all other related works of all electrical and associated equipments as identified in the price schedule as well as other items as and when necessary to complete the given scope of works. The scope of work also includes dismantling of existing electrical equipments of the power plant and store in a designated location as instructed by the Employer. The main electrical items include Horizontal Synchronous salient-pole Generator and Excitation System Brushless Type consisting of rotating rectifier diodes, exciter and regulation device with digital AV/R. The plant automation will be realized through deployment of PLC & SCADA System equipped in Unit Turbine, Generator and Auxiliary Equipments Automatic Elements cubicles. The Unit Generators having separate electrical protection, control and instrumentation system will be synchronized to a common bus with Vacuum Circuit Breakers including instrument transformers. This sub-component also includes station auxiliary system like revamping of underground Power Plant Ventilation System, installation of indoor, Station Service Transformer, Low Voltage Station AC and DC Distribution Cubicles with secondary selective system considering DG set, DC Power Source 110V, 200 Ah Ni Cd Batteries with Charger System having redundant rectifier units and Emergency Diesel Generator of 50 kVA, 400 Volt including arrangement of exhaust system. The indoor Type Vacuum CBs having instrument transformers and instrumentation including C&R Panel is required for station supply and outgoing feeder. Outdoor HTXLPE Armoured Copper Cable and LT Control Cables including termination/jointing kits accessories, earthing, Lighting and Small Power System Power and Light Current Cables are also included in this sub-component. The detail scope of works is included in Section VI C. Specification of AC Generator and Excitation System

---

2 **Component C: Distribution Line and Substation Reinforcement Works.** The scope of work under this component is divided into following sub-components:

---

2 *The scope of works under this Component will be covered by a separate arrangement and hence, shall be considered excluded from this Contract under consideration.*
• **Sub-Component C1: Distribution Line Reinforcement.** The scope of work under this sub-component consists of all works related to dismantling and restringing of 0.1 sq inch ACSR conductor from Tianu HPP to Rajmarga Chauraha Substation, double circuiting in approximately 2.5 km sections of the existing 11 kV distribution line and replacement of different sized distribution transformers connected to the existing 3.3 kV distribution line. The survey for the re-routing of distribution line, dismantling of the existing transformers with minimum power interruption, outage coordination with distribution center is also included in the scope of work. The detail scope of works is included in Section VI E. Specification of reinforcement of distribution line and 33 kV transformer bay at Rajmarga Chauraha Substation.

• **Sub-Component C2: Substation Reinforcement Works.** The scope of work under this sub-component consist of all works related to replacement of existing 1,000 kVA, 3.3/33 kV power transformer by new 6/8 MVA, 11/33 kV power transformer and associated equipments as well as their integration to existing switchgear, control and protection system along with extension of 11 kV switchgear with C&R system. All retrofitting works, adjustments, outage coordination to minimize power interruption are also considered included in the scope of work. The detail scope of works is included in Section VI E. Specification of reinforcement of distribution line and 33 kV transformer bay at Rajmarga Chauraha Substation.

**Component D: GENDER AND SOCIAL INCLUSION PLAN-** Small–scale gender-sensitive infrastructure construction. The scope of works under this component is described hereunder in 2 (two) sub-components.

• **Sub-Component D1: Construction of male/female public toilet facilities along penstock road of Sundarijal HPP in Sundarijal VDC and Tinau HPP area.** The scope of works consists of construction of total of 6 (six) numbers of male/female public toilet with septic tanks and soak pits at the power house, headworks of Tinau and Sundarijal HPP and on the appropriate location of trekking route between power house and headworks along the way of penstock pipe of Sundarijal HPP. The toilet will be constructed as per the given specification having water supply and sanitary works and lighting facility from the nearest available source. The detail scope of works is included in Section VI F. Specifications of Civil Works.

• **Sub-Component D2: Erection of Short Suspension Trail Bridge.** The scope of work under this sub-component consists of all works related to design, supply, fabrication and erection of completely new suspension trail bridges of following sizes at location specified hereunder to enhance the accessibility and safety of commuters primarily NEA staffs and local women in the neighboring areas. The scope includes accessing necessary approval of design, drawings and specifications from the concerned authority (GON/ Swiss Association for Development and Cooperation, HELVETAS) including final certification post construction. It also includes all necessary civil works including excavation, foundation/abutment preparation, backfilling, masonry, concreting, and reinforcements for anchor/tower of suspension bridge. The Contractor will engage the short-listed Consultant approved by the Employer to carry out the detail design for the construction of suspension Trail Bridge. The detail design will be...
approved by the Employer and the fabrication and erection works have to be carried out from the Standing List of Fabricators prepared by Department of Local Infrastructure Development and Agricultural Road (DoLIDAR), Ministry of Local Development, GoN and endorsed by the Employer. The commissioning of suspension Trail Bridge has to be certified by concerned Government Authorities to comply with the statutory provision of the Government of Nepal on suspension trail bridges.

The 3 (three) short suspension trail bridges to be deployed at 3 (three) locations of the HPP premises are described hereunder:

(i) Suspension Trail Bridge of length approx. 61 m and walkway width of 1.1 m erected across Tinau River just down the Siddhartha Highway towards South at Tinau Power House

(ii) Suspension Trail Bridge of length approx. 80 m and walkway width of 1.1 m erected across Tinau River at Tinau Power Plant Headworks Area down the Siddhartha Highway towards South

(iii) Suspension Trail Bridge of length approx. 32 m and walkway width of 1.1 m located near archaeological site near on way to sediment flushing chamber opposite to Siddhartha Highway towards South.

The scope of works also includes complete dismantling of existing suspension bridge at those locations and disposing the certain bridge material at designated location. The detail scope of works is included in Section VI F. Specifications of Civil Works.

5. Power and Energy Analysis

The estimated power and energy from the project considering different parameters is presented separately in the table attached herewith.

<table>
<thead>
<tr>
<th>Months of English Calendar</th>
<th>Tinau River Discharge (m³/sec)</th>
<th>Min Release (m³/sec)</th>
<th>Estimated Water Supply Project release (m³/sec)</th>
<th>Gross Available (m³/sec)</th>
<th>Max Plant Discharge (m³/sec)</th>
<th>Net Head (m)</th>
<th>Days of Month</th>
<th>Turbine Efficiency (As per CEB Consultant)</th>
<th>Generator Efficiency (As per CEB Consultant)</th>
<th>Transformer Efficiency (As per CEB Consultant)</th>
<th>Power Output Generator (kW)</th>
<th>Gross Energy (kWh)</th>
<th>Drawn Generation &amp; Contracted Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>5.85</td>
<td>0.3</td>
<td>3.5</td>
<td>4.95</td>
<td>2.70</td>
<td>45.70</td>
<td>31</td>
<td>69.00%</td>
<td>64.07%</td>
<td>69.00%</td>
<td>1000</td>
<td>744171</td>
<td>739504</td>
</tr>
<tr>
<td>Feb</td>
<td>5.98</td>
<td>0.3</td>
<td>3.6</td>
<td>4.16</td>
<td>2.70</td>
<td>45.70</td>
<td>28</td>
<td>69.00%</td>
<td>64.07%</td>
<td>69.00%</td>
<td>1000</td>
<td>672154</td>
<td>690468</td>
</tr>
<tr>
<td>Mar</td>
<td>5.95</td>
<td>0.3</td>
<td>3.6</td>
<td>3.06</td>
<td>2.70</td>
<td>45.70</td>
<td>31</td>
<td>69.00%</td>
<td>64.07%</td>
<td>69.00%</td>
<td>1000</td>
<td>744171</td>
<td>739504</td>
</tr>
<tr>
<td>Apr</td>
<td>3.08</td>
<td>0.3</td>
<td>2.10</td>
<td>2.10</td>
<td>2.70</td>
<td>42.53</td>
<td>30</td>
<td>97.00%</td>
<td>64.02%</td>
<td>67.90%</td>
<td>754</td>
<td>584210</td>
<td>556207</td>
</tr>
<tr>
<td>May</td>
<td>3.10</td>
<td>0.3</td>
<td>2.40</td>
<td>2.40</td>
<td>2.70</td>
<td>42.25</td>
<td>31</td>
<td>97.00%</td>
<td>64.05%</td>
<td>68.20%</td>
<td>1070</td>
<td>610939</td>
<td>609178</td>
</tr>
<tr>
<td>Jun</td>
<td>10.13</td>
<td>0.3</td>
<td>2.64</td>
<td>2.64</td>
<td>2.70</td>
<td>60.70</td>
<td>30</td>
<td>98.00%</td>
<td>64.07%</td>
<td>98.00%</td>
<td>1000</td>
<td>672154</td>
<td>700090</td>
</tr>
<tr>
<td>Jul</td>
<td>20.43</td>
<td>0.3</td>
<td>40.53</td>
<td>40.53</td>
<td>2.70</td>
<td>60.70</td>
<td>30</td>
<td>98.00%</td>
<td>64.07%</td>
<td>98.00%</td>
<td>1000</td>
<td>744171</td>
<td>739504</td>
</tr>
<tr>
<td>Aug</td>
<td>0.68</td>
<td>0.3</td>
<td>0.68</td>
<td>0.68</td>
<td>2.70</td>
<td>45.70</td>
<td>31</td>
<td>98.00%</td>
<td>64.07%</td>
<td>98.00%</td>
<td>1000</td>
<td>744171</td>
<td>739504</td>
</tr>
<tr>
<td>Sep</td>
<td>38.18</td>
<td>0.3</td>
<td>35.28</td>
<td>35.28</td>
<td>2.70</td>
<td>45.70</td>
<td>30</td>
<td>98.00%</td>
<td>64.07%</td>
<td>98.00%</td>
<td>1000</td>
<td>744171</td>
<td>739504</td>
</tr>
<tr>
<td>Oct</td>
<td>13.41</td>
<td>0.3</td>
<td>12.51</td>
<td>12.51</td>
<td>2.70</td>
<td>45.70</td>
<td>31</td>
<td>98.00%</td>
<td>64.07%</td>
<td>98.00%</td>
<td>1000</td>
<td>744171</td>
<td>739504</td>
</tr>
<tr>
<td>Nov</td>
<td>8.85</td>
<td>0.3</td>
<td>7.85</td>
<td>7.85</td>
<td>2.70</td>
<td>45.70</td>
<td>30</td>
<td>98.00%</td>
<td>64.07%</td>
<td>98.00%</td>
<td>1000</td>
<td>744171</td>
<td>739504</td>
</tr>
<tr>
<td>Dec</td>
<td>6.77</td>
<td>0.3</td>
<td>5.87</td>
<td>5.87</td>
<td>2.70</td>
<td>45.70</td>
<td>31</td>
<td>98.00%</td>
<td>64.07%</td>
<td>98.00%</td>
<td>1000</td>
<td>744171</td>
<td>739504</td>
</tr>
</tbody>
</table>

Total Energy (kWh) 5,484 | 5,26
Further, the summary of monthly flow quantities considered for power/energy estimate is presented below:

**Table 4: Summary of Monthly Flow of Tinau River**

<table>
<thead>
<tr>
<th>Months</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>3.36</td>
<td>2.49</td>
<td>1.23</td>
<td>0.49</td>
<td>0.38</td>
<td>0.40</td>
<td>4.10</td>
<td>10.10</td>
<td>9.38</td>
<td>4.68</td>
<td>2.28</td>
<td>2.00</td>
<td>0.38</td>
</tr>
<tr>
<td>Max</td>
<td>8.94</td>
<td>10.50</td>
<td>7.90</td>
<td>7.58</td>
<td>20.90</td>
<td>176.00</td>
<td>279.00</td>
<td>305.00</td>
<td>227.00</td>
<td>40.50</td>
<td>21.40</td>
<td>12.20</td>
<td>305.00</td>
</tr>
<tr>
<td>Mean</td>
<td>5.85</td>
<td>5.09</td>
<td>3.96</td>
<td>3.00</td>
<td>3.10</td>
<td>10.13</td>
<td>50.43</td>
<td>61.68</td>
<td>36.18</td>
<td>13.41</td>
<td>8.55</td>
<td>6.77</td>
<td>17.47</td>
</tr>
</tbody>
</table>

6. **Preliminary implementation schedule**

Time to complete the plant and services from the effective date is proposed to be 540 days. The Bidders are required to propose work breakdown structure and its time schedule to be submitted along with the Technical Bid.

7. **Basic Project Features**

**Table 5: Basic Proposed Project Features**

<table>
<thead>
<tr>
<th></th>
<th>Gross Head</th>
<th>Net Head</th>
<th>Design Discharge</th>
<th>Environmental Flow</th>
<th>Installed Capacity</th>
<th>Gross Energy</th>
<th>Net Energy</th>
<th>Plant Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 m</td>
<td>45.79 m</td>
<td>2.7 m³/sec</td>
<td>0.3 m³/sec</td>
<td>1,000 kW</td>
<td>8.48 GWh</td>
<td>7.77 GWh</td>
<td>89%</td>
</tr>
</tbody>
</table>

8. **Financial Analysis**

Financial analysis to test the feasibility of the Project has been carried out at discount rate of 12%, assumed inflation rate of 9%, annual O&M cost as 3% of construction cost, economic life of 30 years, wet season tariff and dry season tariff of NRs. 4.8 and NRs. 8.4 respectively at escalation of 3% for 5 (five) times. The energy and capacity royalties have been considered from the prevailing Electricity Act, 2049 (1992). The highlights of the financial analysis are given in the following table:

**Table 6: Highlights of Financial Analysis**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit to cost ratio</td>
<td>1.28</td>
</tr>
<tr>
<td>FIRR</td>
<td>20.51</td>
</tr>
<tr>
<td>Net present value</td>
<td>USD 735,033.64</td>
</tr>
</tbody>
</table>

9. **Assumptions and Important Notes**

9.1 The Employer's Requirements outlined in documents are as per conceptual design and should not be treated as complete in every aspect. The Bidders shall demonstrate their understanding of Employer's Requirement and shall indicate the basis and reliability of their pricing of bid.
9.2 The Bidder shall verify data and information provided in the bidding documents. The error in the given data or unavailability of data will not relieve the Contractor of any responsibility or liability imposed upon it by any provisions of the Contract. The Contractor shall confirm that it has entered into this Contract on the basis of proper examination of the data relating to the Facilities and any failure to acquaint itself with all such data and information shall not relieve its responsibility for properly estimating the difficulty or cost of successfully performing the contract.

9.3 Given the years of operation of plant, if data and drawings as requested are not readily available, the Bidder shall reasonably assume the same at his/her own discretion.

9.4 It is not the intent to specify completely herein all details of design and construction of equipment to be supplied. However, the equipment supplied shall conform, in all respects, to high standards of engineering, design and workmanship and be capable of performing in continuous commercial operation up to contractor's guarantee in a manner acceptable to the Employer who will interpret the meaning of drawings and specifications and shall have the power to reject any work or material which in his judgment are not in full accordance therewith.
VI B. SPECIFICATIONS OF TURBINES AND INLET VALVES
Contents

1.  GENERAL TECHNICAL SPECIFICATIONS ................................................................. 1
   1.1  Design and Workmanship .................................................................................. 1
   1.2  Applicable Standards ...................................................................................... 1
   1.3  Tolerances ...................................................................................................... 2
   1.4  Materials .......................................................................................................... 2
   1.5  Welding ............................................................................................................ 2
   1.6  Pipe, Valves, Flanges and Joints .................................................................... 3
   1.7  Color Code for Piping and Mechanical / Electrical Equipment ................. 3
   1.8  Corrosion Protections and Painting ............................................................... 4
   1.9  Nameplates .................................................................................................... 5
   1.10 Packing .......................................................................................................... 5
   1.11 Tests .............................................................................................................. 5

2.  HYDRAULIC TURBINE ............................................................................................ 6
   2.1  Scope of Supply .............................................................................................. 6
   2.2  Hydraulic System and Turbine Basic Data .................................................... 7
   2.3  Guaranteed Data ............................................................................................ 8
   2.4  Main Design Criteria .................................................................................... 12
   2.5  Turbine Components Construction Details .................................................. 12
   2.6  Model Tests Report (Optional) ...................................................................... 21
   2.7  Shop Tests ..................................................................................................... 21
   2.8  Type Tests ...................................................................................................... 22
   2.9  Hydraulic Tests .............................................................................................. 22
   2.10 Shop Assembly and Tests ............................................................................ 23
   2.11 Field Tests .................................................................................................... 23

3.  GOVERNOR ............................................................................................................ 25
   3.1  Scope .............................................................................................................. 25
   3.2  Design Data .................................................................................................... 25
   3.3  Type and Description .................................................................................... 26
   3.4  Performance Guarantees .............................................................................. 27
   3.5  Speed Governing System Characteristics .................................................... 28

4.  PRESSURE OIL SUPPLY SYSTEM ..................................................................... 30
   4.1  Design Criteria .............................................................................................. 30
   4.2  Requirements for Construction and Characteristics .................................... 30

5.  COOLING WATER SYSTEM .................................................................................. 32
   5.1  Use ............................................................................................................... 32
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)

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) 540 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 540 kW
- Rated net head 45.79 m (as calculated based on assumptions)
- Rated flow 1.35 m³/s
- Rated speed 750 rpm
- Maximum speed rise less than 30%
- Turbine efficiency greater than 89.2%
- Diameter of distributor to be coordinated at connection with the shut-off to shut-off valve design

#### Table 1: Basic Project Data

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Descriptions</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Full reservoir / supply level</td>
<td>EL 243 m</td>
</tr>
<tr>
<td>ii)</td>
<td>Tail water level</td>
<td>EL 192.77 m</td>
</tr>
<tr>
<td>iii)</td>
<td>Gross head</td>
<td>50.23 m</td>
</tr>
<tr>
<td>iv)</td>
<td>Rated Net head</td>
<td>45.79 m</td>
</tr>
<tr>
<td>v)</td>
<td>Elevation of turbine runner centre line</td>
<td>To be verified at site</td>
</tr>
<tr>
<td>vi)</td>
<td>Diameter of penstock (internal)</td>
<td></td>
</tr>
<tr>
<td>A)</td>
<td>Upto furcation from headrace outlet</td>
<td>To be verified at site</td>
</tr>
<tr>
<td>B)</td>
<td>After furcation towards each turbine</td>
<td>To be verified at site</td>
</tr>
<tr>
<td>vii)</td>
<td>Length of penstock</td>
<td></td>
</tr>
<tr>
<td>A)</td>
<td>Total length of Penstock</td>
<td>Please refer to drawings</td>
</tr>
<tr>
<td>viii)</td>
<td>Design discharge (total for 2 machines)</td>
<td>2.7 m³/sec</td>
</tr>
</tbody>
</table>

**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 Tinau HPP

The Francis turbines shall be designed considering the following parameters:

Table 2: Basic Parameters for Turbine

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine type</td>
<td>Francis Horizontal</td>
</tr>
<tr>
<td>Number of units</td>
<td>Two (2)</td>
</tr>
<tr>
<td>Full reservoir / supply level</td>
<td>EL 243 m</td>
</tr>
<tr>
<td>Tail water level</td>
<td>EL 192.77 m</td>
</tr>
<tr>
<td>Maximum tail water level below machines (TWL)</td>
<td>EL 194.4 m</td>
</tr>
<tr>
<td>Gross head</td>
<td>50.23 m</td>
</tr>
<tr>
<td>Net head (2 units running at 100% load)</td>
<td>45.79 m (as calculated)</td>
</tr>
<tr>
<td>Rated Discharge for each machine for maximum output</td>
<td>1.35 m³/s</td>
</tr>
<tr>
<td>Rated Output at Net Head = 45.79 m &amp; Rated Discharge of each unit = 1.3 m³/s</td>
<td>540 kW</td>
</tr>
<tr>
<td>Pitch circle diameter of runner</td>
<td>To be proposed by the Bidder</td>
</tr>
<tr>
<td>Over speed period</td>
<td>To be proposed by the Bidder</td>
</tr>
<tr>
<td>Rotational Speed of the Unit</td>
<td>To be proposed by the Bidder</td>
</tr>
<tr>
<td>Direction of rotation</td>
<td>Clockwise</td>
</tr>
<tr>
<td>Runner centre line elevation</td>
<td>To be proposed by the Bidder</td>
</tr>
<tr>
<td>Shaft coupling face elevation</td>
<td>To be provided by the Bidder</td>
</tr>
</tbody>
</table>

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 540 kW. This output is required at the turbine shaft for a nominal operating level. The corresponding net design head amounts to approximately 45.79 m. The discharge of one turbine is 1.35 m³/sec. The turbine shall have sufficient capacity to produce 10% overload at maximum net head of 48 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 89.2%.

The weighted average efficiency shall be determined by the following formula. The efficiency shall not be less than the guaranteed value.

The Formula:

\[ \mu_w = \left( \frac{w_1 \mu_1 + w_2 \mu_2 + w_3 \mu_3 + w_4 \mu_4}{w_1 + w_2 + w_3 + w_4} \right) \]

where \( w_1, w_2, w_3, \) etc. are weighing factors given below and \( \mu_1, \mu_2, \mu_3, \) etc. are efficiencies determined at the following loading conditions of the turbines at rated net head and \( \mu_w \) is the guaranteed weighted average efficiency.

\( \mu_1 = \) efficiency at 100% power output  
\( \mu_2 = \) Efficiency at 80% rated power  
\( \mu_3 = \) Efficiency at 60% rated power  
\( \mu_4 = \) 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 90%, 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 50 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 Cavitations/Pitting Guarantees

As for material loss due to cavitations, 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 cavitations pitting shall be based on the following conditions of operation during the cavitations 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 cavitations from the runner, discharge ring or wicket gates of the turbine exceeds the following value:

\[ W = 0.15 D^2 \text{ per 1,000 hours of operation} \]

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 cm\(^2\) or more with an average depth of not less than 1 mm shall be considered parts showing excessive cavitations. 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 tailwater level within the guaranteed operating ranges without unacceptable torque and/or pressure oscillations and without unacceptable cavitations, 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 Spiral Case

The spiral case, with stay rings and stay vanes, shall be made as an integral assembly unit having proper hydraulic form and shape.

The spiral case 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 spiral case 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 spiral case, 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.

Spiral case drainage line including a manually operated valve shall be furnished with piping connecting the bottom of the spiral case to drainage pit or tailwater.

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 packing 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 Seals

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 contacts 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 get 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 spiral 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 spiral 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 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,
- 3 kV, 50 Hz, 60 s phase to ground and phase to phase voltage test.

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 ±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 \( \pm 0.15 \% \) of the rated speed; and under no load conditions.
- The amplitude of the sustained power output oscillation shall not exceed \( \pm 1 \% \) of the turbine rated capacity.

Moreover, all parameters and adjustment ranges 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 serve 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 so as unit frequency is different from zero t, 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**: 243.00 masl (verify at site)
- **Valve axis elevation**: 197.80 masl (verify at site)
- **Maximum head**: 53 m
- **Design head (incl. water hammer)**: ~100 m
- **Nominal flow per valve**: 1.35 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 of 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, on 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 superficialies 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 centre/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,
- Draft tube,
- 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.

<table>
<thead>
<tr>
<th>Net Head</th>
<th>Turbine Output (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>

Best Efficiency Point

<table>
<thead>
<tr>
<th>Maximum Head</th>
<th>Turbine Output (kW)</th>
<th>Efficiency (%)</th>
<th>Turbine Discharge (m³/s)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Normal Head</th>
<th>Turbine Output (kW)</th>
<th>Efficiency (%)</th>
<th>Turbine Discharge (m³/s)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Minimum Head</th>
<th>Turbine Output (kW)</th>
<th>Efficiency (%)</th>
<th>Turbine Discharge (m³/s)</th>
</tr>
</thead>
</table>

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
<table>
<thead>
<tr>
<th>Specification</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>6) Turbine discharge at runaway</td>
<td>m³/s</td>
</tr>
<tr>
<td>7) Specific speed</td>
<td>m-kW</td>
</tr>
<tr>
<td>8) Maximum speed rise</td>
<td>%</td>
</tr>
<tr>
<td>9) Maximum pressure rise</td>
<td>%</td>
</tr>
<tr>
<td>10) Moment of Inertia (GD²) (guaranteed)</td>
<td>ton-m²</td>
</tr>
<tr>
<td>11) Wicket gate closing time</td>
<td>s</td>
</tr>
<tr>
<td>Wicket gate opening time</td>
<td>s</td>
</tr>
<tr>
<td>12) Combined Bearing</td>
<td></td>
</tr>
<tr>
<td>- Type</td>
<td></td>
</tr>
<tr>
<td>- Type of self lubrication ring</td>
<td></td>
</tr>
<tr>
<td>- Bearing Temperature (guaranteed)</td>
<td>°C</td>
</tr>
<tr>
<td>13) External oil supply unit for bearings</td>
<td></td>
</tr>
<tr>
<td>- Oil pumps for lubrication</td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Discharge</td>
<td></td>
</tr>
<tr>
<td>- Lubrication oil for bearing</td>
<td></td>
</tr>
<tr>
<td>Quantity required l/min.</td>
<td></td>
</tr>
<tr>
<td>Brand and grade to be recommended</td>
<td></td>
</tr>
<tr>
<td>- Required cooling water for bearings</td>
<td></td>
</tr>
<tr>
<td>Quantity required l/min.</td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>m</td>
</tr>
<tr>
<td>14) Maximum axial hydraulic thrust load on runner</td>
<td>kg</td>
</tr>
<tr>
<td>15) Wicket Gate Servomotor</td>
<td></td>
</tr>
<tr>
<td>- Volume (one servomotor)</td>
<td>l</td>
</tr>
<tr>
<td>- Dynamic capacity</td>
<td>kgf</td>
</tr>
<tr>
<td>- Minimum operating oil pressure</td>
<td>bar</td>
</tr>
<tr>
<td>- Opening force</td>
<td>kgf</td>
</tr>
<tr>
<td>- Closing force</td>
<td>kgf</td>
</tr>
<tr>
<td>16) Shaft seal</td>
<td></td>
</tr>
<tr>
<td>- Type</td>
<td></td>
</tr>
<tr>
<td>- Filtered water flow for cooling (if any)</td>
<td>l/s</td>
</tr>
<tr>
<td>- Leakage (guaranteed)</td>
<td></td>
</tr>
<tr>
<td>17) Wicket gates</td>
<td></td>
</tr>
<tr>
<td>- Number of wicket gates per unit</td>
<td>pcs.</td>
</tr>
<tr>
<td>- Lubrication type of wicket gate bearing</td>
<td></td>
</tr>
<tr>
<td>- Leakage (guaranteed)</td>
<td></td>
</tr>
<tr>
<td>18) Runner</td>
<td></td>
</tr>
<tr>
<td>- Number of runner blades</td>
<td>pcs.</td>
</tr>
<tr>
<td>- Clearance between runner crown and head cover</td>
<td>mm</td>
</tr>
<tr>
<td>- Clearance between runner skirt and discharge ring</td>
<td>mm</td>
</tr>
<tr>
<td>19) Spiral Case</td>
<td></td>
</tr>
<tr>
<td>- Number of stay vanes</td>
<td>pcs.</td>
</tr>
<tr>
<td>- Volume of spiral casing</td>
<td>m³</td>
</tr>
<tr>
<td>20) Draft Tube</td>
<td></td>
</tr>
<tr>
<td>- Mean water velocity at the outlet of draft tube at maximum discharge m/s</td>
<td></td>
</tr>
<tr>
<td>21) Weight of Turbine</td>
<td>ton</td>
</tr>
</tbody>
</table>
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 m$^2$
- 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 I/s
2) Induction Motor
   - Manufacturer and type
   - Rated output kW
   - Speed rpm
3) Hydraulic Accumulator
   - Manufacturer and type
   - Total volume l
4) Oil Pressure
   - Manufacturer
   - Total volume l
   - Effective capacity l
   - Required cooling water I/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,
Section VI B - Specifications of Electric Equipments

VI B-50

Bidding Document for ICB - THPPRP-072/73-01 Procurement of Plant Single-Stage: Two-Envelope Tinau HPP Rehabilitation Project

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.
VI C. SPECIFICATIONS OF AC GENERATOR AND EXCITATION SYSTEM
## Contents

1. **GENERAL** ......................................................................................................................... 1
   1.1 Scope of Work ..................................................................................................................... 1
   1.2 General Service Conditions ............................................................................................. 1
   1.3 Design, Materials and Workmanship ............................................................................... 2
   1.4 Packing ............................................................................................................................ 10
   1.5 Color Code for Cabling, Piping and Electrical/Mechanical Equipment ...................... 10

2. **MAIN GENERATORS** ....................................................................................................... 11
   2.1 Scope of Work ................................................................................................................... 11
   2.2 Design Requirements ........................................................................................................ 16
   2.3 Construction Main Details ............................................................................................... 17
   2.4 The Drawings and Similar Documents to be provided by the Contractor .................... 26

3. **EXCITATION SYSTEM** .................................................................................................... 28
   3.1 Scope of Work .................................................................................................................... 28
   3.2 Automatic Voltage Regulator .......................................................................................... 28
   3.3 Technical Characteristics and Documents ...................................................................... 30
   3.4 Data, Characteristics and Documents ............................................................................ 30

4. **TESTS** ............................................................................................................................. 31
   4.1 Shop Tests ......................................................................................................................... 31
   4.2 Field Tests ....................................................................................................................... 33

Table 1: Technical Particulars of Generator ............................................................................. 34
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 Tinau 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 Tinau 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 540 kW operating under a gross head of 50 m at full flow of 2.7 m$^3$/s. The generators will have a rated capacity of 635 kVA. The generated energy will be evacuated through 11 kV overhead distribution lines connected to INPS (Grid) at Rajmarg Chauraha approximately 4 (four) kilometers South from the power plant.

b) Hydraulic Turbines

Type: Horizontal Shaft Francis Turbine

Number: Two (2) sets

Design head (net): 45.79 m (as calculated)

Output at normal head: 540 kW

Discharge at normal head: 1.35 m$^3$/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: 635 kVA, Voltage: 11 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”.

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 screwable 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 ±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.

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 end painting at the Site shall be delivered in sealed containers packet by the manufacturer.

The Contractor shall supply full details regarding the extend 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 tarpentine 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
Section VI C - Specifications of AC Generators and Excitation Systems

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, 635 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, three (3) 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 635 kVA
Rated voltage 11 kV ± 10 %
Rated current 40 A
Number of phases three (3)
Rated Power factor, lagging 0.80
Frequency 50 Hz
Rated speed 750 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 1: Technical Particulars of Generator

<table>
<thead>
<tr>
<th>SN</th>
<th>Particulars</th>
<th>Rating and Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type</td>
<td>Synchronous Generators with brushless excitation</td>
</tr>
<tr>
<td>2.</td>
<td>Number of unit</td>
<td>Two (2)</td>
</tr>
<tr>
<td>3.</td>
<td>Output in kVA</td>
<td>635 kVA</td>
</tr>
<tr>
<td>4.</td>
<td>Rated Voltage</td>
<td>11 kV</td>
</tr>
<tr>
<td>5.</td>
<td>Rated power factor</td>
<td>Cos φ = 0.80 (lag)</td>
</tr>
<tr>
<td>6.</td>
<td>Rated frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>7.</td>
<td>Rated speed</td>
<td>750 RPM</td>
</tr>
<tr>
<td>8.</td>
<td>Runaway speed</td>
<td>1,500 RPM (Not exceeding 2 times rated speed)</td>
</tr>
<tr>
<td>9.</td>
<td>Moment of inertia</td>
<td>Natural (Preferred) or separately flywheel</td>
</tr>
<tr>
<td>10.</td>
<td>Insulation Class</td>
<td>Class 'F'</td>
</tr>
<tr>
<td>11.</td>
<td>Form of Protection</td>
<td>IP 23</td>
</tr>
<tr>
<td>12.</td>
<td>Incoming cooling water max. temperature</td>
<td>40°C</td>
</tr>
</tbody>
</table>
| 13. | Rise in temperature over cooling water/air at rated output | Stator Class B Temperature rise  
Rotor Class B Temperature rise                                                                 |
| 14. | Type of duty                                          | Continuous                                                                                                                                             |
| 15. | Type of control                                      | Manual / Auto                                                                                                                                           |
| 16. | Temperature rise limit of generator under rated output operating condition | Class 'B' insulation temperature rise limit of generator at rated output                                                                            |
| 17. | Range of voltage variation between phases for rated output | ± 20%                                                                                                                                                 |
| 18. | Range of frequency variation                         | ± 5%                                                                                                                                                  |
| 19. | Stator winding connection                             | Three (3) phase Y connected neutral brought out                                                                                                      |
| 20. | Short circuit ratio                                  | 0.75 Minimum                                                                                                                                            |
| 21. | First critical speed                                 | Maximum Runaway Speed 1,500                                                                                                                              |
| 22. | Cooling                                               | Self ventilated type through rotor mounted fans                                                                                                |
| 23. | Excitation                                            | Brushless                                                                                                                                               |
| 24. | Design conformation                                  | Tropical temperature of 45°C                                                                                                                              |
| 25. | External cable                                       | For 12 kV; 3 x 1 CORE, XLPE copper for 12 kV                                                                                                           |
| 26. | Shaft orientation                                    | Horizontal                                                                                                                                              |
| 27. | Direction of rotation                                | Clockwise when viewed from the generator side                                                                                                           |
| 29. | 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 11 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 Cosφ = 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 ±10% the rated voltage of 11 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 ±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 (GD²) 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 635 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
Section VI C - Specifications of AC Generators and Excitation Systems  

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
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 (GD²) 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:

\[
U_t = 10 U_f \text{ when } 150 \text{ V} < U_f < 500 \text{ V}
\]
\[
U_t = 1,500 \text{ V} \text{ when } U_f < 150 \text{ V}
\]
\[
U_t = 2 U_f + 4,000\text{V} \text{ when } U_f > 500 \text{ V}
\]

\(U_f\) = 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 babbitt 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 piece
- 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 piece
- 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 piece
- 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 three 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 100 amperes or 60 seconds and shall be installed in the barrier fabricated with punch holed steel plates. The rated voltage shall be 11 kV and the value of resistor shall be 38.1 ohm.

The neutral grounding cubicle shall accommodate one current transformer of ratio 100/1A and one isolator (11 kV, 100 A) and neutral grounding resistor as shown in single line diagram. The resistor shall be capable of withstanding over voltage of 16 kV 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 0 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 Tinau Hydropower Plant. 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
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 $I_{fn}$
- Over-excitation ceiling set at approximately: 1.6 $I_{fn}$
- Accuracy at steady state: ±0.5%
- Regulator response time: less than 30 ms
- Line drop compensation range: ±20%
- Ceiling duration: 10s
- 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 GD²
   - 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 equipments 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 equipments 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 the short-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
VI D. SPECIFICATION OF ELECTRICAL EQUIPMENT AND CONTROL SYSTEM
## Contents

1. GENERAL ........................................................................................................... 1
   1.1 Scope of Work ................................................................................................. 1
   1.2 Project Description ......................................................................................... 1
   1.3 Design, Materials and Workmanship ............................................................. 2
   1.4 Packing ........................................................................................................... 10
   1.5 Color Code for Cabling, Piping and the Electrical/Mechanical Equipment . 11
2. GENERATOR LEADS, CUBICLES AND POWER CABLES .................. 11
   2.1 Scope of Work ................................................................................................. 11
   2.2 Design Conditions ......................................................................................... 12
   2.3 Tests .............................................................................................................. 14
   2.4 Data to be furnished by the Bidder ................................................................. 15
3. 12 kV EQUIPMENT ......................................................................................... 17
   3.1 Scope of Work ................................................................................................. 17
   3.2 Extent of Supply .............................................................................................. 18
   3.3 Design Conditions ......................................................................................... 18
   3.4 Accessories .................................................................................................... 21
   3.5 Technical Characteristics .............................................................................. 21
   3.6 Generator Incoming Feeder .......................................................................... 25
   3.7 Outgoing Line Feeder at Tinau HPP ............................................................... 25
   3.8 Station Service Feeder ................................................................................... 26
   3.9 Spare Parts ..................................................................................................... 26
   3.10 Shop Tests .................................................................................................... 26
   3.11 Field Tests .................................................................................................... 28
   3.12 Data to be furnished by the Bidder ............................................................... 28
4. STATION SERVICES ....................................................................................... 31
   4.1 Scope of Work ................................................................................................. 31
   4.2 AC-Station Service System ........................................................................... 31
   4.3 DC-Station Service System ........................................................................... 31
   4.4 Performances ................................................................................................. 33
   4.5 Construction Main Details ............................................................................ 34
   4.6 Tests ............................................................................................................... 37
   4.7 Data, Characteristics and Documents ............................................................ 37
5. STATION SERVICE TRANSFORMER .......................................................... 39
   5.1 SCOPE OF WORK ............................................................................. 39
   5.2 Type and Number Required ............................................................ 39
   5.3 Standards and Quality Certification .................................................. 39
   5.4 Ratings and Requirements for Characteristics .................................. 39
   5.5 Requirements for Construction ......................................................... 40
   5.6 Name Plate and Marking ................................................................. 41
   5.7 Accessories .................................................................................... 42
   5.8 Tests ............................................................................................... 42
   5.9 Evaluation ....................................................................................... 43
   5.10 Bid Documentation ......................................................................... 44
   5.11 Drawings to be furnished by the Contractor ................................... 44
   5.12 Data to be furnished by the Bidder ................................................. 44
   5.13 Installation ..................................................................................... 46

6. EMERGENCY DIESEL GENERATOR SET ................................................. 47
   6.1 General .......................................................................................... 47
   6.2 Description of Supply ...................................................................... 47
   6.3 Starting and Operating ..................................................................... 47
   6.4 Specifications ................................................................................. 48
   6.5 Instrument and Protection ............................................................... 48
   6.6 Guarantees ...................................................................................... 50
   6.7 Nameplates .................................................................................... 50
   6.8 Tests ............................................................................................... 50
   6.9 Data to be Furnished by the Bidder ............................................... 51

7. CONTROL, MONITORING AND PROTECTION SYSTEM ....................... 55
   7.1 Scope of Work ............................................................................... 55
   7.2 Description of the System ............................................................... 56
   7.3 Services to be provided by the Contractor ....................................... 58
   7.4 Operation and Control System ....................................................... 59
   7.5 Electrical Protection ....................................................................... 63
   7.6 Circuit Protection and Wiring .......................................................... 65
   7.7 Water Level Measuring Devices ...................................................... 67
   7.8 Spare Parts and Tools .................................................................... 68
   7.9 Tests ............................................................................................... 68
7.10 Data to be furnished by the Bidder

8. AUTOMATIC CONTROL AND SCADA SYSTEMS

8.1 Scheme and Structure of Control System

8.2 The Function of Control system

8.3 Control Mode of Plant

8.4 Tests

8.5 Equipment List of Control System

9. POWER AND CONTROL CABLES

9.1 Operating Conditions

9.2 Scope of Supply

9.3 Technical Requirements

10. POWERHOUSE TRAVELLING CRANE

10.1 Scope of Work

10.2 Design Standards

10.3 General Requirements

10.4 Construction

10.5 Accessories

10.6 Tests

10.7 Specifications of overhead traveling crane

10.8 Main parameters
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 Tinau 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 of 540 kW operating under a gross head of 50 m, at full flow of 2.7 m³/s. The generators will have a rated capacity of 635 kVA. The generated energy will be evacuated through 11 kV overhead distribution lines connected to INPS (Grid) at Rajmarg Chauraha approximately 4 (four) kilometers South from the Power Plant.

b) Hydraulic Turbines

Type: Horizontal Shaft Francis Turbine
Number: Two (2) sets
Design head (net): 45.79 m (as calculated)
Output at normal head: 540 kW
Discharge at normal head: 1.35 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: 635 kVA, Voltage: 11 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 ±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
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 end painting at the Site shall be delivered in sealed containers packet 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 minimum 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, 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 tarpentine 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
   e) 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 12 kV cubicles
- Power cables between OHTL and 12 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 12 kV cubicles may be installed partially outdoors in a cable channel.

#### General Technical Characteristics

- Nominal voltage: 11 kV
- Maximum System Voltage: 12 kV
- Impulse withstand voltage: 75 kV peak
- Power frequency withstand voltage: 28 kV rms
- Frequency: 50 Hz

However, the actual current ratings shall be selected as per the thermal and dynamic stresses of the highest short-circuit current susceptibly to appear in the 12 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 11 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 11 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.

### 2.2.3 Current and Voltage Transformers

Current and voltage transformers shall be epoxy resin insulated block type. Secondary winding terminals shall be readily accessible. On current transformers, they shall be provided with easy means for short-circuiting. The current transformer shall comply with the requirements of IEC 60185.

**Characteristics:**

1) Current transformers at generator neutral and phase side cubicles  
   **Application:** Protection and measurement  
   **Ratio:** 100/5-5 A  
   **Number required:** 6  
   **Rated burden:** *  
   **Accuracy class:** i) 0.5 ii) 5P20 iii) PS

2) Voltage transformers at phase side cubicle  
   **Application:** Protection, measurement and Voltage reg.  
   **Ratio:** $11/\sqrt{3} / 0.11/\sqrt{3}, 0.11/\sqrt{3}, 0.11/3$  
   **Number required:** 6  
   **Rated burden:** *  
   **Accuracy class:** i) cl: 0.5 ii) cl: 0.5 iii) 3P

*Note: Rated burden of the instrument transformer shall be given by the Bidder.*

The characteristics of current and voltage transformers will have to be checked with the manufacturers of voltage regulation measuring devices and protective relays. Close collaboration between manufacturers is required. Any modification shall be subject to prior Employer's approval.

### 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 12 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 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.

<table>
<thead>
<tr>
<th>Current Transformers</th>
<th>Units</th>
<th>Value</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated voltage</td>
<td>kV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Permissible operating voltage</td>
<td>kV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated frequency</td>
<td>Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary current</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary current</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy classes and burdens</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core 1 accuracy class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burden</td>
<td>VA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core 2 accuracy class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burden</td>
<td>VA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core 3 accuracy class</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Burden \[ \text{VA} \]
- Instrument security factor
- Measuring winding protective winding
- Impulse insulation level \[ \text{kV} \]
- Primary windings power frequency dry and wet, 1 min. kV full wave impulse 1.2/50/\mu s \[ \text{kV} \]
- Secondary windings power frequency dry and wet 1 min. \[ \text{kV} \]
- Minimum admissible over currents
- Continuous permissible over currents \[ \% \]
- Thermal short-time current (1 sec.) \[ X\text{In} \]
- Dynamic current (peak) \[ X\text{In} \]
- Weight net/gross \[ \text{Kg/Kg} \]

**Voltage Transformers**

- Manufacturer
- Type
- Standard

Main Characteristics
- Rated voltage \[ \text{kV} \]
- Maximum Permissible operating voltage \[ \text{kV} \]
- Accuracy class/burden \[ /\text{VA} \]
- Type of insulation
- Insulation level \[ \text{kV} \]
- Impulse withstand voltage 1.2/50 \mu s \[ \text{kV} \]
- HV power frequency test voltage wet/dry \[ \text{kV/kV} \]
- LV power frequency test voltage wet/dry \[ \text{kV/kV} \]
- Continuous permissible overload \[ \% \]
- Weight net/gross \[ \text{Kg/Kg} \]

**Insulators (Support Bushing)**

- Manufacturer
- Type reference
- Standard

Main Characteristics
- Rated voltage \[ \text{kV} \]
- Flash-over voltage
  - Dry \[ \text{kVrms} \]
  - Wet \[ \text{kVrms} \]
  - Impulse \[ \text{kVpeak} \]
- withstand test voltage
  - Dry \[ \text{kVrms} \]
  - Wet \[ \text{kVrms} \]
  - Impulse \[ \text{kVpeak} \]
- Leakage distance \[ \text{mm} \]
- Dry arcing distance \[ \text{mm} \]
- Mechanical strength
  - Axial \[ \text{Kg} \]
Cantilever Kg
- Weight net/gross Kg

**Bar Connections**

<table>
<thead>
<tr>
<th>Units Value Tolerance</th>
<th><strong>Type</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rated current (continuous)</strong></td>
<td>A</td>
</tr>
<tr>
<td><strong>Maximum current in short circuit</strong></td>
<td>A</td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
<td>kApeak</td>
</tr>
<tr>
<td><strong>Short time 7 sec.</strong></td>
<td>kArms</td>
</tr>
<tr>
<td><strong>Short time 8 sec.</strong></td>
<td>kArms</td>
</tr>
<tr>
<td><strong>Conductor profile shape</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Cross section</strong></td>
<td>mm²</td>
</tr>
<tr>
<td><strong>Distance between phase</strong></td>
<td>mm</td>
</tr>
</tbody>
</table>

**Power Cables**

<table>
<thead>
<tr>
<th>Units Value Tolerance</th>
<th><strong>Manufacturer</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Standard</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rated voltage</strong></td>
<td>kV</td>
</tr>
<tr>
<td><strong>Max. Rated current for cable installed in air, shafts and trays with 40°C ambient temperature</strong></td>
<td>A</td>
</tr>
<tr>
<td><strong>Maximum Permissible temperature rise</strong></td>
<td>°C</td>
</tr>
<tr>
<td><strong>Short circuit capacity (1 sec.)</strong></td>
<td>A</td>
</tr>
<tr>
<td><strong>Low frequency test voltage (15 min.)</strong></td>
<td>kV</td>
</tr>
<tr>
<td><strong>Power frequency test voltage (1 min.)</strong></td>
<td>kV</td>
</tr>
<tr>
<td><strong>Maximum admissible continuous service voltage (Phase to earth)</strong></td>
<td>kV</td>
</tr>
<tr>
<td><strong>Cross section of the conductor</strong></td>
<td>mm²</td>
</tr>
<tr>
<td><strong>Overall diameter of the cable</strong></td>
<td>mm</td>
</tr>
<tr>
<td><strong>Material of the insulation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Material of the conductor</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Material of the shielding</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type of armoring</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Resistance per meter of conductor at 30°C</strong></td>
<td>Ohm</td>
</tr>
<tr>
<td><strong>Capacitance per meter of cable</strong></td>
<td>pF</td>
</tr>
</tbody>
</table>

3. **12 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 12 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
- One (1) station service transformer bay
3.2 Extent of Supply

The supply shall comprise all apparatus and required accessories, conductors, insulators, connection boxes, power cables (12 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
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.

The 11 kV distribution line from Tinau HPP is proposed to be connected to 11/33 kV substation at Rajmarga Chauraha. The Substation is currently being reinforced separately by Distribution System Augmentation and Expansion Project under SASEC Power System Expansion Project.

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 11 kV
3.5.2 Technical Characteristics for Circuit Breakers

a) Number required: 4 (Four)
b) Type Indoor, three-phase: VCB type
c) Rating
    Rated voltage : 11 kV
    Rated frequency : 50 Hz
    Rated short circuit breaking current : 25 kArms
    Power frequency withstand voltage : 28 kVrms
    Impulse insulation level : 75 kVpeak

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 (2) (as shown in SLD)
b) Type
   Outdoor, three phase, single throw, manual operating type
c) Rating
    Rated voltage : 11 kV
Maximum system voltage : 12 kV  
Rated frequency : 50 Hz  
Rated continuous current :100 A  
Impulse withstands voltage:  
  common value: 75 kVpeak  
Power frequency withstands voltage (1 min):  
  common value :28 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Station Service</th>
<th>Generator Incomer</th>
<th>Line Feeder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Indoor dry</td>
<td>Indoor dry</td>
<td>Indoor dry</td>
</tr>
<tr>
<td>Number of phase:</td>
<td>Single-phase</td>
<td>Single-phase</td>
<td>Single-phase</td>
</tr>
<tr>
<td>Number required</td>
<td>3</td>
<td>3 (phase)+3 (Neutral)</td>
<td>3</td>
</tr>
<tr>
<td>No. of Cores</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ratio</td>
<td>50/5-5 A</td>
<td>100 /5-5A</td>
<td>100/5-5A</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>i) Core-1 Cl 0.5, n&lt;5</td>
<td>5 P 20</td>
<td>5 P 20</td>
</tr>
<tr>
<td></td>
<td>ii) Core-2 Cl 5 P 20</td>
<td>Cl. 0.5, n&lt;5</td>
<td>Cl. 0.5, n&lt;5</td>
</tr>
<tr>
<td></td>
<td>iii) Core-3 Cl PS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated voltage</td>
<td>11 kV</td>
<td>11 kV</td>
<td>11 kV</td>
</tr>
<tr>
<td>Maximum system voltage</td>
<td>12 kV</td>
<td>12 kV</td>
<td>12 kV</td>
</tr>
<tr>
<td>Impulse insulation level</td>
<td>75 kVpeak</td>
<td>75 kVpeak</td>
<td>75 kVpeak</td>
</tr>
<tr>
<td>Power frequency voltage</td>
<td>28 kVrms</td>
<td>28 kVrms</td>
<td>28 kVrms</td>
</tr>
</tbody>
</table>

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 12 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 : 75kVpeak  
iii. Rated Power Frequency Withstand Voltage: 28kV rms  
iv. Primary Voltage : 11/\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 11kV with knee of saturation curve not lower than 12kV 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 hermetically 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 Um/√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.

### 3.5.6 Technical Characteristics for Lightning Arresters

The lighting arresters shall be installed on the line bays. The surge Arresters shall be 11 kV, nominal discharge current of 8/20 micro second wave shape 10 kA of the gapless Zinc oxide type and suitable for operation under the service conditions specified and be suitable for the protection of Transformer and other substation equipments. The Arresters shall comply with IEC 60099-1, IEC60099-4.

The surge diverters shall be tested in accordance with IEC 60099-4.

### 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 Tinau HPP

One (1) outgoing line feeder at Tinau 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
### 3.8 Station Service Feeder

One (1) station service feeder shall be provided and 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
- 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

### 3.9 Spare Parts

According to Spare Parts List (See Section VI H)

### 3.10 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 the 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.
### 3.11 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

### 3.12 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.

<table>
<thead>
<tr>
<th>Circuit Breakers</th>
<th>Units/ Values/ Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer and Type</td>
<td></td>
</tr>
<tr>
<td>Rated current</td>
<td>A</td>
</tr>
<tr>
<td>Rated rupturing capacity</td>
<td>MVA</td>
</tr>
<tr>
<td>Rated short time thermal capacity (1 sec)</td>
<td>kArms</td>
</tr>
<tr>
<td>Rated making capacity</td>
<td>MVA</td>
</tr>
<tr>
<td>Rated opening time</td>
<td></td>
</tr>
<tr>
<td>Maximum arcing time at the rated rupturing capacity</td>
<td>ms</td>
</tr>
<tr>
<td>Rated breaking time at the rated rupturing capacity</td>
<td></td>
</tr>
<tr>
<td>- Without reclosing system</td>
<td>ms</td>
</tr>
<tr>
<td>- With reclosing system</td>
<td>ms</td>
</tr>
<tr>
<td>Type of control mechanism</td>
<td></td>
</tr>
<tr>
<td>Maximum charging time of control motor</td>
<td>s</td>
</tr>
<tr>
<td>AC consumption</td>
<td>Watt</td>
</tr>
<tr>
<td>DC consumption</td>
<td>Watt</td>
</tr>
<tr>
<td>Number of operations without changing contacts</td>
<td></td>
</tr>
<tr>
<td>At rated current times</td>
<td></td>
</tr>
<tr>
<td>At 100% of rated rupturing capacity times</td>
<td></td>
</tr>
<tr>
<td>At 80% of rated rupturing capacity times</td>
<td></td>
</tr>
<tr>
<td>At 30% of rated rupturing capacity times</td>
<td></td>
</tr>
<tr>
<td>Guaranteed number of operations with normal maintenance (at p.f. 0.7)</td>
<td></td>
</tr>
<tr>
<td>Consumed current by the control circuit in case of:</td>
<td></td>
</tr>
<tr>
<td>- Three phase tripping</td>
<td>A</td>
</tr>
<tr>
<td>- Three phase reclosing</td>
<td>A</td>
</tr>
<tr>
<td>Impulse withstand voltage (1.2/50 μs) to earth</td>
<td>kVpk</td>
</tr>
<tr>
<td>Across open breaker poles</td>
<td>kVpk</td>
</tr>
<tr>
<td>One-minute power frequency withstands voltage dry and wet to earth</td>
<td>kVRms</td>
</tr>
<tr>
<td>Across open breaker poles</td>
<td>kVRms</td>
</tr>
<tr>
<td>Maximum temperature rise at rated current</td>
<td>ºC</td>
</tr>
<tr>
<td>Main contact</td>
<td></td>
</tr>
<tr>
<td>Weight net/gross</td>
<td>Kg/Kg</td>
</tr>
</tbody>
</table>

**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 (1 sec)
- **kA**

### Rated peak short circuit current
- **kV**

### Operating mechanism
- **kV**

### Surge voltage
- **A**
  - On insulation distance
  - To earth and between poles
  - Rupturing capacity
  - Melting current of fuse
  - Weight net/gross **Kg/Kg**

### Load Break Switches and Fuses

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Units/ Values/ Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (Indoor, three phase, manual operating)</td>
<td></td>
</tr>
<tr>
<td>Rated service voltage</td>
<td><strong>kV</strong></td>
</tr>
<tr>
<td>Maximum service voltage</td>
<td><strong>kV</strong></td>
</tr>
<tr>
<td>Rated current</td>
<td><strong>A</strong></td>
</tr>
<tr>
<td>Surge voltage</td>
<td></td>
</tr>
<tr>
<td>On insulation distance</td>
<td><strong>kV</strong></td>
</tr>
<tr>
<td>To earth and between poles</td>
<td><strong>kV</strong></td>
</tr>
<tr>
<td>Power frequency withstand voltage</td>
<td></td>
</tr>
<tr>
<td>On insulation distance</td>
<td><strong>kV</strong></td>
</tr>
<tr>
<td>To earth and between poles</td>
<td><strong>kV</strong></td>
</tr>
<tr>
<td>Rated peak short circuit current</td>
<td><strong>kA</strong></td>
</tr>
<tr>
<td>Number of auxiliary contacts</td>
<td></td>
</tr>
<tr>
<td>Make contacts</td>
<td></td>
</tr>
<tr>
<td>Break contacts</td>
<td></td>
</tr>
<tr>
<td>Weight (net/gross)</td>
<td><strong>Kg/Kg</strong></td>
</tr>
</tbody>
</table>

### Current Transformers (Incoming/Outgoing/Station Feeder)

<table>
<thead>
<tr>
<th>Manufacturer and type</th>
<th>Units/ Values/ Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td><strong>kV</strong></td>
</tr>
<tr>
<td>Maximum permissible operating voltage</td>
<td><strong>kV</strong></td>
</tr>
<tr>
<td>Rated frequency</td>
<td><strong>Hz</strong></td>
</tr>
<tr>
<td>Primary current</td>
<td><strong>A</strong></td>
</tr>
<tr>
<td>Secondary current</td>
<td><strong>A</strong></td>
</tr>
<tr>
<td>Accuracy classes and burdens</td>
<td></td>
</tr>
<tr>
<td>▪ Core 1</td>
<td><strong>/VA</strong></td>
</tr>
<tr>
<td>Accuracy class/Burden</td>
<td></td>
</tr>
<tr>
<td>▪ Core 2</td>
<td><strong>/VA</strong></td>
</tr>
<tr>
<td>Accuracy class/Burden</td>
<td></td>
</tr>
<tr>
<td>▪ Core 3</td>
<td><strong>/VA</strong></td>
</tr>
<tr>
<td>Instrument security factor</td>
<td></td>
</tr>
<tr>
<td>Measuring winding</td>
<td></td>
</tr>
<tr>
<td>Protective winding</td>
<td></td>
</tr>
<tr>
<td>Impulse insulation level</td>
<td></td>
</tr>
</tbody>
</table>
Section VI D - Specifications of Electric Equipments

**Primary windings**
- Power frequency (dry and wet 1 min) \( \text{kV} \)
- Full wave impulse (1.2/50 \( \mu \) s) \( \text{kV} \)

**Secondary windings**
- Power frequency \( \text{kV} \)
- Minimum admissible over currents
- Continuous permissible over currents \( \% \)
- Thermal short time current (1 sec) \( x \text{In} \)
- Dynamic current (peak) \( \text{Inx} \)
- Weight net/gross \( \text{Kg/Kg} \)

**Voltage transformers (Incoming/Outgoing/Station Feeder)**
- Manufacturer
- Type
- Rated voltage \( \text{kV} \)
- Maximum Permissible operating voltage \( \text{kV} \)
- Ratio
- Accuracy class/burden
- Type of insulation class
- Insulation level
- Impulse withstand voltage (1.2/50\( \mu \)s)
- HV Power frequency test voltage wet/dry \( \text{kV} \)
- LV Power frequency test voltage wet/dry \( \text{kV} \)
- Continuous permissible overload \( \% \)
- Weight net/gross \( \text{Kg/Kg} \)

**Lightning Arrester**s (Line feeders)
- Manufacturer
- Type
- Main characteristics
- Rated voltage \( \text{kV} \)
- Excitation voltage \( \text{kV} \)
- 1.2/50 \( \mu \)s spark over voltage \( \text{kVpk (100\% spark)} \)
- 50 cycle spark over voltage (min) \( \text{kVrms} \)
- Rated discharge current \( \text{kA} \)
- Limiting capacity \( \text{kA} \)
- Weight net/gross \( \text{Kg} \)

**Busbars**
- Type
- Standard
- Rated current (continuous) \( \text{A} \)
- Maximum current in short-circuit kA (1 sec.) \( \text{kV} \)
- Conductor profile
- Cross section \( \text{mm}^2 \)
- Material
4. STATION SERVICES

4.1 Scope of Work

This specification covers the requirements for the design, manufacture, erection, commissioning and guarantee of station service equipment for Sundarijal Hydroelectric Power Plant.

The station service equipment to be provided by the Contractor shall consist of mainly:

- One (1) AC main and distribution switchboard
- One (1) Diesel-generator set together with diesel board
- One (1) DC main and distribution switchboard
- One (1) 110 V stationary battery set
- One battery charge system with redundant rectifiers (110 V DC Convertor)

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.

4.2 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.

4.3 DC-Station Service System

4.3.1 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.
4.3.2 **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.

4.3.3 **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 ±10%) during the discharge period of 5 hours.

The battery shall be assembled in heat resistant, 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

4.3.4 **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 ±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

### 4.3.5 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 ±1% to 0-100% load
- Power transformer: 1 phase dry-type
- Voltage regulator: Automatic voltage regulator

### 4.4 Performances

#### 4.4.1 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

#### 4.4.2 Operating Temperature

Temperature range:

- Indoor equipment: 0ºC to 55ºC
- Outdoor equipment: -5ºC to 55ºC

Maximum temperature rise of the buses and insulating materials: 45ºC and 65ºC respectively (above ambient temp)

Maximum temperature rise of the air in the cubicles: 25ºC (above ambient temp.)

Maximum temperature rise of the instrument transformer windings: 55ºC (above ambient temp.)

#### 4.4.3 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.

#### 4.4.4 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.
4.4.5 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.

4.5 Construction Main Details

4.5.1 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.

4.5.2 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.

4.5.3 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.

4.5.4 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.
4.5.5 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.

4.5.6 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.

4.5.7 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

4.5.8 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).

4.6 Tests

4.6.1 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

4.6.2 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.

4.7 Data, Characteristics and Documents

4.7.1 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.

4.7.2 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.
5. **STATION SERVICE TRANSFORMER**

5.1 **SCOPE OF WORK**

The work to be done under this specification covers the design, manufacture, supply, installation, acceptance tests, placing in successful operation and guarantee of station service transformer, installation arrangements including safety net and all required accessories as described hereunder.

5.2 **Type and Number Required**

The transformer shall be indoor type, three-phase, two windings, oil-immersed type with natural oil and natural air cooling system. Dry type transformer may be offered subjected to Employer’s approval. The quantity required is 1 (one) set.

The station service transformer's connection at both high voltage and low voltage side shall be with cables. All the equipment related to this shall be designed and manufactured for satisfactory operation at ambient temperature between –5°C and +55°C, relative humidity up to 100% and altitude up to 2,000 m above msl.

5.3 **Standards and Quality Certification**

5.3.1 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:

<table>
<thead>
<tr>
<th>IEC Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60076</td>
<td>Power transformers</td>
</tr>
<tr>
<td>IEC 60137</td>
<td>Insulating Bushings for alternating voltages above 1 kV</td>
</tr>
<tr>
<td>IEC 60156</td>
<td>Insulating liquids-Determination of the breakdown voltage at power frequency-test method</td>
</tr>
<tr>
<td>IEC 60296</td>
<td>Specification for unused mineral insulating oils for transformers and switchgear</td>
</tr>
<tr>
<td>IEC 60551</td>
<td>Determination of transformer and reactor sound levels</td>
</tr>
<tr>
<td>IEC 60616</td>
<td>Terminal and tapping materials for power transformer</td>
</tr>
<tr>
<td>IEC 60722</td>
<td>Guide to lightning and switching impulse testing of power transformers and reactors</td>
</tr>
<tr>
<td>IEC 60733</td>
<td>Determination of water in insulating oils.</td>
</tr>
<tr>
<td>IEC 5493</td>
<td>Protective coating of iron and steel structures against corrosion.</td>
</tr>
</tbody>
</table>

5.3.2 The manufacturer of the offered transformers must have been accredited with the latest edition of ISO 9001 (including design in the scope of registration) quality certification.

5.4 **Ratings and Requirements for Characteristics**

In addition to the general guarantee the manufacturer guarantees the performance, quality, etc. of his supply to be in conformity with all specific requirements and in particular with the following specifications:

- **Type**: Indoor
- **Rated frequency**: 50 Hz
- **Rated continuous capacity**: 50 kVA
- **Rated voltage**
  - Primary: 11 kV
  - Secondary: 0.4 kV
- **Vector group**: Dyn11
- **Impedance voltage**: 4.5%
- Maximum temperature rise winding (resistance method) : 55°C
- Dielectric test
  - Voltages (H.V. side) impulse (1,2/50 sec.) : 75 kVpeak
  - Power frequency: 28 kVrms
- Tapping range on
  - HV side: ±2.5, %±5%
- Power frequency: 3 kVrms
- Enclosure : IP31

The station service transformers shall be designed to withstand, without injury, to a voltage of 30% greater than the rated voltage. The transformers shall be of the highest efficiency that the Contractor can attain.

5.5 Requirements for Construction

5.4.1 Tank and Interior Structure

The tanks shall be constructed in welded sheets of high quality steel and shall have adequate strength and rigidity for safe handling and service. The interior surface of the tanks shall be treated and finished in accordance with the manufacturer's practice and applicable standards. The tank shall withstand the highest and lowest interior pressures which may exist during the operation.

The sealed joint parts of the tanks shall be designed to prevent oil and gas leakage even after long term use.

Lifting lugs shall be provided on the tank cover for lifting the completely assembled transformer. Each transformer tank shall have a ground terminal which shall be copper faced steel grounded pads, and shall be welded on the tank wall near the base.

The tank shall be provided with the main drain valve near the base for quick evacuation of oil. There shall be also an oil sampling valve of the extreme bottom of the tank. The drain valve can be used for sampling purposes if some special precautions are taken. The base of the tank shall be provided with rolling flat wheels for drawing the transformer in and out and moving. Wheels orientation shall allow for moving the transformer in two directions respectively parallel and perpendicular to the transformer centerline.

5.4.2 Cores

The transformer cores shall be built with non-ageing cold-rolled–grain-oriented steel laminations having a high permeability and low loss coefficient. Laminations shall be thoroughly covered with an inorganic coating.

Cores shall be rigidly clamped so as to resist distortion caused by short-circuit stresses or handling during transportation.

5.4.3 Windings

The windings shall be electrolytic copper, free from burrs and slives and of pure cellulose paper insulated. The windings shall withstand mechanical and thermal stresses caused by short circuit fault current stipulated in applicable standards.
5.4.4 No-Load Tap Changer

Full capacity taps shall be provided on the high voltage winding of each transformer. The tap changer for de-energized operation shall have an operating handle and shall be located at a position convenient for manual operation.

The external mechanism for manual operation shall be protected against unauthorized operation and shall be provided with a visible indication of the tap position. Top position indicator shall be easily observable from the normal ground level. Particular consideration shall be given in the design, as well as in the arrangement of leads and connections thereto, avoid difficulties under transient voltage conditions.

5.4.5 Bushings

Primary, secondary and neutral point bushings shall be solid type and made of homogenous porcelain free from cavities and other defects. The bushings shall have the highest mechanical and electrical strength to withstand continuously in every operation conditions.

The insulation level of the bushings shall be the same as the insulation level of the windings to which they are connected.

It must be possible to change the bushings without opening the cover of the transformer.

5.4.6 Measurement and Protection Equipment

There shall be a dial-type thermometer with a remote bulb sensing element located at the place of the hottest oil. The thermometer shall be mounted on the tank at a point easily observable from ground level. Each thermometer shall have one contact for alarm at an adjusted temperature. The thermometers shall have a second contact adjusted to a higher temperature for alarm plus tripping.

5.6 Name Plate and Marking

Transformer shall be provided with a name-plate fitted at a visible position. Name plate shall be in English languages. Instruction plates, warning signs and any markings whatever on the equipment parts and accessories shall be provided in appropriate locations on transformer and shall be in Nepali. However, if unpractical, only English language will be used subject to the approval of the Employer.

The transformer body shall display the words “Property of Nepal Electricity Authority- THPP” on its sides written in indelible paint.

At least the following information shall be given on the name plates.

- Manufacturer, serial number and date of manufacture,
- Name and number of the standard,
- Capacity (kVA),
- Frequency,
- Primary and secondary currents,
- Primary and secondary voltages,
- Impedance voltage,
- Cooling system,
5.7 **Accessories**

The following accessories shall be provided with transformer.
- Lower oil filter and drain valve
- Liquid level gauge
- Lifting Lug
- Name plate
- Tank grounding terminal connector suitable for grounding cable #6 SWG solid or stranded copper

5.8 **Tests**

Tests shall be performed in accordance with the relevant IEC standards supplemented by the specific requirements indicated below. In the absence of IEC recommendations the tests must be equivalent at least to the conditions, provisions and definitions of the abovementioned standards. The arrangement of all tests and the method of computing the results shall be approved by the Employer.

5.8.1 **Type Tests**

The Bidder shall submit, along with the Bid, type test reports (detail) on the following tests performed on identical units.

- Temperature rise tests
- Dielectric Type tests
  1. Impulse voltage tests
  2. Separate source AC withstand voltage test

The type test certificates shall be furnished for each type of transformer offered which, in addition to other required data, 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 type test reports. The test of the transformer shall have been conducted by an independent accredited laboratory.

5.8.2 **Routine Tests**

The following tests shall be performed on transformer before delivery.
- Applied voltage test
- Induced voltage test
- No load loss and excitation current test
- Impedance voltage and load loss tests
- Resistance measurement
- Ratio tests
- Polarity and phase relation tests
- Leakage tests
- Insulation resistance tests

The bidders are required to furnish the testing facilities available at the manufacturer’s premises for
conducting the tests listed above in 5.8.2

5.7.1 Shop Tests

The following tests shall be made on each transformer:

- General inspection,
- Measurement of winding resistance,
- Voltage ratio measurement at each tap,
- Measurement of polarity,
- Measurement of no-load current and no-load losses at nominal voltage,
- Measurement of load losses at rated current (at medium and extreme taps),
- Measurement of impedance voltage at rated current (at medium and extreme taps),
- Separate source voltage withstand test,
- Induced overvoltage test.

5.7.2 Field Tests

On each transformer the following tests and checks shall be performed:

- Measurement of insulation resistance
- Measurement of dielectric strength of oil
- Check of protective devices
- Check of noise level and operation of tap changers

5.9 Evaluation

5.9.1 The transformer no-load and load losses shall not exceed the following prescribed values. If the guaranteed no load and load losses exceed the prescribed values below, the offer shall be rejected.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>No-load Loss (Watt)</th>
<th>Load Loss (Watt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 kV</td>
<td>120</td>
<td>750</td>
</tr>
</tbody>
</table>

5.9.2 Transformers shall be evaluated for the loss values (no-load losses and load losses) during bid evaluation based on the following loss capitalization formula:

\[
PE = Pb + KL LL + KNL NLN
\]

Where,

- \(PE\) = Evaluated price
- \(Pb\) = Bid price
- \(KNL\) = Value of no-load loss
- \(KL\) = Value of load loss
- \(LL\) = Guaranteed load losses at rated current
- \(LN\) = Guaranteed no-load losses.

The transformer losses shall be capitalized as follows:

- \(KNL\) = Value of no-load loss \(= \text{USD } 4,684/\text{kW}\)
- \(KL\) = Value of load loss \(= \text{USD } 618/\text{kW}\)

5.9.3 Penalty for excessive losses: During testing, if it is found that the actual measured losses are more than the values quoted by the bidder, a penalty shall be recovered from the bidder at double the loss.
5.9.4 A transformer found to have excess Load Loss and No load Loss up to 15% and 10% of the guaranteed value (specified by the Bidder) respectively upon testing carried out before delivery at the delivery point shall be acceptable, provided, however, that each of the Load Loss and No Load Loss derived from the test carried out for each transformer shall be, in any case, not exceed the prescribed value specified in clause 6.1 above. Any transformer failing to meet these criteria shall be rejected.

5.9.5 For the purpose of this Specification type tests are defined as tests performed on similar transformers of the same general arrangements, same ratings and same mechanical and electrical characteristics.

5.9.6 If at any stage it is established that the type test report submitted by the bidder is not satisfactory, discrepant or ambiguous, the NEA reserves the right to ask the bidder/supplier to conduct the type test on the rating/s of transformers chosen by the NEA in presence of their representative to reputed national/international testing laboratory prior to its mass production and all the cost involved in such testing shall be borne by the bidder/supplier.

5.10 Bid Documentation

5.10.1 The Bidder shall furnish with the Bid, the following documentation:

a) One (1) clear copy of the IEC standards governing fabrication and testing of the transformers.

b) Two (2) clear certified copies of type tests carried out for each rating as required by the governing IEC standard and the specifications.

c) Two (2) copies of certified outline drawings for each kVA rating showing dimensions, arrangements, and locations of all parts.

d) A clause-by-clause commentary on the specification, specifying compliance or deviations, if any

5.11 Drawings to be furnished by the Contractor

At least the following drawings shall be prepared and submitted to the Employer's approval. Further drawings which are deemed by the Employer shall also be prepared and submitted to the Employer's approval.

- Main dimensions
- Accessories location and positioning
- Loads on foundation
- Recommended minimum clearances between installed transformer and walls
- Elevation of the main elements such as LV terminals, centerline, HV terminals, oil valves, relays, indicators
- Drawings of the name-plate
- Wiring diagrams for protection and measuring devices

5.12 Data to be furnished by the Bidder

Item Description

1. Manufacturer

2. Copies of IEC standards attached? Yes/No
3. Copies of type test for each rating attached? Yes/No

4. Copies of outline drawings for each size attached? Yes/No

5. Winding material: __________

6. Primary Winding BIL _______ kV

7. Primary Bushing BIL _______ kV

8. Accessories listed below furnished?
   a) Lower oil filter valve Yes/No
   b) Liquid level gauge Yes/No
   c) Lifting lugs Yes/No
   d) Hand hole Yes/No
   e) Tank earthing terminal Yes/No
   f) Overload protection Yes/No
      If yes, details attached? Yes/No

9. Testing facilities available
   Description Name of the test equipment/facility
   Applied voltage test
   Induced voltage test
   No load loss and excitation current test
   Impedance voltage and load loss tests
   Resistance measurement
   Ratio tests
   Polarity and phase relation tests
   Leakage tests
   Insulation resistance tests

10. Design information
    Rated kVA (IEC rating), kVA...................
    Number of phases ................................
    Frequency, Hz..............................
    Voltage ratio at no-load, kV...................
    Winding connections............................
    Type of core sheet............................
    Magnetising current at normal ratio:
        hv, Amp ............
        lv, Amp ............
    Maximum flux density in core iron at normal voltage and frequency based on the net section of iron:
        Cores, T ....................
        Yokes, T ....................
    Type of winding:
        hv ........................
        lv ........................
    Maximum current density in winding at rated power:
        hv, Amp/mm² .................
Section VI D - Specifications of Electric Equipments

<table>
<thead>
<tr>
<th>Type of insulation used for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>hv winding</td>
</tr>
<tr>
<td>lv winding</td>
</tr>
</tbody>
</table>

No-load loss at normal voltage ratio and 75°C, Watt.
Load loss at rated current and at 75°C, Watt.
Regulation at 75°C and rated power as a percentage of normal voltage:
  - at 1 p.f, %
  - at 0.8 p.f, %
Impedance voltage at 75°C and rated power: %
Efficiency at 1 p.f 125% and rated current, %
Efficiency at 1 p.f 100% and rated current, %
Efficiency at 1 p.f 75% and rated current, %
Efficiency at 1 p.f 50% and rated current, %
Efficiency at 1 p.f 25% and rated current, %
Temperature rise at rated kVA by thermometer in oil.
Temperature rise at rated kVA by resistance of windings.
Permissible overload.
Transformer insulating oil specification.
Total volume of insulating oil at 20°C, litre.
Effective expansion capacity of conservator, litre.

11. Approximate weight and dimensions
   Transformer core and windings, kg.
   Tank and fittings, kg.
   Oil, kg.
   Total weight, kg.

   Thickness of tank sides, mm
   Thickness of tank bottom, mm
   Thickness of tank top, mm
   Thickness of radiator, mm

   Approximate dimensions including fittings:
   Overall length, mm.
   Overall width, mm.
   Overall height, mm.

5.13 Installation

The station service transformer shall be installed indoor at designated location by the Employer. The Contractor shall make all arrangements for installation including adequate isolation from the HV/LV terminals of the transformer.
6. EMERGENCY DIESEL GENERATOR SET

6.1 General

The stationary diesel engine generator unit required under the section of the specifications shall be used as an available source of vital power during interruption of normal electricity supply.

All work shall be performed in accordance with the most advanced practice in this field of engineering for each class of equipment and completed in a manner following the best modern practice in the manufacture of high grade equipment.

The diesel engine generator set shall be located in the special diesel room in the power plant. The supply shall comprise the design, manufacture, testing, transportation, erection, painting and commissioning of unit as defined in this specification.

6.2 Description of Supply

The extent of supply shall include:

- One synchronous A.C. generator, one direct connected diesel engine, cooling system, fuel oil system, all valves, piping, fuel day tanks, pumps, battery charger, local control board, control, alarm, protection and instrumentation devices and such other equipment for making the diesel engine-generator set complete and ready for operation.
- Any piping, cabling, wiring between the various items of supply.
- All connecting bolts and nuts, studs, anchoring material etc. as well as all necessary packing, gaskets and jointing materials.
- Foundation of the unit.
- All other material and equipment not specially mentioned above but necessary for safe and proper operation of the unit.

6.3 Starting and Operating

A change over switch for remote or local control of diesel generator set for the power plant will be installed on the local control cabinet.

Start and stop operation of the diesel generator set shall be initiated by push buttons on the local control cabinets and from the control room.

After initiation impulse, the starting sequence shall continue automatically.

The starting cycle includes for automatic adjustment of generator to rated speed and voltage. Coupling on the main bars will be by the manual change over.

If the diesel fails to start, a starting relay locked out and an alarm is actuated. Reset of the starting relay shall be necessary for re-starting.

Automatic shut down of the diesel-generator set operated upon mechanical and/or electrical faults.
6.4 Specifications

6.4.1 Diesel Engine Generator Set

Diesel engine-generator set shall be mounted on a common base plate equipped with vibration eliminators and other attached accessories necessary for accurate mounting on a concrete foundation. Anchor bolts are included in the supply.

Removable safety guards shall be provided for any exposed moving part. The diesel generator set shall be provided with necessary grounding connectors.

6.4.2 Diesel Engine

Rating: Diesel engine shall be sized to operate satisfactorily with the generator at the rated load and shall be capable to furnish enough power and maintain rated frequency within minus or plus 5% when the generator is running at 10% overload.

Type: Engine shall be heavy duty, industrial stationary type, four cycles, water cooled, supercharged diesel, suitable for the use specified.

Crankshaft: Crankshaft shall be a one-piece forging of high quality steel.

6.4.3 Generator

Rating: Capacity: 50 kVA
Power factor: 0.80
Voltage: 400/230 Volt
Phase and connection: 3-phase, star connection with four terminals
Frequency: 50 Hz
Speed: 1,500 rpm
Continuous overload for one hour, not less than: 10%
Insulation class: F
Type: Generator shall be AC synchronous type for horizontal mounting.

Generator shall be manufacturer’s standard design for indoor installation and shall be capable of continuous operation at rated capacity with a 50°C rise based upon an ambient temperature of 45°C. A full capacity insulated neutral of the generator shall be brought out to the generator main leads terminal box. Neutral of the generator shall be solidly grounded through a disconnect link.

Overload: The generators shall be capable of 10% electrical overload for one hour without exceeding its maximum allowable temperature.

Voltage Regulation: The voltage shall be regulated such that the steady state output voltage shall vary by no more than minus or plus 2% from no load to full load at rated power factor.

6.5 Instrument and Protection

The instrumentation shall comprise at least:
1) For measuring: Speed indicator, operation hours counter, voltmeter and ammeter for battery charger, voltmeter for the generator, fuel level indicator on daily service fuel, fuel level indicator on fuel storage tank if any.
2) For alarm and shut-down: Detector for cooling water temperature (shut-down), detector for lubricating
oil pressure (shut-down). Individual signal lamps on the control cabinet for:
- Low lubricating oil pressure, high cooling water temperature, start locked-out.
3) For control: Push-button for control of starting and stopping locked-out reset button, change-over switch for local or remote control. In addition to above relays, the engine shall be protected against the following:
   a) Faulty start
   b) Low lubricating oil pressure
   c) Excessive heating of the engine for the above items diesel generator set should stop automatically and give sound alarm and light signal.

6.5.1 Local Control Board:

The local control board shall be located in the diesel room. It will include all necessary control and protection equipment for the diesel engine-generator set auxiliaries (starting, heater, etc.). The constructional and other specifications will be similar to other station service boards which are explained in the previous sections.

6.5.2 Accessories and Spare Parts

The diesel engine-generator unit shall be provided with the following mechanical and electrical equipment and accessories and with such other parts and equipment as required to form a complete unit.

6.5.3 Piping and Valving

All piping, including piping between main fuel tank and day tank, fill pipes, vent pipes and valves, air pipes with necessary fittings gaskets as required for assembly and connection of engine, air intake, exhaust system lubricating system, fuel supply system and governor shall be provided by the Contractor.

6.5.4 Lubrication System

The Contractor shall supply engine with complete lubrication system including oil reservoir, oil cooler, oil filter with replaceable elements, strainer and pump. A crank case drain valve shall be provided on the unit and shall be so located that it will be accessible when emergency diesel generator is mounted on its foundation.

6.5.5 Air Intake System

The Contractor shall supply manufacturer’s standard air filter for mounting outside of the buildings with necessary piping and flexible couplings, if so designed.

6.5.6 Exhaust System

The Contractor shall supply muffler (spark arresting type), suitable for outdoor mounting with companion flanges for connection exhaust piping and flexible connection between piping and engine exhaust manifold and all other necessary fittings. The supply shall include also an exhaust thermometer. The exhaust pipe shall be insulated.

6.5.7 Cooling System

Closed circuit cooling system with radiator shall be used. Complete cooling system shall be provided including pipes and valves.
6.5.8 Fuel System

The Contractor shall supply a 125 litre service tank. Feeding of the engine from service tank shall be automatic without any electric auxiliary. The service tank shall be fitted with:

- Filling connection with shut off valve.
- Feed connection to engine with shut of valve
- Drain connection with shut of valve
- Went with flame arrester
- Fuel filter
- Overflow
- Level gauge with alarm switches for alarming locally and to the powerhouse control room (low and high levels).
- High and low level contacts for control of electrical pump feeding the service tank.
- Grounding connector
- Oil preheating system through heater with thermostat contact.
- All connections to the engine
- One fuel hand pump.

The main tank (3 ton) and necessary piping between main tank and service tank shall be provided by the Owner. The Contractor may propose other alternatives for tank system.

6.5.9 Starting Equipment

Storage battery shall be used for starting the diesel engine-generator unit. Storage battery of the required voltage and of adequate ampere hour capacity for start of the unit without recharging shall be furnished complete with battery charger and accessories. Battery charger shall be suitable for 220 volts 50 cycle AC source.

6.6 Guarantees

If the rated output, loading time and fuel consumption are different from more than five percent of the values given in the bidding, Owner shall be entitled to reject the supply.

6.7 Nameplates

All major equipment shall be provided by 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 nameplate shall be in English.

6.8 Tests

1) Shop Tests
a) Engine
   - Four hours at 100% rated load.
   - One hour at 110% rated load.
   - Measurement of fuel consumption at 100% rated load.
   - Checking of speed and regulation.
   - Checking of absence of abnormal vibrations, smokes and noises.
   - Overspeed tests at 110% rated during one minute.
   - Checking of exhaust gas rated load.

b) Generator
• Measurement of winding resistance of stator and rotor.
• Measurement of cold stator insulation.
• Determination of the no-load characteristics, saturation curve, de-excitation time.
• Determination of short-circuit characteristics.
• Determination of Xd-X’d and Xo.
• Dielectric test.
• Determination of efficiencies,
• Control of the wave form.
• Overspeed test at 110% rated speed.

c) Complete Diesel Generator Set
• Checking of conformity
• Starting and stopping tests.
• Load tests
  • Four hours at 100% rated load.
  • One hour at 110% rated load.
• Checking of output and fuel consumption.
• Checking of speed and voltage regulation for different loads.
• Checking of automatic system and safety devices including overspeed.

2) Field Tests
• Checking of conformity.
• Starting tests, checking of starting time.
• Load tests.
  • Four hours at 100% rated load.
  • One hour at 110% rated load.
• Checking of speed and voltage regulation, temperatures, specific heat, exhaust gas.
• Checking of automatic sequences.
• Checking of starting battery.
• Checking of alarm, signaling, measurement and safety devices.
• Checking of the fuel system.

In addition to above mentioned elements, the contractor shall supply also the followings:
• Inlet silencer
• Heat insulation jackets
• Lifting lugs
• All sound damping equipment
• Supercharge unit with exhaust turbocharger
• Fuel filter
• Thermometers for lubricating oil and cooling water
• Pressure gauges for lubrication oil and cooling water

6.9 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.

1) Performance data and guaranteed characteristics for diesel engine-generator unit.

<table>
<thead>
<tr>
<th>Description</th>
<th>Units/Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous rated output</td>
<td>kVA</td>
</tr>
<tr>
<td>Time to deliver full load (loading time)</td>
<td>sec</td>
</tr>
</tbody>
</table>
Section VI D - Specifications of Electric Equipments

- Power factor

**Diesel Engine**

Manufacturer

- **Type**
  - **Rated** output kW
  - Rated speed rpm
  - Number of cylinders
  - Engine cycle
  - Bore mm
  - Stroke mm
  - Cubic capacity l
  - Piston velocity at rated speed m/s
  - Heating temperature °C
  - Pre-heating output kW
  - Exhaust gas temperature at rated output °C
  - Mean noise level at 5 m dB
  - Calories to be evacuated at rated output by cooling system kcal/h
  - Necessary air flow for engine operation m³/h
  - Fuel consumption at
    - 4/4 load gr/kWh
    - 3/4 load gr/kWh
    - 1/2 load gr/kWh
  - Material

Cylinder block
Cylinder head
Cylinder liner movable
Piston
Crankshaft
Starting System
  - Manufacturer
  - Type

D.C. Supply
  - Battery voltage V
  - Battery Capacity Ah
  - Rectifier capacity A

Air Inlet Filter
  - Manufacturer
  - Type
  - Model

Inlet Silencer
  - Manufacturer
  - Model

Exhaust Silencer
  - Manufacturer
  - Model
Fuel System Fuel Pump
  
  - Manufacturer
  - Capacity $m^3/h$
  - Motor output $kW$

1. **Generator**
   
   - Manufacturer
   - Insulation class
   - Admissible overload during % of rated load one hour each 12 hours of operation at rated load
   - Synchronous reactance $X_d$
   - Transient reactance $X'd$
   - Subtransient reactance $X'd$
   - Efficiency at p.f. 0.8 lag
     - 4/4 load
     - 3/4 load
     - 1/4 load
   - Excitation
   - Type of excitation

Ceiling voltage

Accuracy (at rated load)

Description Units Values

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage recovery time after sudden rated load pick-up</td>
<td>sec</td>
<td></td>
</tr>
<tr>
<td>Voltage recovery time after rated load rejection</td>
<td>sec</td>
<td></td>
</tr>
<tr>
<td>Transient voltage drop at p.f. = 0.8 for sudden rated load pick-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transient voltage rise at p.f. = 0.8 after rated load rejection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dimension and weights

- Engine weight $t$
- Generator weight $t$
- Total weight $t$
- Shipping weight $t$
- Dimensions of the complete unit $m \times m \times m$

2. **LV Breakers, 380 Volts**
   
   - Manufacturer
   - Type
   - Standard
   - Rated voltage $V$
   - Rated current $A$
   - Rupturing capacity

Description Units Values

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sym.rms</td>
<td>kA</td>
<td></td>
</tr>
<tr>
<td>Assym. Peak</td>
<td>kA</td>
<td></td>
</tr>
</tbody>
</table>
  - Closing capacity assmy. Peak
  - Weight $kg$

3. **LV-AC Switches**
   
   - Manufacturer
   - Type
   - Standard
   - Rated voltage $V$
4. **DC-LV Breakers, 110 Volts**
   - Manufacturer
   - Type
   - Standard
   - Rated voltage
   - Rated current
   - Rupturing capacity
   - Closing capacity
   - Weight

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC-LV Breakers, 110 Volts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. **DC-LV Switches, 110 Volts**
   - Manufacturer
   - Type
   - Standard
   - Rated voltage
   - Rated current
   - Weight kg

6. **Measuring Transformers**
   **A. Current Transformers**
   - Manufacturer
   - Type
   - Max. Permissible operating voltage
   - Accuracy class
   - Type of insulation
   - Rated voltage (primary)
   - Ratio
   - Rated output
   - Continuous permissible over current
   - Short circuit withstanding
     - Thermal
     - Dynamic
   - Saturation factor
   - Standard

   **B. Voltage transformers**
   - Manufacturer
   - Type
   - Max. Permissible operating voltage
   - Accuracy class
   - Type of insulation
   - Primary rated voltage
   - Secondary rated voltage
   - Rated burden
   - Short circuit withstanding sec
   - Standard

7. **For Each Switchboard**
Section VI D - Specifications of Electric Equipments

- Manufacturer
- Main dimensions (LxWxH) m
- Weight kg
- Heaviest parcel to be shipped (gross weight) kg
- Largest parcel to be shipped (dimensions) m
- Painting

Description Units Values

8. **Battery** Ah.
   - Manufacturer
   - Type
   - Rated voltage V
   - Rated insulation voltage V
   - Number of cells
   - Initial discharge voltage per cell V
   - Discharge final voltage per cell (4 hours discharge) V
   - Internal resistance of cells Ohm
   - Internal resistance of battery Ohm
   - Dimensions mm
   - Weights of cells electrolyte and racks Kg
   - Dimensions of cells and complete battery mm
   - Required ventilation in the battery room m³/sec

9. **Rectifier**
   - Manufacturer
   - Type
   - Rated current A
   - Floating voltage V
   - Voltage regulation %
   - Efficiency %
   - Duration of high charging h
   - Dimensions mm

7. **CONTROL, MONITORING AND PROTECTION SYSTEM**

7.1 **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 and 12 kV switchgear family 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
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 12 kV switchgear equipment
   - Two (2) 12 kV incoming feeders for generators
   - One (1) 12 kV station service feeder
   - One (1) 12 kV outgoing feeder for line

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.

### 7.2 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 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.

7.3 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
7.4 Operation and Control System

7.4.1 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”.

7.4.2 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.
7.4.3 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.

7.4.4 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
7.4.5 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.

7.4.6 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.

7.4.7 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 forma and on the touch screen panel.

7.4.8 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 synchronoscope.

7.4.9 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.

7.4.10 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.

7.4.11 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.

7.5 Electrical Protection

7.5.1 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/√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.

7.5.2 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 12 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

**For Diesel Generator**
1) Frequency relay: 81
2) Under voltage: 27
3) Over voltage: 59

### 7.5.3 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. Protection relaying co-ordination, choice of equipment, etc.

### 7.5.4 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.

### 7.5.5 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.
7.5.6 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.

7.6 Circuit Protection and Wiring

7.6.1 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.

7.6.2 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
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.

7.6.3 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.

7.6.4 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.

### 7.7 Water Level Measuring Devices

#### 7.7.1 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

7.8 Spare Parts and Tools

According to the Spare Parts and Tools List (Section VI H)

7.9 Tests

7.9.1 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.

### 7.9.2 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 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.

7.10 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.

7.10.1 Guaranteed Characteristics and Performance Data for Protective Relay (for each type)

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>UNITS VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of relay</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Standards</td>
<td></td>
</tr>
<tr>
<td>Rated voltage</td>
<td>V</td>
</tr>
<tr>
<td>Rated current</td>
<td>A</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>Hz</td>
</tr>
<tr>
<td>Setting range</td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td>A</td>
</tr>
<tr>
<td>Voltage</td>
<td>V</td>
</tr>
<tr>
<td>Time s</td>
<td></td>
</tr>
<tr>
<td>Overall accuracy in percent of setting</td>
<td></td>
</tr>
<tr>
<td>Operating time (without time delay)</td>
<td>s</td>
</tr>
<tr>
<td>Burden per CT</td>
<td></td>
</tr>
<tr>
<td>At rated current</td>
<td>VA</td>
</tr>
<tr>
<td>At setting current</td>
<td>VA</td>
</tr>
<tr>
<td>At 10x rated current</td>
<td>VA</td>
</tr>
<tr>
<td>Burden per PT</td>
<td></td>
</tr>
<tr>
<td>At rated voltage</td>
<td>VA</td>
</tr>
<tr>
<td>At lower setting</td>
<td>VA</td>
</tr>
<tr>
<td>Auxiliary voltage supply (DC)</td>
<td>V</td>
</tr>
<tr>
<td>Dynamic, thermal withstanding of relay in amperes</td>
<td></td>
</tr>
<tr>
<td>Instantaneous, peak</td>
<td>A</td>
</tr>
<tr>
<td>Short time, rms 1 sec</td>
<td>A</td>
</tr>
<tr>
<td>Continuous, rms</td>
<td>A</td>
</tr>
</tbody>
</table>
### Section VI D - Specifications of Electric Equipments

**Insulation level**  
**Highest permissible voltage (30 minutes)**  
**Auxiliary contacts**

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous at 110 V D.C. +15%, -20%</td>
<td>A</td>
</tr>
<tr>
<td>Breaking</td>
<td>A</td>
</tr>
</tbody>
</table>

**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**

#### 7.10.2 Guaranteed Characteristics and Performance Data for Auxiliary Relays

**DESIGNATION**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Type</th>
<th>Standards</th>
<th>Coil rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate voltage</td>
<td>V</td>
<td>Min. pick-up voltage</td>
<td>V</td>
</tr>
<tr>
<td>Maximum drop-out voltage</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of contacts</td>
<td>Make contacts</td>
<td>Break contacts</td>
<td></td>
</tr>
<tr>
<td>Contacts rating</td>
<td>Voltage, D.C.</td>
<td>Current, continuous</td>
<td>A</td>
</tr>
<tr>
<td>Current, breaking</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating time by energizing</td>
<td>Make contact ms</td>
<td>Break contact ms</td>
<td></td>
</tr>
<tr>
<td>Operating time by de-energizing</td>
<td>Make contact ms</td>
<td>Break contact ms</td>
<td></td>
</tr>
<tr>
<td>Burden</td>
<td>On starting</td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>Dimensions mm x mm</td>
<td>Weight</td>
<td>kg</td>
<td></td>
</tr>
</tbody>
</table>

#### 7.10.3 Guaranteed Characteristics and Performance Data for Switches

**DESIGNATION**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Type</th>
<th>Standards</th>
<th>Coil rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate voltage</td>
<td>V</td>
<td>Min. pick-up voltage</td>
<td>V</td>
</tr>
<tr>
<td>Maximum drop-out voltage</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of contacts</td>
<td>Make contacts</td>
<td>Break contacts</td>
<td></td>
</tr>
<tr>
<td>Contacts rating</td>
<td>Voltage, D.C.</td>
<td>Current, continuous</td>
<td>A</td>
</tr>
<tr>
<td>Current, breaking</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating time by energizing</td>
<td>Make contact ms</td>
<td>Break contact ms</td>
<td></td>
</tr>
<tr>
<td>Operating time by de-energizing</td>
<td>Make contact ms</td>
<td>Break contact ms</td>
<td></td>
</tr>
<tr>
<td>Burden</td>
<td>On starting</td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>Dimensions mm x mm</td>
<td>Weight</td>
<td>kg</td>
<td></td>
</tr>
</tbody>
</table>
## Specifications of Electric Equipments

### 7.10.4 Guaranteed Characteristics and Performance Data for Indicating Instruments

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>UNITS /VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Standards</td>
<td></td>
</tr>
<tr>
<td>Rated voltage (phase to phase)</td>
<td>V</td>
</tr>
<tr>
<td>Rated current</td>
<td>A</td>
</tr>
<tr>
<td>CT ratio</td>
<td>A/A</td>
</tr>
<tr>
<td>PT ratio</td>
<td>V/V</td>
</tr>
<tr>
<td>Accuracy class (percent error of full scale deflection)</td>
<td></td>
</tr>
<tr>
<td>Scale graduation</td>
<td></td>
</tr>
<tr>
<td>Range of measurement (at defined CT and PT ratio)</td>
<td></td>
</tr>
<tr>
<td>Consumption at full scale deflection</td>
<td></td>
</tr>
<tr>
<td>Current circuit</td>
<td>VA</td>
</tr>
<tr>
<td>Voltage circuit</td>
<td>VA</td>
</tr>
<tr>
<td>Overcurrent withstanding, permissible highest value</td>
<td></td>
</tr>
<tr>
<td>Continuous Temporary, 1 sec</td>
<td>A</td>
</tr>
<tr>
<td>Instantaneous, peak</td>
<td>A</td>
</tr>
<tr>
<td>Overvoltage withstanding, permissible overvoltage</td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>V</td>
</tr>
<tr>
<td>Temporary, 1 sec.</td>
<td>V</td>
</tr>
<tr>
<td>Instantaneous, peak</td>
<td>V</td>
</tr>
<tr>
<td>Dimensions</td>
<td>mm x mm</td>
</tr>
<tr>
<td>Weight</td>
<td>kg</td>
</tr>
</tbody>
</table>

### 7.10.5 Guaranteed Characteristics and Performance Data for Auto-Synchronizer

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>UNITS/VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
</tbody>
</table>
### Type

#### Standards

<table>
<thead>
<tr>
<th>Input values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>V</td>
</tr>
<tr>
<td>Maximum difference between voltages</td>
<td>%</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
</tr>
<tr>
<td>Power consumption</td>
<td></td>
</tr>
</tbody>
</table>

#### 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 |

7.10.6 Guaranteed Characteristics and Performance Data for Recorders and Converters

#### Converters

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>UNITS/VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Recorder</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Standards</td>
<td></td>
</tr>
<tr>
<td>Measuring range</td>
<td></td>
</tr>
<tr>
<td>Accuracy class</td>
<td></td>
</tr>
<tr>
<td>Indication</td>
<td>%</td>
</tr>
<tr>
<td>Recording</td>
<td>%</td>
</tr>
<tr>
<td>Scale graduation</td>
<td></td>
</tr>
<tr>
<td>Chart speed</td>
<td></td>
</tr>
<tr>
<td>Chart graduation</td>
<td></td>
</tr>
<tr>
<td>Input impedance</td>
<td>Ohm</td>
</tr>
<tr>
<td>Input signal</td>
<td></td>
</tr>
<tr>
<td>Recording width</td>
<td>mm</td>
</tr>
<tr>
<td>Marking system (Preferably inkless)</td>
<td></td>
</tr>
<tr>
<td>Electric drive</td>
<td></td>
</tr>
<tr>
<td>Rated voltage (220 V)</td>
<td>V</td>
</tr>
<tr>
<td>Consumption</td>
<td>VA</td>
</tr>
<tr>
<td>Length of chart in each rolls</td>
<td>m</td>
</tr>
<tr>
<td>Marked paper storage</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>mm x mm</td>
</tr>
<tr>
<td>Weight</td>
<td>kg</td>
</tr>
</tbody>
</table>

b) Converter

| Manufacturer |              |
| Type         |              |
| Standards    |              |
Inputs
Voltage V
Current A
Output (volt or ampere)
Accuracy %
Dimensions mm x mm

7.10.7 Guaranteed Characteristics and Performance Data for Miscellaneous

Equipment

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>UNITS/VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Indicating lamps</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Fitting</td>
<td></td>
</tr>
<tr>
<td>Bulb</td>
<td></td>
</tr>
<tr>
<td>Bulb consumption</td>
<td>W</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>V</td>
</tr>
<tr>
<td>b) Annunciator</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Bib consumption</td>
<td>W</td>
</tr>
<tr>
<td>Rated bulb voltage (DC)</td>
<td>V</td>
</tr>
<tr>
<td>Rated coil voltage, D.C.</td>
<td>V</td>
</tr>
<tr>
<td>c) Terminals</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>For wires up to mm²</td>
<td></td>
</tr>
<tr>
<td>Test voltage</td>
<td>V</td>
</tr>
<tr>
<td>d) Wiring</td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td></td>
</tr>
<tr>
<td>Sizes</td>
<td></td>
</tr>
<tr>
<td>CT circuits mm²</td>
<td></td>
</tr>
<tr>
<td>PT circuits mm²</td>
<td></td>
</tr>
<tr>
<td>Control circuits mm²</td>
<td></td>
</tr>
<tr>
<td>Maximum operational voltage</td>
<td>V</td>
</tr>
<tr>
<td>Test voltage</td>
<td>V</td>
</tr>
</tbody>
</table>

7.10.8 Guaranteed Characteristics and Performance Data for Operator Station

DESIGNATION
8. AUTOMATIC CONTROL AND SCADA SYSTEMS

8.1 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

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
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 11 kV circuit breaker of transmission line
7. A set of UPS power source
8. Working platform
9. Systematic software

8.2 The Function of Control system

8.2.1 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

8.2.2 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.

8.2.2.1 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.

8.2.2.2 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.

8.2.2.3 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.
8.2.2.4 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.

8.2.3 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.

8.2.4 Microcomputer-based protection & control section for generator-transformer block

At this station, there are three generator–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.

8.2.5 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.

8.3 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.

8.4 Tests

8.4.1 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

8.4.2 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. 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.

vii. 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.

8.5 Equipment List of Control System

<table>
<thead>
<tr>
<th>Central computer &amp; its accessories</th>
<th>Computer system</th>
<th>Set</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P-III 800, one pieces of 500 G hard disks, and the internal capacity of 256M.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Printer: A3 color printer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colorful display: 19”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SCADA communication module</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic control &amp; protection section</td>
<td>Turbine control unit</td>
<td>Set</td>
<td>2</td>
</tr>
<tr>
<td>Generator-transformer (if any) block control &amp; protection section</td>
<td>Generator control &amp; protection module</td>
<td>Set</td>
<td>2</td>
</tr>
<tr>
<td>Transmission line control &amp; protection section</td>
<td>Line protection module</td>
<td>Set</td>
<td>1</td>
</tr>
<tr>
<td>Control system for the public device</td>
<td>Auxiliary control system</td>
<td>Set</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>PLC control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchronizing device</td>
<td>UPS</td>
<td>Set</td>
<td>1</td>
</tr>
<tr>
<td>Power source</td>
<td>SCADA software and software of auxiliary system control</td>
<td>Set</td>
<td>1</td>
</tr>
<tr>
<td>Systematic software</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. POWER AND CONTROL CABLES

9.1 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 Tinau 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 11 kV, 11 kV and the bigger sections of 0.4 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.

9.2 Scope of Supply

This specification covers the supply of material, transport, storage at site, erection and testing of the 11 kV, low voltage power and control cables and their related accessories for Tinau 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.

9.3 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 ores, marking of cores, etc.

9.3.1 11 kV Cables (system voltage class 12 kV):

Single-core/ three 11 kV cables, stranded copper conductor, polyethylene insulation (XLPE or equivalent), shielded with copper tape (electrostatic screen), metal armored with thermoplastic jacket overall, for 11 kV
9.3.2 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.

9.3.3 Teletransmission 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.

9.3.4 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.

9.3.5 Laying of Cables

The type of laying 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.

9.3.6 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.

9.3.7 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

10. POWERHOUSE TRAVELLING CRANE

10.1 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.

10.2 Design Standards

Design standards for the crane shall be in accordance with national entrepreneur standards and FEM norms or equivalent standards.

10.3 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:

<table>
<thead>
<tr>
<th>Movement</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main hoist hook, vertical</td>
<td>2 mm</td>
</tr>
<tr>
<td>Trolley travel</td>
<td>8.6 mm</td>
</tr>
<tr>
<td>Bridge travel</td>
<td>8.6 mm</td>
</tr>
</tbody>
</table>

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.
10.3.1 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.

10.3.2 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.

10.3.3 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.

10.3.4 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

10.4 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.
10.4.1 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.

10.4.2 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.

10.4.3 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.

10.4.4 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.
10.4.5 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.

10.4.6 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.

10.4.7 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.

10.4.8 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 brushers 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 food pedal in the operator’s cabin and of sufficient capacity to bring the crane quickly to rest from full speed with rated load.

10.4.9 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.

10.4.10 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.

10.4.11 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.

10.4.12 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.

10.4.13 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.

10.4.14 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.
10.4.15 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.

10.5 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) set 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.

10.6 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.

### 10.7 Specifications of overhead traveling crane

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
<th>Technical Specifications</th>
<th>Unit</th>
<th>Qty</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overhead traveling crane</td>
<td>Lifting capacity: 5T, Rail span: 8.6 m</td>
<td>Set</td>
<td>1</td>
<td>Expectation</td>
</tr>
<tr>
<td>2</td>
<td>Runaway crane rails</td>
<td>Length: 23.0 m</td>
<td>Set</td>
<td>1</td>
<td>46.0 m</td>
</tr>
<tr>
<td>3</td>
<td>Testing devices (anchor, hydraulic dynamometer)</td>
<td>According to the crane</td>
<td>Set</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Electrical wiring</td>
<td>400V cable</td>
<td>Set</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

### 10.8 Main parameters

(i) Name : Overhead traveling crane with two beams  
(ii) Load : 5 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  
(x) Length of the rail-crane : 46 m (Bidder shall verify at site)
VI E. SPECIFICATION OF CIVIL WORKS
TABLE OF CONTENTS

SECTION I – SITE CLEARANCE
SECTION II – EARTHWORKS
SECTION III – MATERIALS AND TESTING OF MATERIALS
CHAPTER IV – CONCRETE WORK
SECTION V – STRUCTURAL STEELWORK
SECTION VI – DRILLING & GROUTING
SECTION VII – STONE MASONRY
SECTION VII – MISCELLANOUS STRUCTURES
SECTION I – SITE CLEARANCE

1. CLEARING AND GRUBBING

1.1 Scope

The Section covers the clearing and grubbing necessary for the construction of the works covered by the contract. Conservation of the top soil and flora is also covered under this Section.

(1) Description of Work

(a) Clearing

Clearing shall consist of the cutting, removing and disposal of all tree, bushes, shrubs, grass, weeds, other vegetation, anthills, rubbish, fences, top organic soil not exceeding 150 mm in thickness and all other objectionable material, resulting from the clearing and grubbing. It shall also include the removal and disposal of structures that obstruct, encroach upon or otherwise obstruct the work.

The moving of a certain amount of soil or gravel material may be inherent to or unavoidable during the process of clearing and no extra payment shall be made for this. Clearing shall include the removal of all rocks and boulders of up to 0.15 m³ in size exposed or lying on the surface.

(b) Grubbing

In the roadway all trees up to 300 mm girth, stumps and roots shall be removed to a depth of not less than 900 mm below the finished road level and a minimum of 500 mm below the original ground level whichever is lower.

Except in borrow areas the cavities resulting from the grubbing shall be backfilled with approved material and compacted to a density not less than the density of the surrounding ground.

(2) Conservation of Top Soil

Where suitable topsoil exists within the limits of the area to be cleared and grubbed, the Contractor shall, if ordered by the Engineer, remove the topsoil together with grass and other suitable vegetation. If not used immediately, the topsoil shall be transported and deposited in stockpiles for later use.

(a) Conservation of Flora

Where provided for in the contract, certain designated flora encountered in the road reserve and borrow areas shall be carefully protected by the Contractor. In his tendered rate for Site Clearance, he shall include for the careful removal and planting of the flora in a protected and fenced-off area and, on completion of the road, for the replanting of the flora in suitable positions in the road reserve in accordance with the Engineer’s instructions.
(3) Execution of Work

(a) Areas to be Cleared and Grubbed

Stumps, embedded logs, roots and all other vegetation growth and accumulated rubbish of whatsoever nature and all other objectionable material shall be completely removed to a depth as specified in Sub-clause (2) (a) and (b) of Section I.

Normally the portions of the road reserve that fall within the limits of the road prism, as well as certain borrow areas shall be cleared and/or grubbed. Where the road reserve is to remain unfenced, the full width of the road reserve shall be cleared and/or grubbed except for such trees designated by the Engineer to be left standing and uninjured.

The Contractor shall mark the boundaries of the area for clearing and grubbing and seek the approval of the Engineer before commencement of the work. The Engineer shall designate in detail the exact areas to be cleared, and grubbed and the time at which it shall be done.

(b) Cutting of Trees

The Contractor shall take the necessary precautions to damage to structures and other private or public property. If necessary, trees shall be cut in sections from the top downwards. The branches of trees to be left standing shall be trimmed so as not to intrude into a space of 7m above the roadway.

Such individual trees as the Engineer may designate and mark in white paint shall be left standing and uninjured. In order to minimize damage to trees that are to be left standing, trees shall be felled towards the center of the areas being cleared, if so required by the Engineer.

Permission for cutting trees must be obtained from the competent authority who may require that trees be numbered, measured and marked in the presence of officials from that authority. Cutting of such trees shall then be carried out by the Contractor and the timber stored at designated locations within the Right of Way.

Felling and cutting of trees on the site and piling them off the site shall conform to the requirements of the competent authority.

All tree trunks and branches in excess of 150 mm in diameter shall be cleaned off, secondary branches cut into suitable length and stacked at sites indicated by the Engineer. Such timber shall not be used by the Contractor for any purpose and shall remain the property of the Employer.

All timber except such timber as can be used and all brush, stumps, roots, rotten wood and other refuse from the clearing and grubbing operations shall be completely removed from within the Right of Way.

(c) Dealing with Anthills

Where anthills are encountered within the limits of the road prism, they shall be excavated to a depth of not less than 750 mm below the finished road level and the
material carted to spoil. Cavities resulting from the clearance of anthill material shall be backfilled with approved material and compacted to a density not less than that of the surrounding ground.

Where directed by the Engineer, the area covered by anthills shall be treated, after excavation and before backfilling of cavities, with an approved ant control chemical. Payment for such treatment shall be made in the manner specified in the contract.

(d) **Disposal of Material**

Material obtained from clearing and grubbing shall be disposed off in borrow pits or other suitable places and be covered up with soil or gravel as directed by the Engineer. The burning of combustible material shall not, normally, be permitted and may only be done with the prior written approval of the Engineer.

Where fences have to be taken down, fencing wire shall be neatly wound into reels and all such wire, together with all fence posts and other serviceable material from structures, etc., shall be stacked at sites indicated by the Engineer.

(e) **Reclearing of Vegetation**

When portions of the road reserve, borrow or other areas have been cleared in accordance with the Specifications, but in the course of time, vegetation grows again during construction, the Engineer may, if he considers it necessary, order that the area be recleared.

Before the bottom layer of the embankment is made, the Contractor shall grub up and remove any vegetation that may in the meantime have grown on the surfaces previously cleared and grubbed.

Such reclearing of areas previously cleared include the removal and disposal of grass, shrubs and other vegetation in the same manner as for the first cleaning operation. No separate payment shall be made for reclearing of vegetation.

(f) **Measurement**

Clearing and grubbing executed as per this Specification shall be measured in square meter.

Cutting trees including removal of stumps and their roots of girth above 300 mm and backfilling to required compaction shall be measured in number according to the sizes given below:

(a) Above 300 mm to 600 mm
(b) Above 600 mm to 900 mm
(c) Above 900 mm to 1800 mm
(d) Above 1800 mm

For this purpose girth shall be measured at a height 1 meter ground.
Cutting of trees up to 300 mm girth including removal of stumps and roots and backfilling of holes with compaction shall not be measured separately.

(4) Payment

Clearing and grubbing and cutting trees shall be paid at their respective contract unit rates which shall be the full and the final compensation to the Contractor. The contract unit rate for cutting of trees of girth above 300 mm shall also include handling, salvaging, piling and disposing off the cleared materials with all leads and lifts.

2. DISMANTLING CULVERTS, BRIDGES, DECKS, OTHER STRUCTURES AND PAVEMENT

i. Scope

This work shall consist of removing as hereinafter set forth existing culverts, bridges, pavements, buildings and other structure like guard-rails, kerbs, manholes, catch basins, inlets, walls, drains etc., which are in place but interfere with the new construction or are not suitable to remain in place, and salvaging and disposing off the resulting materials and back filling the resulting trenches and pits.

ii. General

1. Only those structures designated by the Engineer, or shown on the Drawings, shall be demolished or removed.

2. Dismantling and removal operations shall be carried out in such a way that the adjacent pavement, structures are left intact and in place. All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to start of new work.

3. Existing culverts, bridges, buildings and other structures which are within the road and which are designated for removal, shall be removed up to the limits and extent specified on the Drawing or as indicated by the Engineer.

4. Materials that are to be salvaged shall be carefully removed and stockpiled near the site at a location designated by the Engineer. Materials which are to be salvaged or used in the reconstructed work, have been damaged or destroyed as a result of the Contractor’s operations, shall be repaired or replaced by the Contractor at his expense. Materials that are not to be salvaged and stockpiled, shall be removed and disposed off away from the site by the contractor at his own expenses. In general, piling, piers abutments and pedestals shall be removed to at least 300 mm below ground level measured at the face unless a different depth is designated or specified. Existing reinforcement that is to be incorporated in new work shall be protected from damage and shall be thoroughly cleaned of all adhering material before being embedded in new concrete.

5. When pipe culverts, wooden culverts, gabion walls or other structures with a salvaged value are removed, care shall be exercised in their safe removal.
material involved shall be kept intact without damage. The Contractor shall be responsible for the satisfactory removal of such structures in an usable condition.

6. Salvaged reinforced concrete pipes, corrugated steel pipes, wooden boxes or other structures shall be stored at places as directed by the Engineer or shown on the Drawing. Structures or portions thereof which are specified in the contract for reerection shall be stored in separate piles.

7. Timber or lumber from old structures which is designated by the Engineer as materials to be salvaged shall have all nails and bolts removed therefrom and shall be stored in neat piles in locations suitable for loading.

8. All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

9. All salvaged materials shall be the property of the Employer.

10. All materials obtained from dismantling operations which, in the opinion of the Engineer, cannot be used or auctioned shall be disposed off.

iii. Dismantling Culverts and Bridges and Operation Decks

The structures shall be dismantled carefully and the materials shall be so removed as not to cause any damage to the serviceable materials to be salvaged. The part of the structure to be retained and other structures nearby shall be safeguarded against any damages.

Where existing culverts/bridges are to be otherwise incorporated in the new work, only such parts of the existing structure shall be removed as are necessary and directed by the Engineer to provide a proper connection to the new work. The connection edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained.

Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. The structure shall be removed in a condition suitable for re-erection unless otherwise shown on the Drawing. All members shall be match-marked by the Contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location; all pins, pin holes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.

iv. Dismantling Other Structures and Pavements

In removing pavements, kerbs, gutters, walls and structures like catchpits, outlets, etc., where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with face perpendicular to the surface of existing structure. Sufficient removal shall be made to provide connections with the new work as directed by the Engineer. All pavements, base courses in carriageway and shoulders, etc. designated for removal shall be broken
to pieces whose volume shall not exceed 0.02 cubic meters and stockpiled at designated locations if the materials are to be used later or otherwise arrange for disposal.

v. **Back-filling**

Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to required density as directed by the Engineer.

vi. **Measurement**

Prior to commencement of dismantling, the work of dismantling structures shall be measured in the units given below:

<table>
<thead>
<tr>
<th>Type of Work</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Dismantling brick/stone masonry/Concrete</td>
<td>cu.m.</td>
</tr>
<tr>
<td>(ii) Dismantling gabion</td>
<td>cu.m.</td>
</tr>
<tr>
<td>(iii) Dismantling steel structures</td>
<td>ton</td>
</tr>
<tr>
<td>(iv) Dismantling timber structures</td>
<td>cu.m.</td>
</tr>
<tr>
<td>(v) Dismantling pipes, guard rails, Kerbs and gutters</td>
<td>lin.m.</td>
</tr>
<tr>
<td>(vi) Utility services</td>
<td>lump sum</td>
</tr>
<tr>
<td>(vii) Pavement</td>
<td>cu.m.</td>
</tr>
<tr>
<td>(viii) Dismantling pipe culverts</td>
<td>no.</td>
</tr>
<tr>
<td>(ix) Dismantling pitching and rip raps</td>
<td>sq.m.</td>
</tr>
</tbody>
</table>

Associated works like disposal, stockpiling, marking and numbering, etc., shall not be measured separately.

vii. **Payment**

The various dismantling works shall be paid at their respective contract unit rates which shall be full and the final compensation to the Contractor and for the cost of all operations involved for completion of this item.
SECTION II – EARTHWORKS

1. SCOPE

This section covers the works related to the roadway excavation, roadway filling, excavation for foundation, backfilling, excavation for drains, channels, intercepting drains etc.

2. DEFINITIONS AND GENERAL REQUIREMENTS

i. Earthwork includes two types of operations i.e. (i) earth excavation and disposal of the excavated materials (ii) earth excavation and use of excavated materials. The use of excavated material may be in the form of filling embankment, backfilling, filling other areas as required.

Earth excavation and disposal implies excavation of all types of materials including part of the structures below ground level within and outside of the limit of the right of way except for otherwise specified, shaping the exposed surface of excavation as specified or directed by the Engineer, removal, hauling and disposal of the excavated material at the locations and in the manner as specified or directed by the Engineer.

Excavation and filling implies excavation of materials and shaping the exposed surface of excavated as stated, removal hauling and use of the excavated material at the location and in the manner as specified or directed by the Engineer.

Excavation and disposal shall include:

(i) Excavation and disposal of any type of material included on the Drawing.
(ii) The excavation and disposal of existing surfacing.
(iii) Excavation and disposal of slides, breakages and caving-ins.
(iv) Excavation and disposal for stream channel, trenches and drains etc.
(v) Excavation required in cuts or under embankments below the lowest normal limit of excavation as indicated on the Drawing or below ground line.
(vi) Excavation and disposal of unsuitable materials.
(vii) Removal or partial removal of existing embankments and disposal of the materials as shown on the Drawing or as directed by the Engineer.
(viii) Excavation for foundation and disposal of materials.

Excavation and filling shall include:

(i) Filling for embankment
(ii) Filling for guide bunds, coffer dams, etc.
(iii) Backfilling in trenches, foundation pits etc.
(iv) Any type of other filling or backfilling whereby the ground level is raised or a hole is filled up.
ii. The following definitions of earthworks materials shall apply to this and other Clauses of these specifications, if otherwise not specified.

(i) “Topsoil” shall mean the top layer of soil that can support vegetation. It shall include all turf acceptable for turfing.

(ii) “Suitable Material” shall comprise all that is acceptable in the 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 to form a stable fill having side slopes as indicated in the Drawing. The material used in fill (except for rock fill) shall not contain rock fragments with dimensions of more than 75 mm.

(iii) “Unsuitable Material” shall mean other than suitable material and shall include:

a. Material from swamp, 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;

Material stated above in (d) if otherwise suitable shall be classified suitable when unfrozen.

(iv) “Rock Fill” shall consist of hard material of suitable size for deposition and compaction as given in Clause II (9) and also may comprise rock as defined in Clause II (3) and broken stones.

(v) “Well Graded Granular Material” consisting of gravel and/or sand.

iii. No excavated suitable material other than surplus to requirements of the contract shall be removed from the site except on the direction of the Engineer. Should the Contractor be permitted to remove suitable material from Site to suit his operational procedure, then he shall make good at this own expense any consequent deficit of filling arising therefrom.

iv. Material in surplus to the total requirements of works, and all unsuitable material shall, unless the Engineer permits otherwise, be run to spoil dumps.

v. Where the excavation reveals a combination of suitable and unsuitable materials the Contractor shall carry out the excavation in such a manner that the suitable materials are excavated separately for use in the works without contamination by the unsuitable materials.

vi. The Contractor shall make his own arrangements for the stockpiling of topsoil and/or suitable material.

vii. At all times the Contractor shall ensure that earthworks are not damaged by weather or traffic. In event of such damage, the Engineer may withdraw
approval from the affected works until the Contractor has carried out repairs to restore the works to their original condition.

The cost of all such repairs and any additional testing shall be borne by the Contractor.

viii. Prior to commencement of any earthwork, the work shall be set out where required following the clearing and grubbing and survey of the existing ground shall be conducted jointly by the Contractor and the Engineer. The survey records shall serve as initial measurements for the determination of the final quantities of earthwork performed under the contract.

ix. Works on embankments and/or cutting in areas required for the construction of bridges and other structures shall not be carried out until the Engineer agrees that construction of such structures is sufficiently advanced that there is no interference or damage to them.

x. The Contractor shall get approval of the Engineer in respect of method of earthwork, type of equipment to be used, disposal and other details before commencement of the earthwork.

3. CLASSIFICATION OF EXCAVATED MATERIALS

The excavated materials shall be classified under the following categories. The decision of the Engineer in respect of the classification of excavated materials shall be the final and binding upon the Contractor.

i. **Soft Soil**

It shall mean soft soil comprising any of the following:

a. Vegetable or organic soil, turf, sand, loam clay, mud, peat, black cotton soil, stiff heavy clay, shale, moorum and any mixture of these soil.

b. Mud concrete below ground level.

c. Generally any material which yields to the ordinary application of pick and shovel or other digging implements.

ii. **Hard Soil**

It shall mean hard soil comprising any of the following:

a. Gravel, shingle and river or stream bed boulders having maximum dimensions up to 300 mm in one direction.

b. Soling of roads, paths, etc. and hard core, macadam surfaces of any description (water bound, grouted, bituminous surface etc.)
c. Lime concrete, stone masonry in lime mortar and brick work in lime cement mortar below ground level.

d. Generally material which requires the close application of picks, scarifiers or other digging implement.

iii. Soft Rock

It shall mean rock comprising any of the following:

a. Lime stone, sand stone, late rite, soft conglomerate or other soft or disintegrated rock which can be quarried or split with crowbars or wedges.

b. Unreinforced Portland cement concrete which can be broken up with crowbars or picks; stone or brick masonry in cement mortar below ground level.

iv. Hard Rock

It shall mean rock comprising any of the following:

a. Any rock or Portland cement concrete for the excavation of which the use of pneumatic/mechanical equipment or blasting is required.

b. Reinforced cement concrete (reinforcement cut through, but not separated from the concrete) below ground level.

v. Hard Rock (Blasting Prohibited)

It shall mean rock comprising any of the above mentioned hard rock where blasting is prohibited.

4. EXPLOSIVES AND BLASTING

i. General

The procurement, transportation, storage, use, account and disposal of balance and defective explosive materials shall be strictly as per prevalent laws and ordinances applicable to the work site. Should there be any discrepancy found between procedures described hereunder and the prevalent laws and ordinance, the later shall supersede.

Blasting shall be carried out in a manner that completes the excavation to the lines indicated on the Drawing or as directed by the Engineer, with the least disturbance to adjacent material. It shall be done only with the written permission of the Engineer.
The Contractor shall adopt such method that is consistent with the safety and job requirements. Prior to starting any phase of the operation, the Contractor shall provide information describing pertinent blasting procedures, dimensions and notes.

ii. Material, Tools and Equipment

All the material, tools and equipment used for blasting operations shall be of approved type. The Engineer may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be water-resistant and shall remain unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as shall permit sufficient time to permit the firer to reach a safe place before explosion takes place. Detonators shall be capable for giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc., shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use. The damaged articles, if any, shall be discarded totally and removed from the site immediately.

iii. Personnel

The blasting operation shall remain in the charge of competent and experienced blaster with legal license and thorough knowledge of handling explosives and blasting operations.

iv. Blasting Operations

Explosives shall be used in the quantities and manner recommended by the manufacturers. The written permission of the Engineer shall be obtained for each location or series of locations where the Contractor wishes to use more than 5 kg of explosives in one series of blast. Such permission shall not any way relieve the Contractor of his liabilities under the Conditions of Contract.

The blasting shall be carried out during fixed hours of the day preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the blaster only. The Engineer must be notified at least 24 hours in advance on any blasting operation. When blasting is to be carried out, the Contractor shall determine the danger zone likely to be created, and shall ensure that all personnel, vehicles and livestock are clear of the zone before and during the blast. In settled areas, the Contractor shall take steps to avoid damage to property from flying rock by using blasting mats or other suitable blanketing materials.

The Contractor shall notify each public utility organization/company having structures in proximity to the site to the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury.
Danger red flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area, and all persons including workmen shall be excluded from the flagged area at least 10 minutes before the firing, a warning siren being sounded for the purpose.

The charge holes shall be drilled to required depths and at suitable places. Blasting shall be as light as possible consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshotting shall be discontinued. Not more than 10 charges shall be prepared and fired at a time. The man in charge shall blow a siren in a recognized manner for cautioning the people. The charges shall be lighted by the blasters only. The blaster shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workmen to go back to the work site.

After blasting operations, the Contractor shall compact the loose residual material removed below sub-grade and replace the material removed below sub-grade with suitable material.

When forming final cut faces, pre-split blasting techniques as recommended in the Specification for Road and Bridge (IRC) shall be carried out to ensure that blasting damaged to the cut face is minimized. Details of the pre-splitting technique to be used shall be notified to and approved by the Engineer at least 24 hours in advance of the blasting operation.

v. **Misfire**

In case of misfire, the following procedure shall be observed:

a. Sufficient time shall be allowed to account for the delayed blast. The blaster shall inspect all the charges and determine the missed charge.

b. If it is blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. Should it not blast the old charge, the procedure shall be repeated till the old charge is blasted.

c. In case of charges of gelignite, the blaster shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 30 mm of tamping and the direction then ascertained by placing a stick in the hole. Another hole may then be drilled 150 mm away and parallel to it. This hole shall then be charged and fired when the misfired hole should explode at the same time. The blaster shall at once report to the Contractor’s office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith.
If a misfire had been found to be due to defective detonator or gelignite/dynamite, the whole quantity in the box from which defective article was taken must be sent to the authority as directed by the Engineer for inspection to ascertain whether all or art of the remaining materials in the box are also defective.

vi. **Account**

A careful and day to day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer at all times. Records must be kept by the Contractor of all drilling and blasting operations showing holes diameters and depths, drilling pattern, explosive charge and type per hole, detonator delay times and total charge per blast. These records must be submitted to the Engineer on completion of charging.

5. **EXCAVATION IN CUTTING**

i. Cleaning and grubbing shall be performed as specified in Section I.

ii. While executing excavations, the Contractor shall take adequate precautions against soil erosion and water pollution.

iii. All suitable excavated materials shall be used in construction of the roadway to the extent as required.

iv. Hauling of material from cutting or borrow pits to embankments other areas of fill shall proceed only when plant or labour is operating at the place of deposition to ensure that adequate spreading and compaction of material can take place.

v. Over-excavation shall not be permitted. Any excess depth excavated below the formation levels as specified shall be made good by the Contractor at his own expense by backfilling with suitable material of similar characteristics to those of moved materials with compaction as specified in Clauses (9) and (10) of Section II.

vi. The slopes of cutting shall be cleared of all rock fragments which move when prised by a crowbar, unless otherwise directed by the Engineer. Where the Engineer considers that the slope, immediately after dressing, shall not be permanently stable, he shall direct the Contractor as to the stabilization measures required. The Contractor shall carry out these measures soon after Engineer’s instruction.

When completed, the excavation slopes shall be true to the lines and levels as shown on the Drawing or directed by the Engineer. When completed, no point on slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock, no point shall vary more than 300 mm from the designated slope.
vii. If slips, slides, over breaks or subsidence occur in cutting, they shall be removed. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction.

viii. If water is encountered in excavations due to seepage, springs, or other causes, it shall be removed by suitable diversions or bailing out and the excavation shall be kept dry. The drained water shall be discharged into suitable outlets as not to damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original condition at his own cost or compensate for the damage.

6. EXCAVATION BELOW EMBANKMENTS AND BELOW FORMATION LEVEL

i. Where any unsuitable material below the natural ground level under proposed embankments or below formation level in cutting is required to be excavated, it shall be removed to such depth and over such areas as shown on the Drawing or as directed by the Engineer. The excavated materials shall be disposed off as indicated on the Drawing or directed by the Engineer. The resultant excavation shall be backfilled with suitable material and shall be leveled and compacted to the density as specified for forming of the embankments.

Nevertheless, if such backfill has to be carried out in standing water, the Contractor shall use only an approved non-plastic well-graded granular material having maximum size of not greater than 75 mm. Such materials may be deposited in water without use of compaction equipment.

ii. Where shown on the Drawing, approved, graded stones having size from 380 mm to 150 mm and containing not more than 10 percent, below 150 mm in size shall be placed directly on the natural occurring unsuitable material. This type of rock fill material shall be deposited in accordance with the requirements of Clause 9 of Section II and compacted as per Clause 10 of Section II.

iii. If after the removal of material as specified in Sub-clause 6 (1) of Section II, the Contractor allows the materials so exposed to reach a condition where compaction of back filling is impracticable, he shall make good at his own expense either by additional excavation and filling in the manner specified in this Clause, or by waiting until the condition of the exposed material is fit to receive the approved backfill.

7. EXCAVATION FOR FOUNDATION

i. **Slope**

Excavation shall consist of the removal of material for the construction of foundations for drainage structures, retaining walls, head walls, cut off walls, culvert, bridges and other similar structures to the lines and dimensions.
shown on the Drawing or as instructed by the Engineer in accordance with the requirements of these specifications. The work shall include construction of the necessary cofferdams and cribs and subsequent removal of all necessary sheeting, shoring, bracing, diversion of water/flow, draining and pumping, the removal of all logs, stumps, grubs and other deleterious matters and obstructions necessary for placing the foundation; trimming bottoms of excavations; and cleaning up the site and the disposal of all surplus material.

ii. **Excavation**

Excavation shall be taken to the length and width of the lowest step of the footing and the sides shall be left to plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench does not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

The depth to which the excavation is to be carried out shall be as shown on the Drawing or as directed by the Engineer.

Where blasting is to be restored to, the same shall be carried out in accordance with Clause 4 of Section II.

iii. **Dewatering, Diversion of Flow and Protection**

Normally, open foundation shall be laid dry. Where water is encountered in excavation due to stream flow, seepage, spring, rain or other reasons, the Contractor shall take adequate measure such as bailing, pumping, constructing diversion channels, drainage channels, bunds, cofferdams and other necessary works to keep the foundation pit or trenches dry, when so required and to protect the green concrete/masonry against damage by erosion, failure of cut slope or sudden rising of water level. The methods to be adopted in this regard and other details thereof shall be left to the choice of the Contractor, but subject to approval of the Engineer. Approval of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

Where cofferdams are required, these shall be carried to adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for facilitating construction to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping equipment, etc., inside the enclosed area.

Cofferdam sheet-pilling shall be carried down well below the bottom of the pile caps or footings, but without interference with any bearing piles. Cofferdams shall be rigidly constructed and efficiently braced to withstand
external pressures when water is pumped out. Sheeting shall be reasonably watertight and all appreciable leaks encountered during the operations shall be stopped so that construction of pile caps can be carried out in the dry. The Contractor shall rectify any cofferdam which, for any reason, has moved, tilted, or changed its shape and/or size.

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping shall be permitted during the placing of concrete or for a period of at least 24 hours thereafter, unless it is done from a suitable sump and is separated from the concrete work by a watertight wall or other similar means.

At the discretion of the Contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the area of excavation.

The Contractor shall take all precautions in diverting flow and in discharging the drained water as not to cause damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original at his own cost or compensate for the damage.

iv. Preparation of Foundation Base

The bottom of the foundation pit shall be leveled both longitudinally and transversely or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed, if surface is not wet. In the event of excavation having been made deeper than that shown on the Drawing or as otherwise ordered by the Engineer, the extra depth shall be made up with concrete or masonry of the foundation grade at the cost of the Contractor. Ordinary filling shall not be allowed for the purpose to bring the foundation to level. When rock or other hard strata is encountered, it shall be freed of all soft and loose materials, cleaned and cut to firm surface either leveled or stepped as directed by the Engineer. All seams shall be cleaned out and filled with cement mortar or grout to the satisfaction of the Engineer. In the case of rock excavation, annular space around footing shall be filled with concrete of grade M 10 up to top level of rock.

After the excavation is completed, the Contractor shall inform the Engineer to that effect and no footing, bedding materials or structures shall be placed until the Engineer has approved the depth and the suitability of foundation material.

If, at any point, in any foundation excavation, material unsuitable for foundations is encountered, the Contractor shall, if so instructed by the Engineer, shall remove all such materials and refill with suitable materials thoroughly compacted by tamping or rolling in layers of not more than 150 mm thick each.

v. Slips and Blows
If there are any slips or blows in the excavation, these shall be removed by the Contractor at his own cost.

vi. Public Safety

Where required, trenches and foundations pits shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accident.

The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures.

vii. Removal of Cofferdams

All cofferdams with all temporary sheeting and bracing shall be removed by the Contractor after the completion of the substructure unit. The removal shall be carried out in such a manner as not to disturb or damage the finished concrete. However, sheet piling below the top of the pile caps may be left in place at the Contractor’s option and expenses.

No bracing no other material shall be left in cofferdam in such a way as to extend into the concrete of the structure.

Cofferdam located in embankments under the roadways shall be removed to an elevation at least 1.2 m below the subgrade. Those located in a stream or lake and within the limits of low water shall be removed to the elevation of the stream or lake bed, except that in established navigation channels, they shall be removed to an elevation at least 600 mm below the established bottom of the channel. Those located outside the above defined limits shall be removed to an elevation at least 600 mm below subgrade.

8. REFILING OF FOUNDATION PITS AND TRENCHES, REMOVAL OF SUPPORTS AND FILLING TO STRUCTURES

Refilling of foundation pits and trenches shall consist of previous backfill and/or common backfill as shown on the Drawing or as directed by the Engineer.

i. Materials

a. Pervious Backfill

Unless otherwise specified in the contract, it shall of gravel, crushed gravel, crushed rock, natural sands, manufactured sands or combinations thereof. It shall conform to the grading limits set out in Table 9.1.

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percentage Passing by Weight</th>
</tr>
</thead>
</table>

Table 9.1: Grading Limits of Pervious Backfill
b. **Common Backfill**

Common backfill materials other than pervious backfill shall be suitable material as defined in Sub-clause 2 (2) of Section II.

ii. **Method of Filling**

Backfilling material shall not be permitted under water unless specifically described in the contract or approved by the Engineer. It shall be placed and compacted in layers in compliance with the requirements of Clause 10 of Section II. Any support structures for the excavation shall be withdrawn as the filling proceeds unless described in the contract or ordered by the Engineer to be left in. The backfill shall be placed in by such methods which shall avoid loading the structure in any manner which may affect its stability or overload its underlying foundation material or substructure. The backfill in front of abutments and wing walls shall be placed first to avoid the possibility of forward movement. Precautions shall be taken to prevent any wedge action against upright surfaces, and the slopes bounding the excavation shall be stepped as directed by the Engineer before backfill is placed. The backfill material around box culverts, piers and curtain walls shall be placed simultaneously on both sides of the structure. When the structure is so designed that its strength is dependent on the restraining effect of the superstructure (such as in portal frames and propped abutments), the backfill shall not be placed until the superstructure has been completed to the extent and strength necessary to provide the required restraint. When the Contract requires wedges between steel superstructure and the parapet of wing type abutments, the wedges shall be placed in advance of placing any fill above the lower 1/3 of the abutment and shall be removed when directed by the Engineer.

9. **FORMING OF EMBANKMENT AND OTHERS AREAS OF FILL**

i. The work shall consist of the construction of embankment, filling on other areas and backfill not specified elsewhere by providing material as specified or approved by the Engineer, placing, compacting and shaping to lines, levels, grades and cross sections as shown on the Drawing or as directed by the Engineer. The maximum size of the coarse material in the mixture shall not exceed 75 mm for general earth fill.

ii. The limits of embankment shall be built sufficiently wider than the design dimension to facilitate in achieving required compaction near by outer faces of the embankment. The surplus material shall be trimmed to conform the specified side slopes and width of the embankment.
iii. Where necessary, the original ground shall be scarified, mixed with water, leveled and then compacted so as to achieve the density mentioned in Clause 10. Where the height of embankment, as measured from formation level to the original ground level, is less than 200 mm, the embankment foundation shall be compacted in accordance with the requirements of Clause 10 such that the required compaction is achieved within the upper 300 mm below formation level. Where necessary, embankment foundations shall be excavated/furrowed and brought under OMC and re-compacted in layers of 150 mm each in order to achieve the required level of compaction.

iv. Embankments shall be built up evenly over the entire width and shall be maintained at all times with a sufficient camber to enable surface water to drain rapidly from them. Damage to compacted layers by constructional or other traffic shall be made good by the Contractor.

v. The natural moisture content and the optimum moisture content of the material to be placed in the embankment shall be checked before start of the placing material. If found to be out of the specified limits, the same shall be made good. Where water is required to be added in such constructions, water shall be sprinkled uniformly and thoroughly mixed in soil by blading or harrowing until a uniform moisture content as specified is obtained.

Moisture content, checked in accordance with IS 2720 (Part 2), at the time of compaction shall be between 90% and 105% of the Optimum Moisture Content as determined in accordance with IS 2720 (Part 8).

If the material delivered for fill/backfill is too wet, it shall be dried by aeration and exposure to sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced by the above procedure, compaction work shall be suspended.

If the material deposited as fill subsequently reaches a condition such that it cannot be compacted in accordance with the requirements of the specifications the Contractor shall

(i) Make good by removing the material off the embankment and placing suitable material; or

(ii) Make good by tipping it elsewhere until it is in a suitable physical condition for re-use; or

(iii) Make good the material by mechanical or chemical means to improve it’s properties acceptable to the Engineer.

vi. Where fill is required to be constructed across water logged or soft clayey ground that displays excessive movement under normal constructional equipment, it may be necessary to construct a capping layer.
vii. Rock use in rock fill embankments shall be deposited in horizontal layers not exceeding 450 mm each extending up to the full width of the embankment. Material shall be spread, leveled and compacted in accordance with Clause 10 of Section II. Each layer shall consist of reasonably graded rock and all surface voids shall be filled with broken fragments before the next layer is placed. The top surface and side slopes of embankments so formed shall be thoroughly blinded with approved well graded material to seal the surface.

viii. Isolated boulders each within the range of 0.05 cubic meters in size may be incorporated in embankments, not of rock fill, at the discretion of the Engineer provided that the specified compaction requirements are met and it shall not be placed less than 1 m below formation level of carriageways or shoulders.

ix. While filling embankment up to or over culverts or pipe drains, and where required in the contract, up to bridges, the Contractor shall bring the embankments up equally on both sides. In rock fill embankments the rock shall be carefully packed for such distance form the structure as is described in the contract.

Where provision of filter membrane is specified behind structures, the same shall be laid in layers simultaneously with the laying of fill material.

x. If the Contractor wishes to continue to use the surface of embankments including shallow filling for constructional traffic before trimming to formation level, he shall bring up and maintain the area between the extremities of the carriageway including (if any) central reserve and hard shoulders to a level not less than 150 mm above formation level whereupon constructional traffic shall be allowed to use the surface and shall be made good by the Contractor at his own expense. When it is necessary to complete the formation level and this has been done, the movement and use of construction equipment thereon shall be in accordance general standard practice.

10. COMPACTION OF EMBANKMENT AND OTHER AREAS OF FILL/BACKFILL

i. The Contractor shall obtain the Engineer approval of all fill layers before covering with subsequent layers.

ii. All fill shall be compacted to the depth and degree of compaction as specified in Table 9.2 or as shown on the Drawing. This requirement applies whether the specified zone is in fill or in existing ground, except for any part which may fall within rock or rockfill. Formation level if this context shall mean top of subgrade.

Table 9.2: Compaction Requirements
### Section VI E – Specification of Civil Works

#### IV E-21

### Bidding Document for ICB - THPPRP-072/73-01 Procurement of Plant Single-Stage: Two-Envelope

### Tinau HPP Rehabilitation Project

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth below Formation Level (mm)</th>
<th>Minimum Compaction (% MDD Heavy Compaction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Embankment</td>
<td>0-300</td>
<td>95</td>
</tr>
<tr>
<td>Roadway Cut</td>
<td>0-300</td>
<td>95</td>
</tr>
<tr>
<td>All other roadway fill and backfill not separately specified</td>
<td>-</td>
<td>93</td>
</tr>
</tbody>
</table>

### iii. Each layer of rock used to fill in embankments shall be spread and leveled in accordance with Sub-clause 9 (7) of Section II and systematically compacted.

### iv. Layers of material other than rockfill shall not exceed 150 mm compacted depth unless and until the Contractor can demonstrate to the satisfaction of the Engineer that he can successfully Compact layers of a greater thickness.

### v. Each layer shall be constructed in lengths suitable to the compaction and working methods used. Materials of each layer shall be thoroughly mixed with water as necessary to facilitate its compaction to the specified density.

### vi. In cut areas, the subgrade shall be processed as necessary and compacted to the depth and compaction requirements as given in Table 9.2. In the event that the Contractor is unable to achieve the minimum compaction requirements below formation level he shall excavate and recompact in layer as necessary.

### vii. Where it may be impracticable to use to conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory rollers, power rammers or plate compactor. Care shall be taken to ensure that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to it.

### 11. COMPACTION TRIALS

### i. Before commencing filling embankment and from time to time as may be considered necessary by the Engineer, the Contractor shall carry out compaction trials in the presence of the Engineer on each of the main types of soil and rockfill to be used and compacted in the Works. He shall carry out all necessary laboratory and field testing as required by the Engineer and shall submit to the Engineer the results of all tests. The trial procedure shall include the compaction of trial areas selected by the Engineer. The surface of each area shall first be well compacted to the satisfaction of the Engineer. Each type of material being used shall be compacted in equal layers at
uniform but differing moisture contents to a predetermined number of passes using the Contractor’s proposed compaction equipment.

ii. Following completion of the compaction trials, the Contractor shall submit to the Engineer, for his approval, his proposals for the compaction of each type of material to be encountered in the Works and its degree of compaction specified. The Contractor’s proposals shall include reference to the types of equipment, the operating weights and type pressure, the methods of adjusting the moisture content, the number of passes and the loose depth of each layer.

iii. If, in the opinion of the Engineer, the results of the compaction trials indicate that the Contractor’s proposed plant and methods shall achieve the densities as specified, the Engineer shall approve the same. Otherwise the Contractor shall submit, in writing, proposals for modifying the plant and/or methods and shall, if the Engineer so requires, compact further trial areas in accordance with these modified proposals until the Engineer approves of Contractor’s proposals.

iv. When compaction of earthworks is in progress, the Contractor shall adhere to the compaction procedure approved by the Engineer.

v. Notwithstanding the Engineer’s approval of any of the Contractor’s plant or methods, the Contractor shall at all times be solely responsible for executing the earthworks in accordance with the Specifications and the Drawing.

12. BENCHING

i. Where embankment are to be constructed on hill slopes or slopes with more than or equal to 1 vertical to 4 horizontal slopes, benches with vertical and horizontal faces shall be cut into the existing slope (including rock) and the embankment shall be built up in successive layers. Where the cross slope is less than 1 vertical to 4 horizontal slope (other than rock) shall be loosened by scarifying to a depth of not less than 100 mm measured perpendicular to the slope, to ensure a good bond between the embankment and the embankment foundation. Material which has been loosened shall be covered with the first layer and compacted to the specified density simultaneously with the first layer of embankment material placed.

ii. Where existing embankment are to be widened or included in a new embankment and slopes are not more than 1 vertical to 4 horizontal, the slope of the existing embankment shall be scarified to a depth of not less than 100 mm to ensure bond. Where the slope is less than 1 vertical to 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut in existing slopes and the widened embankment shall be built up in successive layers of thickness of 150 mm to the level of old road.

Where the width of the widened portions is insufficient to permit the use of heavy rollers, compaction to the specified density shall be carried out with
13. EARTHWORKS TO BE KEPT FREE OF WATER

By providing temporary water course, ditches, drains, pumping or other means the Contractor shall arrange for the rapid dispersal of water from the areas of earthworks. Where practicable the water shall be discharged into permanent outfall for the drainage system. Adequate means for trapping silt shall be provided on temporary systems while discharging into permanent drainage systems.

14. WATERCOURSES

Excavations carried out in the diversion, enlargement, deepening or straightening of watercourses shall include the operations of any necessary trimming of slopes, grading of beds, disposal of excavated materials and pumping, tampering works and materials necessary for dealing with the flow of water.

15. FILLING EXISTING WATERCOURSES

Where watercourses have to be diverted from the sites of embankments or other works, the original channels shall be cleared of all vegetable growths and soft deposits and filled in with suitable materials deposited and compacted as specified in Clauses 9 and 10.

16. PROCESS CONTROL

i. Throughout the works the Contractor shall perform tests to determine the suitability and compaction characteristics of soils to be used in roadway. The compaction test shall be conducted in accordance with IS 2720 Part 8 in every 1500 cubic metre of fill material and every change in material type. The moisture content test shall be conducted in accordance with IS 2720 Part 2 in every 250 cubic metre of material.

ii. In addition to the foregoing tests, the Contractor shall carry out field density tests on the compacted fill materials in accordance with IS 2720 part 28/29. At least one set of density determination consisting of three tests per 500 square metres (or any lesser area) shall be carried out in each layer, including original ground surface on which embankment is to be constructed. If the result of any test shows that the minimum specified density has not been achieved, further compaction shall be executed to the area concerned and the layer re-tested. Unless the test results are satisfactory, the addition of another layer shall not be allowed.

iii. The Contractor shall carry out tests for determination of moisture content at frequent intervals on all materials during the course of compaction as per the help of small vibratory roller/plate compactor/rammer or other approved methods.
Sub-clause 909 (5) to ensure that the requirements of Clause 10 are met with.

17. MEASUREMNT

i. The quantities of the various classes of earthwork to be measured for payment under the contract shall be limited to the lines, grades, slopes and dimensions shown on the Drawing or as determined by the Engineer.

ii. Except for foundation, all roadway excavation including side drains, filling and backfilling compacted in place shall be measured in cubic metres by the average end area method as computed from the original and final cross-sections of the completed work. The distance between two end areas shall be the distance measured along central line of the road. Where due to changed conditions, or the nature of a particular operation, or for any other reason, it is impossible or impractical to measure the quantities by means of average end areas, the Engineer shall compute the quantities by a volumetric method, if in his opinion, it is the best suited method to obtain an accurate determination.

No separate measurement for payment shall be made for excavation made on borrow, quarries, temporary works or in places outside the scope of permanent works specified in the contract.

Foundation excavation for structures shall be measured in cubic metres irrespective of all classes of materials except rock encountered. The quantities to be measured shall be the net cubic content of the voids formed by the removal of the materials enclosed between the bottom of the footing and existing ground level by a surface generated by vertical lines passing through the periphery of the bottom of the footing. No payment shall be made for any excavation other than the limited excavation described above. Excavation over increased width or length, cutting of slopes, removal of slides, shoring, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid for. Backfill to be measured shall be limited to this void only with due consideration of the nature of the structure.

Foundation excavation in rock shall be deemed to be covered by the rate for rock excavation.

iii. Consumption of explosive materials, leveling, watering and compaction of original ground, construction of coffer dams, pumping out water and other ancillary and incidental works necessary to complete the item as per this specification shall not be measured for payment. They are deemed included in the measurement of the concerned item.

iv. If the excavated materials are disposed beyond 10 m length and more than 1.5 m height form the place of excavation and if filling materials are brought from beyond 10 m and/or 1.5 m below the place of filling, additional leads and lift shall be measured separately for payment. However initial lead of
10 m and lift of 1.5 m shall not be measured separately. They are deemed included in the measurement of the item itself. However, the measurement of foundation excavation shall be inclusive of all leads and lifts (i.e. no separate leads and lifts shall be measured in foundation excavation).

The measurement of leads and lifts shall be based on mass diagram of the haulage wherever applicable. All leads and lifts shall be measured as per the contract. If the material obtained from roadway excavation is used fully or partially in roadway filling, the quantities for roadway excavation and roadway filling shall be computed as below.

The quantities of roadway excavation and roadway filling of the distances under reference shall be calculated separately adopting the method described as above in this Section. The computed quantity of roadway filling shall be measured in roadway filling while difference between quantities of roadway excavation and filling shall be measured in roadway excavation. The same excavated material shall not be measured both in roadway excavation and roadway filling.

18. PAYMENT

i. Various classes of earthworks i.e. roadway excavation, roadway filling, backfilling, additional leads and lifts measured as described above shall be paid at contract unit rate of the respective item.

The contract unit rates shall be the full and the final compensation to the Contractor and for the cost of:

(i) Arrangement of land as source of materials as much as needed.

(ii) Process Control tests.

(iii) Execution of all relevant operations described above in this Section and necessary to complete the item as per this specification.

ii. Foundation excavation for structures, measured as described above, shall be paid for at the contract unit rate for all classes of excavation. The contract unit rate for foundation excavation shall be the full and the final compensation to the Contractor and for the cost of carrying out the required operations to excavate to the lines and levels as required by the Drawing or as directed by the Engineer. No payment shall be made for the disposal of the excavated materials irrespective of all leads and lifts, preparation of foundation base, cofferdams, cribs, sheeting, shoring and bracing, foundation sealing, dewatering including pumping, removal of logs and stumps, cleaning and grubbing, diversion of flow/channel, if required and all incidentals works necessary to complete the item in accordance with this Specification.
SECTION III – MATERIALS AND TESTING OF MATERIALS

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.

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.

3. SOURCES OF MATERIALS

The use of any 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.

4. INSPECTION AND ACCEPTANCE OF MATERIAL
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.

5. MATERIALS AND MANUFACTURED ARTICLES

(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.

(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.

(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.

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. 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:

(1) 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.

(2) 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.

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 form 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:

(1) 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.

(2) 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.

(3) The Contractor shall advise the Engineer, in writing, at least 20 calendar days in advance of the actual start of any such foreign fabrication.

(4) 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.

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 6.2: Soils and Materials Identification and Utilisation

**UTILISATION CONDITIONS Provided Compliance with the Specification and Special Specification**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>SYMBOL</th>
<th>TYPES</th>
<th>CHARACTERISATION PROCEDURES</th>
<th>SUBGRADE</th>
<th>CAPPING LAYER</th>
<th>GRAVEL Wearing Course</th>
<th>SUBBASE</th>
<th>BASE</th>
<th>SURFACING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedimentary Rock</td>
<td>R1</td>
<td>Lime stone</td>
<td>ACCORDING TO MATERIAL</td>
<td>SUITABLE provided compliance with the Specification for quality, grading &amp; construction</td>
<td>SUITABLE provided compliance with the Specification</td>
<td>SUITABLE as Graded Crushed Stones (GCS)</td>
<td>SUITABLE as GCS Class D2</td>
<td>SUITABLE as GCS Class C1, B</td>
<td>SUITABLE as GCS Class A, B, (CI seal coat)</td>
</tr>
<tr>
<td>R2</td>
<td>Dolomite</td>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>Argillious Rocks</td>
<td>Classes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>Siliceous Rocks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnatic &amp; Metamorphic Rock</td>
<td>R5</td>
<td>Fine grains</td>
<td>ACCORDING TO MATERIAL</td>
<td></td>
<td></td>
<td>SUITABLE d6 as GCS depending on Quality, Grading, (Specification)</td>
<td>SUITABLE as GCS Class D2</td>
<td>SUITABLE as GCS Class C1, B</td>
<td>SUITABLE AS GCS Class A, B</td>
</tr>
<tr>
<td>R6</td>
<td>LARGE GRAINS ROCKS</td>
<td>QUALITY CLASSES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROCK FALL COARSE</td>
<td>RF 1</td>
<td>Blocks</td>
<td>BLOCKS SIZE &gt; 0.3 m3</td>
<td></td>
<td></td>
<td>* Embankments : Not to be placed within 600mm of the formation level. * Cuttings : to be removed from the subgrade (300mm deep)</td>
<td>SUITABLE after processing for Size reduction</td>
<td>After processing for size reduction</td>
<td>After selection, processing for size reduction</td>
</tr>
<tr>
<td>ALLUV. MATER</td>
<td>RF 2</td>
<td>Blocks</td>
<td>BLOCKS SIZE &lt; 0.3 m3</td>
<td></td>
<td></td>
<td>Blocks &gt; 0.05 m3 not to be placed within 450mm the formation level</td>
<td>SUITABLE after processing for Size reduction</td>
<td>After processing for size reduction</td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td>GW</td>
<td>Well graded gravel</td>
<td>According to Soils &amp; Gravels Testing procedures</td>
<td>if CBR &gt; 5,</td>
<td>if CBR &gt; 15,</td>
<td>if CBR &gt;20</td>
<td>if CBR &gt;30</td>
<td>if CBR &gt;80</td>
<td>SUITABLE for Bituminous Mixes according to Specification</td>
</tr>
<tr>
<td>O</td>
<td>Poorly graded gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>Silty Gravel</td>
<td>d6</td>
<td>if CBR &gt; 5,</td>
<td>if CBR &gt; 15,</td>
<td>if CBR &gt;20</td>
<td>if CBR &gt;30</td>
<td>if CBR &gt;80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>Clayey gravel</td>
<td>d6</td>
<td>if CBR &gt; 5,</td>
<td>if CBR &gt; 15,</td>
<td>if CBR &gt;20</td>
<td>if CBR &gt;30</td>
<td>if CBR &gt;80 &amp; PI &lt;15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>SW</td>
<td>Well graded sand</td>
<td>d6</td>
<td>if CBR &gt; 5,</td>
<td>if CBR &gt; 15,</td>
<td></td>
<td></td>
<td></td>
<td>Sand seal 0/10 Sharry Seal</td>
</tr>
<tr>
<td>SM</td>
<td>Silty Sand</td>
<td>d6</td>
<td>if CBR &gt; 5</td>
<td>if CBR &gt; 15,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>Clayey Sand</td>
<td>d6</td>
<td>if CBR &gt; 5</td>
<td>if CBR &gt; 15,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Grained Soils</td>
<td>ML</td>
<td>Low Plasticity Silt</td>
<td>d6</td>
<td>if CBR&gt;5 or Mechanical Stabilisation</td>
<td></td>
<td>UNSuitable unless blended with coarse materials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CL</td>
<td>Low Plasticity Clay</td>
<td>d6</td>
<td>if CBR&gt;5 or Mechanical Stabilisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OL</td>
<td>Organic Silt &amp; Clay</td>
<td>d6</td>
<td></td>
<td>UNSuitable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MH</td>
<td>High Plasticity Silt</td>
<td>d6</td>
<td></td>
<td>Mechanical Stabilisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH</td>
<td>High Plasticity Clay</td>
<td>d6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bidding Document for ICB - THPPRP-072/73-01
Procurement of Plant
Tinu HPP Rehabilitation Project
Single-Stage: Two-Envelope
### Table 6.3: Classes of Material Quality

<table>
<thead>
<tr>
<th>MATERIAL CLASSES</th>
<th>LAA A/V</th>
<th>A/V ACV</th>
<th>SSS Test</th>
<th>Degradability Test</th>
<th>Flakiness Index</th>
<th>Crushing Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;25</td>
<td>&lt;20</td>
<td>&lt;12</td>
<td>&lt;5</td>
<td>&lt;20</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>&lt;30</td>
<td>&lt;20</td>
<td>&lt;12</td>
<td>&lt;5</td>
<td>&lt;25</td>
<td>100</td>
</tr>
<tr>
<td>C</td>
<td>&lt;35</td>
<td>&lt;25</td>
<td>&lt;12</td>
<td>&lt;5</td>
<td>&lt;25</td>
<td>80</td>
</tr>
<tr>
<td>C1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2*</td>
<td>&lt;30</td>
<td>&lt;20</td>
<td>&lt;12</td>
<td>&lt;5</td>
<td>&lt;25</td>
<td>-</td>
</tr>
<tr>
<td>D</td>
<td>&lt;40</td>
<td>&lt;30</td>
<td>&lt;12</td>
<td>&lt;5</td>
<td>&lt;30</td>
<td>60</td>
</tr>
<tr>
<td>D1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>&lt;35</td>
<td>&lt;20</td>
<td>&lt;12</td>
<td>&lt;5</td>
<td>&lt;30</td>
<td>-</td>
</tr>
<tr>
<td>E</td>
<td>&gt;35 &amp; &lt;50</td>
<td>&lt;25</td>
<td>&lt;18</td>
<td>&lt;10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>E1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E2</td>
<td>&gt;40 &amp; &lt;50</td>
<td>&lt;30</td>
<td>&lt;18</td>
<td>&lt;10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>E3</td>
<td>&gt;50</td>
<td>&lt;30</td>
<td>&lt;18</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(1): Criteria to be applied to crushed materials only.
* Classes for rounded materials only.

### 10. DEFINITION OF GENERAL TYPES OF MATERIALS

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

1. **“Topsoil”** shall mean the top layer of soil that can support vegetation. It shall include all turf acceptable for turfin.

2. **“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.

3. **“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.
(4) “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.

(5) “Well Graded Granular Material” Consisting of gravel and/or sand shall conform to Clause 9.

(6) “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.

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

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

12. SOIL AND GRAVELS

(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:

(a) The mass (in g) of a sample required for sieve analysis is about 400D, D being the maximum particle size (mm)

(b) 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 19 mm 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.
(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 6.4: Tests Procedures Applicable to disturbed/Undistributed Samples of Soils and Gravels

<table>
<thead>
<tr>
<th>Test procedure</th>
<th>Test procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determination of:</td>
<td>Test procedure</td>
</tr>
<tr>
<td>i) Moisture</td>
<td>IS 2720 Part 2 (Oven-drying method)</td>
</tr>
<tr>
<td>ii) Liquid Limit</td>
<td>IS 2720 Part 5 (Cone Penetrometer or by Casagrande apparatus)</td>
</tr>
<tr>
<td>iii) Plastic Limit</td>
<td>IS 2720 Part 5</td>
</tr>
<tr>
<td>iv) Plasticity Index</td>
<td>IS 2720 Part 5</td>
</tr>
<tr>
<td>v) Linear Shrinkage</td>
<td>IS 2720 Part 20</td>
</tr>
<tr>
<td>vi) Specific Gravity of Particles</td>
<td>IS 2720 Part 3</td>
</tr>
<tr>
<td>vii) Particles Size Distribution</td>
<td>IS 2720 Part 4</td>
</tr>
<tr>
<td>viii) Organic Matter content</td>
<td>IS 2720 Part 22</td>
</tr>
<tr>
<td>ix) Total Sulphate Content</td>
<td>IS 2720 Part 27</td>
</tr>
<tr>
<td>x) pH Value</td>
<td>IS 2720 Part 26 (Electrometric Method)</td>
</tr>
<tr>
<td>xi) Mica Content</td>
<td>Manual mineralogical counting</td>
</tr>
<tr>
<td>xii) Density - Moisture Content relationship (2.5 kg rammer)</td>
<td>IS 2720 Part 7</td>
</tr>
<tr>
<td>xiii) Density - Moisture Content relationship (4.9 kg rammer)</td>
<td>IS 2720 Part 8</td>
</tr>
<tr>
<td>xiv) California Bearing Ratio</td>
<td>IS 2720 Part 16</td>
</tr>
<tr>
<td>xv) Sand Equivalent</td>
<td>IS 2720 Part 37 (Mechanical Shaker or Manual Shaker Method)</td>
</tr>
<tr>
<td>xvi) Field Dry Density</td>
<td>IS 2720 Part 28/Part 29</td>
</tr>
<tr>
<td>xvii) Unconfined compression test</td>
<td>IS 2720 Part 10</td>
</tr>
<tr>
<td>xviii) Unconfined compression test</td>
<td>IS 2720 Part 15</td>
</tr>
<tr>
<td>xix) Direct shear test</td>
<td>IS 2720 Part 13</td>
</tr>
<tr>
<td>xx) Triaxial test</td>
<td>IS 2720 Part 11, 12</td>
</tr>
<tr>
<td>xxi) Hydrometer analysis</td>
<td>IS 2720 Part 4</td>
</tr>
<tr>
<td>xxii) Vane shear test</td>
<td>IS 2720 Part 30</td>
</tr>
</tbody>
</table>

It is further specified that:

(a) 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 change d in which case the samples for the tests shall be taken after all compaction is complete.
(b) Compaction tests: when the material is susceptible to crushing during compaction, a separate and new sample shall be sued in the determination each point on the moisture/density curve.

(c) 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.

13. STONE, AGGREGATE, SAND AND FILLERS

(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.

(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 6.5: Test Procedures Applicable to Stone Aggregate and Fillers

<table>
<thead>
<tr>
<th>Tests</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determination of:</td>
<td></td>
</tr>
<tr>
<td>i) Particle Size Distribution</td>
<td>IS 2386 Part 1</td>
</tr>
<tr>
<td>(Gradation)</td>
<td></td>
</tr>
<tr>
<td>ii) Clay, Silt, Dust in Aggregates</td>
<td>IS 2386 Part 1</td>
</tr>
<tr>
<td>iii) Flakiness Index</td>
<td>IS 2386 Part 3</td>
</tr>
<tr>
<td>iv) Specific Gravity</td>
<td>IS 2386 Part 3</td>
</tr>
<tr>
<td>v) Moisture Content</td>
<td>IS 2386 Part 3</td>
</tr>
<tr>
<td>vi) Bulk Density, Voids &amp; Bulking</td>
<td>IS 2386 Part 117</td>
</tr>
<tr>
<td>vii) Soluble Chloride Content</td>
<td>BS 812</td>
</tr>
<tr>
<td>viii) Mica Content</td>
<td>Manual mineralogical Counting</td>
</tr>
<tr>
<td>ix) Water Absorption</td>
<td>IS 2386 Part 3</td>
</tr>
<tr>
<td>x) Crushing Ratio</td>
<td>Manual counting &amp; weighing</td>
</tr>
<tr>
<td>xi) Los Angeles Abrasion</td>
<td>IS 2386 Part 4</td>
</tr>
<tr>
<td>xii) AIV-ACV</td>
<td>IS 2386 Part 4</td>
</tr>
</tbody>
</table>
### 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 Pozzolana 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>
<thead>
<tr>
<th>S.N.</th>
<th>Physical Characteristics</th>
<th>OPC/PSC</th>
<th>HSPC</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Finess, m²/kg: (by Blaine’s Air Permeability method)</td>
<td>225</td>
<td>225</td>
<td>IS 4031 Part 2</td>
</tr>
<tr>
<td>ii)</td>
<td>Setting Time: (a) Minimum Initial Setting Time (minutes)</td>
<td>45</td>
<td>45</td>
<td>IS 4031 Part 5</td>
</tr>
<tr>
<td></td>
<td>(b) Maximum Final Setting Time (minutes)</td>
<td>600</td>
<td>600</td>
<td>IS 4031 Part 5</td>
</tr>
<tr>
<td>iii)</td>
<td>Soundness by Lechatelier Method, mm, maximum</td>
<td>10</td>
<td>10</td>
<td>IS 4031 Part 3</td>
</tr>
<tr>
<td>iv)</td>
<td>Compressive Strength: Minimum average Compressive Strength of three mortar cube (N/mm²)</td>
<td></td>
<td></td>
<td>IS 4031 Part 6</td>
</tr>
<tr>
<td></td>
<td>(a) 3 days</td>
<td>16</td>
<td>27</td>
<td>IS 4031 Part 6</td>
</tr>
<tr>
<td></td>
<td>(b) 7 days</td>
<td>22</td>
<td>37</td>
<td>IS 4031 Part 6</td>
</tr>
<tr>
<td></td>
<td>(c) 28 days</td>
<td>33</td>
<td>53</td>
<td>IS 4031 Part 6</td>
</tr>
</tbody>
</table>

---

**Table 6.6: Requirement on the Physical Characteristics of Cement**
15. **CONCRETE**

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

**Table 6.9 Tests Procedures Applicable to Concrete**

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

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

**Table 6.10: Non-destructive Tests Applicable to Concrete**

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

The test specimens shall be cured at a temperature of 27° C ± 2° 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\textsubscript{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.

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.

17. TESTING OF WELDS

(1) 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 form 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 result 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.

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 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.

19. BRICKS

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

20. MORTAR

Mortar shall comply with relevant clauses of Section V.

21. REINFORCED CONCRETE PIPES

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

22. HIGH DENSITY POLYTHENE PIPES

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

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.

24. TIMBER FOR STRUCTURAL WORKS

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

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.

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.

27. PRECAST CONCRETE CHANNELS

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

28. CAST IRON DRAINAGE GRATINGS

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

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).

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.
SECTION IV- CONCRETE WORK

1.1. Scope of work

These Specifications apply to all works and materials in connection with the concrete in the structure which the Contractor shall provide for the fulfilment of his obligations. Prior to the commencement of concreting, necessary investigations in establishing the most favourable mixes will be made by the Engineer. The Contractor shall cooperate with the Engineer for the performance of all tests and investigations.

Unless specifically provided in the Specifications, concrete shall be manufactured, transported, placed cured, finished, and tested by the Contractor in accordance with the provisions of JIS, AASHOTO or other equivalent standards approved by the Engineer.

The Contractor shall cooperate with all other contractor, whether mentioned or not in the Contract, in permitting the forming and setting of blockouts, slots, recesses, chases, sleeves, inserts, bolts, hangers, etc.

1.2. DEFINITIONS

Structural concrete is any class of concrete which is used in reinforced, pre-stressed or unreinforced concrete construction which is subject to stress.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling foundations and similar purpose where it is not subjected to significant stress.

A pour refers to the operation of placing concrete into any mould, bay or formwork, etc. and also to the volume which has to be filled. Pours in vertical succession are referred to as lifts.

1.3. Materials

(1) Cement

Cement for concrete and mortar shall be furnished by the Contractor. Unless otherwise specially provided, cement to be furnished shall conform to the requirements of JIS R 5210-79, AASHTO-N85 or approved equivalent, ordinary Portland cement.

The use of other cement shall be subject to the approval of the Engineer, and the Contractor shall store them separately and take all precautions in its use including the investigation of the suitability of methods, equipment, aggregates and other ingredients to be employed with them.
Cement shall be delivered in the manufacturer's bags or in bulk. Each consignment shall be sampled at the mill and shall be accompanied by a test certificate issued by the manufacturer in quadruplicate. The Engineer will have the right to attend the sampling and testing at the mill any time. If delivery is not directed from the factory, the intermediate storage and delivery arrangements shall be subject to the approval of the Engineer.

If cement is damaged during consignment, handling or storage, it shall be promptly removed from the site of the work.

Cement bags shall be stored in weatherproof buildings with a raised well ventilated wooden floor, and placed so that each consignment can be separated if required and used in order of its age. Cement shall not be stored outdoor, except for immediate use and shall be protected during storage and handling by waterproof covers and a raised floor. Unused cement must be placed in the store buildings. Bags shall not be stacked more than 1.50 m high. Storage shall be provided at the site or the point of delivery for a sufficient quantity of cement to permit execution of the Work without delay. Storage of cement shall be limited to 90 days in bags and 180 days in bulk.

The use of cement in bulk shall be subject to the Engineer's approval of the source, method of transport, method of unloading and storing the cement on site, and arrangements for delivering the cement to the mixer.

The Contractor shall keep and make available to the representative of the Engineer a record of the date, amount, and storage location of each delivery of cement and of the location in which it was used. He shall also similarly make available a record of the daily use of cement and of the stockpile from which it was drawn so as to show the stock of cement at all times, and he shall provide facilities for checking the stock of cement when required.

It is explicitly understood that the Contractor is solely responsible for the ample supply of cement meeting the requirements of the Specifications and no delay due to the lack of suitable cement will give the Contractor any rights for an extension of completion dates, or a claim resulting therefrom.

(2) Aggregates

a. Sources

Aggregates shall consist of hard, durable, clean minerals, naturally occurring or manufactured, and must not contain substances which may impair the quality of the concrete, or may attack reinforcing steel, or reduce bond.

The Contractor shall produce concrete aggregate from the sand and gravel deposits, and required excavation areas shown on the Drawings or other sources approved by the Engineer at the request of the Contractor.
Processing raw materials shall include crushing, screening, and washing to produce fine and coarse aggregate meeting requirement of the specified grading. The fine and coarse aggregate shall be handled so that segregation and breakage will be minimized and aggregate will not be contaminated with soil or other foreign materials.

The following tests shall be carried out in accordance with the respective standards or approved equivalent standards using samples taken from the stockpiles:

### Fine aggregate

- **Grading**: JIS A 1102
- **Specified gravity**: JIS A 1109/T84 (ASTM C128)
- **Unit weight**: JIS A 1104/T121 (ASTM C138)
- **Washing**: JIS A 1103
- **Moisture content**: JIS A 1111
- **Organic impurity**: JIS A 1105

### Coarse aggregate

- **Grading**: JIS A 1102
- **Specified gravity**: JIS A 1110
- **Unit weight**: JIS A 1104/T121 (ASTM C138)
- **Washing**: JIS A 1103
- **Soft particles**: JIS A 1125

When required, fines shall be removed from the coarse aggregate by adequate washing. The shape of the particles in the fine aggregate and in the coarse aggregate shall be generally spherical or cubical. The Contractor shall eliminate soft particles from all aggregate to the degree that the percentage of soft particles present in the processed coarse aggregate shall not exceed 5.0 percent by weight. The sum of the percentages of all deleterious substances in the fine aggregate shall not exceed 5.0 percent by weight. In order to minimize variation in consistency and workability of the concrete, the uniformity of proportions of crushed gravel to natural gravel in any one size group of coarse aggregate shall be maintained relatively constant.

b. **Fine aggregate**

Fine aggregate shall be clean, hard, solid, durable and of proper grading, and it shall be free from dirt, mud, silt, organic matter or other deleterious materials. Fine aggregate, as batched, shall be well graded to conform to the following limits:

<table>
<thead>
<tr>
<th>Sieve designation</th>
<th>Retained on permissible limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean opening</td>
<td>Minimum</td>
</tr>
<tr>
<td>(mm)</td>
<td></td>
</tr>
</tbody>
</table>
The grading of sand shall be controlled so that the fineness modulus of at least 9 out of 10 consecutive test samples of finished sand, when samples are taken hourly, will not vary more than 0.2 from the average of fineness modulus of the 100 test samples.

c. Coarse aggregate

Coarse aggregate shall consist of solid, uncoated rock fragments, clean, hard, durable and free from objectionable quantities of flat or elongated particles, organic matter or other deleterious material.

Unless otherwise approved or directed by the Engineer, the coarse aggregate shall be separated into nominal sizes and graded as follows:

<table>
<thead>
<tr>
<th>Designation of max. size (mm)</th>
<th>Nominal size (mm)</th>
<th>Percent by weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 - 20</td>
<td>20 - 10</td>
</tr>
<tr>
<td>40</td>
<td>55 - 40</td>
<td>35 - 30</td>
</tr>
<tr>
<td>20</td>
<td>-</td>
<td>70 - 30</td>
</tr>
</tbody>
</table>

The maximum size aggregate permitted is 1/5 of the smallest dimension between the sides of forms (or surfaces) of the concrete member, or 3/5 of the minimum clear spacing between reinforcing bars or 1/3 the depth of slab.

d. Storage

Aggregate shall be delivered, stored and handled so as to avoid mixing of different sizes, segregation in a particular size, breakage, contamination with deleterious matter and retention of water. The aggregate shall be stored with free draining condition for at least 48 hours before use and fine aggregate shall not be drawn from the bottom 50 cm of the stockpile. Provision shall be made for suitable equipment to effect spraying or sprinkling of aggregate some periods. All storage facilities shall be subject to the approval of the Engineer and shall be such as to permit easy access for identification and inspection.
Sufficient aggregate shall be maintained at the site at all times to assure continuous placement of concrete at a rate consistent with the requirements of the approved concreting schedule. Loading and unloading facilities for stockpiling aggregate shall be referred to equipment other than wheeled or track-type vehicles, unless otherwise approved by the Engineer.

If the aggregate is stockpiled on the ground, the sites of stockpiles shall be cleared, graded evenly for drainage, and sprinkled if required.

e. Moisture control

The free moisture content of the fine aggregate and of the smallest size group of coarse aggregate, as delivered to the mixers, shall be controlled so as not to exceed 4.0 % and 1.0 %, respectively, by weight of the saturated surface dry aggregates unless higher limits are allowed by the Engineer. The moisture content of the other sizes of the coarse aggregate shall be controlled so that the aggregates are delivered to the mixers with the least amount of free moisture and the least variation in free moisture as practicable under job conditions. The Contractor may accomplish the required moisture control by use of free drainage storage, covered transportation and storage mechanical dewatering devices, or any other means acceptable to the Engineer.

(3) Water

Water for washing aggregates and for the mixing and curing of concrete, mortar, plaster and grout shall be taken from an approved source and shall be clear and free from deleterious substances including salt, oil, alkali, or organic matter.

The methods of delivering and storing the water shall be subject to the approval of the Engineer. If the Engineer so requires, the water shall be tested by an approved testing authority. All costs involved by these tests shall be borne by the Contractor.

(4) Admixtures

(i) General

The Contractor shall furnish admixtures as approved by the Engineer which shall be as specified below. Additional admixtures may be specified or may be used on the written authority of the Engineer, and then only in the manner and with the control specified by the Engineer. Admixtures shall be added to the mix by approved automatic dispensers.

(ii) Air entraining agent
An approved air entraining agent shall be used to produce the specified amount of stable entrained air in the concrete mixture, and shall conform to the requirement of A.S.T.M. Standard C260, "Air-entraining Admixtures for Concrete". The required air content of the concrete is as follows:

<table>
<thead>
<tr>
<th>Maximum Aggregate Size (mm)</th>
<th>Total Air % by Volume of Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>5.0 + 1</td>
</tr>
<tr>
<td>40</td>
<td>4.0 + 1</td>
</tr>
</tbody>
</table>

(iii) Water reducing admixture

A water reducing admixture that does not retard the initial set of the concrete may be added to the concrete mix during mixing in the amount directed by the Engineer. This admixture shall conform to the requirements of A.S.T.M. C494, Type A.

(iv) Initial set retarding admixture

An initial set retarding admixture will be added to the concrete mix during mixing in the amounts as may be required by the Contractor's construction method or as directed by the Engineer in order to obtain the retardation of the initial set of the concrete if the Engineer deems necessary. This admixture shall conform to the requirements of A.S.T.M. C494, Type B and D. No separate payment shall be made for initial set retarding admixture and cost thereof shall be deemed to be included in the respective concrete unit prices in the Bill of Quantities.

(v) Compatibility

The compatibility of admixtures, where more than one is used, shall be proved to the satisfaction of the Engineer and satisfactory test results obtained before incorporation in the works.

(vi) Storage and dispensing of admixtures

Admixtures shall be stored in suitable weatherproof buildings. Admixtures in solution shall be stored at a temperature not higher than 70 dec. C., and approved mechanical agitators shall be used for those admixture solutions requiring agitation prior to and during use as recommended by the admixture manufacturer.

The individual admixtures shall be added separately to different components of the concrete or to the concrete in the mixer at the commencement of the mixing cycle.

1.4. Concrete quality and mix design
(1) Mix proportions

The Contractor shall carry out the design of concrete mixes under the supervision of the Engineer in the laboratory and using testing equipment owned by the Employer so as to ensure that all concrete to be placed in the various structures of the works shall meet the requirements of the Specifications.

The data of mix proportions shall be prepared and proposed by the Contractor to obtain the appropriate water-cement ratio, suitable workability, durability, low shrinkage and required design strength with the minimum cement content and amount of fine aggregate. The mix proportions selected by the Engineer from these data shall be verified through the trial mixes to be executed by the Contractor in a manner as prescribed in sub-clause (2) of this Clause.

Based on the results obtained from the trial mixes above, the Engineer will notify the Contractor of the mix proportions for the concrete to be used in the various portion of the Works.

The Contractor shall furnish sample of cement used for the Works in sufficient quantity required for such design of concrete mixes, cost of which shall be deemed to be included in the appropriate unit prices stated in the Bill of Quantities.

The exact proportions in which concrete materials are to be mixed will be varied by the Engineer from time to time during the performance of the Work. The Contractor shall not be entitled to compensation other than provided herein because of any change which the Engineer may make in the mix proportions.

The determination of the mix proportions by the Engineer shall not relieve the Contractor of his responsibilities for producing and placing concrete conforming to the specified requirements. Before mixing concrete for any structure or part thereof, the Contractor shall satisfy himself that the concrete mixed in the proportions determined by the Engineer will permit the Contractor to produce and place concrete complying with the specified requirements.

Compliance with concrete compressive strength requirements shall be based on compressive strength tests carried out by standard 15 centimetres concrete cubes at the age of 28-days or as instructed by the Engineer in accordance with the applicable JIS standard or other approved standards.

The following table sets out the major classes of concrete to be placed for several structures as shown on the Drawings:

<table>
<thead>
<tr>
<th>Class of Concrete</th>
<th>Coarse Max. Size (mm)</th>
<th>Design Strength (28 days) (kg/sq.cm)</th>
<th>Tentative Cement Content (kg/cu.m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M25</td>
<td>20</td>
<td>250</td>
<td>400</td>
</tr>
</tbody>
</table>
In general, concrete shall be placed with a maximum 8 cm slump. Provided that, where deemed necessary by the Engineer, concrete with slump up to 14 cm may be permitted.

The use of concrete pumps shall in general be limited to locations where other transportation and placement methods are not deemed practicable by the Engineer. The above tables are intended as a general guide and does not in any way preclude the use of other mixes as the need arises.

Cement contents as shown in the above table are intended tentatively. Notwithstanding the cement contents indicated in the above table, the Engineer reserves the right of modifications of mix proportions of concrete during the course of Works.

Cement contents for various mix proportions of concrete shall be determined from the design mixes approved or directed by the Engineer and verified from the batching plant recorder sheets.

(2) Trial mixes

At least 90 days prior to commencement of concrete works in the Permanent Works, the Contractor shall execute trial mixes for each of the classes of concrete specified under the supervision of the Engineer using the aggregate cement and admixtures, by operating batching and mixing plant provided by the Contractor for the execution of the Works. Such trial mixes shall be continued until concrete complying with the Specifications is obtained to the satisfaction of the Engineer.

The cost incurred for executing trial mixes including cost of materials shall be deemed to be included in the appropriate unit prices stated in the Bill of Quantities.

(3) Dry pack mortar

The dry pack mix shall be proportioned by weight, one part cement to 2 - 1/2 parts of sand that will pass a 1.2 mm screen. Only enough water shall be used to produce a mortar which will stick together when moulded into a ball by a slight pressure of the hands and will not exude water but will leave the hand dump.

(4) Mortar
Mortar to be used for repair work shall have the same sand, cement and air proportions as the mortar used in the mix of the concrete to be repaired.

(5) Field quality control

Field quality control test will be carried out by the Engineer in conformity with the following standard or equivalent:

- **Sampling**: JIS A 1115-75/ASTM C172
- **Slump test**: JIS A 1101-75/ASTM C143
- **Flow test**: JIS R 5201-64
- **Air content test**: JIS A 1116-75, A1118-75 or A1128-75/ASTM 231
- **Unit weight of concrete**: JIS A 1116-75/ASTM C567
- **Compressive strength test**: JIS A 1115-63, A1108-63/ASTM C39
- **Bending strength test**: JIS A 1132-63

The Contractor shall assist and cooperate with the Engineer in doing such tests as prescribed above. Samples of fresh concrete will be obtained from the placing sites or the place as the Engineer deems necessary.

The Contractor shall provide water, power, light and working spaces for the batching plant inspector at the batch plant at no additional cost.

The Contractor shall maintain and protect test specimen under the similar curing conditions to the concrete placed for a period of 24 hours after the completion of the relevant pour and thereafter deliver them in a manner as approved by the Engineer to the Employer's laboratory for subsequent curing.

1.5. Equipment

The Contractor shall provide at the sites of the Work automatic batcher 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 instructions 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.

1.6. Batching and mixing of concrete

The batching and mixing of concrete shall not commence unless due notice, at least 24 hours in advance has been given to the Engineer and his written approval obtained for the state of the mixing, transport and placing arrangements and for the preparation and accuracy of the part of the Works in which concrete is to be placed. In order to proceed to the concreting he shall receive written permission from the Engineer for each section separately poured.

Aggregates shall be weighed in their separate sizes in accordance with the approved mix design, and weights shall be easily corrected for the free water contained in the aggregates as well as for other compositions of the mix. The free water shall be determined by an approved method before mixing commences each day and more frequently if the Engineer so requires. The water to be added to the mix shall be similarly corrected. Cement shall be added as the number of whole bags or weighed separated. Details of the equipment which is to be used on the works shall be submitted for approval before construction commences. Weighing and water dispensing equipment shall be maintained clean, properly lubricated and in good working condition.

Concrete shall be mixed in a power-driven batch mixer which shall be approved by the Engineer. It shall be kept clean and in proper working order. The mixing blades in the drum shall be replaced when worn by 10 % of order. The mixing blades in the drum shall be replaced when worn by 10 % of their dimensions. The quantity of material in each batch shall not exceed the normal continuous rated capacity of the mixer and the speed of rotation shall be controlled within ± 1 r.p.m. of the manufacturer's recommended speed. Components shall be fed into the mixing drum so as to ensure the most efficient use of the mixing period and to avoid any loss of material, particularly cement. Mixing is considered to have started, unless otherwise directed by the Engineer, when all solid materials are in the mixer drum, provided that all the mixing water is introduced within one fourth of the mixing time. Mixing shall continue until the concrete is homogeneous and of the uniform appearance, and in no case for less than 2-1/2 minutes for mixers of up to 0.75 cubic meter rated capacity. For mixers above this size the time shall be increased by 20 % for each cubic meter.
The first batch of concrete materials in the mixer shall contain a sufficient excess of cement, sand and water coat the inside of the drum without reducing the required mortar content of the mix. The entire content of the mixer shall be removed from the drum before materials for a succeeding batch are placed therein.

Aggregates and all components shall be mechanically batched and measured by weight. The weights of the aggregates shall be adjusted on the basis of the amount of absorbed and surface moisture content and the ingredients shall be measured separately in approved containers.

Mixing of concrete shall not commence without ensuring that the stocks of components are adequate, with a reasonably safety margin, for the completion of the particular pour of concrete.

The Contractor shall submit detailed drawings and descriptions of his plant, details of the equipment and the handling procedures he proposes to adopt to the Engineer before the plant is delivered to the site and he shall receive the approval of the Engineer in writing as to the suitability of the proposed arrangements. This will not relieve the Contractor from his sole responsibility for the finished works and quality of incorporated material under the Contract.

1.7. 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 segregating.

1.8. Placing of concrete

No concrete shall be placed until the site of placing including forms, 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 or 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 as specified in Clause 3.1.10, 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.

1.9. 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 operated 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.

1.10. 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 staurated burlaps, 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.

1.11. Concreting in adverse weather conditions

The Contractor shall make the necessary provisions in the concrete materials storage, handling and batching facilities as required for complying with hot weather concreting requirements. The proposed method of temperature protection shall be approved by the Engineer. The temperature of the fresh concrete shall not exceed 30 deg. C when placed in the forms. Effective measures such as precooling of aggregates and mixing water and placing at night shall be undertaken to meet the requirements.

The Contractor shall submit for the approval of the Engineer the method he intends to use.

The control of the temperature shall be included in the unit price of the concrete.

1.12. 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, Contractor 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.

Dry pack mortar and fresh mortar for repair shall be defined in Clause 3.1.3 (3) and (4). 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 colour 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 drummy 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.

1.13. Underwater concrete

Underwater concrete shall only be placed when and where approved by the Engineer.

The concrete shall be placed under water by a tremie or concrete pump to the approval of the Engineer. The tremie shall have at least 20 cm bore and shall be constructed in suitable lengths with quick release watertight joints to ensure that no delay shall occur in the placing of concrete. The tremie shall be plugged by an approved method at the start of concreting to prevent ingress of water into the concrete in the tremie and the bottom of the tremie shall be kept at all times below the top of the concrete.

The tremie shall not be moved horizontally during a placing operation and sufficient number of tremies shall be provided so that concrete does not have to flow horizontally a distance of more than 3 m.

1.14. Precast concrete
Precast concrete pipes, curbs, U-ditch, L-ditch, concrete covers, bricks, sills and lintels and blocks shall comply with the relevant standards. Precast structural elements shall be constructed to the details, dimensions, and tolerances given on the Drawings or as otherwise defined by the Engineer.

The concrete components, types, mixes, strengths, general quality, testing, mixing, placing and curing shall be generally as described in the Specifications or as detailed on the Drawings.

The surface of the finished units shall be smooth, dense and hard with clean sharp arises (except where otherwise indicated) and shall be free from cracks, discolouration, holes, honeycombing, watermarks, dusting, or shutter marks.

Units shall be manufactured and cured in a properly equipped casting yard or shop and the arrangements shall be subject to the inspection and approval of the Engineer. The Contractor shall give adequate notice to the Engineer before dispatching precast units to the Site and, if the Engineer so requires, shall provide facilities for inspection, test loading and dimensional checking of the units before they are dispatched. In case of units constructed in a factory or yard remote for its site, details of the concrete components, mix design and compression test results shall be made available to the Engineer. Details of the design and compression test results shall be made available to the Engineer for his approval. Special lifting arrangements shall be incorporated in the design to eliminate damage to arises and surfaces during handling and erection.

Concrete pipe and other parts embedded in concrete shall be accurately positioned and securely held in place to avoid displacement during placing of concrete. Pipe openings shall be kept capped or plugged when the work is suspended during installation to prevent concrete, surface water, mud, and debris from entering the pipes.

Base concrete shall support the reinforced concrete pipe at 120 degrees or 180 degree of support angle or as shown on the Drawings and shall be concrete class M10. Pipe sockets shall face toward the upper end of the culvert. Pipes which have no socket shall be jointed with collars. Joint sections of pipes shall be coated with 1:2 cement mortar unless otherwise specified so that water will not leak.

Reinforced concrete pipes shall be laid with mortared joints. The mortar shall be used within 30 minutes from the time the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar bead on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

After installation of the drainage pipes, gravel shall be placed and tamped around the pipe with all care as not to displace it, specially in case of sand bedding.

1.15. Plug concrete
(1) Plug concrete around steel liner in penstock tunnel

Because of the narrow space between the rock and the steel lining, standard compacting procedure will not be feasible and the use of concrete with best workability will be required. The optimum mix design shall be proposed by the Contractor and shall be approved by the Engineer in collaboration with the Contractor. However, the use of a soft concrete will require additional care in order to avoid segregation during transportation and placing. Sufficient space has been provided at the vertex of the tunnel in order to permit the necessary vibration of the backfill concrete. Special care must be taken to ensure a complete filling the space under the pipe by avoiding the trapping of air pockets and the filling of the tunnel vertex by pulling back the concrete filling pipe only once the remaining gap has been thoroughly filled. The grade of plug concrete around steel liner in penstock tunnel shall be M15 as stated in Bill of Quantities or as directed by the Engineer.

The concrete joint near the end of the pipe element must be perpendicular to the pipe axis. Its formwork may be made of hard full concrete blocks left in place in order to reduce the duration of the concreting cycle.

Backfill concrete around steel liner penstock tunnel will be initiated at the lower end of the inclined or horizontal tunnel. Standard work progress of backfill concreting will generally be suggested to carried out in every 18 m (3 pieces of every 6 m steel liner), however, detailed timing of the operation shall be agreed between the Contractor and approved by the Engineer.

(2) Plug concrete in work adits

The Contractor shall execute plug works in work adits as shown on the drawings. Plug works in adits shall include surface treatment of initial lining concrete or rock surrounding plug portion, concrete placement, form works, furnishing and installing cooling pipes, cement grouting pipes, P.V. C. waterstops and other items necessary to complete the works. The grade of plug concrete in work adits shall be M15 as stated in Bill of Quantities or as directed by the Engineer.

Concrete surface upon or against which concrete is to be placed and to which new concrete is to adhere that have become so rigid as not to enable the new concrete to incorporate integrally with the concrete previously placed are defined as construction joints. The surfaces of construction joints shall be clean and damp when covered with fresh concrete or mortar as approved by the Engineer.

1.16. Concrete lining in underground structures

All the excavated surfaces of the underground structures such as the tunnels, surge tank, penstock shaft, transformer cavern, powerhouse cavern, etc. shall be cleaned by water jets directed over rock surfaces to remove all spoil and loose materials before concreting on it. Concreting shall not be poured unless the Engineer inspects and approves for the same.
Concrete in tunnels, shafts, caverns and underground chambers may be placed by pumping or any other approved method. The equipment used in placing such concrete and the method of its operation shall be such as will permit introduction of the concrete into the forms without high velocity discharge and resultant separation. The grade of concrete shall be as shown in the Drawings or as stated in the Bill of Quantities or as directed by the Engineer.

After the start of placement, the end of the discharge line shall be kept well-buried in the concrete during placement of the side walls and arches to ensure complete filling of the spaces outside the form. Cold joints in tunnel lining shall not be permitted. In the event of equipment breakdown, or if for any other reason continuous placing is interrupted, the Contractor shall thoroughly consolidate the concrete as such joints to a reasonably uniform and stable slope while the concrete is plastic. If cold joints do occur, the concrete at the surface of such cold joints shall be cleaned as required for construction joints as stipulated in Clause 3.1.19, and wetted before being covered with fresh mortar and concrete required to be placed incidental to the installation of tunnel supports or places, unless at least equal in all respects to the permanent concrete specified and unless if, left in place, it will not impair the structure in any way.

Embedded metal required to be installed in concrete, including grout pipes, struts anchors, inserts and similar items, shall be installed in accordance with the requirements of DRILLING AND GROUTING as specified in the specification.

Stripping of forms will not be permitted until the concrete has reached at least 70 kg/sq. cm cylinder compressive strength or its equivalent standard in the cubical mould and not less than 24 hours after the completion of the concreting of that element or as directed by the Engineer.

The Contractor may propose a one step concreting of the tunnel lining. The concrete transportation and placing equipment must be of such capacity as to guarantee the continuous pouring of the lining. The placing system must provide for an optimum filling of the arch vertex.

1.17. Concrete for invert

Before concreting for inverts, the inverts of tunnels, transformer cavern, powerhouse cavern and all other underground structures shall be thoroughly cleaned.

Concrete for inverts of tunnels, shafts, caverns and all other underground structures may be placed by pumping or any other approved method. The equipment used in placing such concrete and method of its operation shall be such that it will permit introduction of the concrete in proper manner without high velocity discharge and resultant separation. The grade of concrete shall be as shown in the Drawings or as stated in the Bill of Quantities or as directed by the Engineer.
1.18. Concrete for embedded of machine parts and other 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 introduce 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.

1.19. Weepholes

Weepholes shall be provided by the Contractor in the retaining walls, facing concrete, wet rubble masonry walls, and other structures as shown on the Drawings or as directed by the Engineer. The pipe shall be P.V.C. pipe and not less then 50 mm in diameter.

1.20. 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 fixes 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 embodies 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 a 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, discolour, or affect exposed surfaces of the structures. Methods of disposal shall be subject to approval of the Engineer.

1.21. Contraction joint and P.V.C. waterstop

(1) Contraction joint
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.

(2) Waterstop

PVC waterstop strip will be placed across the joints which have to remain watertight. The specifications of waterstop shall be complied with the tensile strength of more than 125 kg/sq.cm and an elongation before rupture not less than 300%. Waterstop strips can be glued together at temperature of about 150 deg. C. Glueing and placing shall be done in accordance with the manufacturer's instructions. Physical characteristics of the waterstop strips shall conform the requirements of JIS K6773-74, Flexible Polyvinyl Chloride (PVC) Waterstop, or approved equivalent.

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

<table>
<thead>
<tr>
<th>Dimensions (mm)</th>
<th>Type A</th>
<th>Type B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>300</td>
<td>230</td>
</tr>
<tr>
<td>Thickness</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Allowance: width</td>
<td>± 5%</td>
<td>±10%</td>
</tr>
<tr>
<td></td>
<td>thickness</td>
<td></td>
</tr>
</tbody>
</table>

Except as otherwise shown on the Drawings, waterstop strips shall be installed with an approximately equal with 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 spices 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 labour and perform
all the works necessary to rectify leaking joints and structures to the Engineer's directions and satisfaction.

1.22. Formwork, falsework and centering

(1) General

Unless otherwise provided, detailed drawings for formwork and supports shall be supplied to the Engineer on request; but in no case shall be Contractor be relieved of responsibility for results obtained by the use of these drawings.

For designing form of weight of 2.5 t/cu.m shall be assumed for fresh concrete. All form and support shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. The Engineer may require the Contractor to employ screw jacks or hardwood wedges to take up any settlement in the formwork either before or during the placing of concrete. Formwork shall provide for its own deformation under load, and shall be cambered to allow construction deflection where this is necessary to maintain the required accuracy as approved by the Engineer.

The work shall be set to give the finished structure as specified or indicated on the Drawings.

Formwork shall include all temporary or permanent mold, shutters and any kind of blockout for forming the concrete, together with all construction required for their support. It must be designed and constructed that the concrete can be properly placed and compacted by vibration or otherwise without loss of material, and so that the concrete shall set and Harden without injury and shall conform accurately to the required shape, dimensions, position and level.

Internal formwork supports and ties shall be to the approval of the Engineer as to Material, location and design. The whole or part of such supports and ties shall be removed without damage to the concrete so as to leave no part embedded nearer the surface of the concrete than the designed cover of the reinforcement or 10 cm in the case of reinforced concrete.

Holes left after the removal of supports and ties shall be filled with concrete, dry pack mortar or mortar of approved composition and colour after being roughened and cleaned to ensure bond, and shall be adequately cured. Through bolts will not be permitted in water retaining walls.

Before concreting commences, all blockout shuttering may be firmly fixed in position. Furthermore, such blockout shuttering shall be so constructed that it can be removed without damage to the surrounding concrete. Any remedial work caused by incorrect position and dimensions shall be on the Contractor's expense.

In all classes of formwork special care shall be taken at the tops of walls or piers which are to be left exposed or which are to carry superimposed structures so as to produce a neat even
level or graded line as may be required to which the upper surface or the concrete shall be screened.

All exposed joints, edges, and external corners shall be chamfered not less than 2 cm at 45 deg. except as otherwise shown. Internal corners shall be filleted where indicated or required by the Engineer.

Chamfers, fillets, rounded arises and similar features shall be formed by soild timbers integrated structurally with the formwork. Light fillets nailed into corners of the shutters will not be permitted except with the approval of the Engineer.

Formwork with edges of faces damaged shall not be used until repaired to the approval of the Engineer. Open joints in timber forms shall be closed by soaking the timber or other approved method. Plywood surfaces shall be sealed to prevent the absorption of moisture.

Where faces of vertical construction joints and concrete surfaces shall be roughened, expanded metal shall be applied. Expanded metal shall be fixed at the formwork and has to be removed, if possible, before adjacent lift is poured or plaster is placed. In this case form oil shall not be used.

Quality of the surface finish produced by the formwork shall be appropriate to the classification as described hereunder. Generally it shall be free from honeycombing, segregation, loss of cement or fine material, from damage due to stripping of forms, from bolt-holes abrupt inequalities caused by movement of shutter or components, loose knots and similar features and from bulges or depression in the general plane of the surface.

Formwork shall be cleaned after use, and shall be clean before concrete is placed. Coating material or liquid for preservation or to facilitate stripping shall be subject to the approval of the Engineer. It shall be applied carefully and sparingly.

(2) Classification of formwork

Formwok shall be divided into the Following three classes as shown on the Drawings. and/or otherwise indicated.

a. Class F1

The surface of Class F1 formwork shall be formed by plane segments. This is a rough finish which is generally intended for unexposed surfaces without special treatment.

b. Class F2

The surfaces of Class F2 formwork shall be formed by plane segments and curved surfaces. This is required for structural surfaces Permanently exposed to view. If wooden boards are used for this formwork, they shall be planed boards of uniform thickness and width. The edges and one side shall in all case be planed. These board shall have square edges, but
uniformly arranged and with nail and knot holes filed flush with putty or other approved substance. Other material for this class shall be subject to approval of the Engineer.

c. Class F3

The surfaces of class F3 formwork shall be formed by plane segments and curved surfaces. This finish is required for surfaces of water passages including surfaces of open channels. It shall be free from boardmarks or surface pitting and the formwork shall be faced with plywood, steel plates or equivalent material in sheets as large as possible and arranged uniform pattern.

Joints in the facing shall coincide with architectural feature or changes in direction on the surface and shall be either vertical or horizontal unless otherwise directed or shown on the Drawings.

(3) Preparation of formwork for concreting

Immediately before concreting the forms and other surfaces which will be in contact with the fresh concrete shall be cleaned of all loose material and debris including shavings, woodchips, sawdust, pieces of wire, nails fragments of hardened concrete and mortar. Adequately clean out holes shall be provided for this purpose and subsequently securely closed so as to restore the required formwork quality.

The use of compressed air for cleaning will be subject to approval of the Engineer. Precautions shall be taken to avoid the disposition of suspended oil on construction Joints surfaces, reinforcement or other item which are to be bonded to concrete.

(4) 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-spanned 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

Underground Structures:

- Conduit in open cut  
  72 hrs
- Wall poured separately from arch  
  48 hrs
- Arch  
  24 hrs
- Invert  
  16 hrs

If the formwork has protected the concrete form the effects of extremes of temperature, the permission to remove it may be conditional on the substitution of alternative curing or protection methods to the approval of the Engineer.

If it is required to replace supports after the removal of the formwork either to maintain supports of the concrete, or to carry subsequent construction loads, the operation shall be planned and shall be subject to the approval of the Engineer.

1.23. Finishing unformed surfaces

Unformed concrete surfaces shall be divided into the following three classes as shown on the Drawings or otherwise indicated.:

(1) Class U1

It shall be obtained by leveling and screening the concrete to produce and even, uniform plain or lightly edged surface without laitance and surplus concrete shall be struck off by a straight edge immediately after compaction.

(2) Class U2

Floating shall be done only after the concrete has hardened sufficiently and shall not be continued to the extent of bringing excessive fine material to the surface but only so as to produce a uniform surface free from screed marks.

(3) Class U3

This is a hard smooth high quality finish for concrete surfaces, trowelling shall not commence until the moisture film has disappeared and the concrete is sufficiently hard to prevent the working of excessive laitance to the surface. The surface shall be trowelled firmly and left free from trowel marks.
No separate payment shall be made for the work under this Clause. The cost thereof shall be included in the respective unit prices of the concrete.

1.24. Defective finish

Where any concrete is found to the defective in the quality, accuracy or appearance of its finish, the Engineer may require to have it removed and replaced by concrete of the required standard with no additional cost to the Employer. Repairs to the surface of concrete shall be carried out as soon as possible, subject to the Engineer's prior approval of the extent, nature and method of repair.

1.25. Tolerances

The quality of surface finish shall be in accordance with the classification as described hereunder. Permissible surface irregularities for the various classes of concrete surface finish (including unformed surfaces) are to be distinguished from tolerances as described herein. Unless otherwise stated tolerances shall conform to the requirements of the following table. Parts of concrete structures that exceed the tolerances limits specified herein shall be corrected or removed and replaced by the Contractor at his own expenses.

<table>
<thead>
<tr>
<th>Class of finish</th>
<th>Tolerances form</th>
<th>Irregularities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unformed</td>
<td>Formed</td>
<td>Abrupt</td>
</tr>
<tr>
<td>Base line survey</td>
<td>(mm)</td>
<td>(mm)</td>
</tr>
<tr>
<td>Class U1</td>
<td>Class F1</td>
<td>+ 20</td>
</tr>
<tr>
<td>Class U2</td>
<td>Class F2</td>
<td>+ 10</td>
</tr>
<tr>
<td>Class U3</td>
<td>Class F3</td>
<td>+ 5</td>
</tr>
</tbody>
</table>

*) Measured on a straight or curved length of 2.0 m.

1.26. Reinforcement steel

(1) Quality requirement

Except otherwise shown on the Drawings, the reinforcement steel bars shall be deformed steel bars of approved manufacturer and shall comply with JIS G 3112-75, SD 30 or approved equivalent. All reinforcement when surrounding concrete is placed, shall be free from loose, flaky rust and scale, and free from oil, grease or other coating which might destroy or reduce its bond with the concrete.

(2) Storage

Reinforcement steel shall be stocked on the site, separated into the various sizes in such a manner that the steel does not get contaminated with deleterious matter. If fabric
reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed. Bundles bars shall be ties together at not more than 2 m centers.

(3) Cutting, bending and splicing

The Contractor shall submit to the Engineer for his approval the reinforcing bar bending and cutting drawings.

The cutting, bending and splicing of the reinforcement bars shall be carried out in accordance with the requirements of the Drawings, or prescribed by the Engineer. Reinforcement steel shall be accurately cut and bend to the shapes shown on the Drawings approved by the Engineer.

(4) Placing

All reinforcement steel shall be accurately placed in the positions shown on the Drawings and firmly held during the placing and setting of concrete. When placed in the Work, it shall be free from dirt, detrimental rust, loose scale, paint, oil or other foreign material. Bars shall be securely tied with soft iron wire of not less than 0.9 mm diameter at all intersections and laps except where spacing is less than 30 cm in each direction, in which case alternate intersections shall be tied. The location of laps in reinforcement shall be subject to the approval of the Engineer.

Distances from the forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports. Blocks for holding reinforcement from contact with the form shall be precast mortar blocks of approved shape and dimensions or approved metal chairs on concrete blocks. Layers of bars shall be separated by precast mortar block or other equally suitable devices. The use of pebbles, pieces of broken stone or brick metal pipe and wooden blocks will not be permitted. Reinforcement bars in any member shall be placed and then inspected and approved by the Engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and removed at the Contractor's expense.

Notwithstanding the minimum clear cover to reinforcement as shown on the Drawings, the Engineer may as often as he deems necessary, vary the clear cover to reinforcement during the construction.

1.27. Embedded items

The Contractor shall furnish and install embedded items firmly and securely fastened in place as shown on the Drawings or directed by the Engineer before placing concrete. Embedded items shall be free of oil and other foreign matter such as loose coatings of rust, paint and scale. The embedding of wood or other foreign materials in concrete is prohibited unless specifically authorized or directed by the Engineer. Any air or water lines or other materials
embedded in structures shall conform to the above requirements and upon completion of their use shall be backfilled with concrete or mortar as directed by the Engineer.

1.28. Cooling of Concrete

(1) Scope of work

The plug concrete for construction adits and penstock tunnel shall be cooled by natural water through piping embedded in the concrete as shown on the Drawings or as directed by the Engineer.

The contractor shall furnish, install, operate, maintain and subsequently fill the cooling pipes with cement grouting for removing the excess heat by cooling plant which will consist of pumping units for handling natural water and other equipment applied to cool the concrete in a manner satisfactory to the Engineer.

The movement/transit of concrete temperature will be measured by the Engineer from time to time during the cooling operations at each site, provided that the contractor shall cooperate with the Engineer to measure the concrete temperature by measuring water temperatures at inlet and outlet of piping arrangement of cooling systems and inside mass of plug concrete which shall be reported in writing to the Engineer at the frequency directed by the Engineer.

(2) Cooling plant and operation

The water to be used for cooling system shall be cleared and kept clear of all the mud, debris and other impurities and all necessary precautions shall be taken to prevent the possibility of any part of the cooling system becoming clogged. Prior to execution of cooling operations, the cooling system shall be inspected by the Engineer in the site provided that such inspection executed by the Engineer shall not relieve the contractor of any his responsibility to complete the works. The Contractor shall submit the construction programme to the Engineer for his approval including schedule, organization, housing, location, capacities of equipment of piping arrangement, to ensure dependable and continuous operation for cooling of concrete. The Contractor shall commence the cooling operation for each cooling lift of concrete at such time during the concrete placement or the time directed by the Engineer. Before concrete comment cooling pipes in each lift shall be filled with cooling water to check the water leakage from the cooling pipes and/or its joints to prevent deterioration of concrete caused by leaked water. The cooling operation shall be executed and maintained by the Contractor until the maximum temperature measured at inlet, outlet and inside the mass of plug concrete is reduced to a temperature of the water to be used for cooling operation or a temperature determined by the Engineer. For the measurement of temperature inside mass of concrete, the Contractor shall supply and install 50 mm dia steel pipes to be located from the center of plug concrete to end face thereof shown on the Drawings.
The velocity of water in the cooling pipes shall be not less than 60 cm/sec. The flow direction of water in each cooling circuit shall be reserved not more than once each 24 hours.

(3) Cooling pipes embedded in each concrete

The Contractor shall install 25 mm inside diameter steel pipes through each water will be circulated for the purpose of cooling the plug concrete as shown on the Drawings or as directed by the Engineer. The piping shall be clean and free from scale or any deleterious material that may affect the bond between steel and concrete.

The Contractor shall carefully protect the piping from displacement or damage during the placing and testing of the piping. Any pipe which becomes clogged or in any way blocked before the surrounding concrete has been placed shall be replaced by a new pipe. The spacings, lengths, diameter and weight of the piping and amount of concrete to be cooled may be changed to meet varying conditions during the progress of the work.

(4) Grouting

After cooling system has served its purpose, as determined by the Engineer, the embedded pipes and fittings shall be filled with grout. The grout for filling pipes shall be composed of cement and water mixed in proportions determined by the Engineer. The grout shall be forced into the pipes or tubing with sufficient pressure to insure that they are completely and solidly filled.

1.29. Measurement and payment.

(1) General

Measurement and payment will be made at the unit prices stated in the Bill of Quantities in accordance with the applicable provisions of these Specifications.

(2) 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 overbreak 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.

(3) Formwork

Measurement for payment of formwork for concrete will be made on the basis of concrete surface areas formed under each class of formwork in square meters determined by the dimensions of the concrete structures as shown on the Drawings or as directed by the Engineer. The measurement will include sloping surfaces steeper than 1 vertical to 2 horizontal, the formed surface of contraction joints, construction joints only shown on the Drawings or directed by the Engineer, and the formed surfaces of blockouts larger than 0.1 square meter in cross sectional area.

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 prices for formwork shall constitute full compensation for the cost of all labour, tools, equipments and materials including furnishing, transporting, fabricating, erecting, surveying, fixing, dismembering, removing the form and other items necessary to complete the Works.
Unless otherwise shown on the Drawings or directed by the Engineer, the cost of formwork for surfaces of contraction joints and construction joints shall be included in the respective unit prices for concrete stated in the Bill of Quantities. Forms used to fill over excavation shall be at the expense of the Contractor.

(4) **Reinforcement bars**

The quantity of reinforcement bars placed will be determined as shown in the Drawings and in accordance with bar list approved by the Engineer.

Measurement for payment of reinforcement bars will be made on the basis of actual installed weight of steel bars in metric tons determined by the lengths and numbers of bars as determined above. The unit weight used for deformed bars shall be calculated applying the following Table:

**Size and Area of Reinforcing Bars.**

<table>
<thead>
<tr>
<th>Bar Diameter (mm)</th>
<th>Cross-Sectional Area (mm²)</th>
<th>Unit Weight (kg/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>50.5</td>
<td>0.395</td>
</tr>
<tr>
<td>10</td>
<td>78.6</td>
<td>0.617</td>
</tr>
<tr>
<td>12</td>
<td>113.1</td>
<td>0.888</td>
</tr>
<tr>
<td>16</td>
<td>201.1</td>
<td>1.579</td>
</tr>
<tr>
<td>20</td>
<td>314.3</td>
<td>2.467</td>
</tr>
<tr>
<td>22</td>
<td>380.1</td>
<td>2.98</td>
</tr>
<tr>
<td>25</td>
<td>491.10</td>
<td>3.855</td>
</tr>
<tr>
<td>28</td>
<td>616.0</td>
<td>4.836</td>
</tr>
<tr>
<td>32</td>
<td>804.6</td>
<td>6.316</td>
</tr>
</tbody>
</table>

Measurement for payment will be made for steel bars in laps indicated on the Drawings or required by the Engineer. No measurement for payment will be made for steel bars in laps which area solely for the convenience of the Contractor or for steel reinforcement support, including bracing, etc. and the cost thereof shall be included in the unit price for the reinforcement bars.

Payment will be made for the number for metric tons measured as provided above at the respective unit prices per ton stated in the Bill of Quantities, which unit prices for reinforcement bars shall constitute full compensation for the cost of all labour, tools, equipments, and materials including delivery, transport, storage, cutting, bending, placing wire clips, ties, separators and any other fastening devices and support, and other items necessary to complete the Works.

(5) **Bituminous coating**
Measurement for payment of bituminous coating will be made on the basis of actual installed area of the coating in square meters determined by the dimensions as shown on the Drawings or directed by the Engineer.

Payment will be made for the number of square meters measured as provided above at the unit price per square meter stated in the Bill of Quantities, which unit price for bituminous coating shall constitute full compensation for the cost of all labour, tools, equipments, and materials including furnishing, transporting, fabricating, installing the expansion joint filler and other items necessary to complete the Works.

(6) Waterstops

Measurement for payment of waterstops will be made on the basis of actual installed length of waterstops in linear meter determined by the locations, size and lengths as shown in the Drawings or directed by the Engineer. In computing the quantities, no allowance shall be made for laps to joint.

Payment will be made for the number of linear meters measured as provided above at the respective unit prices for waterstops stated in the Bill of Quantities, which unit price shall constitute full compensation for the cost of all labour, tools, equipments, and materials including furnishing, transporting, fabricating, installing, jointing of the waterstop and other items necessary to complete the Works.

(7) Weepholes and P.V.C. drain pipes

Measurement for payment of the weepholes will be based on the number of linear meter of weephole pipe installed in accordance with the Specifications, or if approved based on the actual length of pipe installed.

The payment of weephole will be made for the linear meters measured at the unit price per linear meter as stated in the Bill of Quantities.

Measurement for payment of P.V.C. drain pipe shall be made on the basis of actual installed length of P.V.C. drain pipe in linear meters measured at the center line of P.V.C. drain pipes as shown on the Drawings or directed by the Engineer.

Payment shall 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 for P.V.C. drain pipe shall constitute full compensation for the cost of all labour, tools, and materials including furnishing, transporting, fabricating and installing and the P.V.C. drain pipes with fittings and other items Necessary to complete the Works.

(8) Precast concrete
Measurement for payment of the precast concrete cover, stoplogs, lintels, curbs, etc. will be made based on the number of cubic meters of concrete for each type placed within the lines and grade shown on the Drawings, in accordance with the specification. The precast concrete pipes shall be measured on the basis of actual installed length of pipes in linear meters measured at the center line of pipes shown on the Drawings or directed by the Engineer.

Payment of precast concrete cover, pipes, stoplogs, lintels, curbs, etc. shall constitute full compensation for the cost of all labour, tools and materials including furnishing, transporting, fabricating, installing and other items necessary to complete the works.

(9) Cooling of concrete

(a) Cooling pipe

Measurement for payment of cooling pipe embedded in the concrete will be made for the length in linear meter determined by the dimensions as shown on the drawings or directed by the Engineer. Payment for cooling pipe in linear meter measured as provided above will be made at the unit prices per meter stated in the Bill of Quantities, which unit price for cooling pipe shall constitute full compensation for the costs of all labour, tools, equipments and materials including furnishing, transporting, fabricating, installing and maintaining the cooling pipes and other items necessary to complete the work.

(b) Cooling works

Measurement for payment of cooling works for plug concrete will be made on the basis of lump sum price for cooling operations stated in the Bill of Quantities, which lump sum price shall constitute full compensation for the cost of all labour, plant and equipment, materials including furnishing, transporting, handling, placing, operating and maintaining the cooling plant, filling the pipes with grouting, measurement for the water temperatures and other items necessary to complete the works.
SECTION VII – STRUCTURAL STEELWORK

GENERAL

1.1. Scope

This Section covers fabrication, storage, handling and erection of steel structures.

Codes of Practice

The fabrication, storage, handling and erection of structural steel works shall comply with the relevant Sections of the IS and IRC, if otherwise not specified in the contract.

Should there be any disagreement between IS and IRC, the provision in the IRC shall prevail to the extent of the disagreement.

1. MATERIALS

2.1 Material for use in connection with the protection of the steel work against corrosion are specified in Clause 9 of Section VII. Other materials used in connection with steel structures such as concrete, bearing pads, etc., shall be governed by the appropriate Sections of these Specifications. Unless otherwise specified or described in the contract, structural steel materials shall comply with the appropriate standards listed below.


IS 2062-1992 : Steel for General Structural Purposes.

IS 9550-1980 : Specifications for Bright bars.

IS 3757-1985 : Specifications for High Strength Structural Bolts.

IS 6623-1985 : Specifications for High Strength structural Nuts

IS 6649-1985 : Specifications for Hardened and tempered Washers for High Strength Structural Bolts and Nuts.
2. FABRICATION: GENERAL REQUIREMENTS

3.1 General

This Clause shall apply to all operations undertaken in the fabrication in the workshop or elsewhere whether on or off the site. The requirements contained herein shall not be waived, nor shall be modified to conform to any set of rules that any shop adopted as its standard unless so authorized in writing by the Engineer.

Substitution of structural Section of different dimensions, weight or strength from those specified in the contract may be made only when approved in writing by the Engineer. No payment shall be made for increased weight or strength/properties resulting from approved substitution, but any decrease in weight shall be deducted from the final pay quantity.

The various components/elements of the steel structure shall be fabricated in accordance with the approved shop Drawing. Any errors or omissions in them shall be reported to the Engineer, and his decision for their correction shall be final.

3.2 Shop Details Drawing

The Contractor shall furnish shop detail Drawing for the complete fabrication of all components/elements required by the contract. When it is specified in the contract that the employer shall furnish prints of standard shop detail Drawing, the Contractor shall be required to make any additions or revisions to the detail Drawing as may be necessary to produce a finished structure in accordance with the contract. Shop detail Drawing shall consist of detailed Drawing showing the dimension and sizes of the components/elements, bolt lists for field erection, a match marking diagram, complete field erection Drawing and such other details and information as may be necessary for fabrication.

Shop detail Drawing of widening or reconstruction work shall contain sufficient field dimension, so that the shop Drawing may be checked. The Drawing shall also contain a note to the effect that these are field measurements which the Contractor has furnished and for which he is responsible. Such detail drawing shall also show a portion of the existing work, using light dotted lines or coloured ink for this purpose.

Shop detail Drawing shall be prepared in a neat and legible form, on the dull side of tracing cloth, with India ink, or by other methods approved by the Engineer. Each sheet shall have a title in the lower right hand corner giving the fabricator’s name, the fabricator’s contract number and brief description of the details shown on the sheet.
Bills of material and bolt lists may be furnished on the fabricator’s own standard sheets.

The Contractor shall submit blueprints of shop Drawing to the Engineer for approval. No work shall be done in the shop until such Drawing has been finally approved. In general, 2 sets of preliminary prints shall be required, but the Contractor shall furnish additional prints free of charge upon request. Only checked Drawing in complete sets shall be submitted for approval. The details of anchorages, bearing plates, castings, etc., shall be submitted in advance, in order to avoid delay in construction.

When changes on the submitted Drawing are requested by the Engineer, or when the Contractor makes additional changes, other than those requested, attention shall be called to the changes on the blueprints submitted for approval by encircling or underscoring all change with contrasting coloured ink or rayon.

After the Drawing has been finally approved, the Contractor shall, without direct compensation thereof, furnish to the Engineer 4 sets of prints of the corrected Drawing, and such additional prints as may be required. The shop Drawing as approved by the Engineer shall become a part of the contract.

The ordering of material or the performance of shop work prior to the Engineer’s approval of shop Drawing shall be at the Contractor’s risk and cost. No changes shall be made in any approved Drawing without the written authorization of the Engineer. The Engineer’s approval of shop Drawing shall not relieve the Contractor of responsibility for the accurate assembly and fitting of all structural members. After the shop work has been completed, the Contractor shall deliver to the Engineer all of the original tracings of the shop details, or positives thereof, on cloth.

3.3 General Shop Practice

3.3.1 Storage

Before and after fabrication, all materials shall be so stored that they are not deformed or damaged, and shall be protected against the accumulation of water, dirt, oil or other foreign matter. Material that has become pitted from exposure or other causes shall not be acceptable for any use. Material that has been damaged during storage shall be replaced with equivalent or better material.

3.3.2 Identification

Structural alloy steel shapes and Sections shall, in addition to standard mill practice identification, be further identified during all operations, from the mill to the completely fabricated structure, by the use of, and continued maintenance of, colour coding in accordance with IS 2049.
Alloy steel and non-ferrous alloy bolts shall be identified by coded markings embossed or impressed on the head or tip during manufacture. Pieces on which identification has been lost shall be rejected.

3.3.3 Workmanship and finish

All metals shall be neatly and accurately cut to required size with proper allowance as may be necessary or required for finishing operations.

All fins, ragged or distorted edges resulting from shearing, speed sawing, or frame cutting shall be removed by milling, chipping, or grinding.

Shearing shall not be used for the purpose of cutting non-ferrous metals where the thickness is greater than 13 mm.

3.3.4 Flame cutting

The gas cutting torch may be employed in the operation of cutting metals or preparing joints provided that the metal in not carrying stress during the operation. Carbon steel above 0.30 carbon alloy steel, heat treated steel or aluminium, wrought non-ferrous metals and plated metal shall not be flame cut unless subsequent corrective treatment is provided which shall be subject to the approval of the Engineer.

When the cutting torch is used, the burned edges shall be trimmed smooth to exact lines by milling, chipping or grinding. Maximum deviation for “free hand” cutting shall be 1.5 mm from true lines. A mechanical guide shall be used for the flame cutting torch on all work requiring precision cutting on which the maximum deviation permitted shall not be greater than 0.8 mm. All “notch effects” shall be completely removed from the portions of members where the extreme fibre is subject to flexure, tension or perpendicular shear.

Where the ends of members which are to which are to take bearing, are cut with a torch, a suitable allowance in their length shall be made to permit proper milling or planning.

Joints for welding may be prepared by “flame gouging” provided all slag and oxidized metal are removed.

3.3.5 Re-entrants

Interior and re-entrant corners shall be filleted to a 25 mm radius unless a shorter radius is indicated in the plan. Fillets less than 25 mm in radius shall be formed by drilling.
3.3.6 **Bending**

All bending or crimping shall be done at the bend lines shown, by a mechanical operated press, without unnecessary loss of Section in the metal being bent. The bends shall conform to wood or metal templates. All low carbon steel and other wrought metals shall be bent cold when the required bending will not produce cracks or fractures. When heating is necessary to accomplish bending of ferrous metals, the material shall be carefully heated to and bent at or above a temperature by a dark red colour, but in no case at a lower temperature. All material bent below such temperature shall be rejected and annealing shall not be considered a corrective measure. Heated material shall be slowly cooled after the bending operation. Heat treated metals shall be shaped before heat treatment. Material having fractures or other defects caused by bending shall be rejected.

Cold-bent load-carrying rolled steel plates shall conform the following:

(i) They shall be so taken from the stock plates that the bent-line is at right angles to the direction of rolling.

(ii) The radius of bends, measured to the concave face of the metal shall be more than specified below.

<table>
<thead>
<tr>
<th>Angle through which plate is bent</th>
<th>Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>61° to 90°</td>
<td>1.0 T</td>
</tr>
<tr>
<td>91° to 120°</td>
<td>1.5 T</td>
</tr>
<tr>
<td>121° to 150°</td>
<td>2.0 T</td>
</tr>
</tbody>
</table>

Where T is the thickness of the plate undergoing bend.

(iii) Before bending, the corners of the plate shall be rounded to a radius of 1.5 mm throughout that portion of the plate at which the bending is to occur. If a shorter radius is essential, the plates shall be bent hot.

3.3.7 **Straightening Material**

All wrought and extruded Sections must be made straight or cambered as shown in the plane before being marked, punched or otherwise worked on in the shop. If straightening is necessary, it shall be done by method which will not change the physical properties, reduce the Section, or otherwise damage the metal. Material which develops kinks, fractures or evidence of embitterment shall be rejected. Materials that are warped by cutting, punching or welding shall be straightened to correct lines and dimensions before being assembled.
Sections that are distorted during assembly and/or welding shall be straightened by methods that will not shear, fracture, or pre-stress the welds or connecting members. If, in the opinion of the Engineer, Section can not be properly straightened after assembly, the bent material shall be taken out, straightened and reassembled in the unit. Any material damaged during such operations shall be replaced with equivalent or better material.

Unless otherwise specified in the contract, structural steel Section which deformations do not exceed normal rolling tolerance will be acceptable without straightening. When the plans so indicate, beams shall have unwrapped webs with flanges at true right angles thereto. Such beams shall, if necessary, be straightened cold by an approved method of web pressing.

3.3.8 Layouts and Templates

Full scale layouts will be required for intricate portions of structures that present problems or fabrication or erection. When requested by the Engineer, such layouts shall be made available to him for checking purposes. Duplicate work shall be fabricated with the aid of templates or jigs. Wood or metal templates shall be used for all mitre joints except when an approved jig is used. Reaming or drilling temperatures shall be made of metal, using hardened steel bushing 25 mm thick.

Sweeps for laying out and checking curved surfaces shall be made of wood or metal and shall be of sufficient length to produce accurate results.

Working points and working lines shall be clearly marked on all templates and sweeps.

All templates shall be made available for the Engineer’s use.

3.3.9 Built-up Members

A built-up member shall be true to detailed dimensions and it shall be free of twists bends, open joints, or other defects resulting from faulty fabrication or workmanship. The assembly shall be such that all field joints will have the planned clearance. The joints shall be smooth, and free from all burrs or other obstructions.

Closed Sections or pockets which might harbour moisture or dust and which cannot be readily cleaned and painted shall be filled with plates or closed by caulking or welding. Filler plates shall be full size and
fitted sufficiently tight to exclude all moisture and dust after being painted. Tack welding may be employed to hold fillers in place.

### 3.3.10 Incidental Items

The following items shall be furnish by the Contractor without additional payment unless otherwise provided for in the contract.

(i) **Pilot Points and Driving Nuts:**

One new pilot and one driving nut for each size of shouldered pin.

(ii) **Erection Pins, Bolts and Washers:**

All erection pins, bolts and washers necessary for field erection

(iii) **Field Rivets:**

Extra rivets of each size and length, in the amount of 10 rivets plus 10 per cent of number actually required for field erection, to compensate for loose due to misuse, improper driving or other contingencies.

(iv) **Field Shims:**

Shims 3 mm or more in thickness shall be made of structural steel and those thinner than 3 mm shall be made of sheet brass.

“Field shims” shall be constructed to mean all metal plates which are required, because of inequalities or inaccuracies in fabrication or erection or because of the substitution of Sections by the fabricator, to bring metal surfaces of members into contact or to bring the structure to the required grade and alignment. “fillers” shall be constructed to mean metal plates which are required by the design to bring metal surfaces of members into contact or to bring the structure to the required grade and alignment, and shall be included in the quantities for which payment shall be made.

(v) **Sections:**

Increase of Sections over net size required in the contract, and other Sections, metals, parts, or equipment added for the purpose of erection only which may or may not subsequently remain a part of the finished structure.

### 3.4 Machining
3.4.1 Definition of Terms

(i) Rough Finish:

The surface shall be true but may show very slight grooves.

(ii) Finish:

The surface shall be true and smooth and shall show no visual evidence of grooves.

(iii) Smooth Finish:

The surface shall be true ad perfectly smooth to the touch.

(iv) Polished Finish:

The surface shall be true, smooth and polished.

(v) Milled Finish:

The surface shall be the same as the defined for rough finish,

(vi) Bored Finish

The surface shall be the same as that defined for smooth finish.

3.4.2 Machine Lubricant

Soap water solution shall be used as a lubricant on all structural material requiring machine work. The use of oil or grease shall not be permitted for this purpose. Cutting oil shall be used on machinery parts and bolt stock.

3.4.3 Edge Planning

Structural steel plates with sheared edges having a thickness of more than 16 mm and structural alloy plates having a thickness of 13 mm or more, except web plates for built-up girders, sole or base plates, and fillers, shall be planed to correct size with square edges by removing not less than 6 mm of metal. The use of mechanically guided needle torch may be permitted in lieu of specified edge planning of expansion plates when used for the purpose of making bevel cuts.

3.4.4 Bearing Surfaces
After a column has been otherwise completely welded and before the cap or base plates are attached, the bearing surfaces shall be milled to the angle shown in the plan.

End connection angles shall be welded to the main member before milling.

Cap and base plates of columns shall have full contact with the surface after assembly. Sole plates of beams and girders shall have full contact with the flanges. Warped for deformed plates shall be machine finished or otherwise straightened by an approved to secure an accurate and uniform contact. Countersunk river heads or extruding weld metal shall be chipped smooth and flush with the surrounding surface.

Castings shall be machined as indicated in the plan.

Bronze bearing plates shall have a “Polished Finish”

3.4.5 Abutting Joints

The ends of members shall not be milled until such members have been completely welded. Members whose ends are improperly milled shall be rejected.

The ends of members forming a compression joint or splice shall be accurately milled to proper length, alignment and bearing, using a wood or steel template as a guide. Gusset plates connecting milled ends of members shall conform to the same wood or metal templates from which the milled ends were formed. The use of bevel square shall not be permitted.

Joints in main chord tension members shall be close and neat, and in no case shall the opening be more than 3 mm.

3.4.6 Boring Pin Holes

Pin holes shall be accurately located as detailed, and bored true to exact dimensions. They shall be bored smooth, straight, and at right angles to the axis of member. A finishing cut, which shall be a complete and separate operation, will be required.

Unless otherwise indicated in the plans, the difference in diameters of the pins and the pin holes shall be 0.8 mm exact.

3.4.7 Pins and Rollers
Pins and rollers shall be accurately turned to the detailed dimensions. The final surface shall be smooth, straight, and free from flaws. The final surface shall be machined to a smooth finish.

All bridge pins and roller 150 mm in diameter and smaller shall be made of Bright steel bars complying with IS 9550.

All segmental rollers and all pins whose nominal diameter is to be greater than 150 mm shall be made from annealed forging.

A hole 50 mm in diameter shall be bored longitudinally through the centre of each pin or roller having a diameter greater than 230 mm. Pins or rollers showing defective interiors shall be rejected.

Pins shall be held in place by recessed nuts. The nuts shall be hexagonal in shape and shall be made of malleable iron, pressed or cast steel. The grip face of the nuts shall be machined square to the axis of the pin. Pins and nuts shall be accurately made so that the recessed face of the nut will bear uniformly against the end face of the pin when the nut is turned up tight. The threaded portion of the pin shall project at least 6 mm through the nut after assembly. Where a recessed cut is made between the threads and the shoulder of the pin, it shall not be wider than 6 mm nor deeper than the base of the thread.

### 3.5 Marking and Dispatching

All material shall be accurately and legibly marked according to the field erection plan, prior to dispatch. Such markings shall be made with contrasting paint on previously painted surfaces. The omission of marks on duplicate pieces shall not be permitted unless otherwise authorized by the Engineer.

When practicable, loose connection plates for a member shall be bottled in position thereon for shipment. All rivets, bolts, nuts and washers shall be parceled separately as to size. They shall be shipped in suitable containers, but the gross weight of any single container shall not exceed 100 kg. A list and description of the included material shall be plainly marked on the outside of each container.

Pins, roller nets, name plates, sheet lead, and small parts be boxed or crated for shipment. Pins shall be shipped with the nuts in place.

When the Engineer directs, finished work shall be weighed in the presence of the Inspector. The fabricator shall supply satisfactory scales and shall do the handling and weighing. When requested by the Engineer, members weighing more than 300 kg shall be marked to show their scale weight.
The loading, unloading, handling, transportation and storing of structural material shall be carefully conducted so that the metal will be kept clean and free from damage. All girders, partly assembled trusses, and large I beams shall be transported in an upright position. Cambered members shall be securely blocked to prevent any loss of camber. All sheets and copper waterstops shall be crated for transport.

Anchor bolts, pier nose angles, and other anchorage or grillage materials shall be dispatched in advance of other material to suit the requirements of the construction work.

3.6 Shop Painting

All ferrous metals which have not been plated, galvanized or enameled shall be given one shop coat of paint of the kind specified in the contract. Non-ferrous metals shall not be painted or otherwise surface treated unless so specified in the contract. All cleaning and painting shall conform to Clause 9.

3.7 Inspection and Testing

3.7.1 General Requirements

The Contractor shall advise the Engineer as to the actual date and place of preparation of materials so that sufficient time may be had, prior to such preparation, to arrange for inspection. This inspection will be dependent upon the character and importance of the work and may involve inspection in the mill, the foundry, the fabricating shop and the field, as may be considered necessary by the Engineer. Information relative to the time of beginning various operations, such as mill rolling, foundry casting, heat treating, shop layout, punching, riveting, welding, milling, assembling, painting and shipping, shall be furnished to the Engineer in sufficient time so that he may provide for the proper supervision and inspection of the work. In general 28 days shall be considered as the required time of advance notice. Failure to furnish information shall result in the rejection of the material involved.

The Employer may depute structural-metals-inspectors for the inspection of all metals at the plant or in the field. When such inspection service can be furnished in the usual routine manner without any additional expenditures, no charge shall be made against the Contractor. When such inspection service entails additional costs, the Contractor shall be charged for the expense incurred but such charges shall not be greater than the amount specified in the contract per person per ton, based on the total metal tonnage of the contract.
As soon as the progress of the work permits, the Contractor shall furnish to the Engineer 2 copies, or more, if required, of each of the following:

Mill or purchase orders, certified reports of physical characteristics and chemical analysis of all materials involved, and the fabricator’s shipping statements showing the net scale weight of each shipment. When requested, the scale weights of individual member or Sections shall be furnished.

All materials and workmanship shall be subjected to inspection and Engineer’s agreement. The inspection of materials and fabrication shall as far as possible be carried out at the place of manufacture.

Expect as provided for above no fabricated steelwork shall be dispatched to the Site before it has been inspected and agreed. All inspected and agreed steelwork shall be marked in accordance with the agreed procedures.

3.7.2 Inspector’s Authority

The Inspector shall reject the materials and/or the workmanship which do not fulfill the requirements of the contract. However, in cases of dispute, the Contractor may appeal to the Engineer, whose decision shall be the final.

Inspection at the mill and shop is provided for the purpose of facilitating fabrication work and to avoid errors, but such inspection shall not relieve the Contractor of his responsibility for the correction of errors and faulty workmanship or for the replacement of imperfect materials.

3.7.3 Facilities for Inspection

The Contractor shall furnish all facilities, tools and such assistance as the Inspector may require for the inspection of material and workmanship in the mill, foundry or shop. The inspector shall be granted free access to the plant premises for the required inspection service. All fabricated parts shall be piled separately in such a manner as to facilitate inspection.

The Contractor shall furnish office space at the fabrication plant for the Inspector’s use during the period of fabrication, assembly and paintings.

3.7.4 Testing

Unless otherwise provided, the Contractor shall furnish test specimens as specified, and all labour, testing machines and tools necessary to prepare the specimens and to make the prescribed tests. Where check tests are required by the Engineer to determine the suitability of any
materials, the Contractor shall furnish representative samples for further testing by the Engineer before such material is finally approved for use.

Where no specified tests are provided for in the contract, tests for metals shall be conducted in accordance with the Engineer’s directions.

3.7.5 Rejection

Rejected materials and workmanship shall be promptly replaced with satisfactory material and workmanship. Any shipment of materials that has been damaged in transit shall not be unloaded until an agreement as to its disposition has been reached with the Engineer.

4. FABRICATION OF BOLTED STRUCTURES

4.1 End Connection Angles

End connection angles of floor beams, stringers and diaphragms shall be accurately assembled to the dimensions shown in the plan, and the length, back of angles, shall be exact. Unless otherwise specified, the finishing of end connection angles shall not be required except as a correction to a faulty assembly. When finishing is necessary for such correction, the thickness of the angles shall not be reduced by more than 3 mm but in no case shall the final thickness of the angle be less than 9 mm. Portions of members extending beyond the face of the connection angles shall be chipped or ground flush. No portion of a web or a connecting member shall be recessed more than 9 mm from the face of the connection angles.

4.2 Stringers

Stringers shall be straight and their bearing surfaces shall be true, and free from all burrs and distorted edges.

The fixed ends of stringers supported on brackets or on the top flanges of floor beams shall be secured by means of bolts having hexagonal heads and nuts.

The maximum clearance between abutting ends of stringers shall be 13 mm unless otherwise specified. Stringers supported on brackets shall have a maximum clearance of 13 mm between the end of the stringer and the web of the floor beam.

4.3 Expansion Devices
Expansion and deflection devices shall be exact dimensions, and no tolerance in materials or dimensions shall be allowed. Unless otherwise indicated in the plan these devices shall be secured to stringers or floor beam by means of bolts having hexagonal heads, hexagonal nuts and lock washers.

4.4 Bolted Plate Girders

The web plate of a finished girder shall in no case project beyond the face of the flange angles or end stiffener angles. In girders with full-length cover plates, the edges of the web shall not be more than 6 mm inside the face of the flange angles except that, in cases of cambered beams, the width of the web may be 13 mm less than the distance (back to back) between the flange angles provided the web is centred. In girders without cover plates, the edges of the web shall not be more than 3 mm below the face of the top flange angles. In girders with partial length cover plates, the above requirements shall apply together with the additional requirement that, unless the edges of the webs are flush with the faces of the flange angles at the ends of the cover plate, any space between them shall be plugged with a weld at least 13 mm long. In no case shall the ends of the webs be more than 9 mm inside the face of the end stiffener angles.

Holes in all girder web splices shall be subpunched or subdrilled. After assembly these holes shall be reamed to specified size.

Splicing of flange angles shall not be permitted, unless required by the Contract, except when girders are to be constructed with curved ends, in which case the flange angles shall be spliced near the curved portion to facilitate bending and assembly. Curved and flange angles shall be bent in pairs. After bending, the curved angles shall be true to the plan radius and free of all wrinkles or waves. After assembly, these curved end angles shall be butt welded to the flange angles, and the weld shall then be ground smooth.

When splices in flange angles are required by the contact, the abutting ends of the angles shall be milled to a close fit. All holes in such splices shall be subpunched and reamed, or drilled form the solid. Smoothly ground butt welds will be acceptable for joints in flange angles in lieu of milling. Such welds shall not be considered as a substitute for the splice plates or angles as detailed.

Unless otherwise indicated in the plan, end stiffeners and intermediate stiffeners intended for supports for concentrated loads shall be milled or ground smooth to secure a uniform, even bearing against the top and bottom flange angles. When welding is indicated or permitted in lieu of milling or grinding, the welds shall be of sufficient size to develop fully the stiffener in bearing and they shall be so placed as to completely seal the stiffener ends against entrapment of moisture. Welding transversely across the tension
flanges of beams or girders which have a flange stress of more than 74 per cent of their designed capacity, shall not be permitted. At locations of higher stress, wedge fillers shall be incorporated in conjunction with longitudinal welds.

Intermediate stiffeners shall fit sufficiently tight to excide moisture after being painted. Fillers under stiffeners shall fit within 1.5 mm at each end. Crimped stiffeners angles or tees shall be properly bent to a steel template, and they shall have full contact bearing against the flange and the web plates.

4.5 Holes for Unfinished Bolts

4.5.1 General

All holes shall be true to the shape and size specified, clean-cut perpendicular to the axis of the member and free from all burrs and distorted, torn or ragged edges.

The minimum distance from the centre of a hole to a sheared edge shall be 38 mm, and the minimum distance to a planed or rolled edge shall be 1.5 times the diameter of the bolt specified for such hole, except as hereinafter provided or otherwise indicated in the plan. The edge distance for lace bars shall be not less than 1.6 times the diameter of the rivet or bolt.

4.5.2 Type

When reaming or drilling is not specified in the contract, full size punched holes in low carbon and low alloy steels may be acceptable, provided the thickness of the metal does not exceed the diameter of the hole to be punched, and provided no more than 5 thickness of metal are to be connected. When there are more than 5 thickness of metal or when any of the material is thicker than the diameter of the hole, all of the holes in the material composing such connections shall be formed by subpunching (or subdrilling) and reaming or by drilling from the solid, as hereinafter specified. Stress-carrying high-carbon steels, non-ferrous metals and alloys 13 mm in thickness or less shall be subpunched (or sub-drilled) and reamed. Where such metals are of greater thickness the holes shall be drilled from the solid with all parts assembled. Railing Sections may be jig drilled full size.

When general reaming is specified in the contract for low carbon and low alloy steels, all bolt holes, including connection holes to main members, shall be subpunched (or subdrilled) and reamed, or drilled from the solid; except for the following, which may be full punched:

- Holes for unfinished bolts, or plug welds.
- Holes in expansion and deflection devices, stringer diaphragms and railings.

- Holes in laterals and lateral plates; away frames other than in towers of bents; brackets; sole, bearings or anchor plates; and grillages.

4.5.3 Punched Holes

The diameter of full sized punched holes shall be 1.5 mm larger than the nominal diameter of the rivet or bolt. The diameter of the die shall not exceed the diameter of the punch by more than 1.5 mm.

All holes shall be so accurately punched that, after the assembly of the component parts of a member, and before any reaming is done, a cylindrical pin whose diameter is 3 mm less than the nominal diameter of the punched hole shall pass freely through at least 75 per cent of the holes in any group. Correspondingly, a pin whose diameter is 5 mm less than the nominal diameter of the punched holes shall pass freely through all holes in any group. Material falling to meet either of the above requirements shall be rejected. Reaming shall not be permitted as a corrective measure.

4.6 Holes for Turned Bolt

The diameter of holes for turned bolts shall be 0.4 mm larger than the diameter of the bolt. If the bolts are to be inserted in the shop, the holes may be either drilled from the solid, or subpunched and reamed. If the bolts are to be inserted in the field, the holes shall be subpunched or subdrilled in the shop and reamed in the field. All drilling or reaming for turned bolts shall be done after the parts to be connected are assembled and securely fastened together. No offsets shall be permitted in holes for turned bolts.

4.6.1 Slotted Holes

Slotted holes shall be securely located, true to planned dimensions, where full size slot punches are not used for this purpose, the holes shall be made under size and subsequently finished to true size and shape by chipping, grinding or filing.

4.7 Bolts

4.7.1 Unfinished Bolts

Unless otherwise specified, all bolts for steel construction shall be unfinished and shall have hexagonal heads, hexagonal nuts and lock
washers. The length of the bolt shall be such that, after placement, it will project through the nut not less than 3 mm nor more than 9 mm. The material for and the manufacture of bolts shall conform to the requirements of IS 1364 or IS 3757 as appropriate.

### 4.7.2 Turned Bolts

The heads and the nuts shall be hexagonal. The bolt shall be machined from a hexagonal bar, the size of which shall be the same as the bolt head. The shank of the bolt shall be turned and given a smooth finish to exact diameter. The length of the unthreaded portion of the bolt under the head shall be 3 mm greater than the thickness of material it is to pass through. The diameter of the unthreaded portion of the bolt shall have a diameter at least 2.4 mm less than the diameter of the unthreaded portion of the bolt, and it shall be the nearest standard bolt size. The threads shall extend from the end of the bolt to within 1 thread distance form the shoulder. Washers 6 mm in thickness shall be used under all nuts, and the hole in the washer shall be the same size as the reamed or drilled hole.

### 4.7.3 Anchor Bolts

Anchor bolts shall be the swage type and shall have hexagonal nuts. Bolts for expansion joints shall be provided with 2 nuts. Those portions of bolts which extend above masonry or concrete shall be painted 1 shop coat of paint.

### 4.7.4 High Strength Friction Grip Bolts

High Strength friction grip bolts shall comply with IS 3757.

All load indicators shall be suitably marked for identification purpose and shall be of standard black, lightly oiled, finish and shall be packed prior to dispatch, by the manufacturer, in waterproof containers and shall be stored in those containers under cover until required for use in the works.

Only general grade load indicators shall be used with general high strength friction grip bolts.

Each high strength friction grip bolt when installed in the works shall be complete with one washer placed under the nut and one indicator placed under the bolt head and each bolt shall be tightened at all stages by rotating the nut only, the bolt head being completely restrained against rotational movement.
Alternatively, in joint where accessibility is limited to the extent that bolts must be tightened by rotating the bolt heads, then washers shall be laced the bolt heads and both load indicators and nut face washer shall be placed under the nuts. In these cases each bolt shall be tightened at all stages by rotating the bolt head only, the nut being completely restrained against rotational movement.

All high strength friction grip bolts shall first be tightened sufficiently to secure the structural steel work during its erection or assembly. Following completion of the erection or assembly of each portion of the structural steelwork those bolts shall be finally tightened until the gaps between the load indicators and either the bolt heads or the nut face washers have been reduced to:

(i) 0.40 mm where load indicators are fitted under the bolt heads

(ii) 0.250 mm where load indicators are fitted under the nuts and beneath nut face washers.

The bolt may be tightened by a part-torque part-turn method. The part-torque tightening for bedding down shall be in accordance with BS 4604: Part 1 except that it shall be carried out by a calibrated tightening device such as a torque-controlled manual wrench or power operated wrench. The bending torque to be applied to the bolts shall be as given in Table 22.1.

**Table 22.1: Preliminary Tightening of Nuts**

<table>
<thead>
<tr>
<th>Nominal dia of bolt mm</th>
<th>Bedding torque ± 10 percent Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>80</td>
</tr>
<tr>
<td>20</td>
<td>160</td>
</tr>
<tr>
<td>22</td>
<td>210</td>
</tr>
<tr>
<td>24</td>
<td>270</td>
</tr>
<tr>
<td>27</td>
<td>340</td>
</tr>
<tr>
<td>30</td>
<td>460</td>
</tr>
</tbody>
</table>

After bedding down of the joints, each nut and the protruding threads of the bolt shall be permanently marked to record their relative positions. The nuts shall then be tightened to the approval of the Engineer by the part-turn of the nut method in accordance with BS 4604: Part 1.

5. **CASTING AND HEAT TREATMENT**
5.1 Foundry Practice

Pattern for casting shall be furnished by the Contractor. They shall be constructed to produce a finished casting in true conformity to the dimensions and details shown in the plan. All sharp angles shall be boldly filleted. Fillets shall be of such size that there is no reduction in planned clearances due to their addition. External corners on all castings, except ornamental type, shall be rounded to a 5 mm radius. Proper allowance for shrinkage shall be made in all patterns. Sufficient materials shall be provided on all surfaces which are to receive a finish so that, after finishing, the casting will be the planned size, and the finished surfaces will be true, free from pockets, sand intrusions, or other defects. Draft provided shall allow the plan dimensions and shall not reduce the thickness of metal specified. All patterns shall be painted, indicating in different colours, the metal, coarse and finished surfaces.

Spilt cores shall not be permitted between unfinished surfaces of restricted clearance. The number and spacing of chaplets shall be such that the strength of the casting is not impaired by their use.

The casting shall be accomplished by a method that will ensure the complete filling of all corners, arises and edges. Castings requiring undercut surfaces shall be cast by the “lost wax process” or equivalent. Where practicable, casting having one machined surface shall be cast with the surface down. Metal from different melts shall not be permitted in the same casting. Casting shall not be withdrawn from the mould until they have properly cooled. Quenching of casting to speed up the cooling shall not be permitted.

All casting shall be thoroughly cleaned of moulding and core sand blasting or by other approved methods. All high spots and rough edges resulting from pouring connections shall be ground smooth.

All casting shall ring true when suspended and struck with a hammer. When ordered by the Engineer, the soundness of the casting shall be further tested by drilling, planning, magnetic particle test or X-ray.

Any structural defect in a casting such as blow holes, pipes sand holes, cracks, checks, slag inclusions, cold shuts, unfilled arises, warped surfaces, or deformations from core or flask movement shall be cause for rejection.

Castings with minor defects shall not be repaired until the Engineer has given his permission. The method employed in such repair work shall be approved by the Engineer.

5.1.1 Heat Treatment
The term “heat treatment” shall mean any method of intentionally and systematically applying heat, at a temperature below the melting point, to any casting after it has cooled. This heat may be applied one or more times irrespective of cooling the procedure.

The term “annealing” shall mean either normalizing (air cooling) a casting or full annealing (furnace cooling) a casting.

Full annealing shall consist of a heat treatment in which the casting is heated slowly to the proper temperature above the critical range, maintained in such temperature for the required time, and allowed to cool slowly in the furnace until the temperature has fallen to 260 degrees F or less. The casting may then be withdrawn from the furnace and air cooled. The furnace temperature shall be controlled by pyrometers.

All other casting shall be annealed when so specified in the contract.

All forgings, and such other steel Sections as may be required by the contract, shall be full annealed. Other steel members, except primped web stiffeners, that have been partially-heated shall be full annealed unless otherwise authorized by the Engineer.

6. WELDED CONSTRUCTION

6.1 General

Welding shall be generally in accordance with IS 1024 and relevant British Standards as further amplified in the following Sub-clauses.

6.2 Materials

Welding materials unless specified in the contract or agreed by the Engineer shall comply with the appropriate Indian Standard listed below:


6.2.2 IS 814 - 1991 filler rods and wires for gas welding (second revision).

Classification and colour coding of electrodes shall be in accordance with IS 814-1991.

6.3 Welding Equipment
Welding equipment shall comply with the appropriate Indian Standard listed below unless otherwise stipulated in the contract or agreed by the Engineer.

- IS 4559 – 1993: Single operator rectifier type DC arc welding power source (second revision).

The welding plant and equipment employed on the works shall be sufficient capacity to carry out the agreed procedures and suitable for the types of electrodes in use. All necessary stagings and screens shall be provided for the welders, supervisors and inspectors and all plant and equipment shall be maintained in an efficient condition. Suitable tong test ammeters shall be provided for measuring the current, except only, when efficient means of so doing are incorporated as part of the welding plant.

The strength of the welding current shall be within the range recommended by the manufacturer of the particular electrode being used and shall be towards the upper limit of the range rather than the lower.

Welding shall wherever possible be carried out in covered workshops and under the specified conditions of temperature, where continuous supervision is exercised. Machine welding may be allowed where approved machines are in use correctly controlled by qualified operators.

Site welding shall not be carried out unless prior written agreement from the Engineer has been obtained. All such welding shall be subject to 100% non-destructive testing.

6.3.1 Qualification of Welders

All welding operators shall be qualified person in accordance with Clause 23 of BS 5135 and the names of all operators and details of their qualifications shall be submitted to the Engineer for agreement. Any operator whose standard of workmanship is unsatisfactory shall be immediately suspended. The operators shall be produced by the Contractor for re-testing and verification of his qualification once he has received further instruction in this respect. Routine testing of all operators shall be required in every six months.
6.3.2 Workmanship

6.3.2.1 Assembly

Material that is to be welded shall be free from loose mill scale, rust, or other foreign matter on the surface to be welded and for a distance of at least 50 mm on each side of the weld. The preparation of edges for welding may be by milling, chipping or cutting with a torch. All traces of overheated metal caused by torch cutting shall be removed. For this chipping to expose clean metal may be required. Grinding shall not be permitted on any surface or edge which is to be welded, unless the surface is subsequently thoroughly cleaned of carborundum and metal particles.

Members or parts which have been painted shall have all of the paint removed from the area which will be affected by the heat of the arc. This shall be accomplished by burning with a blow torch or blow pipe and brushing with a wire brush.

6.3.2.2 Welding

Welding shall not be done in rain, snow or wind, or when the temperature of the metal is below 4\(^\circ\) C, unless satisfactory protection such as shelters, wind-breaks and heat is provided.

During moderately cold weather the use of small movable shelters and preheating the metal by means of blow torches will be in general satisfactory. When the temperature is below- 10\(^\circ\) C, the span or portion of structure under going welding shall be entirely housed in and heated to a minimum of 5\(^\circ\) C. The use of open salamanders for such heating shall not be permitted.

Welding procedures shall be such that distortion is reduced to the minimum practicable and local distortion is negligible in the final structure.

All welding procedures including those items listed in Clause 20 of BS 5135 shall be submitted to the Engineer in advance for agreement. All welding procedure submitted for agreement shall have previously been approved by an Independent Inspector, from authentic documented experience gained with welding of joints similar to that for which the welding procedure applies. Where no such approval is available, then the welding procedure shall be subjected to approval after testing in accordance with the requirement of BS 4870.

All welds shall be of the specified size and shape, and they shall be placed at the locations designated. Welds which are not in conformity with those required or welds which are defective, shall be chipped out and redone in an approved manner. Weld protrusions which interfere with later work or which present an uneven or unworkmanlike appearance shall be finished smooth by chipping and grinding. Deposited weld metal must be completely fused to all metal with which
it is in contact. The weld shall be free of all pits, porous Sections, cold shuts, or slag inclusions. All pits and craters shall be filled and all ends shall be boxed.

An electrode of the proper size shall be selected for the weld desired. The electric current shall be adjusted for the electrode so that full fusion will be obtained without undercutting. Undercut welds shall be chipped back to bright metal and rewelded. The arc shall be kept uniform and steady and shall be applied in a manner which will fuse the metal without boiling, running or unnecessary spatter.

The placement of welds shall be such as to minimize shrinkage or distortion of the members. Members in which there is distortion caused by welding must be straightened to the satisfaction of the Engineer without structural damage to the member or to the welds.

Peening for welds shall not be permitted.

6.3.2.3 Final Finish of Welds

The final finished surface of the weld shall be smooth and regular and shall conform as closely as practicable to the design requirements. All slag shall be removed from the finished weld. All flux deposit which may cause paint to rot shall be entirely removed. The entire surface shall be thoroughly wire-brushed before painting. If required by the Engineer, the final surface shall be finished smooth by chipping and grinding the weld deposit.

6.3.2.4 Weld Inspection

Inspection shall be made during the welding process and after the weld is completed and cooled in accordance with IS 3600. All defects shall be entirely removed or repaired to the satisfaction of the Engineer. The Engineer shall designate at least 25 mm of every 2500 mm of welding for removal, to determine the penetration, fusion and porosity of the weld.

Plug borings shall be furnished when requested with the use of “X-ray” or magnetic-particle examinations may be made where the proper testing equipment is available. In such cases the inspection practice shall be in accordance with IS 1182 or IS 5334 as appropriate.

6.3.2.5 Safety Precaution

Suitable shoes, helmets, hand shields, glasses, gloves, aprons, screens, canvas, wind shields and all other equipment necessary for the protection of the work, the welders, the helpers and the Engineer’s Inspector shall be provide by the Contractor at his own expense. The provisions of IS 818-1968 Code of Practice of safety and health requirements in electric and gas welding and cutting operations (first revision) shall be observed.
6.3.3 **Procedure Trials**

When directed by the Engineer and before fabrication is commenced, welding and flame cutting procedure trials shall be carried out using representative samples of materials to be used in the work.

The samples of material shall be selected and marked by the Engineer when the materials for the work are inspected at the mills.

Trials on material 20 mm thick shall be taken to include all material up to but not exceeding 20 mm thick. Trials on material 38 mm thick shall be taken to include material over 20 mm and up to but not exceeding 38 mm thick. Material over 38 mm thick shall be tested for every thickness increment of 6 mm.

The welding and flame cutting trials shall demonstrate to the satisfaction of the Engineer the procedures to be adopted in the fabrication of the work which shall include:

- **(b)** The heat control techniques required to ensure that the flame cut surfaces of steel are free from cracks, local hardness, and any other defects which would be detrimental to the finished work.

The trials shall include specimen weld details representative of the actual construction which shall be welded in a manner simulating the most unfavorable conditions liable to occur in the particular fabrication. Where primers are to be applied to the work prior to fabrication, they shall be applied to the sample material before the procedure trials are made. After welding the specimens shall be held at a temperature not less than 10°C for a period of not less than 72 hours and shall then be sectioned and examined for cracks and other defects.

The following groups of tests as per BS 709 shall be carried out in accordance with Clause 21 of Section III.

- **(i) Butt Welds**
  - Transverse tensile test
  - Transverse and longitudinal bend tests
  - Separate tests shall be performed in each case with the root of the weld in tension and compression respectively.
- Charpy V-notch impact tests BS 4360.
- Macro examination test.

**(ii) Fillet Welds**

- Fillet weld fracture test
- Macro examination test

6.3.4 Use of Electrodes

Electrodes and fluxes shall be used in accordance with the manufacturers' instruction.

6.3.5 Butt Welds

Unless otherwise described in the contract, all butt welds shall be complete penetration welds made between prepared fusion faces.

In the fabrication of built-up assemblies, all butt welds in each component part shall be Engineer before the work commences.

Where automatic or semi-automatic process are used back gouging of deposited weld shall not be required where the Engineer is satisfied that the root run is free from imperfection.

Where butt welds are to be ground flush, there shall be no loss of parent metal. The final grinding shall be in the direction described in the contract.

Strud shear connector shall be welded in accordance with the manufacture’s instructions.

In butt joints the root edges or root faces shall not be out of alignment by more than 0.125 times the thickness of the thinner material for material up to 12 mm thick or by more than 2 mm for thicker material.

Requirements for “run-on” and run-off” plates shall be as follows:

(a) One pair of run-on plates and one pair of run-off plates all prepared to the same thickness and profile as the parent metal shall be attached by clamps to the start and finish respectively of all butt welds. Unless otherwise required by the Engineer, approximately 1 in 5 pairs of run-off plates, for butt welds in tension flanges and 1 pairs for other butt welds, shall be production test plates. The combined size of each pair of production test plates shall be either
225 mm, 300mm or 375 mm wide x 200 mm long as shown in Table 22.2, the length being measured in the rolling direction of the metal and at right angles to the weld.

### Table 22.2: Sizes of Run-off Production Test Plates

<table>
<thead>
<tr>
<th>Material</th>
<th>Combined size (per pair) of run-off production test plates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plates up to 30 mm thick</td>
</tr>
<tr>
<td>IS-1915</td>
<td>300 x 200</td>
</tr>
</tbody>
</table>

(b) Butt welds shall run the full length of the joint and extend at full weld profile for a minimum distance of 25 mm into the run-off plates, and for a minimum distances of 200 mm, 275 mm, 350 mm respectively into the 225 mm x 200 mm x 200 mm run-off production test plates.

(c) On completion of the welds the run-off production test plates shall not be removed until they have been marked in a manner agreed by the Engineer to identify them with the joints to which they are attached.

(d) When removing the run-on and run-off plates by flame cutting the cuts shall not be nearer than 5 mm to the sides of the parent metal and the remaining metal shall be removed by grinding or other method agreed by the Engineer.

(e) Specimens for the following tests to be carried out in accordance with Clause 21 of Section III shall be selected from the run-off production test plates by the Engineer:

(i) Transverse tensile test(s): The number of test shall be sufficient to cover the full thickness of plate.

(ii) Transverse bend test

### 6.3.6 Camber

Main girders shall be fabricated to the cambers shown on the Drawing. Plates shall be prepared to produce a profile which approximates to a parabolic curve, from the supports to the midspan point of the girder.

### 7. FIELD ERECTION REQUIREMENTS
7.1 Handling and Storage of Materials

Structural metals shall be carefully unloaded manually or by means of suitable equipment so as to avoid damage to the materials or their painted surfaces. Under no circumstances shall structural steel be dropped or skidded off cars or vehicles, nor shall it be dragged over the ground. Beams and girders shall be transported and handled in upright position. Pin holes, or other field connection holes, shall not be used as places for “hook-on”. Material not to be placed directly in the structural shall be stored above probable high water, on skids or platforms in a manner that will prevent distortion in the members or the accumulation of water or dirt on such members. Beams and girders shall be stored in an upright position and securely stored. Provision shall be made to protect all metals against corrosion.

All damaged metals shall be rejected.

7.1.1 Preparation for bearing area

Before placing column bases, bed plates or shoes and the bearing shall be prepared to proper elevation.

7.1.2 Flasework

7.1.2.1 Design

The requirements of Section VI shall apply insofar as they are applicable together with the following modifications and additions: Steel shall be assumed to weigh 8000 kg per cubic meter. In addition to the superimposed dead load the flasework shall be designed so as to carry safely the weight of any equipment which it may be required to support.

7.1.2.2 Plans for Falsework

The Contractor shall prepare plans and design of the flasework. When so requested these plans shall be submitted to the Engineer for his approval, before the construction of the flasework is started. The Engineer’s approval of such plans or his acquiescence in the work shall not relieve the Contractor of responsibility for satisfactory results.

7.1.2.3 Construction

Falsework construction shall conform to the requirements of Section VI insofar as they are applicable, together with the following modifications and additions. Falsework bends shall be so constructed
as to provide a minimum clearance of 600 mm between the falsework caps and the lower members of the structure which are to be supported thereon to provided ample space for the jacking and riveting of such members.

7.1.2.4 Removal

The requirements for the removal of falsework shall be as provided in Section VI insofar as they are applicable.

7.1.3 Straightening Bent Metal

Straightening of bends in main structural members shall not be permitted in the field. Such members shall be return to the fabricator for proper repair or replacement.

Bent material shall be straightened, to the satisfaction of the Engineer and under his direct supervision, before such material is incorporated into the structure.

The straightening of bends shall be done by methods that will not produce embrittlement, fracture or damage. All material shall be straightened cold when practicable. No plated, galvanized, enameled, heat treated aluminium and similar metals shall be heated. When metal of these types can not be satisfactorily straightened cold, they shall be returned to the fabricator for repair or replacement.

Mild steel and structural grade steel may be heated when necessary to accomplish straightening. Other carbon steel and low alloy steels shall not be heated unless specific approval is granted by the Engineer. Heating and straightening shall conform to the requirements of Sub-clause 3 (3) (g).

8. ASSEMBLING AND BOLTING

8.1 General

All field contact surfaces, including shims, which have not been given a shop coat of paint, shall be thoroughly cleaned and given a coat of the specified “soap coat” paint, except when such surfaces are to be completely sealed by welding. Assembly of Sections shall be made while the contact paint is still plastics. All surfaces of metal which will be inaccessible after erection shall be thoroughly cleaned of all foreign matter, spot coated and field painted in accordance with the provisions of Clause 9.

Immediately before assembly, all pins shall be thoroughly cleaned and given a coat of red lead. The pins shall be inserted into the holes before the red lead is dry and the pin nuts are drawn tight. The exposed threads shall be effectively burred or checked at the face of the nut.
Fabricated Sections which have been assembled, reamed, and matchmarked in the shop shall be erected in exact conformity with such match marks. The interchanging of parts shall not be permitted.

Steel structures shall be assembled to correct line and elevation before any welding is undertaken.

9. **Trusses**

Trusses spans, except those portions erected by the cantilever method, shall be erected on blocks so placed as to provide required camber. The camber shall be secured by adjusting all panel points to the elevations as shown in the plan or as directed by the Engineer.

Care shall be taken that trusses are in perfect alignment and that all milled ends of compression members are in full contact. The spans must be fully erected, including all portals, laterals, struts and sways, and all field connections, except connection for stringers, rails and expansion devices shall be securely drift pinned and bolted before any of these is permitted. In case of cantilever spans, the Engineer may permit welding portions of the anchor spans before the cantilever arms are completely erected.

10. **Simple Girders**

Simple girder and beam spans shall be accurately set to square or skew as required in the Drawing, with all diaphragms drift pinned and bolted in place before field welding is permitted. Truss, girder or beam spans designed continuous over supports shall be completely erected before any welding is permitted.

Unless otherwise provided in the contract, suspended spans shall not be until the adjoining spans are completely erected. No welding shall be permitted until the erection is complete.

For continuous or cantilever spans, the number of fitting-up bolts and drift pins required shall be determined by the Engineer for the stresses developed in the various joints during erection. Drift pins and bolts shall be used in equal proportions and shall be located as to hold effectively the joint members in close contact and in correct position during all welding operations.

Erection washers not less than 5 mm in thickness and not less than 50 mm in diameter shall be used with all erection bolts.

11. **Welding**

Connections to be welded shall be held in tight contact by means of bolts and clamps before welding and the welding shall conform to the requirements of Clause 6.

12. **Bolted Connections**
Contact surfaces shall be thoroughly cleaned of rust, mill scale, dirt, grease, paint lacquer, or other foreign material before assembly. All bolts shall be installed with a hardened washer under nut or bolt head whichever is the element turned in tightening. Bolts may be tightened by any method to the required tension. The torque value needed to develop the required bolt tension shall be determined by the Engineer. Bolt tension shall be checked at locations determined by the Engineer in the presence of the Contractor and in such manner that the Engineer can read the torque gauge. Other methods of determining bolt tension may be used, provided the prior approval of the Engineer is obtained in writing. Nuts shall be positioned whenever practicable on the side of the Engineer which will not be visible from the traveled way. Nuts for bolt which can be partially bedded in concrete shall be positioned on the side of the member that will be encased in concrete. Bolts up to 6 mm larger in diameter of those shown in the Drawing may be used provided that the required clearance and edge distance are not reduced below those required for the larger bolt.

13. PROTECTION AGAINST CORROSION

13.1 Preparation of Surface to Receive Paint

Before paint is applied to any surface other than metal-coated surfaces the appropriate surface preparations as described in the contract shall be carried out in accordance with the following:

13.2 Bare Metal Surfaces

Blast cleaning shall be carried out in accordance with BS 4232 to the quality of surface finish as described in the contract. The maximum grade of abrasive permitted shall be as specified in Table 2 of BS 4232. Non-metallic abrasives shall not be permitted. The abrasive used for blasting shall be free from contamination and any recovered material shall be cleaned to the satisfaction of the Engineer before re-use. The maximum amplitude (peak to trough) of the blast-cleaned surface shall not exceed 0.10 mm. Surfaces shall be protected within the following time of having been blast cleaned:

- 2 hours if humidity in air $\leq 85\%$
- 4 hours if humidity in air $\leq 75\%$
- 6 hours if humidity in air $\leq 60\%$

A sample blast-cleaned steel panel measuring not less than 150 mm x 150 mm x 6 mm adequately protected by sealed clean polythene wrapping shall be submitted to the
Engineer for approval before any works is put in hand. The approved sample shall then be retained by the Engineer’s inspectors for comparison with the prepared steel work.

13.3 **Mechanical Cleaning.**

Mechanical cleaning shall be carried out by power-driven tools, such as carborundum grinding discs, chipping hammers and needle guns, followed by steel-wire brushing and dusting to remove all loosened material. Excessive brushing of the metal through prolonged application of rotary wire brushes shall be avoided. Surfaces shall be protected within the time as specified above in Sub-clause 9 (1) (a) after they are mechanically cleaned.

13.4 **Welds and Areas Affected by Welding**

Unless otherwise described in the contract, welds and surfaces which have been affected by welding shall be prepared for painting by the same process as described in the contract for the adjoining metal.

13.5 **Painted Surfaces**

Painted surfaces shall be cleaned of all dust immediately prior to the application of further paint. Any loose paint and rust shall be removed. Areas contaminated by oil and grease shall be cleaned with white spirit. Where required by the Engineer, the whole surface shall then be cleaned by washing down with a solution of an approved liquid detergent followed by rinsing with clean fresh water and allowed to dry thoroughly before paint is applied.

13.6 **Treatment of Surfaces**

13.6.1 **High Strength-Friction Grip Bolt Interfaces**

The treatment of interfaces to be jointed by high strength friction grip bolts shall be as described in the contract. Paint work shall be stopped off at a distance of 75 mm from the joints and all interfaces shall be cleaned by wire brushing before assembly.

13.6.2 **Untreated Surfaces**

Steel work surfaces which will have concrete cast against them shall be left unpainted. The surfaces shall be thoroughly wire brushed to remove loose rust, mill scale and surface contamination.

13.7 **Storage of Paint**
Paint shall be stored in sealed containers in a lock-up store in accordance with the manufacturer’s instructions. Plant which has not been used within the “shelf life” period specified on the containers or within 12 months of the date of manufacture, whichever is the lesser, shall not be used.

Paint from painter’s kettles shall be returned to store at the end of each working period where it shall be kept in a sealed container. Before it is re-issued it shall be thoroughly mixed and no fresh paint or thinners shall be added.

13.8 Application of Paint

All paint shall be supplied from the store to the painters ready for application. The addition of thinners or of any material shall be thereafter prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by skilled painters under competent supervision.

Paint shall be applied to dry surfaces which have been prepared in accordance with Sub-clause 9 (1). The interval between preparation of the metal surface and the application of the first priming coat of paint shall be in accordance with the relevant requirements of Sub-clause 9 (1).

Paint shall not be applied under the following conditions:

(a) When the ambient temperature falls below 4°C or the relative humidity rises above 90% except if otherwise stated in the manufacturer’s instructions.

(b) During rain or mist

(c) When condensation has occurred or is likely to occur on the steel.

Each coat of paint shall be applied by the method instructed by the manufacturer to produce a continuous film paint of uniform and even thickness. As soon as the first priming coat has dried, an extra stripe coat of paint shall be applied by the brush to edges, corners, crevices, bolt heads and welds, using paint of similar composition to the subsequent undercoat, but in a contrasting shade. Successive coats shall have different shades for identification and each coat shall be thoroughly dry before the application of a further coat.

The total dry paint film thickness of the paint system on bare steel surfaces and on metal coated surfaces shall be as described in the contract. The dry paint film shall be measured by Elcometer or other instrument approved by the Engineer.
In order to obtain the dry film thickness specified, the Contractor shall ensure that the coverage rate given by the manufacturer shall enable this thickness to be attained.

Wet film thickness gauges may be used for checking but shall not be permitted as a means of predicting the dry film thickness.

Unless otherwise agreed by the Engineer the paint system applied at the works shall be applied under cover, in controlled conditions, at the fabricator’s works. One undercoat plus one finishing coat shall be applied at Site within the time limit stipulated by the paint manufacturer.

No paint shall be used after the expiration of the “pot-life” stipulated by the manufacturer. The paints of expired “pot-life” shall not be mixed with fresh paint or have thinners added to them.

13.9 Storage of Painted Steelwork

Painted steel work which is to be stored prior to erection shall be kept clear of the ground and shall be laid or stacked in an orderly manner that will ensure that no water or dirt can accumulate on the surfaces. Suitable packing shall be laid between the layers of stacked materials. Where cover is provided, it shall be ventilated.

Prime painted steelwork which is to be stored out-doors or transported prior to fabrication shall not be exposed for periods longer than the following, before being over coated:

- Blast primers - 1 coat maximum 8 weeks, including 2 weeks of this time out doors.

13.10 Repair to damaged Surfaces

Areas of paint which have been damaged during handling, storing, loading and off-loading, transportation, erection and construction shall be cleaned to bare metal, and the edges of the undamaged paint leveled with sandpaper.

The full specified painting system shall then be re-applied and the new paint shall overlap the existing paint by at least 50 mm all round the affected area.

13.11 Painting of Joints

As soon as possible after joints have been made and passed by the Engineer the parent and joint material, exposed parts of bolts, nut washers, weld and
weld affected areas shall be prepared as stated in the contract and brought up to the same state of painting as the adjoining surfaces.

13.12 **Painting Methods**

Coat of paint in a system of painting shall be applied each by one of the following methods:

13.12.1 Brush
13.12.2 Roller (for shop painting only), supplemented by brush where necessary.
13.12.3 Air pressure spraying
13.12.4 Airless spraying

13.13 **Protective Systems**

The Contractor shall furnish the Engineer with duplicate copies of the manufacturer’s data sheets for the paints he proposes to use. Following the Engineer’s written instruction the requirements of the paint manufacturer’s data sheets shall be adopted for the works.

Where called for by the Engineer the Contractor shall carry out paint application procedure trials, either at the fabricator’s works or at Site as appropriate, with the equipment and labour to be used in the works. The Contractor shall supply suitable blast cleaned steel and sufficient paint for the trials and must demonstrate his ability to apply each coat of paint of a designated paint system in accordance with the Specification and the paint manufacturer’s data sheet. No painting of the contract steelwork shall be permitted until the procedure trials have been complete to the satisfaction of the Engineer. Any adjustment to the registered paint formulation shown to be required by the trials, other than an increase in the amount of thinners, must be agreed by the Engineer and made at the paint manufacturer’s work before the final stage of a paint procedure trial and before delivery of the first batch of paint.

All requirements of the paint manufacturer’s data sheets shall be complied with. Paint shall be supplied from the Contractor’s paint store to the painters ready for application, the only adjustment of formulation being as provided in paragraph 2 above. Any addition of thinners must be made in the store under the supervision of the Engineer and only as allowed under the manufacturer data.

(a) **Superstructure Steelwork**

(i) **Steelwork Members**
Surface preparation at works: Blast clean to 1st quality (including joint areas) BS 7079.

**Painting: as shown on the following Table:**

<table>
<thead>
<tr>
<th>Painting at works</th>
<th>Coat</th>
<th>Paint</th>
<th>Method of application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>Zinc Chromates/Red Oxide Blast Primer</td>
<td>Airless Spray</td>
</tr>
<tr>
<td>Excluding joint</td>
<td>(Stripe to edges etc.)</td>
<td>Zinc Phosphates epoxy ester undercoat</td>
<td>Brush (Airless Spray grade paint)</td>
</tr>
<tr>
<td></td>
<td>2nd</td>
<td>As Stripe coat</td>
<td>Airless Spray</td>
</tr>
<tr>
<td></td>
<td>3rd</td>
<td>As Stripe coat</td>
<td>Airless Spray</td>
</tr>
<tr>
<td></td>
<td>4th</td>
<td>As Stripe coat</td>
<td>Airless Spray</td>
</tr>
<tr>
<td>At site</td>
<td>5th</td>
<td>Miscaceous Iron Oxide Phenolic/tung oil undercoat</td>
<td>Brush</td>
</tr>
<tr>
<td></td>
<td>6th</td>
<td>Miscaceous Iron Oxide Phenolic/tung oil Finish Dark Grey</td>
<td>Brush</td>
</tr>
</tbody>
</table>

(ii) **High Strength Friction Grip Bolted Joints**

a. **Cover Plates**

Surfaces preparation at work: Blast clean to 1st quality BS7079.

Painting at work (excluding: Contact surfaces) One coat, Zinc Chromate/Red Oxide Blast primer applied by Airless Spray

Surfaces preparation at site: Before assembly, wire brush contact surfaces by hand

After assembly, wire brush works coat of blast primer.

Painting at site (after bolting): Coats 1, Stripe and 2 to 6 as (i) above but all applied by brush and coat within 4 hours of wire
b. **Contact Surfaces of Steelwork Members**

Surfaces preparation at site: Before assembly, mask around contact surface apply paint stripper and scrape off works coat of blast primer. Wash off stripper and wire brush by hand when dry.

(c) **Bolts, Nuts and Washers**

At site: Removal oil than prepare surface and paint as for cover plates above.

(iii) **Painting System for Repairs to Damaged Surfaces**

Coats 1, Stripe (if relevant) and 2 to 6 as above but all applied by brush.

(b) **Parapet and Guard-rails**

Surface Preparation: Picking
Metal Coating: Hot-dip galvanizing Minimum of galvanizing 1610 g/m² or minimum thickness 85 micron.

13.13.1 **Metal Coatings**

Unless otherwise specified by the Engineer procedures for applying metal coating shall be in accordance with the following:

13.13.1.1 BS 729 Part 1: Hot-dip Galvanised Coating
Part 2: Sheradised Coating

Metal coating to BS 729 shall only be applied to components of a tensile strength up to and including that of General Grade HSFG bolts unless specified by the Engineer.
1. BS 2569 Part 1 Sprayed metal Coatings (Zinc and Aluminium).
   The nominal thickness of coating to be 100 micron.

2. BS 3382: Part 1 and 2. Electorplated Coated on Threaded Components (Cadmium and Zinc). This British Standard shall be deemed to cover the electroplating of components up to and including 36 mm diameter. The minimum thickness of coating to be 5 micron.

Where a metal coating is required only on part of an assembled Section it shall be applied before the rest of the Section receives its priming coat.

13.14 Etch Primers and Blast Primers

Etch primers and blast primers shall be suitable for continuous spray application. They shall not be used on phosphated steel nor shall they be overcoated with zinc rich primers.

1. MEASUREMNT

The structural steel shall be measured in tonne and shall be based on the net weight of metal in the fabricated/erected structure computed on the basis of nominal weight of the elements. While computing the weight, the specific gravity of steel shall be adopted 7.85 tonne per cubic metre. The weight shall be determined from the dimensions shown on the Drawing. The weight so measured shall be inclusive of weld fillets and weight of protective coatings, if any.

All operations like cutting, bending, straightening, heat and cold treatments, machining, temporary and permanent erection, connection, bolts, nuts and washers, welding, painting and protection against corrosion and other ancillary and incidental operations shall be deemed included in the weight of the steel structure as measured above.

2. PAYMENT

The structural steel as measured shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor and also for the cost of all operations required for fabrication, connections, oiling, painting, temporary erection, inspection, tests and final erection including all other ancillary and incidental works needed to complete the work as per these Specifications and/or directed by the Engineer.
SECTION XII. DRILLING & GROUTING

1. Scope of Work

The work covered by this Specifications consists of the performance of all operation in connection with:

- Drilling and redrilling grout holes;
- Pressure washing and water pressure tests;
- Grouting;
- Drilling of test holes.

The general extent of this work and the approximate locations of the grout holes are tentatively indicated in the Drawings and the final location of the grout holes as well as the details of grout mixes, pressures, pumping rates, sequence in which the holes are to be drilled and grouted shall be determined in the field and shall be as directed by the Engineer.

2. Definition of Grouting Works

Grout is a mixture of cement, sand and water with admixtures (setting accelerator and/or bentonite) if required. When properly proportioned, mixed and injected, it develops considerable strength.

Grouting will include the following works:

a. Backfill grouting is the work to be performed for the purpose of filling up openings between the lining concrete/plug concrete of tunnels and the excavated rock surface to unite the lining concrete/plug concrete and the surrounding rock by means of injecting cement-sand grout into the openings behind the lining.

b. Consolidation grouting is the work to be performed for the purpose of uniting and strengthening foundation rock or rock surrounding tunnels by means of injecting cement grout under pressure into openings in it such as fissures, joints and cracks.

c. Cement/mortar grouting is the work to be performed for the purpose of filling up opening between tunnel concrete linings and plug concrete or between excavated rock and concrete by means of injecting cement grout or cement-sand grout through
pipes placed in the concrete. It also includes the filling of voids between steel linings and concrete in penstock tunnel.

The consolidation grouting works shall be preceded by a water pressure testing of the drilled hole unless otherwise directed by the Engineer. The purpose of this test is to gather information on the rock quality in order to determine the consistency of the grout to be used and to wet the surface of rock seams in order to avoid premature sealing of the seam by thickening of the grout mixture.

3. Equipment

3.1 Grouting equipment

The grouting equipment used shall be of a type, capacity and mechanical condition suitable for doing the work, as approved by the Engineer.

The apparatus for mixing and placing grout shall be of a type approved by the Engineer and shall be capable of effectively mixing and stirring the grout and forcing it into the holes or grout connections in a continuous, uninterrupted flow at the pressure as specified hereby.

The grouting equipment shall be maintained in a manner satisfactory to the Engineer and shall be capable of continuous and efficient performance during any grouting operation. The arrangement of the grouting equipment shall be such as to provide a supply line and a return line from the grout hole to the grout pump. Provision shall be made to permit continuous circulation and accurate control of grouting pressures and grout flows into the grout holes. The equipment shall allow to keep the required pressure even when the holes refuse to accept grout.

A full design of the entire equipment for grouting including specifications of all kind of tools used for operation shall be submitted for approval to the Engineer prior to commencement of installation.

Prior to commencement of work, during the work (when asked by the Engineer) and to the end of the work all pressure gauges, automatic level recorder and discharge meters shall be officially checked and calibrated. The corresponding data shall be submitted to the Engineer.

3.2 Drilling equipment

Rotary and percussion type drills may be required for the drilling, only electric or air driven equipment will be accepted for work executed underground.
Casting for test drill holes may be plastic or mild steel, plain or perforated, as directed or approved by the Engineer.

3.3 Mixtures and agitators

The mixtures shall be mechanically operated and provided with an accurate measuring system for controlling the amount of mixing water used in the grout. Equipment for measuring volumes and weight shall permit the measurement of the components of the mixes with an accuracy of ± 2%. Mixing shall be carried out in high speed mixers (more than 800 r.p.m), closed-circuit circulation of the mixes be allowed for.

In addition to the grout mixers, hold-over mechanical agitator tanks shall be provided. Gravity discharge flow shall be provided from the mixers to the agitators.

3.4 Pumps

The pumps shall permit a flow of 100 lit/min. of thick grout (W/C=1) at a pressure of 20 kg/cm².

The pumps for the transportation of the grout from the mixers to the grouting pumps may be of any type approved by the Engineer.

The grouting pumps shall be of the hydraulically driven piston type, or of duplex double acting positive displacement flush pump type. The use of both types is only permitted when and where approved by the Engineer.

The system shall include standby equipment which can immediately carry on with grouting and shall be capable of injecting at least 50 liters per minute at a pressure of 20 kg/cm².

The distance from grouting pump to point of grouting shall not exceed 60 m unless otherwise approved by the Engineer.

The packers shall consist of pneumatic tubes or expansion rings of rubber, leather or other suitable materials, attached to the end of the grout supply pipe.

Pumps shall be provided with pressure gauges (coupled manometers for low and high pressure range. e.g. 0-10 kg/cm² and 10-50 kg/cm².)
4. Materials

4.1 Grout

Grout will be composed of a mixture of water, cement, sand and possibly admixtures. The mix proportion will depend on investigations and geological conditions and will be determined by the Engineer. All materials shall be of approved quality. Grout which has been left standing for two hours or more shall be rejected.

In general, a neat Portland cement grout will be used for consolidation, curtain and contract groutings and a sand mix, so proportioned as to be readily pumpable for backfill and contact groutings.

It may be necessary to add bentonite, rock flour, sand or other fillers and chemical admixtures (as non shrinking agents etc.) for which approval shall be attained from the Engineer.

4.2 Pipes for grouting

Steel pipes and all fittings for foundation and construction joint grouting and for grouting rock surrounding tunnels, caverns and shafts shall be set in the rock and concrete where required.

4.3 Cement

Cement shall meet the requirements of CHAPTER III CONCRETE WORKS or as approved by the Engineer.

Compatibility of the cement with intended admixtures shall be tested by the Contractor before use.

"Special extra-fine ground cement" with specific surface of at least 3.500 cm$^2$/gram measured by the Blaine-Test-Method shall be used if requested by the Engineer.

4.4 Aggregates

Sand shall meet with the required quality as approved by the Engineer and these Specifications with the following modifications:
The sand shall not contain more than three percent of flat or elongated pieces having a maximum percentage shall preclude the possibility of supply pipes being clogged when pumping grout, having the lowest water cement ratio, at the lowest anticipated pressure.

The sand shall be well graded from fine to coarse and the gradation as determined in accordance with the relevant Standard.

The percentage of surface moisture in terms of the saturated surface-dried sand will be determined and checked in accordance with the requirements specified in Clause 3.1.2 or other methods giving comparable results.

The aggregates shall be stored in adequate quantities and in appropriate manner, so that the degree of purity and the aggregate composition remain unchanged.

4.5 Admixtures

Accelerating and non-shrinking agents free from chloride only shall be used. They shall not cause steel corrosion or adversely affect the strength development and hardening pattern of the grout. The Contractor is fully responsible for the suitability of the admixture. Manufacturer's guarantees will not be accepted as relieving the Contractor of his responsibility for the suitability of any admixture.

The quantity of admixture used shall be kept to the absolute minimum.

The admixture shall be fed to the mixer directly and in the exact proportion by weight. Before work is commenced, proof shall be supplied by the Contractor as to show the admixture influences and the characteristics of the grout.

4.6 Water

The water used in the grout shall be fresh, clean and free from harmful amounts of sewage, oil, acid, alkali, salts, or organic matter, or any other deleterious or undesirable matter.

4.7 Selection of materials

The Contractor shall inform the Engineer in writing in good time of the cement, sand and admixtures he proposes to use.

5. Execution
5.1 Grouting program

Before grouting work begins, a program giving all details of the operation shall be prepared by the Contractor and submitted to the Engineer for approval.

Grouting pressures and the rates of injection to be used in the work will vary with conditions encountered in the respective holes, and the pressure used shall be as shown on the Drawings or as directed by the Engineer.

Mixes will be directed by the Engineer who will, from time to time, direct changes to suit the conditions found to exist in any particular grout hole.
Grouting works will be planned in such a way that they can be executed simultaneously with other works, and carried out according to the approved schedule. The amount of work to be carried out will be varied on the basis of further knowledge gained during the progress of excavation and drilling.

5.2 Drilling for grouting

A drilling pattern such as the depth, inclination, direction, layout, spacing and number of holes shall be as shown on the Drawings or as directed by the Engineer. For the consolidation and curtain grouting, the drilling order of holes shall generally be planned in such a pattern that the primary holes shall be drilled alternately so that effectiveness can be checked and assured by the secondary holes which will be drilled at the middle of them (split spacing method). Additional holes may be ordered at the middle of the secondary holes, if necessary.

The bottom hole diameter in all grout borings shall never be less than 38 mm.

The drill holes to be grouted can be drilled with rotary drills without core recovery or by percussion drill. The holes drilled in soft rock or loose formations shall be cased in.

The holes shall be drilled using a sufficient circulation of water (0.1 lit/s minimum) in order to remove all sediments.

The use of lubricants such as metallic salts or mineral soaps in the circulating water to help the drilling process or to reduce the wear on the drill bits shall be subject to the approval of the Engineer. These products shall not impair the quality of the grouting or the setting of the grout. Use of grease and oil shall under no circumstances be permitted.
Grouted boreholes and their adjacent holes shall not be re-drilled and/or drilled before the grout has set to prevent washing out. Prior to commencement of re-drilling, the grout level shall be measured and agreed with the Engineer.

The deviation of the holes from their theoretical axes shall be not greater than 5 degree.

Immediately prior to each grouting operation, boreholes shall be adequately flushed clean. Washing shall be done with water and air under pressure; the pipe shall be inserted to the full depth and washing shall be continued until the re-appearing water is absolutely clean and clear.

5.3 Water pressure test

Prior to commencement of grouting in each stage of the consolidation and curtain groutings, a water pressure test shall be done for the purpose of assessing the rock condition before grouting. Packer shall be set tightly and clean water shall be pumped into the hole under constant pressure. Injection of water shall be continued at least for 10 minutes for each pressure after the injection rate becomes stable.

The testing pressure will be directed by the Engineer and shall not exceed the grouting pressure, unless otherwise directed by the Engineer.

The Contractor shall record all necessary data of the test such as the hole and stage number, ground water level, pressure, injection rates and height of pressure gauge from the neck of the hole.

5.4 Grouting of tunnels and shafts

(1) Backfill grouting

Backfill grouting shall be done in such a manner as to ensure that all voids between the lining concrete of tunnel and the rock face will be filled with grout. The injection of the grout shall be done at low pressures not exceeding 5 kg/cm², if not otherwise directed by the Engineer. No pressure washing or testing will be required prior to injecting grout.

The concrete lining shall have been in place for at least 30 days before grouting is commenced.
Unless otherwise directed by the Engineer, a cement-sand grout shall be used. The mixing ratio of the cement-sand grout will be in the proximity of 1:2:0.8 in a weight proportion of cement, sand, water, but will be directed by the Engineer. The grouting of any hole shall not be considered complete until in the opinion of the Engineer, all voids have been filled to the maximum extent practicable. Vent pipes, for the release of air and water during grouting of crown overbreak cavities which can not be filled with concrete, shall be provided as shown on the Drawing and in such locations as directed by the Engineer.

(1) Unless otherwise directed by the Engineer, after the grouting of any hole is finished, the pressure shall be maintained by means of a stop cock or other suitable device until the grout has set to the extent that it will be retained in the hole.

Check hole drilling and/or check grouting shall be carried out at places as directed by the Engineer to verify the voids have been completely filled with grout. In the opinion of the Engineer, backfill grout hole shall be used for consolidation grouting, the hole should be cleaned all grout, through the depth of the concrete lining to the rock, before the grout takes its final set.

(2) Consolidation grouting

Not earlier than 15 days after the completion of the backfill of the grouting, the Contractor will be permitted to commence the drilling and grouting for the consolidation of the rock surrounding the underground structures.

The grout mixture will consist of a water cement slurry with or without bentonite or other admixture. Mixing ratio of water to cement will be between to 3 to 1 and 0.6 to 1 by weight, unless otherwise directed by the Engineer. Starting grout mixtures and their changing criteria will be indicated by the Engineer.

Grouting pressure will vary according to the geological condition, thickness of overburden, ground water head, planned internal water pressure and lining thickness, but will not exceed 30 kg/cm² except as specifically ordered by the Engineer. Consolidation grouting is classified in two groups, i.e. low pressure consolidation grout of not more than 5 kg/cm² grouting pressure and high pressure consolidation grouting of more than 5 kg/cm² grouting pressure. The location of these grouting, arrangement of grout holes and each grouting pressure are shown in the Drawings and/or directed by the Engineer.

In general, grout mixtures of 1 to 1 of water to cement ratio by weight will be used for the low pressure consolidation grouting and the high pressure consolidation grouting will be
started with thin grout of 3 to 1 water to cement ratio and finished with thick grout of 1 to 1 or 0.6 to 1 water to cement ratio.

The grouting of the consolidation holes will normally be carried out in one stage with a packer (or a sealed nipple) installed within the concrete lining. However, if the geological condition requires it the grouting of some holes will be carried out in stage of 1 meter and more.

Unless otherwise ordered by the Engineer, each hole to be grouted shall be thoroughly washed under pressure immediately before the injection. Washing shall be continued until the returning water becomes clean.

The grouting of any hole shall be continued 30 minutes after the hole takes grout at a rate of less than 4 litters per 10 minutes per a linear meter of the hole. As far as practicable the full grouting pressure shall be maintained constantly during the grout injection. After the grouting of the hole is completed the pressure shall be maintained by means of stopcocks or other suitable valves. If during the grouting of any hole, grout is found to flow from any part of the structure or caulked by the Contractor.

Consolidation grouting may also be ordered by the Engineer during the excavation of the tunnels and shafts in order to consolidate at the heading face.

Check hole drilling for backfill grouting should be done prior to commencement of consolidation grout holes may be used as additional check hole for backfill grouting . if the voids are encountered between concrete lining and rock, backfill grouting shall be done first, then the consolidation grouting shall be executed. Detailed record of the drilling shall be submitted in the appropriate form as directed by the Engineer.

(3) Cement/mortar grouting

(a) Cement/mortar grouting of steel lining

Where shown on the Drawings or as directed by the Engineer, the gap between the steel lining and the concrete shall be filled by the grout in order to ensure continuous contact. The pressure of the cement grouting shall not exceed 3 kg/cm², if not otherwise directed by the Engineer. All care shall be taken in order not to exceed even for a short time the maximum pressure. Threaded hole shall be provided for in the steel liners into which the Contractor shall screw the connecting grouting pipes.

Pressure shall be kept until the Engineer is satisfied that the gap is thoroughly filled. In case of need, additional holes will be opened by the other contractor. Such cement grouting between steel and concrete shall be executed along the horizontal sections of the penstock-manifold system.
After completion of the grouting, the Contractor shall clear the threaded holes and screw the standard plugs into position.

(b) Cement/mortar grouting of plug concrete

Where shown on the Drawings or as directed by the Engineer, the gap between the concrete lining and the concrete plug or between excavated rock and concrete plug shall be filled with grout in order to ensure continuous contact.

Grout pipe system in the plug or fill concrete shall consists of supply headers, return headers, vent headers and vent return header, all being steel pipes of 40 mm in nominal diameter, and of steel riser pipes of 25 mm in nominal diameter which connect supply headers to grout outlets and vent headers to grooves. Valves shall be attached at the end of all headers.

Prior to placing, all the pipes shall be cleaned inside and outside, of any doubtful materials in a manner satisfactory to the Engineer. The grout pipes shall be carefully laid and kept in position as shown on the Drawings or as directed by the Engineer.

Grout outlets as shown on the Drawings or approved equivalent shall be provided in positions and manner as shown on the Drawings or as directed by the Engineer.

Grooves shall be provided in the tunnel lining or in rock and in contraction joints of the concrete plug in the positions and manner on the Drawings or as directed by the Engineer. The grooves shall be covered with steel plates, with the riser pipes welded at their respective ends.

Prior to the grouting, all pipes and opening along contact joints shall be thoroughly washed with clean water injected through supply headers under a pressure not more than the grouting pressure. The pressurized water shall be kept in the pipes, and if leakage of water is found on the surface of the plug or any other location, it shall be caulked effectively in a manner satisfactory to the Engineer. The water shall be drained off before grouting is commenced.

Grout shall be injected through the supply headers; when the injected grout leaks from the ends of the return headers, valves attached to these headers shall be closed one by one, until all headers valves finally closed. When the maximum allowable pressure has been attained and the injection rate has decreased to zero. After the entire process described above has been completed, all valves shall be kept closed. The grouting shall be completed if the grouting pressure is maintained for 30 minutes.
Th valves of headers shall not be opened until the injected grout is set and does not flow under release of pressure.

When injected grout leaks from cracks, fissures, etc., in the course of grouting, the leakage shall be effectively caulked as directed by the Engineer.

The grouting pressure shall be determined in the site by the Engineer, and shall be not more than 10 kg/cm².

5.5 Embedded pipes

All metal pipes and fittings required for constructing grout and drainage holes, grout holes connections and air vents, shall be provided by the Contractor. All pipes shall conform to JIS Specification G3452 or equivalent and the fittings shall be malleable iron. The diameter of pipes will be indicated on the Drawings or as directed by the Engineer. All pipes and fittings embedded in concrete shall be cleaned thoroughly of all dirt, grease, grout and mortar immediately before embedment and shall be firmly held in position and protected from damage or displacement while the concrete is being deposited. The end of the embedded pipe which is nearest the inside finished surface of the tunnel lining shall not be less than 50 mm from the surface. Great care shall be taken to void premature clogging of pipes and any pipe that becomes clogged or obstructed before completion of operations shall be replaced at the expense of the Contractor. All pipes required for the work shall be cut, threaded fabricated and installed by the Contractor as required.

5.6 Closure of holes and cleaning-up

Upon completion of the grouting works the Contractor shall provide for adequate disposal of all wash and waste water and shall remove all wasted grout.

After the completion of the grouting works the interior surface of the tunnel shall be cleaned and restored to its condition as determined by the Engineer.

5.7 Sampling and Testing

Before starting to grout, the Contractor shall carry out suitably tests and during the placing operation, water pressure tests as directed by the Engineer. The respective costs will be at the Contractor's expense, if not stated in the Bill of Quantities. Except as otherwise specified, the Contractor shall make the necessary arrangements and pay for all sampling and testing of
grout materials by an approved laboratory. The Contractor shall furnish certified copies of all laboratories reports to the Engineer. Except as otherwise specified, sampling and testing shall be done as specified in the applicable specification or modification thereof cited herein above for each material. Sampling shall be supervised by the Engineer.

5.8 Records

The Contractor shall submit daily reports on all grout, exploratory hole drilling and grouting operations. These records shall include a log of grout and exploratory holes, an account of pressure washing and water pressure testing operations, time of each change of grouting operation, rate of pumping, grouting pressure, change in the water cement ratio, amounts of various materials, communication with other holes and cracks and such other data may be deemed necessary. Forms for the daily report shall be as directed or approved by the Engineer.

5.9 Measurement and payment

(1) Drilling holes for consolidation groutings

Measurement for payment of drilling holes for consolidation grouting will be made on the basis of drilled length per linear meter as determined by the Drawings or as directed by the Engineer. Payment for drilling holes for consolidation grouting will be made at the Contract unit price stated in the Bill of Quantities per meter measured as provided above, which unit price shall constitute full compensation for the cost of all labour, tools, equipment and materials including drilling through rock and/or concrete, pressure washing of holes, protecting the holes until grouted and other item necessary to complete the works. No separate payment for drilling check holes exclusively used for checking voids between concrete lining and rock will be made.

(2) Grouting and consolidation grouting

Measurement for payment of consolidation grouting in low pressure or high pressure groutings and curtain grouting will be made on the basis of injected weight of cement in tonnage determined by the detailed data verified with records sheets of automatic level recorder or as directed by the Engineer.

Payment for grouting of consolidation grouting will be made at the unit price per kg in Bill of Quantities measured as provided above, which unit price shall constitute full compensation for the cost of all labour, tools, equipment and materials, grouting plant including furnishing, loading, hauling, unloading, storing, mixing and injecting of grouting
materials, packer setting, water pressure testing, furnishing, installing, operating, maintaining and removal of automatic level recorder and other items necessary to complete the works.

(3) Backfill grouting

No payment for backfill grouting will be made for voids between lining concrete/backfill concrete/plug and concrete/rock.

All costs for backfill grouting including grout pipes, grout materials, inject and other items necessary to complete the works shall be included in the respective unit prices of the concrete stated in the Bill of Quantities.

(4) Cement/mortar grouting

Measurement and payment for cement/mortar grouting in periphery of tunnel plugs or backfill concrete around penstock steel liner or other locations as directed by the Engineer will be made on the basis of injected weight of cement determined by the detailed data verified with records sheets of automatic level recorder or as directed by the Engineer.

Payment for cement grouting will be made at the unit price per Kg in Bill of Quantities measured as provided above, which unit price shall constitute full compensation for the cost of all labour, tools, equipment and materials, grouting and including furnishing, loading, hauling, unloading, storing, mixing and injecting of grouting materials, packer setting, water pressure testing, furnishing, installing, operating, maintaining, and removal of automatic level recorder and other items necessary to complete the works.
SECTION XIII – STONE MASONRY

1. SCOPE

This Section covers the furnishing of materials and construction of different types of stone masonry works in accordance with the Drawing and this Specifications or as directed by the Engineer.

2. MATERIALS

(1) Stone

The stones to be used shall be durable and angular in shape. If boulders are used they shall be broken into angular pieces. The stones shall be sound, hard, free from iron bands, spots, sand holes, flaws, shakes, cracks or other defects. The stone shall not absorb water more than 5 per cent. The specific gravity of the stone shall not be less than 2.50. Except otherwise described in the contract, the length of any stone shall not exceed three times its height. The breadth of the stone on the bed shall not be less than 150 mm nor greater than 3/4 the thickness of the wall. At least 85% of the stones used in masonry, except those used for chinking as chips or spalls of stones shall have individual volumes of more than 0.01 m³. The chips or spalls used including voids in the dry stone masonry shall not be more than 20% of the stone masonry by volume. In case of mortared masonry the total volume of mortar and spalls taken together shall not be more than 30% of the mortared masonry. Representative samples of the stones intended for use in the works shall be submitted to the Engineer for prior approval. Further representative samples shall be submitted for approval whenever there is a change in the type or strength of the rock that the Contractor intends to use in masonry work.

(2) Mortar

Mortar for masonry shall conform to Sub-clause IV-02 (2). Sand shall comply with IS 2116 and cement shall comply with Clause II(4).

3. CONSTRUCTION

The method of construction described herein shall hold in all Clauses of this Section, wherever applicable.

(1) General

Construction shall be carried out in accordance with I.S. 1597-1992, Code of Practice for construction of stone masonry, Part 1 Rubble stone masonry or Part 2 Ashlar Masonry as appropriate. All stratified stone possessing bedding planes shall be laid with its natural bed as nearly as possible at right angles to the direction of load. In the case of arch rings, the natural bed shall be radial. Facework groins shall be built to a height not exceeding one metre in advance of the main body of the work and adjacent walling stepped down on either side. Masonry face work between the groins shall then be built to a height not exceeding 500 mm above the backing which shall then be brought up level with the
completed facework. At no time shall the backing be built up higher than the facework. Except for dry rubble walling, all joints (gaps) shall be sufficiently thick to prevent stone to stone contact and the gaps shall be completely filled with mortar. Stones shall be clean and sufficiently wetted before laying to prevent absorption of water from mortar.

Placing loose mortar on the course and pouring water upon it to fill the gaps in stones shall not be allowed. Mortar shall be fluid, mixed thoroughly and then poured in the joints. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all its faces completely covered with mortar of the thickness as specified for joints.

The bed which is to receive the stone shall be cleaned, wetted and covered with a layer of fresh mortar. All stones shall be laid full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet immediately after placement and solidly embedded in mortar before it has set. Clean and wet chips and spalls shall be wedged into the mortar joints and bed whenever necessary to avoid thick joints or bed of mortar.

When the foundation masonry is laid directly on rock, the bedding face of the stones of the first course shall be dressed to fit into rock snugly when pressed down in the mortar bedding over the rock. For masonry works over rock, a levelling course of M15/40 or M15/20 concrete 100mm thickness shall be laid over rock and then stone masonry work shall be laid without foundation concrete block.

In case, any stone already set in mortar is disturbed or the joints broken, it shall be taken out without disturbing the adjoining stones and joints. Dry mortar and stones thoroughly cleaned from the joints and the stones shall be reset in fresh mortar. Sliding one stone on top of another which is freshly laid, shall not be allowed.

Shaping and dressing of stone shall be done before it is laid in the work. Dressing and hammering of the laid stones which will loosen the masonry, shall not be allowed.

Building up face wall tied with occasional through stones and filling up the middle with stones spalls and chips or dry packing shall not be allowed.

Vertical joints shall be staggered. Distance between the nearer vertical joints of upper layer and lower layer in course rubble masonry shall not be less than half the height of the course.

Masonry in a structure between two expansion joints shall be carried up nearly at one uniform level throughout but when breaks are unavoidable the masonry shall be raked in sufficiently long steps to facilitate jointing of old and new work. The stepping of raking shall not be more than 45 degrees with the horizontal.

Masonry shall not be laid when the air temperature in the shade is less than 3°C. Newly laid masonry shall be protected from the harmful effects of weather.

(2) Concreting Capping

Where masonry structures are to receive a concrete capping. The joints to the upper surface of the masonry shall be raked out to a depth of 10 mm prior to placing of the concrete to the capping. The concrete for capping shall be as per the Drawing or as directed by Engineer and shall conform to Section V.

(3) Pointing

Where external faces of the mortared masonry work will be backfilled or otherwise permanently covered up, the mortared joint shall be finished flush to the faces of the adjacent stonework.
Where mortared masonry faces will remain exposed, the mortar joints shall be pointed to a consistent style as shown on the Drawing. Pointing shall be carried out using mortar 1:3 by volume of cement and sand or as shown on the Drawing. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing, if not otherwise mentioned shall be ruled type for which it shall, while masonry work is still green, be ruled along the centre with half round tools of such width as may be specified by the engineer. The excess mortar shall then, be taken off from the edges of the lines and shall not be unnecessarily plastered over the exposed stone works. The thickness of the joints shall not be less than 3mm for Ashlar masonry. However, the maximum thickness of joints in different works shall be as follows:

- Random Rubble: 20 mm
- Coursed Rubble: 15 mm
- Ashlar Masonry: 5 mm

4. ASHLAR

All stones shall be dressed to accurate planes on the beds and joints and they shall be fair and neatly or fine tooled on the face unless otherwise described in the contract.

5. BLOCK-IN-COURSE

Beds and joints shall be squared and dressed for a distance of at least 220 mm from the exposed face. Bond stones shall form at least one sixth of the area of the exposed face and shall extend at least 900 mm into the wall or for the full thickness of the wall if the latter is less than 900 mm. Unless described in the contract as tooled or drafted, the exposed face of all stones shall be blocked and left rough. Arises shall be dressed square at all beds and joints.

6. SQUARE RUBBLE-COURSED OR BROKEN COURSE

All stones shall be truly squared and dressed for a distance at least 120 mm from the face of the wall. Bond stones shall be provided at the rate of at least one to every 0.8 m² of exposed face and shall measure not less than 150 mm x 150 mm on the face and not less than 450 mm in length or the full thickness of the wall, whichever is the less. Vertical joints in any layer shall be broken in the next layer and the horizontal lapping of the stones shall not be less than 100 mm.

7. RANDOM RUBBLE-COURSED OR UNCOURSED

All stones shall be carefully set with a bond stone provided at the rate of at least one to every 0.9 m² of exposed face. Bond stones shall measure not less than 150 mm x 150 mm on the exposed face and not less than 450 mm in length or the full thickness of the wall, whichever is the less.

8. DRY RANDOM RUBBLE

Dry random rubble masonry shall be constructed generally to the requirements of coursed random rubble masonry as specified in Clause 7 but with the omission of mortar. All stones shall be carefully shaped to obtain as close a fit as possible at all beds and joints.
any interstices between the stones being filled with selected stone spalls. The stones in courses shall be laid perpendicular to the batter face. The exposed tops or capings of dry rubble structures shall be formed as shown on the Drawing.

9. COMPOSITE RANDOM RUBBLE

Materials for composite random rubble shall comply with Clause 2 and construction with Clause 3. Mortar masonry shall be coursed and comply with Clause 7 and the dry stone insets with Clause 8. The dry stone insets shall be constructed when the level of the surrounding mortared masonry surround has reached the top of the dry stone inset.

10. TEST AND STANDARD OF ACCEPTANCE

Before laying any mortar, the Contractor shall make three sets of mortar test cubes from each source of sand to demonstrate the compliance of the mix to the specified strength. Each set shall comprise two cubes, one to be tested at 7 days and the other to be tested at 28 days. During construction, the Contractor shall make and test mortar cubes at the rate of three cubes for every 10m³ of masonry to assess the strength subject to a minimum of 3 cubes samples for a days work.

Testing of cubes shall be in accordance with IS 2250. The stones shall be tested for the water absorption as per IS: 1124 and it shall not be more than 5 percent. The stones shall also be tested for Specification gravity and it shall not be less than 2.65. Sand shall be tested as per Clause III (3) or as directed by the Engineer.

At least 3 set of tests for stone and sand shall be conducted for every source. About one square meter (1m x 1m) measured in front face of the completed stone masonry in every 200 sq.m or part of it shall be dismantled during the process of construction upto complete depth and the aggregate volume of the stones having volume more than 0.01m³ shall be obtained by the method of displacement of water to find the volume of spalls and mortars in the case of mortared masonry and the volume of spalls and voids in the case of dry masonry. The dismantling shall be made in such a manner that the quality of the surrounding work is least affected. While dismantling, the tightness of the joints shall also be compared with the thickness of joints as specified for assessment of the quality of work. If the volume of spalls and mortars is more than the specified volume and/or the joints are not filled completely with mortar, then the entire work which the sample and test represent shall be rejected.

The dismantled portion shall be made good by the Contractor at his own cost after completion of the test.

11. MEASUREMENT

Stone masonry shall be measured in cubic metres. The pointing shall be measured in sq.m.

12. PAYMENT
The stone masonry and the pointing shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per provisions of measurement and payment.

**Payment for Sub-standard Works**

Stone masonry in cement sand mortar not meeting the requirements of the relevant Specifications. (termed as substandard stone masonry in cement sand mortar) shall be paid as substandard work provided it is accepted by the Engineer as substandard work. For the acceptance of such work Engineer may require further investigation and/or tests which the Contractor shall conduct at his own cost. Acceptance or rejection of such work is the sole responsibility of the Engineer and his decision in this respect shall be the final and binding upon the Contractor If accepted as substandard work the payment for such work shall be made at the contract unit rate reduced by the formula given below Percent of reduction, \( P = \) The reduced contract unit rates of substandard stone masonry in cement sand mortar and other items contained shall be the full and the final compensation to the Contractor.
SECTION XIV – MISCELLANOUS STRUCTURES

GABIONS

(1) Scope

This Clause covers the furnishing of materials and construction of gabion works that may be required to act as buttresses, retaining walls, catch wall, stream or river training structures, check dams within gullies, or where placed as mattresses, to prevent stream or gully erosion.

(2) Materials

(a) Stone

Stones used for filling the gabion boxes or mattresses shall be clean, hard, sound, unworn 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 24.1: Standard Size of Wire Mesh Gabions**

<table>
<thead>
<tr>
<th>Dimensions in Meters (Prior to fill)</th>
<th>Number of diaphragms</th>
<th>Dimension of diaphragms in metres</th>
<th>Volume of crate in cubic metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 1 x 1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>1.5 x 1 x 1</td>
<td>1</td>
<td>1 x 1</td>
<td>1.5</td>
</tr>
<tr>
<td>2 x 1 x 1</td>
<td>1</td>
<td>1 x 1</td>
<td>2</td>
</tr>
<tr>
<td>3 x 1 x 1</td>
<td>2</td>
<td>1 x 1</td>
<td>3</td>
</tr>
<tr>
<td>1 x 1 x 0.75</td>
<td>-</td>
<td>-</td>
<td>0.75</td>
</tr>
<tr>
<td>2 x 1 x 0.75</td>
<td>1</td>
<td>1 x 0.75</td>
<td>1.5</td>
</tr>
<tr>
<td>3 x 1 x 0.75</td>
<td>2</td>
<td>1 x 0.75</td>
<td>2.25</td>
</tr>
<tr>
<td>1 x 1 x 0.5</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>2 x 1 x 0.5</td>
<td>1</td>
<td>1 x 0.5</td>
<td>1</td>
</tr>
<tr>
<td>3 x 1 x 0.5</td>
<td>2</td>
<td>1 x 0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>1 x 1 x 0.3</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
</tr>
<tr>
<td>2 x 1 x 0.3</td>
<td>1</td>
<td>1 x 0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>3 x 1 x 0.3</td>
<td>2</td>
<td>1 x 0.3</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Table 24.2: Standard Size of Mesh and Wire in Gabions**

<table>
<thead>
<tr>
<th>Mesh opening (DxH)</th>
<th>Mesh type</th>
<th>Thickness of mesh wire</th>
<th>Thickness of binding and connecting wire</th>
<th>Thickness of selvedge wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>64 x 83</td>
<td>60 x 80*</td>
<td>11, 12</td>
<td>13, 14</td>
<td>8, 9</td>
</tr>
<tr>
<td>83 x 114</td>
<td>80 x 100</td>
<td>9, 10, 11</td>
<td>11, 12, 13</td>
<td>6, 7, 8</td>
</tr>
<tr>
<td>114 x 128</td>
<td>100 x 120</td>
<td>10, 9</td>
<td>12, 11</td>
<td>7, 6</td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th>SWG</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>4.88</td>
<td>4.75</td>
<td>4.06</td>
<td>3.66</td>
<td>3.25</td>
<td>2.95</td>
<td>2.64</td>
<td>2.34</td>
<td>2.03</td>
</tr>
</tbody>
</table>
(3) **Construction of Gabion**

(a) **General Requirements**

Before filling any gabion boxes and mattresses, the Contractor shall submit samples of gabion boxes and/or gabion mattresses assembled, erected and filled with stones for approval which, when approved, shall be retained for reference and comparison with the gabions built as part of the permanent works. The size, type and location of the samples shall be as directed by the Engineer.

Gabion boxes and gabion mattresses shall be assembled, erected and filled with stones in the dry on prepared surfaces except as may be otherwise approved. Approval for assembling and erecting gabions in water shall be given only, if in the Engineer’s opinion such a method will produce work which is otherwise in accordance with the Specification.

(b) **Preparation of Foundation and Surface for Bending**

The bed on which the gabion boxes or mattresses are to be laid shall be even and conform to the levels shown on the Drawing. If necessary cavities between rock protrusions shall be filled with material similar to that specified for gabion filling.

(c) **Arrangement of Joints**

(i) **Walls**

In walls gabion boxes shall be placed such that vertical joints are not continuous, but staggered. Aprons shall be formed of headers. If more than one unit is required to obtain the necessary width, unit of unequal length shall be used and the joints between should be staggered.

(ii) **Channel linings**

In channel linings, gabion box and mattress units shall be laid so that the movement of stone inside the mesh due to gravity or flow of water is avoided. Hence, on side slopes, unit shall be placed with their internal diaphragms at right angles to the direction of the slope and, on inverts, as far as possible, at right angles to the direction of flow.
(d) **Assembly**

Gabion boxes and gabion mattresses shall be assembled on a hard flat surface. After fabrication, unpacking or unfolding, they shall be stretched out and any kinks shall be removed. Creases shall be in the correct position for forming the boxes or mattress compartments. The side and end panels shall be folded into an upright position to form rectangular boxes or compartments. The top corners shall be joined together with the thick selvedge wires sticking out of the corners of each panel. The tops of all sides and partitions shall be leveled except as may be appropriate to special units. The sides and end panels shall be tied together using binding wire of the thickness given in Table 24.2, starting at the top of the panel by looping the wire through the corner and twisting the wire together. Binding shall continue by looping the wire through each mesh and around both selvedges with three rounds which shall be joined tightly together by twisting and the end shall be pocked inside the unit. The diaphragms shall be secured in their correct positions by binding in the same way. The bindings wire shall be fixed using 250 mm long nose fencing pliers or equivalent approved tools.

The gabion boxes and gabion mattresses shall be laid in such a manner that the hinges of the lid will be on the lower side on slopes and on the outer side in walls.

Where mattresses are laid horizontally hinges shall not be placed on the downstream side as much as practicable.

(e) **Filling**

Except in the case of sack gabions, the crates shall be placed in their final position before filling commences. They shall be stretched to their full dimension and securely pegged to the ground or wired to adjacent gabion before filling. The vertical corners shall be kept square and to full dimension by inserting a steel bay of at least 20 mm diameter at each vertical corner, maintaining it in the correct final position throughout the filling process, and removing it when the crate is full. Before filling commences, the selvedges of the crate shall be bound to the selvedges of adjacent crates with binding wire. Where crates are being assembled in position in a wall the binding of the edges of each crate in the assembly process and the binding together of adjacent crates shall be carried out in the same operation.

Before filling with stone, gabion shall be anchored at one end or side and stretched from the opposite end or side by inserting temporary bars and levering them forward. The top and bottom shall be kept stretched by tensioning with tie wires attached to an anchorage or
equivalent approved method until the gabion has been filled. The gabions shall be inspected at this stage but before filling with stone to ensure that the tie/wiring has been properly carried out and the gabion boxes or gabion mattresses are not pulling apart. Gabion boxes or gabion mattresses may be tensioned either singly or in the case of a long straight structure by staining a number of units together using an approved tensioning system.

The filling shall be carried out by placing individual stones into the gabion by hand in courses in such a manner that the stones are bedded on each other and bonded as in dry random rubble masonry as per Clause 2608. No loose stones shall be tipped into the crate and the practice of coursing and bonding the outer layer and filling the interior with unlaid stones shall not be permitted.

All 1m deep gabions shall be filled in three equal layers and 0.5 m deep gabions in two equal layers. Horizontal bracing wires made with the same bindings wire as used for tying shall be fixed directly above each layer of the stone in the compartments, the wires being looped round two adjoining meshes in each side of the compartment and joined together to form a double tie which shall be tensioned by windlassing together to keep the face of the gabions even and free from bulges. Bracing wires shall be spaced horizontally along and across the gabions at distances not greater than 0.33 m. Where the upper faces of gabion boxes are not covered with further gabions vertical bracing wires shall be fitted between the top and bottom mesh using two tie wires per square metre of surface.

The ties shall be fixed to the bottom of the units prior to filling and tied down to the lid on completion. Where a double layer of gabion boxes is used to form an apron both upper and lower layers shall have vertical tie wires.

(f) **Securing Lids**

The gabion boxes and mattress compartment shall be over filled by 50 mm above their tops to allow for subsequent settlement. The lids shall then be tied down with binding wire to the tops of all partition panels. The lids shall be stretched to fit the sides exactly by means of suitable tool but due care shall be taken to ensure that the gabions are not so full that the lids are overstretched. The corners shall be temporarily secured first.

(g) **Tolerance**

On completion, the crates shall be completely and tightly filled, square, true to dimensions and the line and level shown on the Drawing. However the tolerance limit permitted in the length, height and width
of the gabion boxes and mattresses as manufactured shall be ± 3 percent from the ordered size prior to filling. The tolerances on the wire mesh opening shall be ± 10% on the nominal dimension ‘D’ values as follows:

<table>
<thead>
<tr>
<th>Mesh Type</th>
<th>Nominal dimension ‘D’ values</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 x 80</td>
<td>64</td>
</tr>
<tr>
<td>80 x 100</td>
<td>83</td>
</tr>
<tr>
<td>100 x 120</td>
<td>114</td>
</tr>
</tbody>
</table>

Dimensions are measured at right angles to the center axis of the opening and parallel to the twist along the same axis.

However, the number of opening per gabion box/mattress shall not be less than the nominal length divided ‘D’ on horizontal direction and nominal height divided by ‘H’ in vertical direction where D and H are per Table 24.2.

(4) Test and Standard of Acceptance

(a) The gabion wire shall be tested for mass, uniformity and adhesion of zinc coating and tensile strength of the wire itself. Failure of test results to comply with the specifications shall lead to the rejection of gabion wires. The test on the samples taken as per Table 24.3 from each lot of the G.I. wire received at the side of the work shall be carried out in accordance with NS 169-2045 and NS 163-2045.

Table 24.3: Scale of Sampling and Permissible Number of Defective

<table>
<thead>
<tr>
<th>No. of coils in a lot</th>
<th>No. of coils randomly selected for sampling*</th>
<th>Permissible no. of defective coil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 25</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>26-50</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>51-150</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>151-300</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>300 and above</td>
<td>13</td>
<td>1</td>
</tr>
</tbody>
</table>

*One sample per coil shall be tested in all respect

(b) The stones shall be tested for specific gravity and water absorption. At least 3 set of tests shall be made for every source of material. The test results shall meet the specified criteria.

(c) In each two hundred cu.m. or part thereof one representative sample of completed gabion box mattress i.e. assembled, filled with stones and tied up in position shall be dismantled during the process of
construction. The dismantling shall be made in such a manner that the quality of the surrounding work is least affected. The stones having least dimension more than or equal to the specified dimension shall be gathered at one place and the rest at another place. By displacement of water total volume of these specified stones shall be determined separately. Ratio of volumes of specified stone and voids including spalls to the volume of the total volume of the gabion box shall be worked out. The test result shall meet the requirement of the Specifications.

(d) The dismantled portion shall be made good by the Contractor at his own cost after completion of the test.

(5) Measurement

Gabion wire mesh for boxes and mattresses shall be measured in sq. metre. The boxes and mattresses shall be physically measured and be verified with their tolerances.

The binding wires, selvedge wire and tension wires shall not be measured separately. They are deemed included in the measurement of the gabion boxes and/or mattresses.

Stone filling in gabions including fixing of gabion in position, tying with binding wires and tension wires as specified shall be measured in cu.m.

(6) Payment

Gabion boxes, gabion mattresses, stone filling shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per The Contract to complete the work in accordance with these Specifications.
VI F. Inspection, Testing and Commissioning
INSPECTION, TESTING AND COMMISSIONING

1.1 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.

1.2 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.

1.3 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 subcontractors’ 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.

1.4 TESTS AT MANUFACTURERS WORKS

1.4.1 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.

After receiving the prior information about the completion of manufacturing at the factory, the Employer will depute his personnel to the Contractor's factory to witness the fabrication, assembly and testing of any or all parts of major equipment. The number of the Employer's personnel and equipment to be witnessed will be as listed below. The duration of such visits shall be as per inspection/testing requirements.

- Hydraulic Turbines and Speed Governor  2 persons, 1 visit
- Synchronous Generators and Excitation System  2 persons, 1 visit
- PLC and SCADA System     2 persons, 1 visit
- 12 kV Switchgears, Instrument transformers  2 persons, 1 visit

The visits can be combined depending on the location, timing and the manufacturers.

1.4.2   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.

1.4.3   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.

1.5 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.

1.6 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.

1.7 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.

1.8 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.

1.9 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.

1.10 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.

1.10.1 Test Procedures

The following basic tests, in addition to others, shall be carried out:
- Measurement of insulation resistance.

1.10.2 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.

1.10.3 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.

1.10.4 “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.

1.10.5 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

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.

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.

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.

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.

**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.

**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.

**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.

**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.

**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.
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.

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.

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.

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.

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.
VI G. 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.

### Table 1: Mechanical

#### 1. TURBINE

Output, efficiency and turbine discharge at net head of 45.79 m

<table>
<thead>
<tr>
<th>REF</th>
<th>DESCRIPTION</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge (%)</td>
<td>Turbine efficiency (%)</td>
<td>Turbine output (kW)</td>
<td>Turbine efficiency (%)</td>
</tr>
<tr>
<td>100</td>
<td>89.2</td>
<td>540</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>87.4</td>
<td>424</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>83.9</td>
<td>305</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>78.6</td>
<td>190</td>
<td></td>
</tr>
</tbody>
</table>

The figure showing the curves for output, efficiency and turbine discharge at the respective heads shall also be submitted with the proposed specifications.

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing's Designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applicable standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Horizontal Double Jet Pelton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direction of rotation (Viewed from generator side)</td>
<td>C.W.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated speed</td>
<td>rpm</td>
<td>750</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runaway speed</td>
<td>rpm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific speed (at optimum point)</td>
<td>m-kW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum speed variation and maximum pressure variation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output (maximum)</td>
<td>kW</td>
<td>540</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbine discharge</td>
<td>m³/s</td>
<td>1.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective net head</td>
<td>m</td>
<td>45.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>mpa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum speed variation</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum pressure variation</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum pressure</td>
<td></td>
<td>mpa</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Starting time in turbine at maximum power of:**

<table>
<thead>
<tr>
<th></th>
<th>s</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand still to no load running</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load take-up</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Servomotor**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of servomotor</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Minimum operating oil pressure</td>
<td></td>
<td>bar</td>
</tr>
</tbody>
</table>

**Runner**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge diameter</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Number of runner vanes</td>
<td>pcs</td>
<td></td>
</tr>
</tbody>
</table>

**Shaft seal**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Turbine guide bearing (if any)**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of lubrication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling water flow (if required)</td>
<td>m³/s</td>
<td></td>
</tr>
<tr>
<td>Temperature of bearing metal not higher than</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

**Material of major parts**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Runner</td>
<td>ZG0Cr13Ni5Mo</td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>Q235-B</td>
<td></td>
</tr>
<tr>
<td>Distributor pipe</td>
<td>ZG230-450</td>
<td></td>
</tr>
<tr>
<td>Servomotor</td>
<td>Cast Steel</td>
<td></td>
</tr>
<tr>
<td>Spiral Casing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guide vanes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft Tube</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Moments of Inertia**

<table>
<thead>
<tr>
<th></th>
<th>t-m²</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GD² required by turbine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GD² of generator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Weight of turbine**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine total</td>
<td></td>
<td>kg</td>
</tr>
<tr>
<td>Delivery of equipment in months following</td>
<td></td>
<td>month</td>
</tr>
<tr>
<td>award of contract (Allowing time for approval of drawing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder? Yes/No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Has manufacturer exported units? Yes/No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Technical literature/drawings submitted? Yes/No</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………… As representative for……………………………….
Address………………………………………….. Date…………………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

2. TURBINE GOVERNOR

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing's Designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applicable standard</td>
<td>IEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of governor</td>
<td>PLC-based digital with PID controller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power supply</td>
<td>AC 230, 50 Hz DC110V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rating</td>
<td>Kg-m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guaranteed Sensitivity (minimum speed range to which governor will respond)</td>
<td>%</td>
<td>≤1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed signal</td>
<td>Tooth wheel type speed signalizer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range of adjustment of permanent speed drop</td>
<td>%</td>
<td>0 to 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range of adjustment in speed setting</td>
<td>%</td>
<td>0 to 100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total opening time of load limiter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total opening time of wicket gates</td>
<td>Programmable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total closing time of wicket gates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjustment range in governor opening and closing time</td>
<td>s</td>
<td>1 to 99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum over speed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% load rejection</td>
<td>%</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% load rejection</td>
<td>%</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>%</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>----</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25% load rejection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dead time equal or less than (IEC Rules)</td>
<td>s</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dead band</td>
<td>%</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Regulating parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporary speed drop</td>
<td>s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derivative time constant, $T_n$</td>
<td>s</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Description and method of operation</strong></td>
<td></td>
<td>Closed loop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</td>
<td>month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has manufacturer exported units?</td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical literature/drawings submitted?</td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………... As representative for………………………………………
Address………………………………………… Date…………………………………………………

---

### 3. HYDRAULIC UNIT

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturing's Designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil pump</td>
<td>Type</td>
<td>Screw type</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delivery pressure</td>
<td>bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delivery rate</td>
<td>l/min</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type and Capacity of Motor</td>
<td>kW</td>
<td>AC driven screw type as required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number</td>
<td>No</td>
<td>2 (one main + one stand by)</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Accumulator</td>
<td>Number per unit</td>
<td>No</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total capacity</td>
<td>liter</td>
<td>To suit the system requirement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>------</td>
<td>-------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oil Pressure</strong></td>
<td>bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum operating oil pressure</td>
<td>bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum operating oil pressure</td>
<td>bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oil sump tank</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective capacity</td>
<td>liter</td>
<td>As required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimension of oil sump tank</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (including oil)</td>
<td>kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade of oil recommended</td>
<td>VG 68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</td>
<td>month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has manufacturer exported units?</td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical literature/drawings submitted?</td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………...  As representative for……………………………….
Address………………………………………….  Date…………………………………………………

**TECHNICAL DATA SHEET**
(To Be Completed By the Tenderer)

### 4. COOLING WATER SYSTEM

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of manufacturing experience</td>
<td></td>
<td>Years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing's Designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applicable standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source- penstock tapping or tailrace pumping</td>
<td></td>
<td>As per site condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling water pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------------------</td>
<td>---------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Delivery rate</strong></td>
<td>m³/min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Delivery head</strong></td>
<td>m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Automatic washing strainer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Material of filter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maximum admissible differential pressure for filter element</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Design pressure of filter housing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flow meters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Range of indication</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</strong></td>
<td>month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Is manufacturer is ISO 9001 holder?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Has manufacturer exported units?</strong></td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technical literature/drawings submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed……………………………………………... As representative for………………………………
Address…………………………………………. Date…………………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

### 5. INLET VALVE

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturing's Designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Pressure oil operated butterfly type counter weight closing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operating method</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nominal diameter</td>
<td>mm.</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------</td>
<td>--------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of valve (flange to flange)</td>
<td>mm.</td>
<td>As required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head loss with Q=1.35 m$^3$/sec</td>
<td>m.w.c.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum leakage through closed valve</td>
<td>l/min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bypass valve</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>mm.</td>
<td>As required</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Valve seal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td>Metal seal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material of seat ring</td>
<td></td>
<td>Carbon casting steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material of seal ring</td>
<td></td>
<td>Stainless steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Time required for operation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Main valve</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening time</td>
<td>sec.</td>
<td>60-120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closing time</td>
<td>sec.</td>
<td>60-120</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bypass valve</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening time</td>
<td>sec.</td>
<td>60-120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closing time</td>
<td>sec.</td>
<td>60-120</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oil pressure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated pressure</td>
<td>bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum oil pressure to hold the valve at closed position</td>
<td>bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum force acting on</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve supports</td>
<td>ton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Servomotor supports</td>
<td>ton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve body</td>
<td></td>
<td>Carbon casting steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve disc</td>
<td></td>
<td>Carbon casting steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve shaft</td>
<td></td>
<td>Carbon steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dismantling joint</td>
<td></td>
<td>Carbon steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upstream pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</td>
<td>month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has manufacturer exported units?</td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………... As representative for……………………………….
Address…………………………………………. Date…………………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

6. DEWATERING AND DRAINAGE SYSTEM

| 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 |

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………... As representative for……………………………….
Address…………………………………………. Date…………………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

Table 2: Electrical

1. GENERATOR

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturing's Designation as per submitted catalogue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Applicable standard</strong></td>
<td>IEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Horizontal Synchronous AC Generators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rated Output</strong> kVA</td>
<td>635</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Continuous over load capacity</strong> %</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rated power factor</strong></td>
<td>0.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rated frequency</strong> Hz</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rated voltage (phase to phase)</strong> kV</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Voltage variation range</strong> %</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rated current</strong> A</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No. of Phases</strong></td>
<td>No 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Connection</strong></td>
<td>Star</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No. of terminals</strong></td>
<td>No 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rated speed</strong> rpm</td>
<td>750</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Runaway speed</strong> rpm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Runaway speed durability</strong> min</td>
<td>5 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Insulation class</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stator winding (Class F) class</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotor winding (Class F) class</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Insulation level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stator winding (incl. neutral) V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotor winding V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maximum service voltage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stator winding V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotor winding V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maximum temperature</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stator winding °C</td>
<td>145</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotor winding °C</td>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrust bearing °C</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guide bearing °C</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Cooling methods

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator</td>
<td>IC01</td>
</tr>
<tr>
<td>Bearing</td>
<td>Water cooling or as proposed by Manufacturer</td>
</tr>
</tbody>
</table>

### Voltage rise in case of sudden load rejection at rated speed with AVR acting

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>At p.f. 0.80</td>
<td>%</td>
</tr>
<tr>
<td>At p.f. 1.0</td>
<td>%</td>
</tr>
<tr>
<td>Wave form deviation factor</td>
<td>% 5</td>
</tr>
</tbody>
</table>

### Short circuit ratio

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.75 (Minimum)</td>
</tr>
</tbody>
</table>

### Vibration maximum, half amplitude of rotor

<table>
<thead>
<tr>
<th></th>
<th>micron</th>
</tr>
</thead>
</table>

### Surge impedance of generator

<table>
<thead>
<tr>
<th></th>
<th>ohm</th>
</tr>
</thead>
<tbody>
<tr>
<td>One phase</td>
<td></td>
</tr>
<tr>
<td>Comprehensive value for three phases</td>
<td>ohm</td>
</tr>
</tbody>
</table>

### Rated current

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stator windings</td>
<td>A</td>
</tr>
<tr>
<td>Rotor windings</td>
<td>A</td>
</tr>
</tbody>
</table>

### Dimensions of generator

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Weights of generator</td>
<td>ton</td>
</tr>
</tbody>
</table>

### Characteristic curve

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power chart</td>
<td></td>
</tr>
<tr>
<td>No-load saturation and three-phase short-circuit curve</td>
<td></td>
</tr>
<tr>
<td>VEE curve sheet</td>
<td></td>
</tr>
<tr>
<td>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</td>
<td>month</td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td>Yes/No Yes</td>
</tr>
<tr>
<td>Has manufacturer exported units?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Technical literature/drawings submitted?</td>
<td>Yes/No Yes</td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:
Section VI G – Technical Data Sheet

Signed..................................................  As representative for.............................................
Address..................................................  Date........................................................................

**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.

<table>
<thead>
<tr>
<th>Percentage of Load</th>
<th>Efficiency</th>
<th>Output (kVA)</th>
<th>Efficiency</th>
<th>Output (kVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>94.27</td>
<td>635</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80%</td>
<td>94.04</td>
<td>508</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70%</td>
<td>93.85</td>
<td>444</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60%</td>
<td>93.85</td>
<td>381</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed..................................................  As representative for.............................................
Address..................................................  Date........................................................................

**TECHNICAL DATA SHEET**
*(To Be Completed By the Tenderer)*

2. **BRUSHLESS EXCITATION SYSTEM**

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturing's Designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td>IEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Brushless</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exiter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rating</td>
<td>kVA</td>
<td>As required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winding temperature rise</td>
<td>°C</td>
<td>&lt;40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. one hour power requirement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total rated losses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Unit</td>
<td>NEA Requirement</td>
<td>To be filled by</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>------</td>
<td>-----------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>Rated voltage</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Excitation rectifiers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. continuous current rating</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling voltage rating</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling current</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of parallel connected rectifier circuits</td>
<td>No 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of serial connection diodes</td>
<td>No 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak reverse voltage rating of diodes</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetitive peak reverse voltage of diodes</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. range current rating of diodes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. operating temperature of diodes</td>
<td>°C 75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total rectifier losses at rated output</td>
<td>kW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity of requested cooling air</td>
<td>m³/min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temp. at rated load</td>
<td>°C &lt;60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Voltage regulating equipment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage setting range manual adjustment, minus, plus or rated voltage</td>
<td>% 30-130</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage setting range of automatic regulator, minus, plus or rated voltage</td>
<td>% 70-110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Limiters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limits of frequency for which the excitation equipment is suitable</td>
<td>cps 47.5-52.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</td>
<td>month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td>Yes/No Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has manufacturer exported units?</td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical literature/drawings submitted?</td>
<td>Yes/No Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………… As representative for……………………………………
Address………………………………………… Date…………………………………………………………
<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manufacturer and country of origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Manufacturer's designation as per submitted catalogue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Applicable standard</td>
<td></td>
<td>IEC</td>
</tr>
<tr>
<td>5</td>
<td>Type</td>
<td></td>
<td>3 Phase, Indoor</td>
</tr>
<tr>
<td>6</td>
<td>Rated Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Nominal</td>
<td>kV</td>
<td>11</td>
</tr>
<tr>
<td>6.2</td>
<td>Maximum</td>
<td>kV</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>Rated Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Continuous at 45 degree ambient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1.1</td>
<td>Generator Incomer</td>
<td>A</td>
<td>630</td>
</tr>
<tr>
<td>7.1.2</td>
<td>Outgoing (Line &amp; Station Service)</td>
<td>A</td>
<td>630</td>
</tr>
<tr>
<td>7.1.3</td>
<td>Busbar</td>
<td>A</td>
<td>2000</td>
</tr>
<tr>
<td>7.2</td>
<td>Short time for 1 sec at max. kV</td>
<td>kA</td>
<td>25</td>
</tr>
<tr>
<td>8</td>
<td>Frequency</td>
<td>Hz</td>
<td>50</td>
</tr>
<tr>
<td>9</td>
<td>Rated short circuit breaking current</td>
<td>kA</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.1</td>
<td>Peak</td>
<td>kA</td>
<td>63</td>
</tr>
<tr>
<td>10.2</td>
<td>RMS Symmetrical</td>
<td>kA</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Interrupting time at 100% capacity</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>11.1</td>
<td>Maximum Opening time</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>11.2</td>
<td>Total interrupting time</td>
<td>ms</td>
<td>60</td>
</tr>
<tr>
<td>12</td>
<td>Closing time</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Make time</td>
<td>ms</td>
<td>120</td>
</tr>
<tr>
<td>14</td>
<td>Maximum capacitive current breaking capacity (rms)</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Insulation level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.1</td>
<td>Impulse withstand voltage (peak)</td>
<td>kV</td>
<td>75</td>
</tr>
<tr>
<td>15.2</td>
<td>Power frequency withstand voltage</td>
<td>kV</td>
<td>28</td>
</tr>
<tr>
<td>16</td>
<td>Vacuum chamber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Operating mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.1</td>
<td>Type</td>
<td></td>
<td>Spring Operated</td>
</tr>
<tr>
<td>17.2</td>
<td>Operating voltage of closing and tripping coil</td>
<td>V DC</td>
<td>110</td>
</tr>
<tr>
<td>17.3</td>
<td>Operating voltage range</td>
<td>% of rated voltage</td>
<td>85-110%</td>
</tr>
<tr>
<td>17.4</td>
<td>Closing and tripping current</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>17.5</td>
<td>Spring charging motor rating</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td>17.6</td>
<td>Time required by motor to charge the spring completely</td>
<td>sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>17.7</td>
<td>Push button for local/remote control</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>17.8</td>
<td>Selection switch for local/remote control</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>18</td>
<td>Current transformer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nos of core (Generator Incoming and outgoing)</td>
<td>3 and 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ratio/class/burden</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Generator &amp; Line)</td>
<td>100/5-5A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Station Service)</td>
<td>50/5-5A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metering</td>
<td></td>
<td>5P20, 30VA</td>
</tr>
<tr>
<td></td>
<td>Protection</td>
<td></td>
<td>0.5, 30VA</td>
</tr>
<tr>
<td></td>
<td>Differential</td>
<td></td>
<td>PS, 30VA</td>
</tr>
<tr>
<td>19</td>
<td>Indicating Instruments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.1</td>
<td>Ammeter</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i Manufacturer and country of origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii Type</td>
<td>digital</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii Current range (300-200-100/1 Amp CT operated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv Accuracy class</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>v Scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range of indication (300-200-100/1A CT operated)</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Linear/Nonlinear</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overload range</td>
<td>%</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>vi VA Burden</td>
<td>VA</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Is manufacturer ISO holder</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>19.2</td>
<td>Voltmeter</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i Manufacturer and country of origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii Type</td>
<td>digital</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii Accuracy class</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv Scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range of indication</td>
<td>kv</td>
<td>0-15</td>
</tr>
<tr>
<td></td>
<td>v VA Burden</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is manufacturer ISO holder</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>19.3</td>
<td>Apparent Power meter</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i Manufacturer and country of origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rated voltage</td>
<td>kV</td>
<td>11(\sqrt{3}):0.11(\sqrt{3})</td>
</tr>
<tr>
<td></td>
<td>Rated Current</td>
<td>A</td>
<td>100-50-25/1</td>
</tr>
<tr>
<td></td>
<td>Accuracy class</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range of indication</td>
<td>MVA</td>
<td>0-15 or 10</td>
</tr>
<tr>
<td></td>
<td>VA burden</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current coil</td>
<td>VA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage coil</td>
<td>VA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is manufacturer ISO holder</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>19.4</td>
<td>KWh Meter</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i Manufacturer and country of origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii Type</td>
<td>static 3-phase, 4 wire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii Accuracy class</td>
<td>0.2/0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv Rated voltage</td>
<td>kV</td>
<td>11(\sqrt{3}):0.11(\sqrt{3})</td>
</tr>
<tr>
<td></td>
<td>v Rated Current</td>
<td>A</td>
<td>100-50-25/1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>19.5</td>
<td>Annunciators</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer and country of origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of active points</td>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Type of mounting</td>
<td>Flush</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Replacement of individual inscription plates and lamps from front panel possible</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Sequence of operation as per specification</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>20</td>
<td>Protective Relay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.1</td>
<td>Over current relay</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer and country of origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>static Non-directional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer's type designation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No of poles</td>
<td>three</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current setting range</td>
<td>% of rated current</td>
<td>20-200%</td>
</tr>
<tr>
<td></td>
<td>Operating time at 10 times current setting</td>
<td>sec</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Reset time</td>
<td>ms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Characteristics</td>
<td>IDMT (standard inverse)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instantaneous unit provided</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Current setting range</td>
<td>% of rated current</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operating range</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO Contacts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Insulation test according to IEC</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Indication</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hand reset flags provided</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Light emitting diode provided</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Auxiliary DC supply</td>
<td>V</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Technical literature provided</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>20.2</td>
<td>Earth fault relay</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer and country of origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Static/no directional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td>IEC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuous overload capacity</td>
<td>xIn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current setting range</td>
<td>% of In</td>
<td>10-80%</td>
</tr>
<tr>
<td></td>
<td>Operating time at 10 times current setting</td>
<td>sec</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Characteristics</td>
<td>IDMT (standard inverse)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instantaneous unit provided</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>Current setting range</td>
<td>% of In</td>
<td>200-1600%</td>
</tr>
<tr>
<td>Operating range</td>
<td>NO Contacts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>ix Insulation test according to IEC</td>
<td>yes/no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>x Indication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand reset flags provided</td>
<td>yes/no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Light emitting diode provided</td>
<td>yes/no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>xi Auxiliary DC supply</td>
<td>V</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>xii Is Manufacturer ISO 9001 holder?</td>
<td>yes/no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>xiii Technical literature submitted</td>
<td>yes/no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>xiv Type test certificate submitted</td>
<td>yes/no</td>
<td>yes</td>
<td></td>
</tr>
</tbody>
</table>

20.3 Auxiliary Tripping and Lockout Relay

i Manufacturer and country of origin

ii Type

iii Manufacturer's type designation

iv Applicable standard

v Operating time | ms | <15 |

vi Contact rating at 125V Dc | A |

21 Earthing switch

Type Integrated

rating

interlocking yes/no yes

22 Surge Arrestor

Type Zno

Rating kA 9kV, 10kA

23 Space heater provided for cubicle yes/no yes/rating

24 Operating duty cycle | 0-0.3sec-co-3min-co |

25 Number of possible operation without maintenance under:

Rated short circuit braking current | No 100 |

Rated normal current | No 10000 |

26 Clearances

26.1 Phase to phase | mm | 127 |

26.2 Phase to earth | mm | 76.2 |

27 Padlocking provision for cubicle yes/no yes

28 Total weight of the circuit breaker kg

29 Mechanical Dimension (LXWXH) mmxmmxmm

30 Delivery of equipment in months following award of contract (Allowing time for approval of drawing)

31 Type test certificate submitted? yes/no yes

32 Has manufacturer exported units? yes/no yes

33 Technical literature submitted? 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)
### 4. HV XLPE POWER CABLE

<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>Unit</th>
<th>NEA Requirement</th>
<th>To be filled by the Bidder</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manufacturer and country of origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Manufacturer's type designation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Applicable Standards</td>
<td></td>
<td>IEC</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Voltage ratings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suitable for max. system voltage</td>
<td>kV</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rated voltage between each conductor and screen</td>
<td>kV</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type of system earthing</td>
<td></td>
<td>Solidly grounded</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Conductor material</td>
<td></td>
<td>copper</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cross section of wires</td>
<td>sq.mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nos &amp; dia of wires of each conductor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Insulating material and thickness</td>
<td></td>
<td>XL Polyethylene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall jacket material/thickness</td>
<td></td>
<td>PVC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall cable diameter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Continuous current</td>
<td>mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>in ground</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>in duct</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Electrical parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>ohm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reactance</td>
<td>ohm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>net weight of the cable</td>
<td>kg/m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Technical literature submitted</td>
<td>yes/no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Type test certificate submitted</td>
<td>yes/no</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Delivery of equipment in months following award of contract</td>
<td>month s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed: .......................................................... As representative for: ..........................................................

Address: .......................................................... Date: ..........................................................

---

### 5. LV CONTROL CABLES

**TECHNICAL DATA SHEET**  
*(To Be Completed By the Tenderer)*

<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>Unit</th>
<th>NEA requirement</th>
<th>To be filled by Bidder</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manufacturer and country of origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Manufacturer's type designation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Applicable Standards</td>
<td></td>
<td>IEC</td>
<td></td>
</tr>
</tbody>
</table>
### Technical Data Sheet

#### Section VI G – Technical Data Sheet

**Bidding Document for ICB -THPPRP-072/73-01 Procurement of Plant Single-Stage: Two-Envelope Tinau HPP Rehabilitation Project**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Voltage ratings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Suitable for max. system voltage</td>
<td>V</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>Voltage grade of the cables</td>
<td>V</td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>Rated voltage between each conductor and screen</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rated voltage between two conductors</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Conductor material</td>
<td></td>
<td>copper</td>
</tr>
<tr>
<td>7</td>
<td>Conductor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cross section of wires</td>
<td>sq.mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nos &amp; dia of each core in cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall jacket of thickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Insulating material</td>
<td></td>
<td>Polyethylene</td>
</tr>
<tr>
<td>9</td>
<td>Overall jacket material</td>
<td></td>
<td>PVC</td>
</tr>
<tr>
<td>10</td>
<td>Net weight of the cable</td>
<td>kg/m</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Standard drum length</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Continuous current at 45 deg C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>in ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>in duct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Electrical parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistance</td>
<td>ohm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reactance</td>
<td>ohm</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Technical literature submitted</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>15</td>
<td>Type test certificate submitted</td>
<td>yes/no</td>
<td>yes</td>
</tr>
<tr>
<td>16</td>
<td>Delivery of equipment in months following award of contract</td>
<td>months</td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………...  As representative for……………………………….
Address…………………………………………...  Date…………………………………………………

---

**TECHNICAL DATA SHEET**

*(To Be Completed By the Tenderer)*

### 6. DC Power Source

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturer and country of origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer's designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td>IEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rated voltage</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type of Cell</td>
<td>NiCd</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rated discharge capacity of 10 h rate to end-point voltage /cell</td>
<td>Ah</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acid density of full charged battery Charging current Initial Final</td>
<td>Kg/dm³ A A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cells</td>
<td>Output capacities at different values of discharge rate and final voltage</td>
<td>no. –</td>
<td>Curve</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>Cell weight without electrolyte</td>
<td>kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrolyte volume</td>
<td>dm³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell dimensions</td>
<td>mm x mm x mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal resistance of cell</td>
<td>Quantity of air to be changed in the battery room</td>
<td>Mohm</td>
<td>m³/min</td>
<td></td>
</tr>
<tr>
<td>Rated current of battery fuse</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</td>
<td></td>
<td>month</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has manufacturer exported units?</td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical literature/drawings submitted?</td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………...  As representative for……………………………………
Address………………………………………….  Date………………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

7. BATTERY CHARGER GUARANTEED DATA

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer and country of origin</td>
<td></td>
</tr>
<tr>
<td>Year of manufacturing experience</td>
<td>Years</td>
</tr>
<tr>
<td>Manufacturer's designation as per submitted catalogue</td>
<td></td>
</tr>
<tr>
<td>Applicable standard</td>
<td>IEC</td>
</tr>
<tr>
<td>-A.C. input voltage and no. of phases</td>
<td>V/No</td>
</tr>
<tr>
<td>-Allowable A.C voltage variation</td>
<td>%</td>
</tr>
<tr>
<td>-Maximum A.C supply current</td>
<td>A</td>
</tr>
<tr>
<td>-Frequency variation</td>
<td>%</td>
</tr>
<tr>
<td>-D.C output at constant voltage • float charging • equalize charge</td>
<td>V V</td>
</tr>
<tr>
<td>-Max. D.C output voltage automatic control manual control</td>
<td>V V</td>
</tr>
<tr>
<td>Parameter</td>
<td>Unit</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Max. load current via voltage dropping diodes</td>
<td>A</td>
</tr>
<tr>
<td>Output voltage ripple with battery connected</td>
<td>mV</td>
</tr>
<tr>
<td>Boost charging current</td>
<td>A</td>
</tr>
<tr>
<td>Duty class as per IEC 146 clause 463.2</td>
<td>–</td>
</tr>
<tr>
<td>Rated current of A.C supply fuse</td>
<td>A</td>
</tr>
<tr>
<td>Rated current of D.C supply fuse</td>
<td>A</td>
</tr>
<tr>
<td>Selection of charging characteristic:</td>
<td></td>
</tr>
<tr>
<td>Manually                      • Automatically                      • with electronic timer</td>
<td>– – –</td>
</tr>
<tr>
<td>Protection class</td>
<td>IP</td>
</tr>
<tr>
<td>Weight</td>
<td>kg</td>
</tr>
<tr>
<td>Dimensions</td>
<td>mm x mm x mm</td>
</tr>
<tr>
<td>Max. charging time of completely discharged battery</td>
<td>h</td>
</tr>
<tr>
<td>RFI suppression grade</td>
<td>–</td>
</tr>
<tr>
<td>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</td>
<td>month</td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Has manufacturer exported units?</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Technical literature/drawings submitted?</td>
<td>Yes/No</td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………...  As representative for……………………………………

Address…………………………………………  Date…………………………………………………

**TECHNICAL DATA SHEET**
(To Be Completed By the Tenderer)

### 8. UPS

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INPUT • Voltage • Voltage range without battery contribution • Voltage tolerance • Input frequency • Power factor • Input phases</td>
<td>V V V Hz %</td>
<td>%100 load, 50% load</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BYPASS • Voltage tolerance • Frequency tolerance</td>
<td>V %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Technical Data Sheet

#### OUTPUT
- Rated power
- Active power
- Phases number
- Wave form
- Rated voltage
- Voltage distortion with distorting load
- Voltage distortion with linear load
- Frequency
- Crest factor ($I_{\text{peak}}/I_{\text{rms}}$)
- Output phases

<table>
<thead>
<tr>
<th>kVA</th>
<th>V</th>
<th>Hz</th>
<th>&lt; &lt;</th>
</tr>
</thead>
</table>

#### Delivery of equipment in months following award of contract (Allowing time for approval of drawing)

<table>
<thead>
<tr>
<th>month</th>
</tr>
</thead>
</table>

#### Is manufacturer is ISO 9001 holder?
- Yes/No

#### Has manufacturer exported units?
- Yes/No

#### Technical literature/drawings submitted?
- Yes/No

#### 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. DIESEL GENERATOR SET

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturer and country of origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer's designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Operating duty</td>
<td>Continuous excitation method</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Operation type</td>
<td>4-stroke</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Aspiration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cylinders/Form</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Output acc. to ISO 3046</td>
<td>HP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Speed</td>
<td>rpm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Fuel supply system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Motor electric</td>
<td>VDC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Synchronous Generator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Nominal power</td>
<td>kVA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Power factor</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Voltage</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Connection</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specifications</td>
<td>Details</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage variation static</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage range</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>rpm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation class</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree of Protection</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excitation</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery of equipment in months</td>
<td>month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>following award of contract (Allowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>time for approval of drawing)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has manufacturer exported units?</td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical literature/drawings submitted?</td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………... As representative for……………………………….
Address…………………………………………. Date…………………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

10. NEUTRAL GROUNDING EQUIPMENT

A. Grounding Transformer

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer and country of origin</td>
<td></td>
</tr>
<tr>
<td>Year of manufacturing experience</td>
<td>Years</td>
</tr>
<tr>
<td>Manufacturer's designation as per</td>
<td></td>
</tr>
<tr>
<td>submitted catalogue</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Dry type</td>
</tr>
<tr>
<td>Rating of the transformer</td>
<td>As required</td>
</tr>
<tr>
<td>Voltage rating of primary winding</td>
<td>kV 11</td>
</tr>
<tr>
<td>Voltage rating of Secondary winding</td>
<td>V 110</td>
</tr>
<tr>
<td>Designed ambient temperature</td>
<td>40 °C</td>
</tr>
</tbody>
</table>

B. Resistor

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Punched stainless steel grid</td>
</tr>
<tr>
<td>Duty</td>
<td>Continuous</td>
</tr>
<tr>
<td>Applicable standards</td>
<td></td>
</tr>
<tr>
<td>Designed ambient temperature</td>
<td>40 °C</td>
</tr>
<tr>
<td>Material of Resistor Element (Required Stain less Steel )</td>
<td>Stainless steel</td>
</tr>
</tbody>
</table>
### Section VI G – Technical Data Sheet

#### VI G-23

**Bidding Document for ICB -THPPRP-072/73-01 Procurement of Plant Single-Stage: Two-Envelope Tinau HPP Rehabilitation Project**

<table>
<thead>
<tr>
<th><strong>Continuous current rating</strong></th>
<th>A</th>
<th>As required</th>
</tr>
</thead>
</table>

#### C. Neutral Isolating Switch

<table>
<thead>
<tr>
<th><strong>Type and designation</strong></th>
<th>Air brake switch, knife type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name of the Manufacturer</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Rated voltage</strong></td>
<td>kV</td>
</tr>
<tr>
<td><strong>Rated frequency</strong></td>
<td>Hz</td>
</tr>
<tr>
<td><strong>Current rating continuous</strong></td>
<td>A</td>
</tr>
</tbody>
</table>

##### Auxiliary contacts

<table>
<thead>
<tr>
<th><strong>No. of auxiliary contact NO &amp; NC</strong></th>
<th>As desired</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current rating of contacts make and brake</strong></td>
<td>A</td>
</tr>
</tbody>
</table>

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. STATION TRAVELLING CRANE

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturer's type designation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type of Crane</td>
<td>EOT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type of Hoist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hoisting Capacity</td>
<td>MT</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electric Motor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Braking System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limit Switch</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Maximum Lift</strong></th>
<th>m</th>
<th>To be determined by Bidder as per site conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hoisting Speed (Operating Speed)</strong></td>
<td>m/min</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td><strong>Equivalent Running Time</strong></td>
<td>Hrs/day</td>
<td>To be determined by Bidder</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Operation</strong></th>
<th>Operator Cabin/Pendant Control Device</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electric Power Supply</strong></td>
<td></td>
</tr>
<tr>
<td>i) Main Power Supply:</td>
<td>380 V/ 50 Hz</td>
</tr>
<tr>
<td>ii) Control Supply:</td>
<td>230 V/ 50 Hz</td>
</tr>
</tbody>
</table>
### Section VI G – Technical Data Sheet

<table>
<thead>
<tr>
<th>iii) Power Consumption</th>
<th>/-Phase 110 V DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td></td>
</tr>
<tr>
<td>Wheel</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Shaft</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Gear</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Pinion</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Portal, Bogie, Deck etc</td>
<td>To be determined by Bidder</td>
</tr>
</tbody>
</table>

### Bridge Structure

<table>
<thead>
<tr>
<th>Lifting Capacity</th>
<th>MT 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span</td>
<td>mm</td>
</tr>
<tr>
<td>To be determined by Bidder as per site conditions</td>
<td></td>
</tr>
<tr>
<td>Wheel Base</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Total Length of Travel</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Class</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Travelling Equipment</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Crane Travelling Speed (fast/slow)</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Crane Travel</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>No. of Wheels</td>
<td>No</td>
</tr>
<tr>
<td>To be determined by Bidder</td>
<td></td>
</tr>
<tr>
<td>Rail Size</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Limit Switch</td>
<td>Extreme position as well as for centre of each bay</td>
</tr>
<tr>
<td>No. of wheel boogies</td>
<td>Four hinged to end carriage in which two are driving units and two are idle type</td>
</tr>
<tr>
<td>Drive System</td>
<td>VSD</td>
</tr>
</tbody>
</table>

### 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
<table>
<thead>
<tr>
<th>Rail Gauge</th>
<th>Meter</th>
<th>To be determined by Bidder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel Gauge</td>
<td>Meter</td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>End Buffers</td>
<td></td>
<td>To be determined by Bidder</td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td>Spring Loaded Type</td>
</tr>
<tr>
<td>Outer Static Housing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movable spring housing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking Arrangement</td>
<td></td>
<td>Anchoring to prevent movement from parking position and interlocking to prevent over travel during parking and anchoring</td>
</tr>
<tr>
<td>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</td>
<td>Month</td>
<td></td>
</tr>
<tr>
<td>Is manufacturer is ISO 9001 holder?</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Type test certificate submitted?</td>
<td></td>
<td>Wherever required</td>
</tr>
<tr>
<td>User's certificate submitted?</td>
<td></td>
<td>Required</td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………... As representative for…………………………………
Address…………………………………………. Date…………………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

12. AUTOMATIC CONTROL AND SCADA SYSTEM

<table>
<thead>
<tr>
<th>REF</th>
<th>DESIGNATION</th>
<th>UNIT</th>
<th>EMPLOYER</th>
<th>BIDDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLC SYSTEM</td>
<td>Manufacturer and Country of Origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year of manufacturing experience</td>
<td>Years</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturing's Designation as per submitted catalogue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable standard</td>
<td>IEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electromagnetic Compatibility according to IEC</td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication protocol type</td>
<td>IEC 60870-5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability class according to IEC 60870-4 (MTBF)</td>
<td>R1 &gt; 8760 h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time change in PLC input to change in diagram</td>
<td>&lt; 2 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time executing command diagram change output PLC</td>
<td>&lt; 2 s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processing module microprocessor type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. possible number of process stations on the bus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. ambient temperature (continuous operation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. relative humidity (continuous operation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus system cable kind/ type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. number of clients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution time tagged event and alarms in PLC</td>
<td>10 ms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution time tagged event alarms protection relays</td>
<td>2 ms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of data points</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total No. of Analog Inputs</td>
<td>Nos.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total No. of Analog Outputs</td>
<td>Nos.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total No. of Digital Inputs</td>
<td>Nos.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Digital Outputs</td>
<td>Nos.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard cubicle:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- protection class</td>
<td>IP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- thickness of sheet steel</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- dimensions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>height</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>depth</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>width</td>
<td>mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary power supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- AC source</td>
<td>V AC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- DC source</td>
<td>V DC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- internal power supply</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- type of back-up power supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permissible ambient conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- operating temperature range</td>
<td>°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- relative humidity range</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overvoltage protection incorporated</td>
<td>Yes/No Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power Supply Voltage</strong></td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Processor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</strong></td>
<td>Month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Is manufacturer is ISO 9001 holder?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ISO 9001 certificate submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type test certificate submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Has manufacturer exported units?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>User's certificate submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technical literature/drawings submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INSTRUMENTATION DEVICES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturer and Country of Origin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Year of manufacturing experience</strong></td>
<td>Years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturing's Designation as per submitted catalogue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Applicable standard</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Current Output</strong></td>
<td>mA</td>
<td>4..20</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overvoltage protection incorporated</strong></td>
<td>Yes/No</td>
<td>As specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Power Supply Voltage</strong></td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>%</td>
<td>Up to 0.02% of measuring range</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Measurement Range</strong></td>
<td>As required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operating temperature range</strong></td>
<td>°C</td>
<td>-25…+60°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protection Class</strong></td>
<td>IP67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vibration resistance (IEC 68-2-6)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shock resistance (IEC 68-2-27)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Delivery of equipment in months following award of contract (Allowing time for approval of drawing)</strong></td>
<td>Month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Is manufacturer is ISO 9001 holder?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ISO 9001 certificate submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type test certificate submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Has manufacturer exported units?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>User's certificate submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technical literature/drawings submitted?</strong></td>
<td>Yes/No</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SERVER HARDWARE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturer and Country of Origin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturer's type designation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Processor Type</strong></td>
<td>Intel Xeon, Quad-Core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Applicable standard</strong></td>
<td>IEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Processor frequency</strong></td>
<td>GHz 3.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hard Disk Storage</strong></td>
<td>TB 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PC Hard disk Controller</strong></td>
<td>SATA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PC Standard Drives</strong></td>
<td>SATA16xDVD+/−RW Super Multi SATA Drive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Monitor</strong></td>
<td>24” LED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Floppy Drive</strong></td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Size of graphics card</strong></td>
<td>GB 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Size of RAM</strong></td>
<td>GB 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technical literature submitted</strong></td>
<td>Yes/No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Delivery of equipment in months</strong></td>
<td>Month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>following award of contract (Allowing</td>
<td>time for approval of drawing)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Is manufacturer is ISO 9001 holder?</strong></td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviations from technical requirements and reasons for such deviations:

Signed…………………………………………... As representative for………………………………………
Address…………………………………………... Date………………………………………………………
Tinau Hydropower Plant Rehabilitation Project

VI H. Spare Parts
## LIST OF MANDATORY COMPONENTS FOR TINAU REHABILITATION PROJECT

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Turbine</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Turbine Runner</td>
<td>1 No</td>
</tr>
<tr>
<td>1.2</td>
<td>Guide vane bushes (upper, middle, lower)</td>
<td>1/2 of used</td>
</tr>
<tr>
<td>1.3</td>
<td>Guide vane seal rings</td>
<td>4 No</td>
</tr>
<tr>
<td>1.4</td>
<td>Guide vane half diversion key</td>
<td>1/3 of used</td>
</tr>
<tr>
<td>1.5</td>
<td>Guide vane shear pin</td>
<td>1/2 Set</td>
</tr>
<tr>
<td>1.6</td>
<td>Guide vane stopping bearing piece</td>
<td>1/2 of used</td>
</tr>
<tr>
<td>1.7</td>
<td>Main shaft working seals</td>
<td>1 Set</td>
</tr>
<tr>
<td>1.8</td>
<td>Main shaft maintenance seals</td>
<td>1 Set</td>
</tr>
<tr>
<td>1.9</td>
<td>Head cover &amp; bottom ring anti-wear plates</td>
<td>1 Set</td>
</tr>
<tr>
<td>1.10</td>
<td>Guide vane lever shaft bush</td>
<td>1/4 of used</td>
</tr>
<tr>
<td>1.11</td>
<td>Washers and fillers for all turbine connection</td>
<td>1 Set</td>
</tr>
<tr>
<td>1.12</td>
<td>Turbine facing plates</td>
<td>2 Set</td>
</tr>
<tr>
<td>1.13</td>
<td>Resistance temperature detectors of each type</td>
<td>1 Lot</td>
</tr>
<tr>
<td>1.14</td>
<td>Flow indicators of each type</td>
<td>1 Lot</td>
</tr>
<tr>
<td>1.15</td>
<td>Oil level indicators complete with switches</td>
<td>1 Set</td>
</tr>
<tr>
<td>1.16</td>
<td>Indicating instrument of each type</td>
<td>1 Lot</td>
</tr>
<tr>
<td>2)</td>
<td>Governing Equipment</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Frequency measurement card in PLC for governor</td>
<td>1 No</td>
</tr>
<tr>
<td>2.2</td>
<td>Sensor for position indicator in governor</td>
<td>2 No</td>
</tr>
<tr>
<td>2.3</td>
<td>Relay Board</td>
<td>1 No</td>
</tr>
<tr>
<td>2.4</td>
<td>Signal Board</td>
<td>1 No</td>
</tr>
<tr>
<td>2.5</td>
<td>Safety Tube</td>
<td>4 No</td>
</tr>
<tr>
<td>2.6</td>
<td>Indicator Light</td>
<td>1 No</td>
</tr>
<tr>
<td>2.7</td>
<td>Seal</td>
<td>1 Set</td>
</tr>
<tr>
<td>2.8</td>
<td>Power Supply Card</td>
<td>2 No</td>
</tr>
<tr>
<td>2.9</td>
<td>Push Button</td>
<td>4 No</td>
</tr>
<tr>
<td>2.10</td>
<td>Filter</td>
<td>4 No</td>
</tr>
<tr>
<td>3)</td>
<td>Oil Pressure Unit &amp; Cooling Water System</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Oil pump for pressure oil supply (only gear pump)</td>
<td>1 No</td>
</tr>
<tr>
<td>3.2</td>
<td>Seals/Pickings</td>
<td>1 No</td>
</tr>
<tr>
<td>3.3</td>
<td>Filter element</td>
<td>2 No</td>
</tr>
<tr>
<td>3.4</td>
<td>Solenoid/Coil</td>
<td>1 No</td>
</tr>
<tr>
<td>3.5</td>
<td>Oil level switch</td>
<td>1 No</td>
</tr>
<tr>
<td>3.6</td>
<td>Pressure switch</td>
<td>1 No</td>
</tr>
<tr>
<td>3.7</td>
<td>Safety relief valve</td>
<td>1 No</td>
</tr>
<tr>
<td>3.8</td>
<td>Valve of each type for Cooling Water System</td>
<td>1 Lot</td>
</tr>
<tr>
<td>4)</td>
<td>Main Inlet Valve</td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>Seal of each type</td>
<td>1 Lot</td>
</tr>
<tr>
<td>5)</td>
<td>Station EOT Crane</td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>Brake drum of each type</td>
<td>1 No</td>
</tr>
<tr>
<td>5.2</td>
<td>Wrapped friction lining of each size and type</td>
<td>1 No</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>5.3</td>
<td>Suspension hook with isolated plates</td>
<td>1 Set</td>
</tr>
<tr>
<td>5.4</td>
<td>Flexible joints and collection rings of each type</td>
<td>1 No</td>
</tr>
<tr>
<td>5.5</td>
<td>Contactor</td>
<td>1 Set</td>
</tr>
<tr>
<td>5.6</td>
<td>Collector</td>
<td>1 Set</td>
</tr>
<tr>
<td>5.7</td>
<td>Fuses, indicating lamps and lighting lamps (100% of used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>5.8</td>
<td>Relay, button and limit switch</td>
<td>1 No</td>
</tr>
<tr>
<td>6)</td>
<td>Generator</td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>RTD’s (Resistance Temperature detector)</td>
<td>2 No</td>
</tr>
<tr>
<td>6.2</td>
<td>Bearing pad</td>
<td>1 No</td>
</tr>
<tr>
<td>6.3</td>
<td>Oil level indicators complete with switches</td>
<td>1 Set</td>
</tr>
<tr>
<td>6.4</td>
<td>Indicating instrument of each type</td>
<td>1 Lot</td>
</tr>
<tr>
<td>7)</td>
<td>Brushless Excitation System</td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>SCRs</td>
<td>1 Set</td>
</tr>
<tr>
<td>7.2</td>
<td>Indicating Lamps, Push Button &amp; Fuses (50% used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>7.3</td>
<td>Current meter, Voltmeter, kw/kVA meter (100% used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>7.4</td>
<td>Power Supply Card</td>
<td>2 Nos</td>
</tr>
<tr>
<td>7.5</td>
<td>Auxiliary Relays (50% used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>7.6</td>
<td>Transformers</td>
<td>1 No of each type</td>
</tr>
<tr>
<td>8)</td>
<td>Control &amp; Instrumentation, Monitoring &amp; Protection System</td>
<td></td>
</tr>
<tr>
<td>8.1</td>
<td>Generator Protection Relay</td>
<td>1 No</td>
</tr>
<tr>
<td>8.2</td>
<td>Indicating Lamps, Push Button &amp; Fuses (100% used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>8.3</td>
<td>Power Supply Card (100% used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>8.4</td>
<td>CPU</td>
<td>1 No</td>
</tr>
<tr>
<td>8.5</td>
<td>I/O Card (1/3 of installed)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>8.6</td>
<td>Communication Module</td>
<td>1 No</td>
</tr>
<tr>
<td>8.7</td>
<td>Frequency Transducer (50 % of installed)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>8.8</td>
<td>CPU internal battery</td>
<td>2 Nos</td>
</tr>
<tr>
<td>8.9</td>
<td>Indicating lamps (100% of used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>8.10</td>
<td>Flash Card (if any)</td>
<td>1 No</td>
</tr>
<tr>
<td>8.11</td>
<td>Bulbs / Fuses (Annunciation Window)</td>
<td>1 No.</td>
</tr>
<tr>
<td>8.12</td>
<td>Lockout Relay (Master trip relay)</td>
<td>1 No.</td>
</tr>
<tr>
<td>8.13</td>
<td>Relay terminal blocks</td>
<td>1 No.</td>
</tr>
<tr>
<td>9)</td>
<td>Generator Voltage Equipment</td>
<td></td>
</tr>
<tr>
<td>9.1</td>
<td>Current Transformer</td>
<td>3 Nos</td>
</tr>
<tr>
<td>9.2</td>
<td>Vacuum Interrupter</td>
<td>2 Nos</td>
</tr>
<tr>
<td>9.3</td>
<td>Tripping &amp; Closing Coils</td>
<td>2 Nos. each</td>
</tr>
<tr>
<td>9.4</td>
<td>Spring Charging Motor</td>
<td>1 Nos</td>
</tr>
<tr>
<td>9.5</td>
<td>Ammeter</td>
<td>2 Nos</td>
</tr>
<tr>
<td>9.6</td>
<td>Voltmeter</td>
<td>2 Nos</td>
</tr>
<tr>
<td>9.7</td>
<td>kVA meter</td>
<td>1 No</td>
</tr>
<tr>
<td>9.8</td>
<td>Indicating Lamps &amp; Fuses (100% used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>9.9</td>
<td>Operating Handle</td>
<td>1 No</td>
</tr>
<tr>
<td>10)</td>
<td>DC &amp; UPS System</td>
<td></td>
</tr>
<tr>
<td>10.1</td>
<td>Indicating lamp, push button, fuses of each type (100% of used)</td>
<td>1 Lot</td>
</tr>
</tbody>
</table>
### Section VI H – Spare Parts

**VI H-3**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2</td>
<td>One of each type of switch, relay and other special devices</td>
<td>1 Lot</td>
</tr>
<tr>
<td>10.3</td>
<td>Ammeter</td>
<td>1 No</td>
</tr>
<tr>
<td>10.4</td>
<td>Voltmeter</td>
<td>1 No</td>
</tr>
<tr>
<td>10.5</td>
<td>One of each type of control cards (PCBs)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>10.6</td>
<td>NiCd Cell</td>
<td>5 Nos.</td>
</tr>
</tbody>
</table>

**11) 12 kV Switchgear Equipment**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.1</td>
<td>Current Transformer</td>
<td>3 Nos</td>
</tr>
<tr>
<td>11.2</td>
<td>Voltage Transformer</td>
<td>3 Nos</td>
</tr>
<tr>
<td>11.3</td>
<td>Vacuum Interrupter</td>
<td>2 Nos</td>
</tr>
<tr>
<td>11.4</td>
<td>Tripping &amp; Closing Coils</td>
<td>4 Nos. each</td>
</tr>
<tr>
<td>11.5</td>
<td>Spring Charging Motor</td>
<td>1 Nos</td>
</tr>
<tr>
<td>11.6</td>
<td>3-ϕ, O/C relay with ground fault</td>
<td>1 No</td>
</tr>
<tr>
<td>11.7</td>
<td>Ammeter</td>
<td>2 No</td>
</tr>
<tr>
<td>11.8</td>
<td>Voltmeter</td>
<td>2 No</td>
</tr>
<tr>
<td>11.9</td>
<td>kVA meter</td>
<td>2 No</td>
</tr>
<tr>
<td>11.10</td>
<td>Indicating Lamps &amp; Fuses (100% used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>11.11</td>
<td>Operating Handle</td>
<td>1 No</td>
</tr>
<tr>
<td>11.12</td>
<td>11 kV Indoor/Outdoor Heat Shrinkable Cable Termination Kit of required size</td>
<td>3 Nos each</td>
</tr>
</tbody>
</table>

**12) Emergency Diesel Generating Unit**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.1</td>
<td>Alternator carbon brush (100% of used)</td>
<td>1 Lot</td>
</tr>
<tr>
<td>12.2</td>
<td>Crank shaft bearing</td>
<td>1 Nos</td>
</tr>
<tr>
<td>12.3</td>
<td>1 complete set of spare parts recommended by manufacture of generator for 1 overhauling after running hour &gt; 4000 hrs</td>
<td>1 Lot</td>
</tr>
</tbody>
</table>

**13) Station & Distribution Transformers**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1</td>
<td>H.V. Bushings</td>
<td>1 No.</td>
</tr>
<tr>
<td>13.2</td>
<td>Neutral Bushings</td>
<td>1 No.</td>
</tr>
<tr>
<td>13.3</td>
<td>L.V. Bushings</td>
<td>1 No.</td>
</tr>
<tr>
<td>13.4</td>
<td>Gaskets</td>
<td>1 No.</td>
</tr>
<tr>
<td>13.5</td>
<td>Magnetic oil level gauge</td>
<td>1 No.</td>
</tr>
<tr>
<td>13.6</td>
<td>Buchholz relay</td>
<td>1 No.</td>
</tr>
<tr>
<td>13.7</td>
<td>Oil and winding temperature indicator</td>
<td>1 No. each</td>
</tr>
</tbody>
</table>
### 14) OTHER MISCELLANEOUS COMPONENTS

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1</td>
<td>500 V, 100 Mega ohm hand driven generator type megger with leather case</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.2</td>
<td>DIGITAL Tong tester 0-600 V, 0-300 A clip on volt – meter and Ammeter with leather case</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.3</td>
<td>Digital multimeter</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.4</td>
<td>Hand held type phase sequence meter 50 to 500 V</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.5</td>
<td>Blower</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.6</td>
<td>Soldering iron</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.7</td>
<td>Hand held speedometer</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.8</td>
<td>Vernier Caliper 300 mm</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.9</td>
<td>Dial gauge with magnetic base 0 – 0.1 mm accuracy</td>
<td>1 set</td>
</tr>
<tr>
<td>14.10</td>
<td>Inside &amp; outside calipers 150 mm, 200 mm, 250 mm and 300 mm</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.11</td>
<td>Master level 0.02 mm / M accuracy</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.12</td>
<td>Ring spanners 5 mm to 36 mm set 36 x 41 and 46 x 51 mm size</td>
<td>1 set each</td>
</tr>
<tr>
<td>14.13</td>
<td>Single end open Jaw spanners 46, 50, 51, and 55 mm</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.14</td>
<td>Box spanners 10 to 50 mm with accessories</td>
<td>1 set</td>
</tr>
<tr>
<td>14.15</td>
<td>Circlip opener (inside &amp; outside) 6”</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.16</td>
<td>Hammers – Ball peen 1 kg and straight – 5 kg &amp; 10 kg</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.17</td>
<td>Pistol drilling machine (Black &amp; Décor)</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.18</td>
<td>Shim cutter 12” size</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.19</td>
<td>Pipe wrench 18”, 24”</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.20</td>
<td>Screw wrench 18”, 24”</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.21</td>
<td>Allen keys 5 mm to 24 mm</td>
<td>1 set</td>
</tr>
<tr>
<td>14.22</td>
<td>1 Cutting pliers 6” &amp; 8” size</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.23</td>
<td>Nose pliers 6” 8” size</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.24</td>
<td>Hacksaw frame 12” with 12 nos. blade</td>
<td>1 no.</td>
</tr>
<tr>
<td>14.25</td>
<td>Rough &amp; Smooth flat, round, half round and triangular file 12” size</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.26</td>
<td>Centre punch &amp; letter punch</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.27</td>
<td>Chisels 12 mm and 20 mm width</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.28</td>
<td>Bench vice 12” size</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.29</td>
<td>Screw drivers 6”, 9” 16”</td>
<td>1 No. each</td>
</tr>
<tr>
<td>14.30</td>
<td>Grease gun 12”</td>
<td>1 No.</td>
</tr>
<tr>
<td>14.31</td>
<td>Tap set with wrench M10, 12, 16, 18, 20, 24</td>
<td>1 set</td>
</tr>
<tr>
<td>14.32</td>
<td>Feeler gauge 0.05 mm to 1 mm size 6”, 18”</td>
<td>1 set each</td>
</tr>
<tr>
<td>14.33</td>
<td>Torque wrench 0-675 NM</td>
<td>1 No.</td>
</tr>
</tbody>
</table>
VI I. Drawings and Details of Existing Equipment
The details of existing equipment are presented in the following tables:

<table>
<thead>
<tr>
<th>Turbine No. 1</th>
<th></th>
<th>Turbine No. 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine No.</td>
<td>2627</td>
<td>Turbine No.</td>
<td>2525</td>
</tr>
<tr>
<td>Manufacture Date</td>
<td>1932</td>
<td>Manufacture Date</td>
<td>1932</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>KVAERNER BRUGG</td>
<td>Manufacturer</td>
<td>KVAERNER BRUGG</td>
</tr>
<tr>
<td>Head</td>
<td>54 m</td>
<td>Head</td>
<td>54 m</td>
</tr>
<tr>
<td>Capacity (HP)</td>
<td>580</td>
<td>Capacity (HP)</td>
<td>580</td>
</tr>
<tr>
<td>RPM</td>
<td>750</td>
<td>RPM</td>
<td>750</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generator No. 1</th>
<th></th>
<th>Generator No. 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>A/s Norsk Elektrisk &amp; Brown Boveri, Oslo</td>
<td>Manufacturer</td>
<td>NEBB, Norsk Arbeid</td>
</tr>
<tr>
<td>Voltage</td>
<td>3,000 V</td>
<td>Type</td>
<td>D8/500</td>
</tr>
<tr>
<td>Ampere</td>
<td>120</td>
<td>No. of Phases</td>
<td>3</td>
</tr>
<tr>
<td>PF (Cos φ)</td>
<td>0.8</td>
<td>Volt</td>
<td>3000 V</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz</td>
<td>Ampere</td>
<td>97</td>
</tr>
<tr>
<td>Capacity</td>
<td>590/470 kW</td>
<td>PF (Cos φ)</td>
<td>Not available</td>
</tr>
<tr>
<td>RPM</td>
<td>750/900</td>
<td>Capacity</td>
<td>500 kVA</td>
</tr>
<tr>
<td>RPM</td>
<td>750</td>
<td>RPM</td>
<td>750</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generator No. 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Aktieselskabet Norsk Elektrisk &amp; Brown Boveri Kristiania</td>
</tr>
<tr>
<td>Type</td>
<td>D8/500</td>
</tr>
</tbody>
</table>
### Electrical Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Phases</td>
<td>3</td>
</tr>
<tr>
<td>Volt</td>
<td>3,000 V</td>
</tr>
<tr>
<td>Ampere</td>
<td>97</td>
</tr>
<tr>
<td>PF (Cos $\phi$)</td>
<td>Not available</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Capacity</td>
<td>500 kVA</td>
</tr>
<tr>
<td>RPM</td>
<td>750</td>
</tr>
<tr>
<td>Exciter Voltage</td>
<td>115 V</td>
</tr>
<tr>
<td>Ampere</td>
<td>Not available</td>
</tr>
</tbody>
</table>

### Exciter Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Aktieselskarbet Norsk Elektrisk &amp; Brown Boveri Kristianai</td>
</tr>
<tr>
<td>No.</td>
<td>K10988</td>
</tr>
<tr>
<td>Type</td>
<td>E.8</td>
</tr>
<tr>
<td>Volt</td>
<td>115 V</td>
</tr>
<tr>
<td>Ampere</td>
<td>62</td>
</tr>
<tr>
<td>Revolutions</td>
<td>750/m</td>
</tr>
<tr>
<td>Capacity</td>
<td>7 kW Continuous .... Intermiterende</td>
</tr>
</tbody>
</table>

### Note:

There is no information available with regards to Turbine of Unit No. 3. However, it is comparatively larger in size than the remaining two turbines. The related drawings are attached separately.