

Nepal Electricity Authority
(A Government of Nepal Undertaking)
Transmission Directorate



Bidding Document for
Package KC-2 "Procurement of Plant Design, Supply, and
Installation, Testing and Commissioning of Koshi Corridor
(Tumlingtar, Baneshwar, Basantapur, Inaruwa) 220 KV
Substations

(Single Stage Bidding)

IFB No: KOSHI/NEA/72/73 -1

Issued to: _____

Employer: Nepal Electricity Authority
Koshi Corridor 220 KV Transmission Line Project
Part II of III
Section VI: Employer's Requirements

July, 2016

Package-KC2

Koshi Corridor 220/132/33 kV Substations (Basantapur-Baneshwar-Tumlingtar- Inaruwa Substations))

Part II-Section VI: Employer's Requirements

CONTENTS

Package-KC2**Koshi Corridor 220/132/33 kV Substations**
(Basantapur-Baneshwar-Tumlingtar- Inaruwa Substations)**Part II-Section VI: Employer's Requirements****Contents**

S.no.	Description	
1.	Section-1	General Information and Scope
2.	Section-2	General Technical Requirement
3.	Section-3	Specific Technical Requirement
4.	Section-4	Technical Specifications
	Chapter-1	Surge Arrestors
	Chapter-2	Capacitive Voltage Transformers/Voltage Transformers
	Chapter-3	Current Transformer
	Chapter-4	245/145/36 kV Isolator And Isolator With Earth Switch
	Chapter-5	245/145/36kv SF6 (Gas) Circuit Breakers For Outdoor Application
	Chapter-6	Power Transformers
	Chapter-7	Earthing System
	Chapter-8	Lightning Protection
	Chapter-9	Substation Automation and Control System
	Chapter-10	Control and Relay Panels
	Chapter-11	Fibre Optics Terminal Equipment
	Chapter-12	A.C Distribution Board
	Chapter-13	D.C. Battery, Battery Charger & DC Distribution Board
	Chapter-14	Power and Control Cables

		Chapter-15	Illumination/Lighting System
		Chapter-16	Civil Works
		Chapter-17	Substation Galvanized Steel Structures
		Chapter-18	Miscellaneous Items For Sub-Stations
		Chapter-19	Erection, Testing And Commissioning of Electrical Equipment
		Chapter-20	Station Transformers
		Chapter-21	100 KVA, 415 V Diesel Generator Sets
		Chapter-22	CCTV System
		Chapter-23	Mandatory Spares, Tools & Testing Equipment
5.	Section-5	Guaranteed Technical Particulars	
6.	Section-6	Drawings	

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-1

General Information and Scope

SECTION 1

GENERAL INFORMATION AND SCOPE

CONTENTS

S.NO	DESCRIPTION	PAGE NO.
1.0	INTRODUCTION	1
1.1	SCOPE	3
1.2	SCHEME	9
1.3	TOPOGRAPHY OF SUBSTATION SITES	9
1.4	ACCESS & GENERAL INFORMATION	9
1.5	CONNECTIVITY AND ROAD CONDITIONS	11
1.6	COMPLETION SCHEDULE	17

SECTION 1

GENERAL INFORMATION AND SCOPE

1.0. INTRODUCTION

Nepal has large hydro-power potential of about 83290 MW, out of which a meager of less than 1000 MW has been developed so far leading to chronic shortage of power in Nepal. To address the problem of acute shortage of power, numbers of hydro power projects are proposed to be developed by Govt. of Nepal in Koshi and Mechi Zones by 2020-25 and 2025-2035. To evacuate power from these hydro power projects, NEA has planned a transmission system namely Koshi Corridor 220kV Transmission System which inter-alia comprises the following components:

- (i) 220 kV D/C Transmission Line from Inaruwa to Basantapur with Quad moose ACSR conductor.
- (ii) 220 kV D/C Transmission line from Basantapur to Tumlingtar with Twin moose ACSR conductor with loop in and loop out of its one circuit at Baneshwar Substation.
- (iii) 220 kV Transmission line from Change to Basantapur with Twin moose ACSR conductor.
- (iv) 220/132/33 kV Sub-station at Basantapur.
- (v) 220/33 kV Sub-station at Baneshwar.
- (vi) 220/132/33 kV Sub-station at Tumlingtar.
- (vii) 220/132/33 kV (In 1st Phase 132/33 kV) Sub-station at Dhungesangu.
- (viii) 2 Nos. of 220 kV Line Bays at Inaruwa Substation.

A separate 400 kV transmission system comprising 400KV D/C Transmission Line from Inaruwa to Hetauda via Dhalkebar and three Substations at Inaruwa, Dhalkebar and Hetauda is presently under execution by Govt. of Nepal which would be operated at 220 kV at present and the same is being connected to Indian System at Muzaffarpur Substation in Bihar through a 400 kV transmission line link from Dhalkebar Substation. The proposed Koshi Corridor 220 kV transmission system would be integrated with aforesaid 400KV transmission system through a 220kV D/C transmission line from Basantapur to Inaruwa.

The locations of substations have been so chosen by NEA so that power from hydro power projects could be evacuated through proposed 220 kV System. The power which would be available at the proposed Substations by 2025 and 2035 for evacuation is as under:

S.No.	Name of Substation	Available Power Generation (MW)	
		By 2025	By 2035
1	Basantapur 220/132/33 kV	19.1	311.1
2	Baneshwar 220/33 kV	52.22	52.22
3	Tumlingtar 220/132/33 kV	505.6	905.6
4	Dhungesangu 220/132/33 kV (In 1 st Phase 132/33 kV)	140.6	706.1
Total		717.52	1975.02

The voltage levels at each substation have been decided based on the voltage at which power from hydro power projects would be received and the volume of power which is required to be evacuated from each substation.

Government of Nepal has signed a DOLLAR CREDIT LINE AGREEMENT (CREDIT AGREEMENT) with Export-Import Bank of India for the purpose of financing infrastructure projects such as roads and power transmission in Nepal. Nepal Electricity Authority (Government of Nepal Undertaking) is the beneficiary for the construction of power transmission lines. NEA intends to apply a portion of the proceeds of this fund for payments under the Contract for for the construction of Koshi Corridor 220 KV Transmission Line and concomitant substations. Under this package i.e Package KC-2, the construction of new 220 kV substations at Basantapur, Baneshwar and Tumlingtar and 220 kV Bay extensions at Inaruwa SS has been covered. The proposed transmission lines and substations will help in evacuating power from the candidate hydropower projects in the Koshi and Mechi Zone of Nepal that will come in near future.

1.1. SCOPE

- A. This specification covers the Design, Supply and Installation of the 220/132/33 kV Sub-station at Basantapur& Tumlingtar, 220/33 kV Sub-station at Baneshwar and 2 nos. of 220 kV Line Bays at Inaruwa Substation. The Scope of Work includes Design, Supply, Erection, Testing and Commissioning of all electrical equipments including execution of all necessary Civil works at aforesaid Substations. On turnkey basis the breakdown of scope of work is as under:
- B. Topographical survey and preparation of Contour maps of each substation site including area of Inaruwa Extension bays on 1:1000 scale with contour interval of 0.5m;
- C. Geo-technical Investigation at each Substation sites including Inaruwa Extension bays for determining engineering properties of soil required for the design of foundations, earth mat etc;
- D. Site development works including but not limited to leveling, filling, formation of Terraces at each substation site by cutting and filling including disposal of excess earth and providing slope protection works and earth retaining structures like breast walls, retaining walls etc as per site requirements;
- E. Supply of all electrical equipments including Power Transformers, Circuit Breakers, Lightning Arresters, Isolators, CTs/PTs/CVTs, Battery & Battery charger, ACDB & DCDB, DGs, Bus Bar & Shielding materials, Conductors, Insulators, Power and Control Cables, Control and Relay Panels, Optical Fibre Termination Equipment, Substation Automation System, Lightning and Fixtures, Earthing materials, Fire-fighting Equipments etc.;
- F. Supply of Galvanized Steel structures comprising Gantry tower and beams, Equipment supporting structures, Lighting mast, any other structure required for line termination etc;
- G. Construction of Foundations for Gantry towers, Equipment supporting structures, Lighting mast, Transformers etc;
- H. Construction of Control room cum administrative building with provision for office space& stores, conference room, including all finishes, Water supply and Sanitary fitting and fixtures, air conditioning, Lighting, Ventilation etc;

- I. Design of earthing and providing the earth mat in the substation area.
- J. Providing drainage system including disposal of surface run off water to nearest natural drain.
- K. Construction of Cable trenches with pre cast R.C.C. covers and necessary embedment etc;
- L. Erection of all Gantry and equipment supporting structures;
- M. Construction of all internal roads, fencing for switchyard and switch yard gates
- N. Supply and installation of Complete lighting and illumination for the switchyard including street Lightning, Control Room cum administrative building, Switchyard Panel Room.
- O. Design, Supply and Installation of Bus Post Insulators , insulator strings and hardware, clamps & connectors, Equipment terminal connectors, Conductors, Aluminum tubes, Bus bar and earthing materials, Bay marshalling box, spacers, cable supporting angles/channels, Cable trays & covers, Junction box, buried cable trenches.
- P. Design , Supply and Installation of SCADA and Complete Substation automation including hardware and software for remote control station (based on IEC 61850) along with associated equipments.
- Q. Design, Supply, Installation of Communication system consists of optical line terminal equipment (OLTE) of SDH-STM-4 technology, MUX, tele protection signaling equipment, optical distribution frame (ODF) , Optical approach cable, OPGW, and new telephone exchange system.
- R. Supply and Installation of fire protection System
- S. Erection of all electrical equipments and panels including laying of power and control cables;
- T. Testing and Commissioning of all electrical equipments, Control and Relay panels and Lighting (External and Internal);
- U. Finishing of outdoor switchyard area by providing a layer of coarse sand and stone metal; and

- V. Any other work or equipment or material required for successful commissioning of substations.

1.1.1. The main components of each substation are as under:

1) Basantapur 220/132/33kV Substation

A. 220 kV Side:

- i. Bus bar Scheme: One and Half Breaker
- ii. 1 No. of 220 kV Incoming line bay with full equipment for Tumlingtar-Basantapur Single Circuit Line.
- iii. 1 No. of 220 kV outgoing line bay with full equipment for Basantapur-Inaruwa Single Circuit Line.
- iv. 2 Nos. of 220 kV bay for 220/132kV Auto Transformer with full equipment.
- v. 2 Nos. of 100 MVA Auto Transformers comprising 6 Nos. +1 No spare, 220/132 kV, 33.3 MVA Single phase Auto Transformers.

B. 132 kV Side:

- i. Bus bar Scheme: Double bus with bypass isolator.
- ii. 1 No. of 132 kV line bay with full equipment for Basantapur – Dhungesangu Single Circuit Line.
- iii. 1 No. of Bus Coupler Bay.
- iv. 2 Nos. of Transformer bay for 100 MVA, 220/132 kV Transformer with full equipment.
- v. 1 No. of 132 kV Transformer bay for 25/30MVA, 132/33kV Transformer with full equipment.
- vi. 1 No. 25/30 MVA, 132/33kV Three Phase Power Transformers.

C. 33 kV Side:

- i. Bus bar scheme: Single Bus.

- ii. 1 No. of 33kV Transformer bay for 132/33kV transformer with full equipment.
- iii. 1 No Line Bay for NEA use.
- iv. 1 No of Station transformer bay.
- v. 1 No 400 KVA, 33/0.4kV Three Phase Station Transformer.

D. Supervisory Control and Data Acquisition (SCADA) system and Substation Automation System based on IEC 61850.

E. Communication system consists of optical line terminal equipment (OLTE) of SDH-STM-4 technology, MUX, tele protection signaling equipment, optical distribution frame (ODF) and new telephone exchange system.

F. Site Development works, foundations for gantries, equipment supporting structures, transformers, cable trenching etc. Control Room Building with provision for office space & stores, and all other necessary civil works in substation.

2) Baneshwar 220/33 kV Substation:

A. 220 kV Side:

- i. Bus bar Scheme: One and Half Breaker Scheme.
- ii. 1 Nos. of 220 kV Incoming line bays with full equipment for Loop in and Loop out of Tumlingtar-Basantapur line.
- iii. 1 Nos. of 220 kV Outgoing line bays with full equipment for Baneshwar-Basantapur line.
- iv. 2 Nos. of 220 kV bay for Main Power Transformer with full equipment.
- v. 2 Nos. of 25/30 MVA, 220/33 kV Three Phase Power Transformers.

B. 33 kV Side:

- i. Bus bar scheme: Single Bus with Bus sectionalizer.
- ii. 2 Nos. of 33kV Transformer bay for 220/33kV transformer with full equipment.

- iii. 1 No Line Bay for NEA use.
- iv. 1 No 33kV Bus Sectionalizer Bay
- v. 1 No of Station transformer bay.
- vi. 1 No 400 KVA, 33/0.4kV Three Phase Station Transformer.
- C.** Supervisory Control and Data Acquisition (SCADA) system and Substation Automation System based on IEC 61850.
- D.** Communication system for Baneshwar Substation consists of optical line terminal equipment (OLTE) of SDH-STM-4 technology, MUX, tele protection signaling equipment, optical distribution frame (ODF) and new telephone exchange system.
- E.** Site Development works, foundations for gantries, equipment supporting structures, transformers, cable trenching etc. Control Room Building with provision for office space & stores, and all other necessary civil works in substation.

3) Tumlingtar 220/132/33Kv Substation:

A. 220kV Side:

- i. Bus bar Scheme: One and Half Breaker Scheme.
- ii. 1 Nos. of 220 kV Outgoing line bay with full equipment for Tumlingtar-Basantapur line.
- iii. 2 Nos. of 220 kV bay for Auto Transformer with full equipment.
- iv. 2 Nos. of 100 MVA Auto Transformers comprising 6 Nos. + 1 No.spare 33.3 MVA 220/132 kV Single phase Auto Transformer.

B. 132 kV Side:

- i. Bus bar Scheme: Double bus with bypass isolator.
- ii. 2 Nos. of 132 kV Outgoing Transformer bay with full equipment.

- iii. 2 Nos. of 132 kV Incoming Transformer bay with full equipment.
- iv. 1 No. of Bus Coupler Bay with full equipment.
- v. 2 Nos. of 25/30 MVA, 132/33 kV Three Phase Power Transformers.

C. 33 kV Side:

- i. Bus bar scheme: Single Bus with Bus Sectionalizer.
- ii. 2 Nos. of 33kV Transformer bay for 132/33kV transformers with full equipment.
- iii. 1 No. Line Bay for NEA use.
- iv. 1 No. 33kV Bus Sectionalizer Bay.
- v. 1 No. of Station transformer bay.
- vi. 1 No. 400 KVA, 33/0.4kV Three Phase Station Transformer.

D. Supervisory Control and Data Acquisition (SCADA) system and Substation Automation System based on IEC 61850.

E. Communication system for Tumlingtar Substation consists of optical line terminal equipment (OLTE) of SDH-STM-4 technology, MUX, tele protection signaling equipment, optical distribution frame (ODF) and new telephone exchange system.

F. Site Development works, foundations for gantries, equipment supporting structures, transformers, cable trenching etc. Control Room Building with provision for office space & stores, and all other necessary civil works in substation.

4) Extension of two nos. of 220 kV line bays at Inaruwa Substation:

A. 2 Nos. of 220 kV Bay Extension at Inaruwa Substation. The Construction of Inaruwa Substation is separately undertaken by NEA under Nepal India Electricity Transmission and Trade Project. The Scope of Work includes the supply and installation of Bay equipments for 2 Nos. of 220 kV Line Bay and construction of

small control room for BCU to be located at switchyard itself. The 220 kV Bus Bar extension shall be in the scope of NIETTP, NEA. Inaruwa Bus Bar Conductor and Bus Bar Scheme(Double Main and Transfer Bus Scheme with Twin Thermal Resistance Aluminium Alloy Conductor (TRAAC) as main bus and Single TRAAC as Transfer Bus with nominal area (Al/Steel-1000/125)mm²with current rating of 1432A at 90°C, 1744A at 110°C and 2230A at 150°C) . Under this contract, the contractor has to supply and install all the connectors and fittings in commensurate with the thermal temperature of TRAAC.

B. Integration of SCADA communication system in Inaruwa Substation.

Note: The Employer may get the work done of one number 220kV Bay instead of two number 220kV Bay at Inaruwa Substation depending upon its requirement during the execution of the contract

1.2. SCHEME

Network Diagram and Single Line Diagram (SLD) for the proposed Koshi Corridor 220 kV Transmission System is enclosed as **Annex-I**.

1.3. TOPOGRAPHY OF SUBSTATION SITES

The general topography of project area including substation sites is hilly/mountainous in nature. The substations at Basantapur and Baneshwar are located on hill slopes whereas substation at Tumlingtar is located in a valley on relatively flat terrain and substation at Inaruwa is located on a flat land in Tarai area of Nepal. The approximate altitudes of substations are as under:

- (i) Basantapur: MSL +2415 m to MSL +2480m;
- (ii) Baneshwar: MSL +1415 m to MSL + 1460 m;
- (iii) Tumlingtar: MSL +445m to MSL +450 m; and
- (iv) Inaruwa: MSL+80 m

1.4. ACCESS AND GENERAL INFORMATION

The other general information about the substation sites is given below for information of Bidders:

1.4.1. Basantapur

Site is located on Koshi Highway which connects Dharan, the District HQ of Eastern Region, to Khandbari via Tumlingtar. The site is approximately 88 Km from Dharan and 7 Km from Basantapur town. Site is located on a relatively steep slope of a hill on left side of Koshi highway. One natural stream/drain is passing through the site and one other stream/drain is running on its left periphery. One Kachcha road taking off from highway is also passing through the substation and it forms the boundary of substation towards the hill side. The stream passing through the substation site divides the site into two parts and is quite deep and may be carrying significant quantity of water during monsoon period. It may not be desirable to divert these drains. However, the Kachcha road passing through the substation site shall be required to be diverted, which shall be done by the Employer. A catch drain shall be required on hill side periphery for arresting the rain water runoff from hill side towards substation site. It may not be possible to locate the whole substation at one terrace but may need two to three terraces.

1.4.2. Baneshwar

Baneshwar substation Site is also located on Koshi Highway and it is approximately 138 Km from Dharan and 50 Km from Basantapur town. Site is located on a relatively mild slope of a hill on right side of Koshi highway. Highway is running practically on three sides of substation site like a garland. One small drain is running on hill side at left end and it discharges into a culvert under the road. There is one more small drain on right side within the substation plot and it discharges into another culvert under the road. A catch drain shall be required on hill side periphery for arresting the rain water from hill side towards substation site. The creation of two terraces may be necessary to accommodate the substation and other facilities at this site.

1.4.3. Tumlingtar

Tumlingtar substation Site is also located on Koshi Highway and it is approximately 163 Km from Dharan and 25 Km from Baneshwar Sub-station site. Site is located on table top type of

topography with mostly a flat land without any large difference in its levels. There is Koshi highway on one side and river Sabha Khola on other side. Site is not located exactly on Koshi Highway which but little inside through a Kachcha road off taking from Koshi highway. A small village with a few houses is located on one end of substation site. It would be possible to locate the whole substation at one terrace.

1.4.4. Inaruwa Substation

Inaruwa Substation is located on East-West Highway of Nepal near Inaruwa town in terai plains of Nepal. It is about 30 km from Dharan/Biratnagr and it is mostly a levelled land.

1.5. CONNECTIVITY AND ROAD CONDITIONS

1.5.1. Connectivity of Substation Sites from Nepal & India

The places where substations are located viz. Inaurwa, Basantapur, Baneshwar and Tumlingtar are connected by roads having different road conditions. Inaurwa is located on all weather East – West Highway of Nepal, about 30 km from Biratnagar which is an industrial town and the second largest town of Nepal after Kathmandu. Biratnagar is connected by Air from Kathmandu through regular flights. Biratnagar is located on Indo-Nepal border and nearest border town in India is Jogbani of Bihar at a distance of about 5 km from Biratnagr. Jogbani is connected by rail through broad gauge rail line to main rail route from Delhi to Guwahati. The nearest airport in India is Bagdogra near Siliguri in West Bengal at a distance of about 150 km from Dharan/Biratnagar and can be approached through East-West highway of Nepal. Tumlingtar is connected by Air from Kathmandu and Biratnagar.

Basantapur, Baneshwar and Tumlingtar substations can be approached through Koshi Rajmarg of Nepal which connects Dharan to Khandbari via Hilly, Basanatpur, Chainpur, Baneshwar and Tumlingtar. Dharan is at a distance of about 50 km from Biratnagar.

1.5.2. Road Conditions

East–West Highway of Nepal is all weather road and it is running parallel to Indo-Nepal boarder (West Bengal-Bihar-Uttar Pradesh). The road connecting Biratnagar & Dharan crosses the East-West Highway at Itahari and it is also all weather road and mostly passes through plain terrain.

The Koshi Rajmarg (i.e. Highway) from Dharan to Khandbari passes through hilly terrain throughout its length with altitudes as high as about 2500 m. Highway crosses many rivers, Kholas, Streams etc in its route. The major river en-route to Basantapur from Dharan is Tamur river which is one of the main tributary of river Koshi. The road from Dharan to Inaruwa is an all weather road and mostly passes through plain terrain.

The conditions of Koshi Rajmarg which is the only road available to reach the substation sites vary along its route and also with the season. These are briefly described below for the information of Bidders:

- i) The stretch of road from Dharan to Hille is all weather road except a small stretch near Tamur river which is damaged by landslide and it is presently under repair.
- ii) The stretch of road from Hille to Deuralli passing through Basantapur is a tar road and it is in relatively fair conditions.
- iii) The most of the stretch of the road from Deuralli to Chainpur is in bad shape with large & deep pot holes. During monsoon period from July to September, it may not be possible to travel by motor vehicle on this stretch of Koshi Rajmarg. The road conditions remain bad in this stretch throughout the year but become extremely difficult during monsoon period even for four wheel drive vehicles. The stretch from Chainpur to Tumlingtar is fairly good and is being tarred and expected to be all weather road in due course.

The Bidders shall make their own assessment of existing road conditions including capacity of bridges & culverts as well as transportation limitations with respect to both size wise and weight wise, for transportation of materials and equipments to project site through existing road conditions and quote accordingly.

The bidders are advised to visit the substation sites and acquaint themselves with the topography, infrastructure and also the design philosophy. Before proceeding with the construction work of the new Sub-stations and existing substations, the Contractor shall fully familiarize himself with the site conditions and General arrangements & scheme etc. Though the Employer/PMC shall endeavor to provide the information, it shall not be binding for the

Employer/PMC to provide the same. The bidder shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the construction and successful commissioning, operation & maintenance of the substation in all respects. All materials required for the Civil and construction/installation work shall be supplied by the Contractor.

The complete design (unless specified otherwise in specification elsewhere) and detailed engineering shall be done by the Contractor based on conceptual tender drawings. Drawings for civil works enclosed with tender drawings are for information only. However civil drawings shall be developed by the contractor as per his design.

1.5.3. The Contractor shall also be responsible for the overall co-ordination with internal/external agencies; project management, training of Employers's manpower, loading, unloading, handling, moving to final destination for successful erection, testing and commissioning of the substation/switchyard etc.

1.5.4. Design of substation and its associated electrical & mechanical auxiliaries systems includes preparation of single line diagrams and electrical layouts including layout arrangement for transformers, foundation layout, cable trench layout, earthmat layout, erection key diagrams, electrical and physical clearance diagrams, design calculations for earthing and lightening protection system (including Direct Stroke Lighting Protection), control and protection schematics, wiring and termination schedules, civil designs and drawings, design of fire fighting system and air conditioning system, indoor/outdoor lighting/illumination and other relevant drawings & documents required for engineering of all facilities within the fencing to be provided under this contract, are covered under the scope of the Contractor.

1.5.5. Any other items not specifically mentioned in the specification but which are required for erection, testing and commissioning and satisfactory operation of the substation are deemed to be included in the scope of the specification unless specifically excluded.

1.5.6. Schedule of Quantities

The requirement of various items/equipments and civil works are indicated in Schedules of Rates and Prices.

All equipments/items and civil works for which bill of quantity has been indicated in Schedules of Rates and Prices) shall be payable on unit rate basis/quoted rate basis. During actual execution, any variation in such quantities shall be payable as per relevant clauses of the condition of Contract.

Wherever the quantities of items/works are not indicated and quantified, the bidder is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Schedules of Rates and Prices under contractor assessed quantities. For erection hardware items, Bidders shall estimate the total requirement of the works and indicate module-wise lump sum price bay wise and include the same in relevant Schedules of Rates and Prices under contractor assessed quantities. For module identification, Bidder may refer typical drawings enclosed with the specifications. Any material/works for the modules not specifically mentioned in the description in Schedules of rates and prices, as may be required shall be deemed to be included in the module itself.

The detailed bill of quantities of the mandatory spares for which break up is not given in the bid price Schedules are indicated in chapter 23 of Technical Specification.

The quantities specified in the Schedules of Rates and Prices are only estimates. As soon as practicable, the Contractor shall complete all survey, design and investigation works and accordingly revise the quantities and the Schedules of rates and Prices based on the unit/lump sum prices quoted in the Schedules of rates and Prices to complete the Facilities in accordance with the Technical Specifications and submit for Employer's approval. The revised price adjustment due to variation of quantities shall be as per the Condition of the Contract.

Bidder should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of substation shall be considered included in the bid price and shall be provided at no extra cost to Employer.

1.5.7. Basic Reference Drawings

Single line diagram and general arrangements are enclosed with the bid documents for reference, which shall be further engineered by the bidder.

The reference drawings, which form a part of the specifications, are given at Annexure-II. The bidder shall maintain the overall dimensions of the substation, phase to earth clearance, phase to phase clearance and sectional clearances.

The enclosed drawings give the basic scheme, layout of substation, substation buildings, associated services etc. In case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general. However, the Bidder is advised to get these clarified from Owner.

1.5.8. Special Tools and Tackle

The bidder shall include in his proposal the deployment of all special tools and tackles required for operation and maintenance of equipment. The special tools and tackles shall only cover items which are specifically required for the equipment offered and are proprietary in nature. The Contractor shall furnish a list of special tools and tackles for the various equipment in a manner to be referred by the Employer during the operation of these equipments. The scope of special tools and tackles are to be decided during detail engineering and the list of special tools and tackles, if any shall be finalized.

1.5.9. Transmission line side insulator String (including Hardware) i.e. tension insulator on the line side of the take off gantry for 220kV, 132kV & 33kV lines termination is under the present scope of specification. Also the Supply and installation of ACSR Moose conductor, OPGW and Approach cable and all associated hardware on line side of take off gantry is also under the present scope of specification.

1.5.10. Altitude factor consideration

For Equipments including Transformers, all design parameter including air clearances, insulation coordination shall be corresponding to altitude of 2480 m for Basantapur Substation and 1460 m for Baneshwar Substation (Accordance to relevant IEC).

1.5.11. Non CFC refrigerant shall be utilized for Air conditioning system, offered for Control room building and switchyard panel room is under the scope of contract

1.5.12. Training for Employer's manpower

Training to Employer's Personnel/manpower shall be the fundamental aspect of the Contract.

➤ **Training at manufacturer's work :**

The training shall be provided in the field of design, testing and maintenance at Manufacturer's works as per following:-

1. Control & Protection and Substation Automation System:. (4 Nos. Trainees)- 7 Days
2. Switchyard Equipments (Circuit Breaker, Isolator, CT, CVT & LA): (4Nos Trainees)- 7 Days
3. Telecommunication Equipment (SDH, MUX & NMS (Craft Terminal)) and PLCC: (4Nos. Trainees)- 7 Days
4. Power Transformer (2 Nos. Trainees)- 5 days

The Contractor shall bear all the training charges and shall include the payment of USD 300 per trainee per day towards per Diem allowance to cover NEA trainees' accommodation, meals and other incidental expenses and to and fro economy class air ticket from Nepal to place of training . The duration of training shall be excluding the travelling period. There will be no separate payment for this activity and the cost of same shall be embedded in the contractor's price.

➤ **On Job Training in Nepal:**

The training shall be provided to Employer's personnel in the field of erection, testing, Installation, operation and maintenance at substation site as per following:-

1. Control & Protection: 5 Days.
2. Substation Automation System including integration aspect of existing SCADA (of Siemens supplied SINAUT spectrum) at Load Dispatch Centre: 5 days.
3. Switchyard Equipments (Circuit Breaker, Isolator, CT, CVT& LA): 5 days.
4. Telecommunication Equipment (SDH ,MUX & NMS (Craft Terminal)) and PLCC: 5 Days
5. Power Transformer: 3 days

The traveling, boarding and lodging expenses of Employer's personnel for the training programme conducted in Nepal shall be borne by the Employer. The duration of training shall be excluding the travelling period.

During the Detail Engineering phase, the Contractor is required to submit the schedule and training modules for each of the training mentioned above in consultation with the Employer.

The training Courses shall be offered in a periodic cycle such that none of the courses overlap.

1.5.13. Opening of Site office

The contractor within the 30 days from the contract effectiveness shall open and maintain the four site office and stores at each of the Substations i.e Tumlingtar, Baneshwar, Basantapur and Inaruwa. The Contractor shall depute the qualified manpower in each office to carry out the job as per Contract.

1.6. COMPLETION SCHEDULE

The complete work i.e. design, manufacture, testing and commissioning including all site development and civil works of all the substations comprises 220/132/33kV Substations at Basantapur & Tumlingtar, 220/33 kV substation at Baneshwar and extension of 2 Nos. of 220 kV Line Bays in Inaruwa Substation shall be completed on turnkey basis within 30 (Thirty) months from date of Contract Effectiveness. The Bidder shall submit along with his Bid a bar chart or any other appropriate program giving schedule for completion of entire work covered in the scope of this specification indicating commencement and completion of each activity for each substation separately considering zero date as the date on which Contract becomes effective. Further the supply schedule of the Equipments shall commensurate with the actual progress in the field.

1.6.1. Precommissioning, Commissioning, Trial-Run & Completion

As soon as the Facilities covered by these specifications are physically completed in all respects, the Pre commissioning, Commissioning, Trial-run and Completion of the Facilities, as mentioned below, shall be attained in accordance with the procedure given in the Conditions of Contract, Vol.-I of the Bidding Documents.

(i) Pre commissioning : As per relevant Chapters

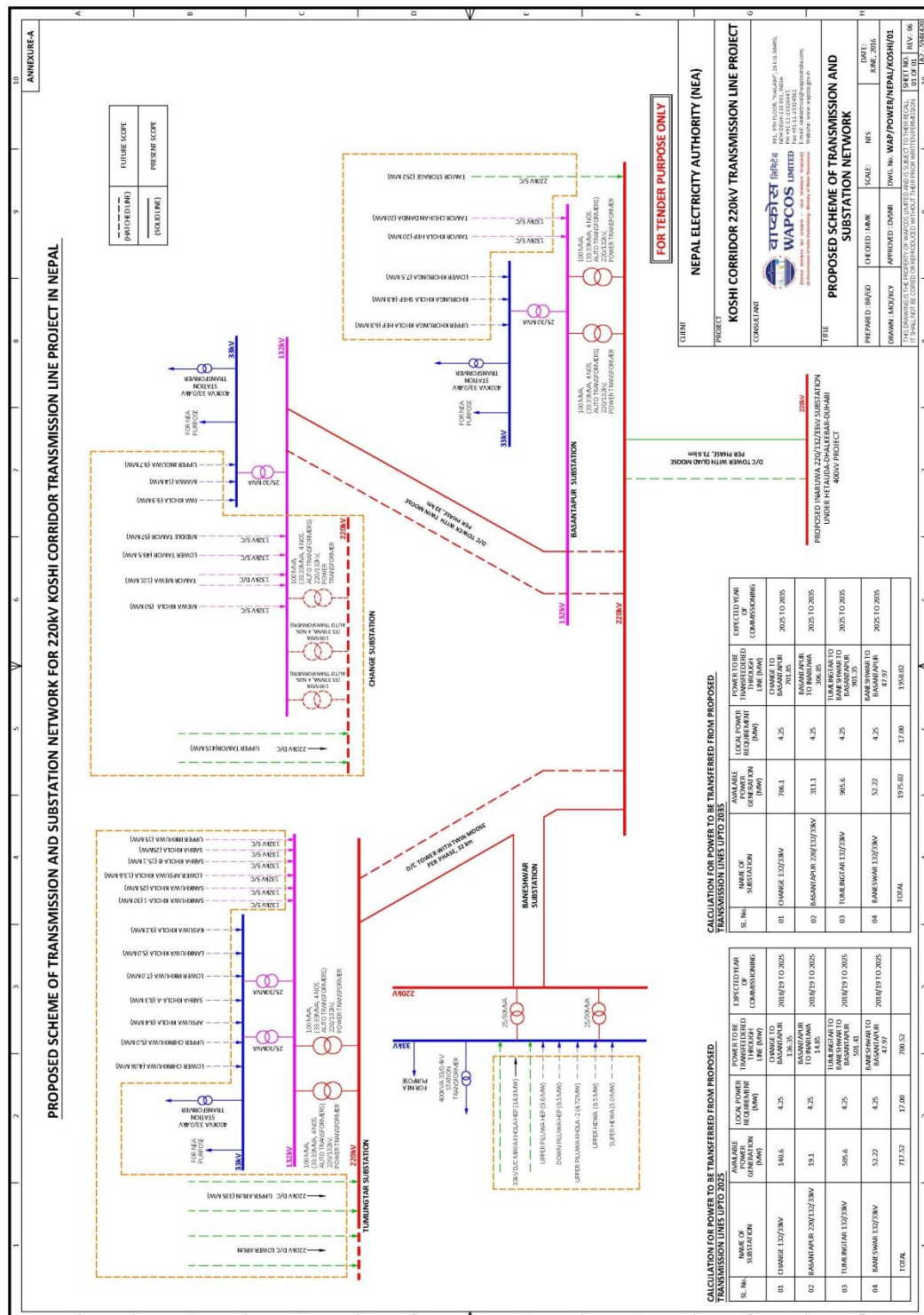
(ii) Commissioning : Charging of the Facilities at rated voltage

Further, wherever appearing in these specifications, the words – ‘commissioning checks’, ‘installation checks’, ‘site tests’, ‘performance guarantee tests for fire protection system’, are to be considered as ‘pre commissioning checks’.

(iii) Trial-run : Operation of the Facilities or any part thereof by the Contractor immediately after the Commissioning for a continuous period of 72(Seventy two) hours continuously. In case of interruption due to problem / failure in the respective equipment, the contractor shall rectify the problem and after rectification, continuous 72(Seventy two) hours period start after such rectification.

(iv) Completion : Upon successful completion of Trial-run. ‘Guarantee Test(s)’ and/or ‘Functional Guarantees’ are applicable only for Substation Automation System as specified in relevant chapter -‘Substation Automation System.’

Annexure-I



Annexure-II

SL NO	DRAWING NAME	DRAWING NUMBER
1)	PROPOSED SCHEME OF TRANSMISSION AND SUBSTATION NETWORK	WAP/POWER/NEPAL/KOSHI/01
2)	SINGLE LINE DIAGRAM OF 220/132/33 kV TUMLINGTAR SUBSTATION	WAP/POWER/NEPAL/KOSHI/KC2/01
3)	SINGLE LINE DIAGRAM OF 220/33 kV BANESHWAR SUBSTATION	WAP/POWER/NEPAL/KOSHI/KC2/02
4)	SINGLE LINE DIAGRAM OF 220/132/33 kV BASANTAPUR SUBSTATION	WAP/POWER/NEPAL/KOSHI/KC2/03
5)	PLOT & LAYOUT PLAN OF 220/132/33 kV SUBSTATION AT TUMLINGTAR	WAP/POWER/NEPAL/KOSHI/KC2/04
6)	PLOT & LAYOUT PLAN OF 220/33 kV SUBSTATION AT BANESHWAR	WAP/POWER/NEPAL/KOSHI/KC2/05
7)	PLOT & LAYOUT PLAN OF 220/132/33 kV SUBSTATION AT BASANTAPUR	WAP/POWER/NEPAL/KOSHI/KC2/06
8)	TYPICAL DETAILS OF CABLE TRENCH WITH CABLE TRAY	WAP/POWER/NEPAL/KOSHI/KC2/C1
9)	UNDERGROUND WATER TANK DETAILS	WAP/POWER/NEPAL/KOSHI/KC2/C2
10)	TYPICAL DETAILS FOR STONE MASONARY BREAST WALL AND TYPICAL SECTION OF RCC RETAINING WALL	WAP/POWER/NEPAL/KOSHI/KC2/C3
11)	TYPICAL SECTION FOR STONE MASONARY DRAIN	WAP/POWER/NEPAL/KOSHI/KC2/C4
12)	DETAILS OF ROAD CUM RAIL TRACK	WAP/POWER/NEPAL/KOSHI/KC2/C5
13)	PLAN AND SECTION FOR 36 kV VCB CIRCUIT BREAKER	WAP/POWER/NEPAL/KOSHI/KC2/C6
14)	PLAN AND SECTION FOR 36 kV ISOLATOR	WAP/POWER/NEPAL/KOSHI/KC2/C7
15)	PLAN AND SECTION FOR 36 kV (3 POLE)	WAP/POWER/NEPAL/KOSHI/KC2/C8

	VCB CIRCUIT BREAKER	
16)	PLAN AND SECTION FOR 245kV AND 145kV (3 POLE)ISOLATOR	WAP/POWER/NEPAL/KOSHI/KC2/C9
17)	FOUNDATION PLAN FOR 245 kV SF-6 CIRCUIT BREAKER	WAP/POWER/NEPAL/KOSHI/KC2/C10
18)	FOUNDATION PLAN AND SECTION FOR 145 kV& 36 kV GANTRY FOUNDATION	WAP/POWER/NEPAL/KOSHI/KC2/C11
19)	FOUNDATION PLAN AND SECTION FOR 245kV GANTRY COLUMN AND LIGHTNING MAST	WAP/POWER/NEPAL/KOSHI/KC2/C12
20)	FOUNDATION PLAN AND SECTION FOR 145 kV (SINGLE POLE)ISOLATOR	WAP/POWER/NEPAL/KOSHI/KC2/C13
21)	TYPICAL LAYOUT OF R.C.C. RETAINING WALL	WAP/POWER/NEPAL/KOSHI/KC2/C14
22)	TYPICAL LAYOUT FENCE FOR SWITCHYARD	WAP/POWER/NEPAL/KOSHI/KC2/C15
23)	A TYPICAL SECTIONAL ELEVATION FOR 100MVA TRANSFORMER FOUNDATION	WAP/POWER/NEPAL/KOSHI/KC2/C16
24)	TYPICAL FOUNDATION PLAN FOR TRANSFORMER	WAP/POWER/NEPAL/KOSHI/KC2/C17
25)	TYPICAL PLAN AND ELEVATION FOR OIL COLLECTION PIT	WAP/POWER/NEPAL/KOSHI/KC2/C18
26)	TYPICAL DETAILS OF DG SET ROOM	WAP/POWER/NEPAL/KOSHI/KC2/C19
27)	CONTROL ROOM BUILDING LAYOUT FOR TUMLIGTAR SUB-STATION	WAP/POWER/NEPAL/KOSHI/KC2/CRB-01
28)	CONTROL ROOM BUILDING LAYOUT FOR BANESHWAR SUB-STATION	WAP/POWER/NEPAL/KOSHI/KC2/CRB-02
29)	CONTROL ROOM BUILDING LAYOUT FOR BASANTPUR SUB-STATION	WAP/POWER/NEPAL/KOSHI/KC2/CRB-03

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-2

General Technical Requirement

SECTION 2**GENERAL TECHNICAL REQUIREMENT****CONTENTS**

S.NO	DESCRIPTION	PAGE NO.
1.0	Foreword	1
1.1	General Requirements	1
1.2	Standards	1
1.3	Service to be performed by the Equipments being furnished	2
1.4	Engineering data and drawing	5
1.5	Drawings	5
1.6	Approval Procedure	6
1.7	Material/Workmanship	8
1.8	Provisions for Exposure to Hot and Humid climate	10
1.9	Space Heaters	10
1.10	Fungi Static Varnish	10
1.11	Ventilation Opening	11
1.12	Degree of Protection	11
1.13	Rating Plates, Name Plates and Labels	11
1.14	First Fill of Consumables, Oil and Lubricants	12
1.15	Design Improvements/Coordination	12
1.16	Quality Assurance Program	13
1.17	Quality Assurance Documents	14
1.18	Type Testing, Routine Testing Inspection (Including Acceptance Test), Testing & Inspection Certificate	14
1.19	Tests	17
1.20	Packaging & Protection	18
1.21	Finishing of Metal Surfaces	18
1.22	Hot Dip Galvanizing	19

1.23	Painting	20
1.24	Handling, Storing and Installation	21
1.25	Tools and Tackles	23
1.26	Auxiliary Supply	23
1.27	Equipment Supporting Structure	24
1.28	Clamps and Connectors including Terminal Connectors	24
1.29	Control Cabinets , Junction boxes, Terminal boxes & Marshalling boxes for outdoor equipment	26
1.30	Terminal Blocks and Wiring	28
1.31	Lamps & Sockets	30
1.32	Switches and Fuses	30
1.33	Bushings, Hollow Column Insulators, Support Insulators	31
1.34	Motors	32
1.35	Enclosures	32
1.36	Operational Features	32
1.37	Starting Requirements	33
1.38	Running Requirements	33
1.39	Testing and Commissioning	34
1.40	Technical Requirement of Equipments	34
	Annexure-A	36
	Annexure-B	50

SECTION 2

GENERAL TECHNICAL REQUIREMENT

1.0. FOREWORD

The provisions under this chapter are intended to supplement Employer's requirements for the materials, equipments and services covered under all the chapters of tender documents and are not exclusive.

1.1. GENERAL REQUIREMENT

- a) The contractor shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification during detailed engineering.
- b) Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, testing and commissioning and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification and bid price schedule but which are necessary for successful erection, testing and commissioning and satisfactory operation of the substation unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

1.2. STANDARDS

- a) The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of Nepal, relevant IEC standards, Indian Standard Codes any other equivalent neutrally acceptable International Standards.

- b) The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the date of bid opening) of standard specified under Annexure-A of this chapter, unless specifically mentioned in the specification.
- c) The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.
- d) The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IEC or equivalent international standard.
- e) When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.
- f) Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure-A / individual chapters for specification shall also, be accepted by the bidders, however the salient points of difference shall be clearly brought out in the Additional Information Schedule of the bid along with English language version of such standards. The equipment conforming to standards other than specified under Annexure-A/ individual chapters of specification shall be subject to Employer's approval.

1.3. SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

The equipment furnished under this specification shall perform all its intended functions and operate satisfactorily without showing undue strain, restrike etc under such over voltage conditions.

All equipments shall also perform satisfactorily under various electrical, electro-mechanical and meteorological conditions of the site of installation.

- a) All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc for the equipment.

- b) The bidder shall design terminal connectors of the equipment taking into account various forces that are required to be withstand.
- c) The equipment shall also comply with the following:
 - i) To facilitate erection of equipment, all items to be assembled at site shall be “match marked”.
 - ii) All piping, if any between equipment control cabinet/operating mechanism to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.
- d) Equipments and system shall be designed to meet the following climatic conditions and major technical requirements.

1.3.1. Climatic Condition

1) Ambient air temperature: 34°C(Max) and -5°C(Min)

2) Elevation above mean sea level

- a) Baneshwar: 1440 meter
- b) Basantapur: 2470 meter
- c) Tumlingtar: 440 meter
- d) Inaruwa: 80 meter

1.3.2. System Parameters

S.No.	Parameter	Unit	220 kV	132 kV	33 kV
1.	Nominal Rated Voltage	kVrms	220	132	33
2.	Highest system voltage	kVrms	245	145	36
3.	Phase		3	3	3
4.	Rated frequency	Hz	50	50	50
5.	Nominal Creepage Distance	mm/ kV	25	25	25
6.	Rated fault current	kA	40 for 1 sec	31.5 for 1	25 for 3

				sec	sec
7.	Minimum corona extinction voltage	kVrms	156	105	-
8.	Maximum radio interference voltage for frequency between 0.5 to 2 MHz	μ V	1000 at 156 kVrms	500 at 92 kVrms	-
9.	System Neutral earthing		Effectively earthed		
10.	Auxiliary ac supply 3ph,4 wire 50Hz	V	400 \pm 10%	400 \pm 10%	400 \pm 10%
11.	a).Auxiliary DC supply 2 wire ungrounded	V	110 \pm 10% 220 \pm 10%	110 \pm 10%	110 \pm 10%
12.	Minimum clearances				
i.	Phase to phase	mm	2100	1300	320
ii.	Phase to ground	mm	2100	1300	320
iii.	Sectional Clearance	mm	5000	3800	3000
iv.	Ground clearance for live conductor	mm	5500	4800	3700
v.	Height of insulator bottom from ground	mm	2500	2500	2500

Note:

1. The above parameters and minimum safety clearance are for altitude not exceeding 1000 MSL correction factor of 1.25% per 100m is to be applied for increasing the safety clearances for altitude more than 1000 m.
2. 220 V auxiliary DC supply is applicable for Inaruwa substation.

1.3.3. Technical Parameters of Bushings, hollow insulators and support insulators:

S.No	Parameter	Unit	220 kV	132 kV	33 kV
1.	Full wave Impulse Withstand Voltage (1.2/50 micro. Sec)	kVp	1050+210	650+130	170+34
2.	Power frequency withstand voltage	kV rms	552	330	84

Note:

The nominal creepage distance shall be increased by 20% to take care of the higher altitude of greater than 1000 MSL. Nominal creepage distance shall be applicable for Inaruwa substation.

1.4. ENGINEERING DATA AND DRAWINGS

- a) The list of drawings/documents which are to be submitted to the Employer shall be discussed and finalized by the Employer at the time of award.

The Contractor shall necessarily submit all the drawings/ documents unless anything is waived.

- b) The Contractor shall submit 4 (four) sets of drawings/ design documents / data sheets / detailed bill of quantity and 2 (two) set of test reports for the approval of the Employer. The contractor shall also submit the softcopy of the above documents in addition to hardcopy.

1.5. DRAWINGS

- a) All drawings submitted by the Contractor shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications or desired by the Employer.

- b) Drawings submitted by the Contractor shall be clearly marked with the name of the Employer, the unit designation, the specifications title, the specification number and the name of the Project. Distribution copies of standard drawings/documents shall be submitted as per provision of the contract. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions shall be in SI units.
- c) The review of these data by the Employer shall cover only general conformance of the data to the specifications and documents interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the Employer may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review and/or approval by the Employer shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications.
- d) All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the Contractor's risk. The Contractor may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of the Contract and such changes shall again be subject to approval by the Employer. Approval of Contractor's drawing or work by the Employer shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.
- e) All engineering data submitted by the Contractor after final process including review and approval by the Employer shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity with contract, unless otherwise expressly requested by the Employer in writing.

1.6. APPROVAL PROCEDURE

The scheduled dates for the submission of the designs & drawings as well as for, any data/information to be furnished by the contractor would be discussed and finalized at the time of award. The following schedule shall be generally followed for approval and for providing final documentation.

Approval/comments	As per agreed schedule
Resubmission (Whenever required)	Within 2 (Two) weeks from date of comments
Approval or comments	Within 2 (two) weeks of receipt of resubmission
Furnishing of distribution Copies (5 hard copies per Substation and one soft Copy in pdf and in editable format)	2 weeks from the date of approval
Furnishing of distribution Copies of test reports (a) Type test reports (Softcopy in pdf format per substation plus one for corporate centre & two hardcopy per substation) (b) Routine Test Reports(two copy for each substation)	2 weeks from the date of final approval. -do-
Furnishing of instruction/operation manuals(2 copies per substation and one softcopy in pdf and in editable format)	As per agreed schedule
As built drawings (three sets of hardcopy per substation plus one set for corporate centre and & softcopy in pdf as well as in editable format)	On completion of entire works

NOTE :

- (1) The contractor may please note that all resubmissions must incorporate all comments given in the earlier submission by the Employer or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.
- (2) All drawings should be submitted in softcopy form, however substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also.
- (3) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, testing, commissioning, operation, trouble shooting, servicing and overhauling procedures.
- (4) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Employer.
- (5) The Contractor shall furnish to the Employer catalogues of spare parts.
- (6) All As-built drawings/documents shall be certified by site in charge/PMC indicating the changes before final submission.

1.7. MATERIAL/WORKMANSHIP**General Requirement**

- a) Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.
- b) Incase where the equipment, materials or components are indicated in the specification as "similar" to any special standard, the Employer shall decide upon the question of similarity. When required by the specification or when required by the Employer, the Contractor shall submit, for approval, all the information concerning the materials or components to be used in

manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection and the cost as well as the time delay associated with the rejection shall be borne by the Contractor.

- c) The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their intended functions. In general, screw threads shall be standard metric threads. The use of other thread forms shall only be permitted when prior approval has been obtained from the Employer.
- d) Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials specifications and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.
- e) All materials and equipment shall be installed in strict accordance with the manufacturer's recommendation(s) and this specification workmanship. Only first-class work in accordance with the best modern practices shall be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, it shall include unpacking, cleaning and lifting into position, grouting, levelling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer's tolerances, Employer's instructions and the Specification. All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer's limits suitable guards shall be provided for the

protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

- f) The Contractor shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The Contractor shall apply all operational lubricants to the equipment installed by him.

1.8. PROVISIONS FOR EXPOSURE TO HOT AND HUMID CLIMATE

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

1.9. SPACE HEATERS

- a) Suitable anti condensation heaters with the provision of thermostat shall be provided.
- b) The heaters shall be suitable for continuous operation at 230V as supply voltage. On-off switch and fuse shall be provided.
- c) One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.

1.10. FUNGI STATIC VARNISH

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where

the treatment shall interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

1.11. VENTILATION OPENING

Wherever ventilation is provided, the compartments shall have ventilation openings with fine wire mesh of brass to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds and suitable provision shall be made so as to avoid any communication of air / dust with any part in the enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc.

1.12. DEGREE OF PROTECTION

The enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc. to be installed shall provide degree of protection as detailed here under:

- a) Installed outdoor: IP- 55
- b) Installed indoor in air conditioned area: IP-31
- c) Installed in covered area: IP-52
- d) Installed indoor in non air conditioned area where possibility of entry of water is limited: IP-41.
- e) For LT Switchgear (AC & DC distribution Boards): IP-52

The degree of protection shall be in accordance with IEC-60947 (Part-I) / IEC-60529. Type test report for degree of protection test, shall be submitted for approval.

1.13. RATING PLATES, NAME PLATES AND LABELS

- a) Each main and auxiliary item of substation shall have permanently attached to it, a rating plate of non-corrosive material in a conspicuous position upon which shall be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Employer. The rating plate of each equipment shall be according to IEC requirement.

- b) All such nameplates, instruction plates, rating plates of transformers, reactors, CB, CT, CVT, SA, Isolators, C & R panels and PLCC equipments shall be provided with English inscriptions.

1.14. FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

All the first fill of consumables such as oils, lubricants, filling compounds, touch up paints, soldering/brazing material for all copper piping of circuit breakers and essential chemicals etc. Which shall be required to put the equipment covered under the scope of their specifications, into successful Operation, shall be furnished by the Contractor unless specifically excluded under the exclusions in these specifications and documents.

1.15. DESIGN IMPROVEMENTS/COORDINATION

- a) The bidder shall note that the equipment offered by him in the bid only shall be accepted for supply. However, the Employer or the Contractor may propose changes in the specification of the equipment or quality thereof and if the Employer & contractor agree upon any such changes, the specification shall be modified accordingly during execution without any financial implication.
- b) The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best co-ordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.
- d) The Contractor shall coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Employer. The names of agencies shall be intimated to the successful bidders.
- e) The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractors and the Consultants of the Employer (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Employer's Corporate Centre/Site office, Nepal or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

1.16. QUALITY ASSURANCE PROGRAMME

To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Contractor's Works or at his Sub-contractor's premises or at the Employer's site or at any other place of Work are in accordance with the technical specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be broadly outlined by the contractor and finalised after discussions before the award of contract. The detailed programme shall be submitted by the contractor after the award for reference. A quality assurance programme of the contractor shall generally cover but not limited to the following:

- (a) His organisation structure for the management and implementation of the proposed quality assurance programme;
- (b) Documentation control system;
- (c) Qualification data of contractor's key personnel;
- (d) The procedure for purchases of materials, parts components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
- (e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;
- (f) Control of non-conforming items and system for corrective actions;
- (g) Inspection and test procedure both for manufacture and field activities.
- (h) Control of calibration and testing of measuring instruments and field activities;
- (i) System for indication and appraisal of inspection status;
- (j) System for quality audits;
- (k) System for authorising release of manufactured product to the Purchaser.
- (l) System for maintenance of records;

(m) System for handling storage and delivery; and

(n) A quality plan detailing out the specific quality control measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered.

The Employer or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/his vendor's quality management and control activities.

1.17. 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 equipment/material

1.18. TEST AND INSPECTION

- 1.18.1. All equipment being supplied shall conform to type tests including additional type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective Chapters. Employer reserves the right to witness any or all the tests. The Contractor shall intimate the Employer the detailed program about the tests at least three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.
- 1.18.2. The reports for all type tests and additional type tests as per technical specification shall be furnished by the successful bidder (Contractor) along with equipment / material drawings for all the major materials like Transformer , Circuit Breaker , Isolator with earth and without earth switch, Surge Arrestor, SAS(Control & Protection Panel), Optical fibre Communication , Terminal Equipment , DC Battery & Battery Charger , ACDB / DCDB , Insulators , Insulator's Hardwares, Power and Control cables etc. supplied against this specification.
- 1.18.3. The test reports submitted shall be of the tests conducted within last 10 (Ten) years prior to the originally Scheduled date of bid Opening. In case the test reports are of the test conducted earlier than 10 (Ten) years prior to the Bid Opening, the Contractor shall repeat these tests at no extra cost to the Employer.

In case of instrument transformers, the following type tests should have been conducted within 10 (Ten) years prior to the originally Scheduled date of bid opening.

- i) Lightning Impulse Test
- ii) Switching Impulse Test
- iii) Multiple Chopped Impulse Test (For CT)
- iv) Chopped Impulse Test (For CVT)

Further, In the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design / manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all additional type tests not carried out, same shall be carried out without any additional cost implication to the Employer.

The Contractor shall intimate the Employer the detailed program about the tests atleast two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

Further, in case type tests are required to be conducted/repeated and the deputation of Inspector/Employer's representative is required, then all the expenses shall be borne by the contractor.

- 1.18.4. The Employer, his duly authorised representative and/or outside inspection agency acting on behalf of the Purchaser shall have at all reasonable times free access to the Contractor's/sub-vendors premises or Works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the Works during its manufacture or erection if part of the Works is being manufactured or assembled at other premises or works, the Contractor shall obtain for the Engineer and for his duly authorised representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. Inspection may be made at any stage of manufacture, despatch or at site at the option of the Purchaser and the equipment if found unsatisfactory due to bad workmanship or quality, material is liable to be rejected.

- 1.18.5. The Contractor shall give the Employer /Inspector fifteen (15) days written notice for on-shore and six (6) weeks' notice for off-shore material being ready for joint testing including contractor and Employer. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Employer /inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector duly certified copies of tests in triplicate.
- 1.18.6. The Employer shall, within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Contractor, of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Purchaser /Inspector giving reasons therein, that no modifications are necessary to comply with the Contract.
- 1.18.7. When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Purchaser/inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Purchaser /Inspector, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Engineer/Inspector. Failure of the Purchaser /Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract. The equipment shall be dispatched to site only after approval of test reports and issuance of CIP by the Employer.
- 1.18.8. In all cases where the Contract provides for tests whether at the premises or at the works of the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such items as labour, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer /Inspector or his authorised representative to carry out effectively such tests of the equipment in accordance with the

Contract and shall give facilities to the Employer /Inspector or to his authorised representative to accomplish testing.

- 1.18.9. The inspection by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed quality assurance programme forming a part of the Contract.
- 1.18.10. The Employer will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.
- 1.18.11. The Employer reserves the right for getting any field tests not specified in respective chapters of the technical specification conducted on the completely assembled equipment at site. The testing equipments for these tests shall be provided by the Purchaser.
- 1.18.12. Please also Refer General Conditions Clause 23 of Part III of Bidding Document and Technical Specifications of Part II

1.19. TESTS

a) Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Employer and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The lists of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor's quality assurance programme.

b) Commissioning Tests

The available instrumentation and control equipment to be used during such tests, the Employer shall calibrate all such measuring equipment and devices as far as practicable.

- i) Any special equipment, tools and tackles required for the successful completion of the Commissioning Tests shall be provided by the Contractor, free of cost.
- ii) The specific tests required on equipment have been brought out in the respective chapters of the technical specification.

- iii) The Contractor shall be responsible for obtaining statutory clearances from the concerned authorities for commissioning the equipment and the switchyard. However, necessary fee if charged by concerned authorities shall be reimbursed on production of requisite documents.

1.20. PACKAGING & PROTECTION

- a) All the equipments shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. On request of the Employer, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Employer to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes or Road trailer size & capacity including transportation limitations both in tones of weight and size shall be taken into account. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor. Employer takes no responsibility of the availability of the Railway wagons.
- b) All coated surfaces shall be protected against abrasion, impact, discolouration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

1.21. FINISHING OF METAL SURFACES

All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed between Employer & contractor, shall be hot-dip galvanized after fabrication. High tensile steel nuts & bolts and spring washers shall be electro galvanized to service condition 4. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to Equivalent International Standards.

1.22. HOT DIP GALVANIZING

- a) The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be 610 gm/sq. m minimum.
- b) The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.
- c) After galvanizing, no drilling or welding shall be performed on the galvanized parts of the equipment except that nuts may be threaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.
- d) The galvanized steel shall be subjected to one minute dip test in copper sulphate solution as per IEC.
- e) Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests shall be performed as per relevant International Standards.
- Coating thickness
 - Uniformity of zinc coating
 - Adhesion test
 - Mass of zinc coating
- f) Galvanized material must be transported properly to ensure that galvanized surfaces are not damaged during transit. Application of zinc rich paint at site shall not be allowed.

1.23. PAINTING

- A) All steel sheet work shall be degreased, pickled, phosphated in accordance with the relevant international standard. All surfaces, which shall not be easily accessible for repainting after shop assembly, shall beforehand be treated and protected against corrosion for the life of the equipment. The metal surfaces, which are to be finished painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of red oxide primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
- b) After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.
- c) After application of the primer, the surface shall be finished by applying two coats of synthetic enamel paint, each coat followed by stoving. The second coat of paint shall be applied after inspection of first coat of painting.
- d) The exterior and interior colour of the paint in case of new substations shall preferably be RAL 7032 for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective chapters of the equipments. Glossy white colour inside the equipments/boards/panels/junction boxes is also acceptable. The exterior colour for panels shall match with the colour of existing panels in case of extension of a substation. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.
- e) In case, the Bidder proposes to follow his own standard surface finish and protection procedures or any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted along with the Bids for Employer's review & approval.

- f) For aluminium casted surfaces, the surface shall have smooth finish. Further, in case of aluminium enclosures the surface shall be powder coated with coating thickness of not less than 60 microns after surface preparation as per relevant Indian/International codes.

1.24. HANDLING, STORING AND INSTALLATION

- a) In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Employer or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of substation equipment means successful completion of all site tests specified and energisation at rated voltage.
- b) Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by him separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s).
- c) The contractor shall ensure that the indoor and outdoor storage areas are in place prior to commencement of delivery of material at site. Contractor shall also ensure availability of proper unloading and material handling equipment like cranes etc. and polyester/nylon ropes of suitable capacity to avoid damage during unloading and handling of material at site. All indoor equipments shall be stored indoors. Outdoor equipment may be stored outdoors but on a hard, flat and raised area and properly covered with waterproof and dustproof covers to protect them against water seepage and moisture ingress. However, all associated control panels, marshalling boxes, operating boxes etc. of outdoor equipments are to be stored indoors only.

Storage of equipment on top of another one shall not be permitted if the wooden packing is used. Material opened for joint inspection shall be repacked properly as per manufacturer's recommendations.

During storage of material, regular periodic monitoring of important parameters like oil level / leakage, SF6 / Nitrogen pressure etc. shall be ensured by the contractor.

- d) In case of any doubt as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained by the contractor from the Employer. Contractor shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings/instructions correctly.
- e) Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also carryout necessary adjustments/alignments for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness of contractor or otherwise shall be replaced by him at his own expense.
- f) Contractor shall be responsible for examining all the shipment and notify the Employer immediately of any damage, shortage, discrepancy etc. for the purpose of Employer's information only. The Contractor shall submit to the Employer every week a report detailing out all the receipts during the week. However, the Contractor shall be solely responsible for any shortages or damages in transit, handling and/or in storage and erection of the equipment at Site. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.
- g) The Contractor shall be fully responsible for the equipment/material until the same is handed over to the Employer in an operating condition after commissioning. Contractor shall be responsible for the maintenance of the equipment/material while in storage as well as after erection until taken over by Employer, as well as protection of the same against theft, elements of nature, corrosion, damages etc.
- h) Where material / equipment is unloaded by Employer before the Contractor arrives at site or even when he is at site, Employer by right can hand over the same to Contractor and there upon it shall be the responsibility of Contractor to store the material in an orderly and proper manner.

- i) The Contractor shall be responsible for constructing suitable indoor storage facilities at his own cost, to store all equipment which requires indoor storage.
- j) The words 'erection' and 'installation' used in the specification are synonymous.
- k) Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.
- l) The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 1.3.2 the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.
- m) Equipment Bases

A welded steel base plate shall be provided for all rotating equipment which are to be installed on a concrete base unless otherwise agreed to by the Employer. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

1.25. TOOLS AND TACKLES

The Contractor shall supply with the equipment one complete set of all special tools and tackles for the erection, assembly, dis-assembly and maintenance of the equipment. However, these tools and tackles shall be separately, packed and brought to Site.

1.26. AUXILIARY SUPPLY

The sub-station auxiliary supply is normally met through a system having the parameters given in table below. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform the parameters as indicated in the following.

Normal Voltage	Variation in Voltage	Phase/Wire	Neutral connection
400V AC	$\pm 10 \%$	3/4 Wire	Solidly Earthed.
230V AC	$\pm 10 \%$	1/2 Wire	Solidly Earthed.
110V DC	$\pm 10 \%$	–	Isolated 2 wire System
220V DC	$\pm 10 \%$	–	
48V DC	–	–	2 wire system (+) earthed

220 V DC is applicable for Inaruwa substation.

1.27. EQUIPMENT SUPPORTING STRUCTURES

- All equipment supporting structures shall be supplied along with brackets, angles, stools etc. for attaching the operating mechanism, control cabinets & marshalling box (wherever applicable) etc.
- Equipment supporting structure shall meet the following mandatory requirements:
- The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.5 meters.

1.28. CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

- All power clamps and connectors shall conform to ANSI/NEMA CC1/ Equivalent International standard and shall be made of materials listed below:
 - For connecting ACSR conductors, Aluminum alloy casting conforming to BS:1490/ Equivalent International Standard
 - For connecting equipment terminal made of copper with ACSR conductors, Bimetallic connectors made from aluminum alloy casting conforming to BS: 1490/ Equivalent International Standard with 2mm thick bimetallic liner.
 - For connecting GI Galvanized mild shield wire

- Bolts nuts and plain washers Electro galvanised for sizes Plain, washers below M12, shall be hot dip galvanized.
 - Spring washers Electro galvanised mild steel
- b) Necessary clamps and connectors shall be supplied for all equipment and connections. The requirement regarding external corona and RIV as specified for any equipment shall include its terminal fittings. If corona rings are required to meet these requirements, they shall be considered as part of that equipment and included in the scope of work and no separate payment shall be made for this.
- c) Where copper to aluminum connections are required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress.
- d) Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified in each particular case, also included in the scope of Work.
- e) No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanized. Copper alloy liner of minimum 2 mm thickness shall be cast integral with aluminum body or 2 mm thick bi-metallic strips shall be provided for Bi-metallic clamps.
- f) All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.
- g) Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of 4" IPS aluminium. tube as required. In both the cases, the clamp height (top of the mounting pad to centre line of the tube) should be same.
- h) Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

- i) All current carrying parts shall be designed and manufactured to have minimum contact resistance.
- j) Clamps and connectors shall be designed to be corona controlled.

TESTS

Clamps and connectors should be type tested as per NEMA CC1/ Equivalent International Standard and shall also be subjected to routine tests as per NEMA CC1/ Equivalent International Standard. Following type test reports shall be submitted for approval as per clause 9.2 above except for sl. no.(ii) & (iii) for which type test once conducted shall be applicable (i.e. the requirement of test conducted within last ten years shall not be applicable).

- a) Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient)
- b) Short time current test
- c) Corona (dry) and RIV (dry) test (for 220 KV and above voltage level clamps)
- d) Resistance test and tensile test

1.29. CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES & MARSHALLING BOXES FOR OUTDOOR EQUIPMENT

- a) All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IEC-60439, as applicable, and the clauses given below:
- b) Control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of steel sheet or aluminum and shall be dust, water and vermin proof. Steel sheet used shall be atleast 2.0 mm thick cold rolled or 2.5 mm thick hot rolled or alternately 1.6 mm thick stainless steel can also be used. The cabinets & box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum box, the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with steel sheet of specified thickness.

- c) A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.
- d) Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be such so as to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/cracked during the operation of the equipment.
- e) All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM/Neoprene gaskets. The gasket shall be tested in accordance with approved quality plan, BS: 4255/ Equivalent International Standard. Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.
- f) All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS: 6121.
- g) A 230V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.
- h) For illumination, a fluorescent tube or CFL of approximately 9 to 15 watts shall be provided. The switching of the fittings shall be controlled by the door switch. .

For junction boxes of smaller sizes such as lighting junction box, manual operated earth switch mechanism box etc., plug socket, heater and illumination is not required to be provided.

- i) All control switches shall be of MCB/rotary switch type. Toggle/piano switches shall not be accepted.
- j) Positive earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.
- k) The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.
 - i) The following routine tests along with the routine tests as per IEC 60529/ Equivalent International Standard shall also be conducted:
 - a) Check for wiring
 - b) Visual and dimension check
 - ii) The enclosure of bay marshalling kiosk, junction box, terminal box shall conform to IP-55 as per IEC 60529/ Equivalent International Standard including application of, 2.0 KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

1.30. TERMINAL BLOCKS AND WIRING

- a) Control and instrument leads from the switchboards or from other equipment shall be brought to terminal boxes or control cabinets in conduits. All inter phase and external connections to equipment or to control cubicles shall be made through terminal blocks.
- b) Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non breakable type. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. But preferably the terminal blocks shall be non-disconnecting stud type of Elmex or Phoenix or Wago or equivalent make.
- c) Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.

- d) The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.
- e) The conducting part in contact with cable shall preferably be tinned or silver plated. However, Nickel plated copper or zinc plated steel shall also be acceptable.
- f) The terminal blocks shall be of extensible design.
- g) The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.
- h) The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.
- i) Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors on each side.
 - a) All circuits except CT/PT circuits Minimum of two of 2.5 sq mm copper flexible.
 - b) All CT/PT circuits Minimum of 4 nos. of 2.5 sq mm copper flexible.
- j) The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.
- k) Atleast 20 % spare terminals shall be provided on each panel/cubicle/box and these spare terminals shall be uniformly distributed on all terminals rows.
- l) There shall be a minimum clearance of 250 mm between the First/bottom row of terminal block and the associated cable gland plate for outdoor ground mounted marshalling box and the clearance between two rows of terminal blocks shall be a minimum of 150 mm.

- m) The Contractor shall furnish all wire, conduits and terminals for the necessary inter phase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets.
- n) All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment.

1.31. LAMPS & SOCKETS

a) Sockets

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round plug as per Nepalese Standard. They shall be switched sockets with shutters.

b) Hand Lamp:

A 230 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

1.32. SWITCHES AND FUSES:

Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker / switch fuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses. All fuses shall be of HRC cartridge type conforming to relevant International Standard mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts shall also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

1.33. BUSHINGS, HOLLOW COLUMN INSULATORS, SUPPORT INSULATORS:

- a) Bushings shall be manufactured and tested in accordance with IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-62155. The support insulators shall be manufactured and tested as per IEC-60168 and IEC-60273. The insulators shall also conform to IEC-60815 as applicable. The bidder may also offer composite hollow insulators, conforming to IEC-61462.
- b) Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.
- c) Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects. Support insulators/ bushings/ hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they shall be used.
- d) When operating at normal rated voltage, there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.
- e) Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.
- f) All iron parts shall be hot dip galvanized and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

g) Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with relevant international standard.

1.34. MOTORS

Motors shall be "Squirrel Cage" three phase induction motors of sufficient size capable of satisfactory operation for the application and duty as required for the driven equipment and shall be subjected to routine tests as per applicable standards. The motors shall be of approved make.

1.35. ENCLOSURES

a) Motors to be installed outdoor without enclosure shall have hose proof enclosure equivalent to IP-55 as per IEC 60529/ Equivalent International Standard. For motors to be installed indoor i.e. inside a box, the motor enclosure shall be dust proof equivalent to IP-44 as per relevant International Standard.

b) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of earthing conductor.

c) Motors shall have drain plugs so located that they shall drain water resulting from condensation or other causes from all pockets in the motor casing.

d) Motors weighing more than 25 Kg. shall be provided with eyebolts, lugs or other means to facilitate lifting.

1.36. OPERATIONAL FEATURES

a) Continuous motor rating (name plate rating) shall be at least ten (10) percent above the maximum load demand of the driven equipment at design duty point and the motor shall not be over loaded at any operating point of driven equipment that shall rise in service.

b) Motor shall be capable at giving rated output without reduction in the expected life span when operated continuously in the system having the particulars as given in Clause 15.0 of this Chapter.

1.37. STARTING REQUIREMENTS:

- a) All induction motors shall be suitable for full voltage direct-on-line starting. These shall be capable of starting and accelerating to the rated speed along with the driven equipment without exceeding the acceptable winding temperature even when the supply voltage drops down to 80% of the rated voltage.
- b) Motors shall be capable of withstanding the electrodynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.
- c) The locked rotor current shall not exceed six (6) times the rated full load current for all motors, subject to tolerance as given in relevant International Standard.
- d) Motors when started with the driven equipment imposing full starting torque under the supply voltage conditions specified under Clause 15.0 shall be capable of withstanding atleast two successive starts from cold condition at room temperature and one start from hot condition without injurious heating of winding. The motors shall also be suitable for three equally spread starts per hour under the above referred supply condition.
- e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case, it is not possible to meet the above requirement, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than 19% and open for speeds above 19% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

1.38. RUNNING REQUIREMENTS:

- a) The maximum permissible temperature rise over the ambient temperature of 50 degree C shall be within the limits specified in relevant International Standard (for 3 - phase induction motors) after adjustment due to increased ambient temperature specified.

- b) The double amplitude of motor vibration shall be within the limits specified in relevant International Standard. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.
- c) All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

1.39. TESTING AND COMMISSIONING

An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

- (a) Insulation resistance.
- (b) Phase sequence and proper direction of rotation.
- (c) Any motor operating incorrectly shall be checked to determine the cause and the conditions corrected.

1.40. TECHNICAL REQUIREMENT OF EQUIPMENTS

1.40.1. 1.1 KV Grade Power & Control Cables

1.40.1.1. Applicable for PVC Control Cable

The manufacturers, whose PVC control cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 100 Kms of 1.1 KV grade PVC insulated control cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 27C x 2.5 Sq.mm or higher size as on the originally Scheduled date of bid opening.

1.40.1.2. Applicable for PVC Power Cable

The manufacturer, whose PVC Power Cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 100 Kms of 1.1 KV or higher grade PVC insulated power cables as on the date of bid opening. Further, the manufacturer should also

have designed, manufactured, tested and supplied at least 1 km of 1C x 150 Sq. mm or higher size as on the originally Scheduled date of bid opening.

1.40.1.3. Applicable for XLPE Power Cables

The Manufacturer, whose XLPE Power cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 25 Kms of 1.1 KV or higher grade XLPE insulated power cables as on the date of bid opening. Further, the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 630 Sq. mm or higher size as on the originally Scheduled date of bid opening.

1.40.2. LT Switchgear

- a) The Manufacturer whose LT Switchgear are offered, should be a manufacturer of LT Switchboards of the type and rating being offered. He should have designed, manufactured, tested and supplied at least 50 nos. draw out circuit breaker panels, out of which at least 5 nos. should have been with relay and protection schemes with current transformer. He should have also manufactured at least 50 nos MCC panels comprising of MCCBs (i.e. Moulded Case Circuit Breakers) modules of the type offered which should be in successful operation as on originally Scheduled date of bid opening.
- b) The Switchgear items (such as circuit breakers, fuse switch units, contactors etc.), may be of his own make or shall be procured from reputed manufacturers and of proven design. At least one hundred circuit breakers of the make and type being offered shall be operating satisfactory as on originally Scheduled date of bid opening.

ANNEXURE - A**LIST OF SPECIFICATIONS**

GENERAL STANDARDS AND CODES : The following standards or equivalent Indian standards shall be considered for concerned equipment:

IEC-60060 (Part 1 to P4) - High Voltage Test Techniques**IEC 60068 - Environmental Test****IEC-60117 - Graphical Symbols****IEC-60156 - Method for the Determination of the Electrical Strength of Insulation Oils.****IEC-60270 - Partial Discharge Measurements.****IEC-60376 - Specification and Acceptance of New Sulphur Hexafluoride****IEC-60437 - Radio Interference Test on High Voltage Insulators.****IEC-60507 - Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.****IEC-62271-1 - Common Specification for High Voltage Switchgear & Controlgear Standards.****IEC-60815 - Guide for the Selection of Insulators in respect of Polluted Conditions.****IEC-60865 (P1 & P2) - Short Circuit Current - Calculation of effects.****ANSI-C.1/NFPA.70 - National Electrical Code****ANSI-C37.90A - Guide for Surge Withstand Capability (SWC) Tests****ANSI-C63.21, - Specification for Electromagnetic Noise and****C63.3 - Field Strength Instrumentation 10 KHz to 1 GHZ****C36.4ANSI-C68.1 - Techniquet for Dielectric Tests****ANSI-C76.1/EEE21 - Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.****ANSI-SI-4 - Specification for Sound Level Metres**

ANSI-Y32-2/C337.2 - Drawing Symbols

- ANSI-Z55.11 - Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray**
- NEMA-107T - Methods of Measurements of RIV of High Voltage Apparatus**
- NEMA-ICS-II - General Standards for Industrial Control and Systems Part ICSI-109**
- CISPR-1 - Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz**
- CSA-Z299.1-1978h - Quality Assurance Program Requirements**
- CSA-Z299.2-1979h - Quality Control Program Requirements**
- CSA-Z299.3-1979h - Quality Verification Program Requirements**
- CSA-Z299.4-1979h - Inspection Program Requirements**

TRANSFORMERS AND REACTORS

- IEC-60076 (Part 1 to 5) - Power Transformers**
- IEC-60214 - On-Load Tap-Changers.**
- IEC-60289 - Reactors.**
- IEC- 60354 - Loading Guide for Oil - Immersed power transformers**
- IEC-60076-10 - Determination of Transformer and Reactor Sound Levels**
- ANSI-C571280 - General requirements for Distribution, Power and Regulating Transformers**
- ANSI-C571290 - Test Code for Distribution, Power and Regulation Transformers**
- ANSI-C5716 - Terminology & Test Code for Current Limiting Reactors**
- ANSI-C5721 - Requirements, Terminology and Test Code for Shunt Reactors Rated Over 500 KVA**
- ANSI-C5792 - Guide for Loading Oil-Immersed Power Transformers upto and including 100 MVA with 55 deg C or 65 deg C Winding Rise**

ANSI-CG, 1EEE-4 - Standard Techniques for High Voltage Testing**CIRCUIT BREAKERS**

- IEC-62271-100 - High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers
- IEC-62271-101 - High-voltage switchgear and control gear - Part 101: Synthetic testing
- IEC-62155 - Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
- IEC-62271-110 - High-voltage switchgear and control gear - Part 110: Inductive load switching
- IEC-62271-109 - High-voltage switchgear and control gear - Part 110: Inductive load switching

CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS

- IEC-60044-1 - Current transformers.
- IEC-60044-2 - Inductive Voltage Transformers.
- IEC-60044-5 - Instrument transformers - Part 5: Capacitor voltage transformers
- IEC-60358 - Coupling capacitors and capacitor dividers.
- IEC-60044-4 - Instrument Transformes : Measurement of Partial Discharges
- IEC-60481 - Coupling Devices for power Line Carrier Systems.
- ANSI-C5713 - Requirements for Instrument transformers
- ANSIC92.2 - Power Line Coupling voltage Transformers
- ANSI-C93.1 - Requirements for Power Line Carrier Coupling Capacitors

BUSHING

IEC-60137 - Insulated Bushings for Alternating Voltages above 1000V

SURGE ARRESTERS

IEC-60099-4 - Metal oxide surge arrestors without gaps

IEC-60099-5 - Selection and application recommendation

ANSI-C62.1 - IEEE Standards for S A for AC Power Circuits

NEMA-LA 1 - Surge Arresters

CUBICLES AND PANELS & OTHER RELATED EQUIPMENTS

IEC-60068.2.2 - Basic environmental testing procedures Part 2: Test B: Dry heat

IEC-60529 - Degree of Protection provided by enclosures.

IEC-60947-4-1 - Low voltage switchgear and control gear.

IEC-61095 - Electromechanical Contactors for household and similar purposes.

IEC-60439 (P1 & 2) - Low Voltage Switchgear and control gear assemblies

ANSI-C37.19 - Switchgear Assemblies, including metal enclosed bus.

ANSI-C37.50 - Test Procedures for Low Voltage Alternating Current Power Circuit Breakers

ANSI-C39 - Electric Measuring instrument

ANSI-C83 - Components for Electric Equipment

NEMA-AB - Moulded Case Circuit and Systems

NEMA-CS - Industrial Controls and Systems

NEMA-PB-1 - Panel Boards

NEMA-SG-5 - Low voltage Power Circuit breakers

- NEMA-SG-3 - Power Switchgear Assemblies**
- NEMA-SG-6 - Power switching Equipment**
- NEMA-5E-3 - Motor Control Centers**
- 1248 (P1 to P9) - Direct acting indicating analogue electrical measuring instruments & their accessories.**

DISCONNECTING SWITCHES

- IEC-62271-102 - High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches**
- IEC-60265 (Part 1 & 2) - High Voltage switches**
- ANSI-C37.32 - Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories**
- ANSI-C37.34 - Test Code for high voltage air switches**
- NEMA-SG6 - Power switching equipment**

PLCC AND LINE TRAPS

- IEC-60353 - Line traps for A.C. power systems.**
- IEC-60481 - Coupling Devices for power line carrier systems.**
- IEC-60495 - Single sideboard power line carrier terminals**
- IEC-60683 - Planning of (single Side-Band) power line carrier systems.**
- CIGRE - Teleprotection report by Committee 34 & 35.**
- CIGRE - Guide on power line carrier 1979.**
- CCIR - International Radio Consultative Committee**
- CCITT - International Telegraph & Telephone Consultative Committee**

EIA - Electric Industries Association

PROTECTION AND CONTROL EQUIPMENT

IEC-60051: (P1 to P9) - Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories.

IEC-60255 (Part 1 to 23) - Electrical relays.

IEC-60297 (P1 to P4) - Dimensions of mechanical structures of the 482.6mm (19 inches) series.

IEC-60359 - Expression of the performance of electrical & electronic measuring equipment.

IEC-60387 - Symbols for Alternating-Current Electricity meters.

IEC-60447 - Man machine interface (MMI) - Actuating principles.

IEC-60521 - Class 0.5, 1 and 2 alternating current watt hour metres

IEC-60547 - Modular plug-in Unit and standard 19-inch rack mounting unit based on NIM Standard (for electronic nuclear instruments)

ANSI-81 - Screw threads

ANSI-B18 - Bolts and Nuts

ANSI-C37.1 - Relays, Station Controls etc.

ANSI-C37.2 - Manual and automatic station control, supervisory and associated telemetering equipment

ANSI-C37.2 - Relays and relay systems associated with electric power apparatus

ANSI-C39.1 - Requirements for electrical analog indicating instruments

MOTORS

IEC-60034 (P1 to P19)- Rotating electrical machines

IEC-Document 2 - Three phase induction motors

(Central Office) NEMA-MGI Motors and Generators

ELECTRONIC EQUIPMENT AND COMPONENTS

MIL-21B, MIL-833 & MIL-2750

IEC-60068 (P1 to P5) - Environmental testing

IEC-60326 (P1 to P2) - Printed boards

Material and workmanship standards

ASTM - Specification and tests for materials

CLAMPS & CONNECTORS

NEMA-CC1 - Electric Power connectors for sub station

NEMA-CC 3 - Connectors for Use between aluminium or aluminum-Copper Overhead Conductors

BUS HARDWARE AND INSULATORS

IEC-60120 - Dimensions of Ball and Socket Couplings of string insulator units.

IEC-60137 - Insulated bushings for alternating voltages above 1000 V.

IEC-60168 - Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V.

IEC-62155 - Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V

IEC-60273 - Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.

- IEC-61462 - Pressurized and un-pressurized insulator for use in electrical equipment with rated voltage greater than 1000V – Definitions, Test methods, acceptance criteria and design recommendations**
- IEC-60305 - Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for a.c. systems Characteristics of String Insulator Units of the cap and pin type.**
- IEC-60372 (1984) - Locking devices for ball and socket couplings of string insulator units : dimensions and tests.**
- IEC-60383 (P1 and P2) - Insulators for overhead lines with a nominal voltage above 1000 V.**
- IEC-60433 - Characteristics of string insulator units of the long rod type.**
- IEC-60471 - Dimensions of Clevis and tongue couplings of string insulator units.**
- ANSI-C29 - Wet process porcelain insulators**
- ANSI-C29.1 - Test methods for electrical power insulators**
- ANSI-C92.2 - For insulators, wet-process porcelain and toughened glass suspension type**
- ANSI-C29.8 - For wet-process porcelain insulators apparatus, post-type**
- ANSI-G.8 - Iron and steel hardware**
- CISPR-7B - Recommendations of the CISPR, tolerances of form and of Position, Part 1**
- ASTM A-153 - Zinc Coating (Hot-Dip) on iron and steel hardware**

STRAIN AND RIGID BUS-CONDUCTOR

- ASTM-B 230-82 - Aluminum 1350 H19 Wire for electrical purposes**
- ASTM-B 231-81 - Concentric - lay - stranded, aluminum 1350 conductors**
- ASTM-B 221 - Aluminum - Alloy extruded bar, rod, wire, shape**
- ASTM-B 236-83 - Aluminum bars for electrical purpose (Bus-bars)**

ASTM-B 317-83 - Aluminum-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors)

BATTERIES AND BATTERIES CHARGER

Battery

IEC:60896-21&22 - Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements

IEC: 60623 - Vented type nickel Cadmium Batteries

IEC:60622 - Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell

IEC:60623 - Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell

IEC:60896-11 - Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests

IEEE-485 - Recommended practices for sizing of Lead Acid Batteries

IEEE-1115 - Sizing of Ni-Cd Batteries

IEEE-1187 - Recommended practices for design & installation of VRLA Batteries

IEEE-1188 - Recommended practices for design & installation of VRLA Batteries

IEEE-1189 - Guide for selection of VRLA Batteries

Battery Charger

IEEE-484 - Recommended Design for installation design and installation of large lead storage batteries for generating stations and substations.

IEEE-485 - Sizing large lead storage batteries for generating stations and substations

WIRES AND CABLES

ASTMD-2863 - Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)

IEC-60096 (P0 to P4) - Radio Frequency cables.

IEC-60183 - Guide to the Selection of High Voltage Cables.

IEC-60189 (P1 to P7) - Low frequency cables and wires with PVC insulation and PVC sheath.

IEC-60227 (P1 to P7) - Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.

IEC-60228 - Conductors of insulated cables

IEC-60230 - Impulse tests on cables and their accessories.

IEC-60287 (P1 to P3) - Calculation of the continuous current rating of cables (100% load factor).

IEC-60304 - Standard colours for insulation for low-frequency cables and wires.

IEC-60331 - Fire resisting characteristics of Electric cables.

IEC-60332 (P1 to P3) - Tests on electric cables under fire conditions.

IEC-60502 - Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV

IEC-754 (P1 and P2) - Tests on gases evolved during combustion of electric cables.

PAINTING

ANSI-Z551 - Gray finishes for industrial apparatus and equipment

SSPEC - Steel structure painting council

HORIZONTAL CENTRIFUGAL PUMPS

API-610 - Centrifugal pumps for general services

- Hydraulic Institutes Standards

BS:599 - Methods of testing pumps

PTC-8.2 - Power Test Codes - Centrifugal pumps

DIESEL ENGINES

ASME Power Test Code - Internal combustion engine PTC-17

- Codes of Diesel Engine Manufacturer's Association, USA

PIPING VALVES & SPECIALITIES

BS:5150 - Specification for cast iron gate valves

PG Test Procedures

NFPA-13 - Standard for the installation of sprinkler system

NFPA-15 - Standard for water spray fixed system for the fire protection

NFPA-12A - Standard for Halong 1301 Fire Extinguishing System

NFPA-72E - Standard on Automatic Fire Detectors

NFPA-12 - Standard on Carbon dioxide extinguisher systems

ELECTRICAL GENERATING AND DISTRIBUTING STATIONS CODE OF PRACTICE

Steel structures

ANSI-B18.2.1 - Inch series square and Hexagonal bolts and screws

ANSI-B18.2.2 - Square and hexagonal nuts

ANSI-G8.14 - Round head bolts

ASTM-A6	-	Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use
ASTM-A36	-	Specifications of structural steel
ASTM-A47	-	Specification for malleable iron castings
ASTM-A143	-	Practice for safeguarding against embilement of Hot Galvanized structural steel products and procedure for detaching embrilement
ASTM-A242	-	Specification for high strength low alloy structural steel
ASTM-A283	-	Specification for low and intermediate tensile strength carbon steel plates of structural quality
ASTM-A394	-	Specification for Galvanized steel transmission tower bolts and nuts
ASTM-441	-	Specification for High strength low alloy structural manganese vanadium steel.
ASTM-A572	-	Specification for High strength low alloy colombium-Vanadium steel of structural quality
AWS D1-0	-	Code for welding in building construction welding inspection
AWS D1-1	-	Structural welding code
AISC	-	American institute of steel construction
NEMA-CG1	-	Manufactured graphite electrodes

Piping and pressure vessels

ASME - Boiler and pressure vessel code

ASTM-A120	-	Specification for pipe steel, black and hot dipped, zinc-coated (Galvanized) welded and seamless steel pipe for ordinary use
ASTM-A53	-	Specification for pipe, steel, black, and hot-dipped, zinc coated welded and seamless

- ASTM-A106 - Seamless carbon steel pipe for high temperature service**
- ASTM-A284 - Low and intermediate tensile strength carbon-silicon steel plates for machine parts and general construction.**
- ASTM-A234 - Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures**
- ASTM-S181 - Specification for forgings, carbon steel for general purpose piping**
- ASTM-A105 - Forgings, carbon steel for piping components**
- ASTM-A307 - Carbon steel externally treated standard fasteners**
- ASTM-A193 - Alloy steel and stainless steel bolting materials for high temperature service**
- ASTM-A345 - Flat rolled electrical steel for magnetic applications**
- ASTM-A197 - Cupola malleable iron**
- ANSI-B2.1 - Pipe threads (Except dry seal)**
- ANSI-B16.1 - Cast iron pipe flanges and glanged fitting. Class 25, 125, 250 and 800**
- ANSI-B16.1 - Malleable iron threaded fittings, class 150 and 300**
- ANSI-B16.5 - Pipe flanges and flanged fittings, steel nickel alloy and other special alloys**
- ANSI-B16.9 - Factory-made wrought steel butt welding fittings**
- ANSI-B16.11 - Forged steel fittings, socket-welding and threaded**
- ANSI-B16.14 - Ferrous pipe plug, bushings and locknuts with pipe threads**
- ANSI-B16.25 - Butt welding ends**
- ANSI-B18.1.1 - Fire hose couplings screw thread.**
- ANSI-B18.2.1 - Inch series square and hexagonal bolts and screws**
- ANSI-B18.2.2 - Square and hexagonal nuts**
- NSI-B18.21.1 - Lock washers**
- ANSI-B18.21.2 - Plain washers**

ANSI-B31.1 - Power piping

ANSI-B36.10 - Welded and seamless wrought steel pipe

ANSI-B36.9 - Stainless steel pipe

ACSR MOOSE CONDUCTOR

IEC:437-1973 Test on High Voltage Insulators NEMA:107-1964

CISPR

Part - V Overhead Transmission Purposes

BS:215(Part-II) Aluminium Conductors galvanized IEC:209-1966 steel reinforced extra high

BS:215(Part-II) voltage (400 kV and above)

GALVANISED STEEL EARTHWIRE

P5:1992 - Overhead Transmission Purposes.

ANNEXURE - B

SI No. LIST OF DRAWINGS/DOCUMENTS

- 1 Single Line Diagram
- 2 Electrical Layout – Plan and Sections
- 3 Tower, Equipment & cable trench layout drawing
- 4 Earthing system design calculation & layout drawing
- 5 Lighting protection system design & drawings
- 6 Structure Layout (Plan & Section) drawing
- 7 Cantilever Strength calculations (if applicable)
- 8 Design calculation for Sag – Tension stringing chart
- 9 GTP and drawings for Bus-Post Insulator
- 10 Tension/suspension string insulator and Hardware Assembly GTP and drawing
- 11 Soil Investigation Report (if applicable)
- 12 Circuit Breakers (220kV, 132kV, 33 kV- As applicable)
Drawing, GTP, Type test Reports
- 13 CTs & CVTs (220kV, 132 kV, 33kV- As applicable)
Drawing, GTP, Type test Reports
- 14 Surge Arrestors (216kV, 120kV, 30kV- As applicable)
Drawing, GTP, Type test Reports
- 15 Isolators (220kV, 132kV, 33 kV- As applicable)
Drawing, GTP, Type test Reports
- 16 Control, Relay Panels and Substation Automation system

Drawings, GTP, technical literature, type test reports

17 Civil Works (as applicable)

- a) **Control Room Building, Structure Design, Foundation Design & Drg., Plinth Beam Design & Drg. and column Design & Drg. upto G.F. Level**
- b) **Auto transformer foundation design/drawings**
- c) **Reactor foundation design/drawings**
- d) **220/132/33kV Tower, structure & foundation design/drawings.**
- e) **220/132/33kV Equipment support structure & foundation design/drawing**

NOTE:

The above list of drawing/document is only illustrative and not exhaustive. The contractor shall submit drawings/documents as per requirement of Technical specification.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-3

Specific Technical Requirement

SECTION 3

SPECIFIC TECHNICAL REQUIREMENTS

CONTENTS

S.NO	DESCRIPTION	PAGE
1.0	SPECIFIC TECHNICAL REQUIREMENTS	1
1.1	SURGE ARRESTORS	1
1.2	CAPACITIVE VOLTAGE TRANSFORMERS/VOLTAGE TRANSFORMERS	2
1.3	CURRENT TRANSFORMER	4
1.4	245/145/36 kV ISOLATOR AND ISOLATOR WITH EARTH SWITCH	9
1.5	245/145/36 kV SF6 (GAS) CIRCUIT BREAKERS FOR OUTDOOR APPLICATION	15
1.6	POWER TRANSFORMERS	23
1.7	EARTHING SYSTEM	31
1.8	FIBER OPTICS TERMINAL EQUIPMENT	35
1.9	A.C. DISTRIBUTION BOARD	35
1.10	D.C. BATTERY, BATTERY CHARGER & DC DISTRIBUTION BOARD	38
1.11	POWER AND CONTROL CABLES	40
1.12	ILLUMINATION/LIGHTING SYSTEM	40
1.13	MISCELLANEOUS ITEMS FOR SUB-STATIONS	41
1.14	STATION TRANSFORMERS	44
1.15	100 KVA, 415 V DIESEL GENERATOR SETS	46

SECTION 3

SPECIFIC TECHNICAL REQUIREMENTS

1.0 SPECIFIC TECHNICAL REQUIREMENTS

The Standard Technical Particulars of the various items are given below and in the relevant schedule/chapters of Specifications. The Bidders are required to comply with the same.

1.1 SURGE ARRESTORS

TABLE-1.1(a) Surge Arrestor Technical Particulars for 220/132/33 kV Substations

i.	Type	Heavy duty, station class, Gapless Metal oxide, outdoor		
ii.	Arrestor rating (kV rms)	216	120	30
iii.	Maximum Continuous Operating voltage (kV rms)	168	102	25
iv.	Standard Nominal Discharge Current	10 kA (8/20 micro impulse shape)		
v.	Line discharge class	Class-3		
vi.	Degree of protection	IP 55		
vii.	Max. Steep current impulse residual voltage at 10 kA (kV _p)	650	380	110
viii.	Max. Lightning Impulse residual voltage at 10 kA (kV _p)	600	330	90
ix.	Max. switching surge residual voltage at 1 kA (kV _p)	500	280	NA
x.	Partial discharge at 1.05 COV not greater than	50pC		
xi.	Max. discharge capability corresponding to rated voltage	5Kj/kV		
xii.	Low current long duration test value	2400 μs		

xiii.	High current short duration test value (4/10 μ second wave)	100kA		
xiv.	Minimum Corona Extinction Voltage (kVrms)	156	105	NA
xv.	Maximum partial discharge at 1.05*Continuous Over Voltage(COV)	50 pC		
xvi.	Prospective symmetrical fault current for pressure relief test for (0.2 sec) kA	40	31.5	25

TABLE-1.1(b) Insulator Housing

Power frequency withstand test voltage (wet) (kV rms)	552	330	90
Lightning impulse withstand/tests voltage (kVp)	1260	780	204
Pressure Relief Class	Class 'A'		
Creepage distance not less than (mm)	6125+20%	3625+20%	900+20%
Cantilever Strength (Kg)	350	350	350

1.2 CAPACITIVE VOLTAGE TRANSFORMERS/VOLTAGE TRANSFORMERS

TABLE-1.2 (a) TECHNICAL PARTICULARS

SL.NO	DESCRIPTION			
(i)	Rated voltage kV (rms)	220	132	33
(ii)	Max System Voltage kV (rms)	245	145	36
(iii)	Rated frequency	50(Hz)		
(iv)	System Earthing	Solidly Earthed		
(v)	Short circuit level for one second kA (rms)	40 kA	31.5 kA	25 kA
(vi)	Rated primary operating voltage	220 / $\sqrt{3}$ (kV)	132/ $\sqrt{3}$ (kV)	33/ $\sqrt{3}$ (kV)

(vii)	Rated secondary voltage			
	• Winding No.1	110/ $\sqrt{3}$		
	• Winding No. 2	110/ $\sqrt{3}$		
	• Winding No. 3	110/ $\sqrt{3}$		
(viii)	Class of accuracy of Each secondary winding			
	• Winding No.1	3P		
	• Winding No.2	0.2		
	• Winding No.3	3P		
(ix)	Temperature rise	As per IS 3156 & IEC 60044-2& 60044-5		
(x)	Voltage factor	1.5 for 30 sec. , 1.2 Continuous		
(xi)	Rated Insulation level			
	a) Rated voltage kV	220	132	33
	b) 1.2 /50 micro sec. impulse withstand voltage (kV peak)	1260	780	204
	c) One minute dry power frequency Withstand voltage (kV peak)	552	330	90
(xii)	Rated burden (VA)			
	• Wdg I	50		
	• Wdg II	30		
	• Wdg III	50		
(xiii)	Standards reference range Of frequency for which the Accuracy's are valid	96 % to 102 % for protection and 99 % to 101 % for measurement		
(xiv)	One minute power frequency test Withstand voltage for secondary winding (kV rms)	3		
(xv)	Partial discharge level (Pico	<10		

	coulombs)			
(xvi)	Rated Capacitance (picco-farad)	4400 (+10% to -5%)	4400 (+10%to -5%)	NA
(xvii)	Minimum Corona extinction Voltage (kVrms)	156	105	
(xviii)	Maximum Radio interference voltage for frequency between 0.5 to 2 MHz (at 156 kVrms)	1000	500	
(xix)	Equivalent resistance over entire carrier frequency range (ohms) for CVT	<40	< 40	< 40

TABLE-1.2 (b) Insulator Housing

Voltage Level (kV)	220	132	33
Power frequency withstand test voltage (wet) (kV rms)	552	330	84
Lightning impulse withstand/tests voltage (kVp)	1260	780	204
Creepage distance not less than (mm)	6125+20%	3625+20%	900+20%
Cantilever Strength (Kg)	350	350	350

1.3 CURRENT TRANSFORMER

TABLE-1.3 (a) 220 kV CT TECHNICAL PARTICULARS

i.	Rated Voltage	220 kV
ii.	Rated frequency	50 Hz.
iii.	System neutral earthing	Solidly Earthed
iv.	Installation	Outdoor

v.	Current rating(A)	2000-1000-500/1-1-1-1-1
vi.	a).Rated fault current current for 1 second (kA)	40
	b).Rated dynamic short circuit current	100 kA
vii.	Rated insulation level (Standard Values)	
	a) Lightning Impulse withstand voltage (Peak) kV	1260
	b) One minute power frequency withstand voltage (kV rms)	552
viii.	Type of insulation	Class A
ix.	Rated continuous thermal current	120% of the rated current
x.	Accuracy Class of CT cores	
xi.	1. core-1	PS
	2. core-2	PS
	3. core-3	0.2
	4. core-4	PS
	5. core-5	PS
xii.	Maximum temperature rise over maximum ambient temperature	As per IEC
xiii.	ISF for metering core	<5
xiv.	Power frequency withstand voltage for secondary winding for 1 minute	3kV

xv.	Max. Corona excitation voltage (kV)	156
xvi.	Max.RIV for frequency between 0.5 to 2 MHz (μ Volt)	1000 at 156 kV
xvii.	Cantilever Strength	350 Kg
xviii.	Max. Partial discharge level (pC)	10

TABLE-1.3 (b) 132 kV CT TECHNICAL PARTICULARS

i.	Rated Voltage	132 kV
ii.	Rated frequency	50 Hz.
iii.	System neutral earthing	Solidly Earthed
iv.	Installation	Outdoor
v.	Current rating(A)	1200-600-300/1-1-1-1-1
vi.	a). Rated short circuit current for 1 second (kA) b). Rated dynamic short circuit current (kA)	31.5 78.75
vii.	Rated insulation level (Standard Values) a) Lightning Impulse withstand voltage (Peak) kV b) One minute power frequency withstand voltage (kV rms)	780 330
viii.	Type of insulation	Class A

ix.	Rated continuous thermal current	120% of the rated current
x.	Accuracy Class of CT cores	
xi.	1. core-1 2. core-2 3. core-3 4. core-4 5. core-5	PS PS 0.2 PS PS
xii.	Maximum temperature rise over maximum ambient temperature of 37°C	As per IS:2705
xiii.	ISF for metering core	<5
xiv.	Power frequency withstand voltage for secondary winding for 1 minute	5 kV
xv.	Max. Corona excitation voltage (kV rms)	105
xvi.	Max.RIV for frequency between 0.5 to 2 MHz	500 at 92kV
xvii.	Cantilever Strength	350 Kg
xviii.	Max. Partial discharge level (pC)	10

TABLE-1.3 (c) 33 kV CT TECHNICAL PARTICULARS

i.	Rated Voltage	33 kV
ii.	Rated frequency	50 Hz.
iii.	System neutral earthing	Solidly Earthed
iv.	Installation	Outdoor

v.	Current rating(A)	600-300/1-1-1-1	
vi.	a). Rated short circuit current for 1 second (kA)	25	
	b). Rated dynamic short circuit current (kA)	62.5	
vii.	Rated insulation level (Standard Values)	204	
	a) Impulse withstand voltage (Peak) kV		
	b) One minute power frequency withstand voltage (kV rms)	90	
viii.	Type of insulation	Class A	
ix.	Rated continuous thermal current	120% of the rated current	
x.	Accuracy Class of CT cores	Feeder Bay	Transformer Bay
xi.	1. core-1	PS	PS
	2. core-2	0.2	0.2
	3. core-3	5P20	5P20
	4. core-4	PS	PS
xii.	Maximum temperature rise over maximum ambient temperature.	As per IEC	
xiii.	ISF for metering core	<5	
xiv.	Power frequency withstand voltage for secondary winding for 1 minute	5 kV	
xv.	Max. Partial discharge level (pC)	10	
xvi.	Max. Cantilever Strength (Kg)	350	

TABLE-1.3 (d) Insulator Housing

Voltage Level(kV)	220	132	33
-------------------	-----	-----	----

Power frequency withstand test voltage (wet) (kV rms)	552	330	90
Lightning impulse withstand/tests voltage (kVp)	1260	780	204
Creepage distance not less than (mm)	6125+20%	3625+20%	900+20%

1.4 245/145/36 kV ISOLATOR AND ISOLATOR WITH EARTH SWITCH

TABLE-1.4 (a) 245 kV ISOLATOR TECHNICAL PARTICULARS

S.No.	Description	Parameter			
1.	Rated voltage kV (r.ms)/Highest System Voltage kV	220/245			
2.	Rated frequency (Hz)	50			
3.	System neutral earthing	Solidly Earthed			
4.	Number of poles	3			
5.	Installation	Outdoor			
	Type	Three phase, centre break, triple pole, single throw, gang operated, with one control cabinet with/without earth switch.			
6.	Rated current (Amp.)	Tumlingtar Substation	Basantapur Substation	Baneshwar Substation	Inaruwa Substation
		2500	2500	2500	2500
7.	a) Rated lightning impulse withstand voltage between line terminals and ground [kV(peak)]	1260			
	b) Between terminals with Isolator contacts open [kV(peak)]	1440			

8.	One min. power frequency withstand voltage in kV (rms)	
	a) between line terminals kV (rms) and earth (Kv rms)	552
	b) Between terminals with isolator contacts open Across the isolating distance kV (rms)	636
9.	Rated fault current rating for 1 sec (kA)	40
10.	Rated dynamic short circuit current (kA)	100
11.	Temperature rise	As per IS: 9921(part II)-1982
12.	Rated mechanical load	As per IS: 9921/IEC
13.	Operating mechanism of	
	I. Mode of operation of isolator	A.C Motor operated
	II. Operating motor voltage	415V, AC
	III. Mode of operation of earthing switch	Manual
14.	Operating time	12 Sec. or less
15.	i) Number of auxiliary contact of each isolator	12NO + 12 NC for Isolator and 2 pairs to make before break contact
	ii) Earth Switch	8 NO + 8 NC for ES
16.	Phase to phase spacing	Minimum 4500 mm
17.	Metal for rotating blade	Aluminium
	Material for fixed contact	HDE copper
18.	D.C. Supply voltage for Interlocks	110 V / 220 V (For Inaruwa Substation)

19.	No. of terminal in control cabinet(including inter pole cabinet)	All contacts and control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.
20.	Minimum Corona extinction voltage in open and close position (kV rms)	156
21.	Maximum RIV for frequency between 0.5 to 2 MHz in close and open position (micro volt)	1000 at 156 kV rms
22.	Mechanical Endurance Class	M2 for isolator , M0 for Earth Switch

TABLE-1.4 (b) 145 kV ISOLATOR TECHNICAL PARTICULARS

S.No.	Description	Parameter
1.	Rated voltage kV (r.ms)/highest System Voltage kV	132/145
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Number of poles	3
5.	Installation	Outdoor
	Type	Three phase, centre break, triple pole, single throw, gang operated, with one control cabinet with/without earth switch.
6.	Rated current (Amp.)	1250
7.	Rated lightning impulse withstand voltage	
	a) Between the terminals and ground [Kv(peak)]	780
	b) Between the terminals	900

	with contacts open	
8.	One min. power frequency withstand voltage in kV (rms)	
	a) Across the isolating distance kV (rms)	378
	b) To earth between poles	330
9.	Rated short circuit current rating for 1 sec (kA)	31.5
10.	Rated dynamic short circuit current (kA)	80
11.	Temperature rise	As per IS: 9921(part II)-1982,IEC 694
12.	Rated mechanical load	As per IS: 9921/IEC
13.	Operating mechanism of	
	I. Mode of operation of isolator	A.C Motor operated
	II. Operating motor voltage	415V AC Manual
	III. Mode of operation of earthing switch	
14.	Operating time	12 Sec. or less
15.	Number of auxiliary contact of each isolator	12NO + 12 NC for Isolator and 2 pairs to make before break contact
		8 NO + 8 NC for Earth Switch
16.	Phase to phase spacing	Minimum 3000 mm
17.	Metal for rotating blade	Aluminium
	Material for fixed contact	HDE copper
18.	D.C. Supply voltage for Interlocks volts	110 V

19.	No. of terminal in control cabinet(including inter pole cabinet)	All contacts and control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.
20.	Minimum Corona extinction Voltage in open and close position (kVrms)	105
21.	Maximum RIV for frequency between 0.5 to 2 MHz in close and open position (micro volt)	500 at 92 kVrms
22.	Mechanical Endurance Class	M2 for isolator , M0 for Earth Switch

TABLE-1.4 (c) 36 kV ISOLATOR TECHNICAL PARTICULARS

S.No.	Description	Parameter
1.	Rated voltage kV (r.ms)/Highest System Voltage kV	33/36
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Number of poles	3
5.	Installation	Outdoor
	Type	Three phase, centre break, triple pole, single throw, gang operated, with one control cabinet with/without earth switch.
6.	Rated current (Amp.)	600
7.	Rated lightning impulse withstand voltage	
	a) Across isolating distance [kV(peak)]	234
	b) Between terminals and ground	204

8.	One min. power frequency withstand voltage in kV (rms) a) Across the isolating distance kV (rms) b) Between terminals and ground	96 90
9.	Short circuit current rating for 1 sec (kA)	25
10.	Rated dynamic short circuit current (kA)	62.5
11.	Temperature rise	As per IS: 9921(part II)-1982, IEC 694
12.	Rated mechanical load	As per IS: 9921/IEC
13.	Operating mechanism of a. Mode of operation of isolator ii. Operating motor voltage iii. Mode of operation of earthing switch	A.C Motor operated 415V AC Manual
14.	Operating time	12 Sec. or less
15.	Number of auxiliary contact of each isolator	10 NO + 10 NC for Isolator and 2 pairs to make before breakcontact 8 NO + 8 NC for Earth Switch
16.	Phase to phase spacing	Minimum 1500 mm
17.	Metal for rotating blade Material for fixed contact	Aluminium HDE Copper
18.	D.C. Supply voltage for Interlocks	110 V
19.	No. of terminal in control	All contacts and control circuits are to be wired

	cabinet(including inter pole cabinet)	up to control cabinet plus 24 spare terminals evenly distributed.
20.	Endurance Class	M2 for isolator and M0 for earth switch

1.5 245/145/36 kV SF₆ (GAS) CIRCUIT BREAKERS FOR OUTDOOR APPLICATION

TABLE-1.5 (a) 245 kV SF₆ CIRCUIT BREAKERS TECHNICAL PARTICULARS

S.No	Parameters/Standards	For 220 kV			
1.	Rated Voltage (kV rms)	220/245			
2.	Rated frequency (Hz)	50			
3.	System neutral earthing	Solidly Earthed			
4.	Type of arc quenching medium	SF ₆ (Gas)			
5.	Number of poles	1 pole/phase			
6.	Rated normal current (A)	Tumlingtar Substation	Inaruwa Substation	Basantapur Substation	Baneshwar Substation
		2500	2500	2500	2500
7.	Installation	Outdoor			
8.	Rated short circuit current breaking capacity at rated voltage (kA rms)	40			
9.	Rated short circuit making current (kA rms)	100			
10.	Rated short circuit current duration (seconds)	1			
11.	First pole to clear factor	1.3			
12.	a) Total break time for any current upto the rated breaking current with limiting conditions of operating & quenching media pressure (ms)	65			
	b) Rated break time(ms)	60			
13.	Closing time (ms)	100			
14.	Standard value of rated transient recovery	As per IEC			

S.No	Parameters/Standards	For 220 kV
	voltage for terminal fault	
15.	Rated operating duty cycle	0-0.3 sec-CO-3 Min-CO
16.	Auto reclosing	Single phase & Three phase auto reclosing.
17.	Rated insulation level	
	a) 1.2/50 micro second lightning impulse withstand voltage between line terminals and ground between terminals with contact open	1260
	b) One minute power frequency withstand voltage between line terminals and ground and ground between terminals with contact open (kV rms)	552
18.	Minimum corona extinction voltage in open and close position (kV rms)	156
19.	Maximum radio interference voltage for frequency between 0.5 to 2 mhz in open and close position (micro volt)	1000 at 156 kV rms
20.	Maximum line charging current (rms)	125 Amps
21.	Rated cable charging breaking current capacity (rms)	250 Amps
22.	Difference in instants of closing/opening of contacts	
	a) Within a pole(ms)	2.5
	b) Between poles for opening(ms)	3.3
	c) Between poles for closing(ms)	5
23.	Maximum noise level upto 50 m distance from the base of CB (dB)	140
24..	Temperature rise	As per limits specified in IEC

S.No	Parameters/Standards	For 220 kV
25.	Set of trip coils	2
26.	Operating mechanism	
	a) Type	Spring/Pneumatic
	b) Charging	Motor charging & manual charging
	c) Max. actuating force required for manual charging of spring	Not to exceed 250 N
	d) Supply voltage	230V, 50 Hz, AC supply
27.	Permissible supply tolerance variation in case of motor charging	70%-110% of rated supply
28.	a) Type of tripping	Trip free
	b) No. of Auxiliary contacts	10 No. and 10 NC on each pole
	c) Number of auxiliary contacts (Over and above for Control/Supervision)	10NO & 10 NC
	d) Auxiliary contacts continuous current rating	10 A
	e) Auxiliary contacts breaking capacity	2 A
29.	Minimum Creepage distance (mm)	6125+20%
30.	Control circuit voltage	110V DC / 220 V DC(Inaruwa Substation)
31.	Maximum corona extinction voltage	156 kV
32.	Circuit breaker class	C2, M2 as per IEC 62271-100
33.	CLEARANCES	
	a) Phase to Phase spacing in the switchyard i.e. Available interpole spacing for breaker (mm)	4500

TABLE-1.5 (b) 145 kV SF6 CIRCUIT BREAKERS TECHNICAL PARTICULARS

S.No	Parameters/Standards	For 132 kV
1.	Rated Voltage (kV rms)	132/145
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Type of arc quenching medium	SF ₆ (Gas)
5.	Number of poles	1 pole/phase
6.	Rated normal current (A)	1250
7.	Installation	Outdoor
8.	Rated short circuit current breaking capacity at rated voltage (kA rms)	31.5
9.	Rated short circuit making current (kA rms)	78.5
10.	Rated short circuit current duration (seconds)	1
11.	First pole to clear factor	1.3
12.	a) Total break time for any current upto the rated breaking current with limiting conditions of operating & quenching media pressure (ms) b) Rated Break time (ms)	65 60
13.	Closing time (ms)	100
14.	Standard value of rated transient recovery voltage for terminal fault	As per IEC
15.	Rated operating duty cycle	0-0.3 sec-CO-3 Min-CO
16.	Auto reclosing	Three phase auto reclosing.
17.	Rated insulation level	
	a) 1.2/50 micro second lightning impulse withstand voltage	780

S.No	Parameters/Standards	For 132 kV
	between line terminals and ground between terminals with contact open	
	b) One minute power frequency withstand voltage between line terminals and ground and ground between terminals with contact open (kV rms)	330
18.	Minimum corona extinction voltage in open and close position (kV rms)	105
19.	Maximum radio interference voltage for frequency between 0.5 to 2 MHz in open and close position (micro volt)	500 at 92 kV rms
20.	Maximum line charging current (rms)	125 Amps
21.	Rated cable charging breaking current capacity (rms)	160 Amps
22.	Difference in instants of closing/opening of contacts	
	a) Within a pole(ms)	2.5
	b) Between poles for opening(ms)	3.3
	c) Between poles for closing(ms)	5
23.	Maximum noise level up to 50 m distance from the base of CB (dB)	140
24.	Temperature rise	As per limits specified in IEC
25.	Set of trip coils	2
26.	Operating mechanism	
	a) Type	Spring/Pneumatic
	b) Charging	Motor charging & manual charging

S.No	Parameters/Standards	For 132 kV
	c) Max. actuating force required for manual charging of spring	Not to exceed 250 N
	d) Supply voltage	230V, 50 Hz, AC supply
27.	Permissible supply tolerance variation in case of motor charging	70%-110% of rated supply
28.	a) Type of tripping	Trip free
	b) No. of Auxiliary contacts	10 No. and 10 NC on each pole
	c) Number of auxiliary contacts (Over and above for Control/Supervision)	10NO & 10 NC
29.	Minimum Creepage distance (mm)	3625+20%
30.	Control circuit voltage	110V DC
31.	Circuit breaker class	C2, M2 as per IEC 62271-100
32.	CLEARANCES	
	a) Phase to Phase spacing in the switchyard i.e. available interpole spacing for breaker (mm)	3000

TABLE-1.5 (c) 33 kV VACUUM SF6 CIRCUIT BREAKERS TECHNICAL PARTICULARS

S.No	Parameters/Standards	For 33kV
1.	Rated Voltage (kV rms)	33/36
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Type of arc quenching medium	Vaccum/SF ₆ (Gas)
5.	Number of poles	3
6.	Rated normal current (A)	600 A

S.No	Parameters/Standards	For 33kV
7.	Installation	Outdoor
8.	Rated short circuit current breaking capacity at rated voltage (kA rms)	25
9.	Rated short circuit making current (kA rms)	62.5
10.	Rated short circuit current duration (seconds)	3 sec
12.	a) Total break time for any current upto the rated breaking current with limiting conditions of operating & quenching media pressure (ms). b) Rated break time (ms)	105 100
13.	Closing time (ms)	100
14.	Standard value of rated transient recovery voltage for terminal fault	As per IEC
15.	Rated operating duty cycle	0-0.3 sec-CO-3 Min-CO
17.	Rated insulation level	
	a) 1.2/50 micro second lightning impulse withstand voltage between line terminals and ground between terminals with contact open	204
	b) One minute power frequency withstand voltage between line terminals and ground and ground between terminals with contact open (kV rms)	84
18.	Minimum corona extinction voltage in	NA

S.No	Parameters/Standards	For 33kV
	open and close position (kV rms)	
19.	Maximum radio interference voltage for frequency between 0.5 to 2 MHz in open and close position (micro volt)	NA
20.	Maximum line charging current (rms)	10 Amps
21.	Rated cable charging breaking current capacity (rms)	50 Amps
22.	Difference in instants of closing/opening of contacts a) Within a pole(ms) b) Between poles for opening(ms) c) Between poles for closing(ms)	NA
23.	Maximum noise level up to 50 m distance from the base of CB (dB)	140
24.	Temperature rise	As per limits specified in IEC
25.	Set of trip coils	1
26.	Operating mechanism	
	a) Type	Spring
	b) Charging	Motor charging & manual charging
	c) Max. actuating force required for manual charging of spring	Not to exceed 250 N
	d) Supply voltage	230V, 50 Hz, AC supply
27.	Permissible supply tolerance variation in case of motor charging	70%-110% of rated supply
28.	a) Type of tripping	Trip free
	b) No. of Auxiliary contacts	8 NO. and 8 NC
	c) Number of auxiliary contacts (Over and above for Control/Supervision)	10 NO & 10 NC

S.No	Parameters/Standards	For 33kV
29.	Minimum Creepage distance (mm)	900+20%
30.	Control circuit voltage	110V DC
31.	Circuit breaker class	C2, M2 as per IEC 62271-100
32.	CLERANCES	
a)	Phase to Phase spacing in the switchyard i.e available interpole spacing for breaker (mm)	1500

1.6 POWER TRANSFORMERS

TABLE-1.6 (a)

SPECIFIC TECHNICAL REQUIREMENTS FOR 220/132kV 100 MVA (3 X 33.33 MVA) POWER TRANSFORMER BANK

(i)	Rating of Unit	Rating/Type
	HV (MVA)	33.33
	LV (MVA)	33.33
(ii)	Single/Three Phase design	Single
(iii)	Applicable standard	IEC 60076
(iv)	Frequency (Hertz)	50
(v)	Cooling	ONAN/ONAF
(vi)	Rating at different cooling	60 % / 100 %
(vii)	Rated MVA of Bank	100
(viii)	Type of installation	Outdoor

(ix) Frequency	50 \pm 3% Hz
(x) Cooling medium	Mineral oil
(xi) Rated Voltage	
a) High voltage side	(220/ $\sqrt{3}$) kV
b) Intermediate Voltage side	(132/ $\sqrt{3}$) kV
(xii) Highest Continuous System Voltage :	
a) High voltage (HV)	245 kV
b) Low Voltage (IV)	145 kV
(xiii) Method of system earthing:	
a) High voltage (HV)	Neutral terminal- Solidly earthed
b) Intermediate Voltage (IV)	Neutral terminal- Solidly earthed
c)	
(xiv) Type of tap changer	OLTC
(xv) Range of tapping	Minus 5% to Plus 15% with sixteen (16) equal steps of 1.25%
(xvi) Location of tap changer	On the 132 kV side of Series winding
(xvii) Design of tap changer	Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I
(xviii) Tap Control	Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow

(xix) Impedance at rated MVA Base on Principal tap at 75 Deg C	HV-LV : 12.5 %	
(xx) Tolerance on Impedance	AS PER IEC/ISS	
(xxi) Duty	Continuous	
(xxii) Overload Capacity	IEC 60076-7 or IS: 6600	
(xxiii) Type of insulation & insulation level for winding:	220 kV	132 kV
a) Type of insulation:	Graded	Graded
b) One minute power frequency withstand test voltage (kV RMS)	395kV	230kV
c) Impulse withstand test voltage (kVp):	950kV	550kV
(xxiv) Winding connection	Star (HV)	Star (IV)
Material	Copper	Copper
(xxv) Vector group:	YNao	
(xxvi) Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency	1.6 wb/m ²	
(xxvii) Short circuit level of the system to which Transformer is to be connected	40 kA for HV, 31.5 KA for LV sec.	
(xxviii) Short circuit	40 kA for HV, 31.5 KA for LV for for 2 sec+	

withstand capacity	
(xxix) Terminal details	
a) 220 kV Termination	ACSR "Moose" conductor for connecting to bushing terminals.
b) 132 kV Termination	ACSR "Moose" conductor for connecting to bushing terminals.
(xxx) Rail	
a. Shorter Axis:	1676 mm
b. Longer Axis:	1676 mm
(xxxi) Ten delta of winding	Less than 0.005 at 20 deg C
(xxxii) Maximum Temperature Rise for various types of cooling over an ambient of 50 deg C	
a) Temperature rise of top oil(Measured by Thermometer)	50 ⁰ C
b) Temperature rise of winding (Measured by resistance)	55 ⁰ C
Note: The allowable temp rise during testing shall be reduced by 1 ⁰ K for every 250m above 1000m as per IS 2026 part II.	
(xxxiii) Noise Level at Rated Voltage & Frequency	Less than 75 db for ONAN Less than 80db at full load
(xxxiv) Transformer Bushings	
Type	HV- Oil Impregnated Paper (OIP) condenser type LV-Oil Impregnated Paper (OIP) condenser type Neutral- Porcelain and oil communicating type

	HV	LV	Neutral
Rated Voltage	245kV	145kV	36kV
Rated current	1250A	1250A	800A
Lighting Impulse withstand voltage (kVp)	1260kV	780 kV	204kV
One minute power frequency withstand voltage (kV RMS)	552kV	330kV	90kV
Corona Extinction voltage	HV-156 kV _{rms}		
Ten Delta of Bushing (for HV and LV)	Less than 0.004 at 20 ⁰ C		
Minimum Total Creepage Distance	For HV: 6125 mm +20% For LV: 3625 mm + 20%		
Note: The arcing distance of the busing shall be increased by 15% at all the substations to account for the high altitude as per IEC 60137-2003.			
(xxxv) Transformer Oil	As per IS:335 (latest edition), with pouring temperature -10 ⁰ C		
(xxxvi) Max partial discharge at 1.5 U _m /√3	100 pC		

TABLE-1.6 (b)

SPECIFIC TECHNICAL REQUIREMENTS FOR 220/33 kV 25/30 MVA 3-PHASE TRANSFORMER

(i) Rated MVA of the Transformer	25/30 MVA ONAN/ ONAF
(ii) Type of installation	Outdoor
(iii) Service	Continuous
(iv) Frequency	50 Hz
(v) Cooling medium	Mineral oil

(vi) Rated Voltage		
a) High voltage side	220 kV	
b) Low Voltage side	33 kV	
(vii) Highest Continuous System Voltage :		
a) High voltage (HV)	245 kV	
b) Low Voltage (LV)	36 kV	
(viii) Method of system earthing:		
a) High voltage (HV)	Neutral terminal- Solidly earthed	
b) Low Voltage (LV)	Neutral terminal- Solidly earthed	
(ix) Type of tap changer	OLTC	
(x) Range of tapping	Plus 5% to minus 15% with sixteen (16) equal steps of 1.25%, Tap changer to be located at neutral end of HV winding	
(xi) Tap Control	Full capacity - on load tap changer suitable for group / independent, remote / local electrical and local manual operation and bi-directional power flow	
(xii) Impedance at rated MVA Base on Principal tap	HV-LV : 12.5 %	
(xiii) Impedance at rated MVA Base on Max and Minimum Voltage tap	HV-LV (Max Voltage tap) : 13.51% HV-LV (Min Voltage tap): 12.1%	
(xiv) Tolerance on Impedance	As per IEC	
(xv) Type of insulation & insulation level for winding:	220 kV	33 kV
a) Type of insulation:	Graded	Uniform

b) One minute power frequency withstand test voltage (kV RMS)	395kV	70kV
c) Impulse withstand test voltage (kVp):	950kV	170kV
(xvi) Winding connection	Star (HV)	Star (LV)
Material	Copper	Copper
(xvii) Vector group:	Ynyn0	
(xviii) Type of cooling	ONAN /ONAF	
(xix) Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency	1.6 wb/m ²	
(xx) Short circuit level of the system to which Transformer is to be connected	40 kA for HV, 25 KA for LV for 1 sec.	
(xxi) Short circuit withstand capacity	40 kA for 2 sec	
(xxii) Terminal details		
a. 220 kV Termination	ACSR "Moose" conductor for connecting to bushing terminals.	
b. 33 kV Termination	ACSR "Moose" conductor for connecting to bushing terminals.	
(xxiii) Rail		
a. Shorter Axis:	1676 mm	
b. Longer Axis:	1676 mm	
(xxiv) Tan delta of winding	Less than 0.005 at 20 deg C	
(xxv) Maximum Temperature Rise		

for various types of cooling over an ambient of 50deg C			
a) Temperature rise of top oil(Measured by Thermometer)			
b) Temperature rise of winding(Measured by resistance)	50 ⁰ C		
	55 ⁰ C		
Note: The allowable temp rise during testing shall be reduced by 1 ⁰ K for every 250m above 1000m as per IS 2026 part II.			
(xxvi) Overload Capacity	As per IEC 60076-7 or IS: 6600		
(xxvii) Noise Level at Rated Voltage & Frequency	Less than 75db for ONAN Less than 80db at full load		
(xxviii) Transformer Bushings			
Type	HV- Oil Impregnated Paper (OIP) condenser type LV- Oil Impregnated Paper (OIP) condenser type Neutral- Porcelain and oil communicating type		
	HV	LV	Neutral
Rated Voltage	245kV	36 kV	36kV
Rated current	1250A	800 A	800A
Lighting Impulse withstand voltage (kV _p)	1260kV	204kV	204 kV
One minute power frequency withstand voltage (kV RMS)	552kV	90 kV	90kV
Minimum creepage distance	6125mm +20%	900 mm+20%	900mm+20%
Corona Extinction voltage	HV-156 kV _{rms}		
Tan Delta for bushings	Less than 0.004 at 20 ⁰ C		
Note: The arcing distance of the busing shall be increased by 15% at all the substations			

to account for the high altitude as per IEC 60137-2003.	
(xxix) Transformer Oil	As per IS:335 (latest edition), with pouring temperature -10°C
(xxx) Maximum partial discharge level at 1.5 pu	100 pico-coulomb

TABLE-1.6 (c)

SPECIFIC TECHNICAL REQUIREMENTS FOR 132/33 kV 25/30 MVA 3-PHASE TRANSFORMER

(i) Rated MVA	25/30MVA ONAN/ONAF
(ii) Type of installation	Outdoor
(iii) Service	Continuous
(iv) Frequency	50 Hz $\pm 3\%$
(v) Cooling medium	Mineral oil
(vi) Rated Voltage	
High voltage side	132 kV
Low Voltage side	33 kV
(vii) Highest Continuous System Voltage :	
High voltage (HV)	145 kV
Low Voltage (LV)	36 kV
(viii) Method of system earthing:	Neutral terminal- Solidly earthed
(ix) Type of tap changer	OLTC
(x) Range of tapping	Plus 5% to minus 15% with sixteen (16) equal steps of 1.25%. Tapping shall be located at the neutral end of the HV
(xi) Tap Control	Full capacity - on load tap changer suitable for group / independent, remote / local electrical and local manual operation and bi-directional power flow

(xii) Impedance at rated MVA and on principal/ tap	12.5 %/	
(xiii) Type of insulation & insulation level for winding:	132 kV	33 kV
d) Type of insulation:	Graded	Uniform
e) One minute power frequency withstand test voltage (kV RMS)	230kV	70kV
f) Lightning Impulse withstand test voltage (kVp):	550kV	170kV
(xiv) Winding connection	Star	Star
(xv) Material	Copper	Copper
(xvi) Vector group:	YNd11	
(xvii) Type of cooling	ONAN /ONAF	
(xviii) Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency	1.6 wb/m ²	
(xix) Short circuit level of the system to which Transformer is to be connected	31.5 kA for HV and 25 KA for LV side for one sec.	
(xx) Short circuit withstand capacity	31.5 kA for HV and 25 KA for LV for 2 sec	
(xxi) Terminal details		
a) 132 kV Termination	ACSR "Moose" conductor for connecting to bushing terminals.	
b) 33 kV Termination	ACSR "Moose" conductor for connecting to bushing terminals.	

(xxii) Rail			
a) Shorter Axis:	1676 mm		
b) Longer Axis:	1676 mm		
(xxiii) Ten delta of winding	Less than 0.005 at 20 deg C		
(xxiv) Maximum Temperature Rise for various types of cooling over an ambient of 50deg C	50 ⁰ C 55 ⁰ C		
a) Temperature rise of top oil(Measured by Thermometer)			
b) Temperature rise of winding(Measured by resistance)			
Note: The allowable temp rise during testing shall be reduced by 1 ⁰ K for every 250m above 1000m as per IS 2026 part II.			
(xxv) Overload Capacity	As per IEC 60076-7 or IS: 6600		
(xxvi) Noise Level at Rated Voltage & Frequency	Less than 75db for ONAN Less than 80db at full load		
(xxvii) Transformer Bushings			
Type	HV- Oil Impregnated Paper (OIP) condenser type LV- Porcelain and oil communicating type Neutral- Porcelain and oil communicating type		
	HV	LV	Neutral
Rated Voltage	145kV	36kV	36kV
Rated current	800A	800A	800A
Lighting Impulse withstand voltage (kV _p)	780kV	204kV	204 kV

One minute power frequency withstand voltage (kV RMS)	330 kV	90kV	90kV
Minimum creepage distance	3625mm+20%	900mm+20%	900mm+20%
Corona Extinction voltage	HV-320kV _{rms}		
Ten Delta	Less than 0.004 at 20 ⁰ C		
Note: The arcing distance of the busing shall be increased by 15% at all the substations to account for the high altitude as per IEC 60137-2003.			
(xxviii) Transformer Oil	As per IS:335 (latest edition), with pouring temperature -10 ⁰ C		
(xxix) Maximum partial discharge level at 1.5 pu	100 pico-coulomb		

1.7 EARTHING SYSTEM

TABLE-1.7 (a) TENTATIVE SIZE OF THE FLATS TO BE USED

S. No.	Item	Specification
a.	Control room	MS flat 50 x 10 mm ²
b.	Outdoor yard	MS flat 50 x 10 mm ²
c.	Riser	50 x 6 mm ²
d.	Earthing electrodes	3 m long x 40 mm dia MS rod
e.	Earthing Electrode for treated earthing pits	25 mm dia x 3 meter long G.I pipe

TABLE-1.7 (b) TECHNICAL PARTICULARS

S.No.	Item	Description
a.	50 x 10 mm ² MS flat for earthing mat	As per drawing prepared by the Contractor for each sub – station with complete BOQ
b.	Equipment earthing with 50 x 6 mm ²	--- do ---

	GI /flat complete with clamps accessories	
c.	25 mm dia. G.I pipe ,3 meter long with suitable arrangements for fixing earth strip	---do---

1.8 FIBER OPTICS TERMINAL EQUIPMENT

TABLE 1.8 (a) OPTICAL WAVELENGTH AND OPTICAL UNIT OPTIONS

WAVELENGTH	OPTION
1310 nm	High Power (Laser Version)
1550 nm	High Power (Laser Version)
1310 nm	Low Power (LED Version) when available from the Fiber Optic terminal Equipment Manufacturer

1.9 A.C. DISTRIBUTION BOARD

TABLE 1.9 (a) TECHNICAL PARTICULARS

1.	AC SYSTEM	3 phase, 4 wire, solidly earthed
	a. Voltage	400 volts- 15 % to +10 %
	b. Frequency	50 Hz \pm 3 %
	c. Combined variation in voltage & frequency	- 10 % to + 10 % Absolute sum
	d. Fault level	10 kA (rms)
2.	BUS BAR	
	a. Continuous	630 A Aluminum
	b. Short time (1 Sec)	10 kA rms
3.	ONE MINUTE POWER FREQUENCY WITHSTAND VOLTAGE	
	a. Power circuits	2.5 kV (rms)

	b. Control circuits	2.5 kV (rms)
4.	MOULDED CASE CIRCUIT BREAKER	
	a. Voltage	AC 3- phases –415 V (-15 to + 10 %)
	b. Frequency	50 Hz
	c. Short circuit Performance	10 kA (rms)
	d. Making capacity	2.5 times breaking capacity
	e. Operating Mechanism	Manual , trip free
	f. Temperature rise	As per IS: 2516
	g. Mechanical rise	As per IS: 2516
	h. Auxiliary contacts	4 No., 4 NC
5.	METERS	
	a. Accuracy class	1.0 or better
	b. one minute power frequency withstand voltage	2.5 kV (rms)
6.	CURRENT TRANSFORMERS	
	a. Type	Cast resin, Bar primary
	b. Secondary circuit	1 Amp.
	c. Voltage class and Frequency	1100 V, 50 Hz
	d. Class of insulation	E or better
	e. Accuracy	
	I. Accuracy class metering CT	Class 1, 10 VA
	II. Accuracy class protection CT	5p 10 , 15 VA
	f. Short time current rating	10 kA (rms) for 1 sec.
	g. one minute power frequency withstand voltage	2.5 kV (rms)
7.	VOLTAGE TRANSFORMERS	

	I. Type	Cast resin
	II. Rated voltage	415 V \pm 10%
	a. Primary	415 V / $\sqrt{3}$
	b. Secondary	110V/ $\sqrt{3}$
	III. Accuracy class and VA burden	
	a. Metering	1.0, 10 VA
	b. Protection	3 p, 50 VA
	IV. Method of connection	
	a. Primary	Star
	b. Secondary	Star
	V. Rated voltage factor	1.1 continuous , 1.5 for 3 sec.
	VI. Class of insulation	E or better
	VII. One minute power frequency withstand voltage	2.5 kV (rms)
8.	RELAY	
	a. One minute power frequency withstand voltage	2.0 kV (rms)

1.10 D.C. BATTERY, BATTERY CHARGER & DC DISTRIBUTION BOARD**TABLE 1.10 (a) TECHNICAL PARTICULARS**

A	D.C. Battery	For Station Battery	For Communication
	I. Type	Nickel-Cadmium/Lead Acid battery, completely sealed, maintenance free stationary, normal discharge performance type suitable for application in sub stations having life of not less than Ten years on float operation	
	II. Ambient temperature		
	a. Max.	37.5 ⁰ C Do...
	b. Min.	14 ⁰ C Do...
	c. No. of cells	87	38
	d. Rated voltage	110 V	48 V
	III. Minimum capacity for: 10 hr. Discharge rate to end voltage V/cell at 27 ⁰ C	400 AH	100AH
	IV. Capacity of the one hour discharge rate to end voltage V/cell at 27 ⁰ C	40 AH	10 AH
	V. Float voltage	1.4 to 1.42 V/cell	1.4 to 1.42 V/cell
	VI. Optimum float voltage	To be specified by the manufacturer	To be specified by the manufacturer
	VII. Boost voltage	1.53 to 1.7 V/Cell	1.53 to 1.7 V/Cell
	VIII. Ampere-hour efficiency	Not less than 90%	Not less than 90%

	IX. Watt-hour efficiency	Not less than 75%	Not less than 75%
	X. Self-discharge	< 1% per week	< 1% per week
	XI. Life	>10 Years	>10 Years
B.	Battery Charger	Float-cum-Boost Charger.	
	I. Type	Solid state, full wave controlled bridge rectifier (preferably half controlled type)	Solid state, full wave controlled bridge rectifier (preferably half controlled type)
	II. A.C. Input		
	a. Supply	400 V, 3 phase, 4 wire	400 V, 3 phase, 4 wire
	b. Frequency	50 Hz	50 Hz
	c. Input voltage variation	-15% to +10%	-15% to +10%
	d. Frequency variation	+5%	+5%
	e. Combined voltage & frequency variation	-15% to +10%	-15% to +10%
	f. System Earthing	Effectively earthed	Effectively earthed
	III. D.C. Output	For Station Battery	For Station Battery
	a. Continuous D.C. load	To charge as well as supply DC load	To charge as well as supply DC load
	b. Output voltage range	0-150V	0-65V
	c. For D.C. load variation from 0 to 100% output Voltage stable within	+1% (digitally controlled)	+1% (digitally controlled)

	d. Continuous Current settings	100% (digitally controlled)	100% (digitally controlled)
	e. Ripple content	Less than 2%	Less than 2%
	IV. AC input /DC output	(to be controlled by for both float-cum-boost) MCCB/MCB &with links to isolate circuits)	

1.11 POWER AND CONTROL CABLES

TABLE 1.11 (a) TECHNICAL PARTICULARS

1.	L.T. POWER & CONTROL CABLES	Description
(a)	Size of Cable	As per requirement (given in the text)
(b)	Voltage rating	650/1100 V
(c)	Short circuit withstand for 1 sec.	13 kA/system requirement
(d)	Conductor for LT power cable	Copper
(e)	Conductor for control cable	Copper

1.12 ILLUMINATION/LIGHTING SYSTEM

TABLE 1.12 (a) TECHNICAL PARTICULARS

a.	Supply voltage	230 V
b.	Frequency	50 Hz
c.	Variation of voltage	± 10%
d.	Variation of frequency	± 5%
e.	Combined voltage & frequency variation	± 10%
f.	Type of internal lighting wires	Copper wiring, P.V.C. insulated 1100 V grade.
g.	Conduit	14 mm, 25mm, 32mm and 63 mm PVC medium duty pipe

h.	Earthing wire	
	i. Material	Copper
	ii. Size	8 SWG GI
	iii. Light Points	16 SWG (stranded) with green colour insulation
	iv. Power Points	14 SWG (stranded) with green colour insulation
i.	Temperature rise	As per IS:10322 (Pt-4)
j.	Lighting fixtures & accessories panel	As per IS:8623 (Part-1)

1.13 MISCELLANEOUS ITEMS FOR SUB-STATIONS

TABLE 1.13 (a) Aluminium Tube particulars for 220 kV, 132 kV & 33 kV Bus Bars

Sl. No.	Item	220 kV Bus Bar	132 kV Bus Bar	33 kV Bus Bar
a.	Material	Aluminium	Aluminium	Aluminium
b.	Diameter	120 mm	100 mm	100 mm
c.	Maximum Span	8500 mm	7500 mm	6000 mm

TABLE 1.13 (b) Physical Properties of Conductor

a.	Type	ACSR "Moose"
b.	Overall Diameter	31.77 mm
c.	Cross Sectional Area	597 mm ²
d.	Stranding (nos./mm)	54+7/3.53mm
e.	Mass	1998 kg/km
f.	Ultimate Strength	16275 kg (159.60 kN)

g.	Rated DC resistance at 20°C	0.05596 Ω/km
----	-----------------------------	--------------

TABLE 1.13 (c) Conductor accessories

Sl. no	Item	220kV Level	132kV Level
i)	Type	Anti fog type, Outdoor Ball and Socket complying with IS 731 & IS 2486 (Part-II)	Anti fog type, Outdoor Ball and Socket complying with IS 731 & IS 2486 (Part-II)
ii)	Size of Disc	254x145 mm ²	254x145 mm ²
iii)	Rated Voltage	11 kV	11 kV
iv)	No. of Disc. Unit per string		
	a. Suspension (S/S)	16	10
	b. Tension (S/T)	16	10
v)	Minimum failing load		
	a. Suspension	120 kN	120 kN
	b. Tension	120 kN	120 kN
vi)	Creepage Distance of insulator	320mm	320mm
vii)	Power Frequency (wet) withstand voltage	75 kV	75 kV
viii)	Power Frequency (puncture) withstand voltage of single disk	1.3 times the dry flashover voltage of the unit	1.3 times the dry flashover voltage of the unit
ix)	Impulse withstand voltage of the disk	170kV	170kV

TABLE 1.13 (d) Technical Parameters of Bus Post Insulators

Sl. No	Description	220 kV	132 kV	33KV
a)	Type	Solid Core	Solid Core	Solid Core
b)	Voltage Class (kV)	245	145	36 kV
c)	Dry and wet one minute power frequency withstand voltage(kV rms)	552	330	90
d)	Dry lightning impulse withstand Voltage (kVp)	+ 1260	+780	204
e)	Radio interference voltage (Micro volt at 1 MHz) at a system voltage of 156 kV.	>500	>500	NA
g)	Corona extinction voltage (kV rms) (min.)	156	105	NA
h)	Cantilever Strength			
(i)	Total minimum cantilever strength (Kg)	800	600	450
(ii)	Total minimum breaking strength (Kg)	1000	720	-----
i)	Minimum torsional moment	As per IEC-273	As per IEC-273	As per IEC-273
k)	P.C.D Top (mm)	127	127	127
Sl. No	Description	220 kV	132 kV	33KV
	Bottom (mm)	254	254	254
l)	No. of bolts			
	Top	4	4	4
	Bottom	8	8	8
m)	Diameter of bolt/holes (mm)			
	Bolt dia	M16	M16	M16
	Hole dia	18	18	18
o)	Minimum total creepage distance for Heavy Pollution (mm)	6125+20%	3165+20%	900+20%

TABLE 1.13 (e) Earth Wire

a.	Material	G.S. Wire
b.	Size	7/4.115 mm
c.	Ultimate Tensile Strength	10300 kg
d.	Overall diameter	12.35 mm
e.	Modulus of Elasticity	149000 MPA
f.	Co-efficient of linear expansion	12.9×10^{-6} per degree C
g.	Weight (kg/km)	619
h.	Cross sectional Area	77.89 mm ²

1.14 STATION TRANSFORMERS**TABLE 1.14 (a) SPECIFIC TECHNICAL REQUIREMENTS FOR 400KVA TRANSFORMER**

(i) Rated KVA of the Transformer	400 KVA ONAN
(ii) Type of installation	Outdoor
(iii) Frequency	50 Hz \pm 3%
(iv) Cooling medium	Mineral oil
(v) Rated Voltage	
c) High voltage side	33 kV
d) Low voltage side	0.4 kV
(vi) Highest Continuous System Voltage :	
c) High voltage (HV)	36 kV
d) Low Voltage (LV)	0.45 kV
(vii) Method of system earthing:	
d) High voltage (HV)	Solidly earthed
e) Low Voltage (IV)	Solidly earthed
(viii) Type of tap changer	Off load Tap changer

(ix) Range of tapping	Plus 5% to minus 10% with sixt(6) equal steps of 2.5%	
(x) Impedance at rated MVA Base on Principal tap	10 %	
(xi) Type of insulation & insulation level for winding:	33 kV	0.4 kV
d) Type of insulation:	Uniform	Uniform
e) One minute power frequency withstand test voltage (kV RMS)	70	28
f) Lightning Impulse withstand test voltage (kVp):	170	75
(xii) Winding connection	Delta (HV)	Star (LV)
Material	Copper	Copper
(xiii) Vector group:	Dyn1	
(xiv) Type of cooling	ONAN	
(xv) Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency	1.6 wb/m ²	
(xvi) Short circuit level of the system to which Transformer is to be connected	25 kA for one sec.	
(xvii) Maximum Temperature Rise for various types of cooling over an ambient of 40 deg C	50 ⁰ C	
c) Temperature rise of top oil		

(Measured by Thermometer)	55 ⁰ C
d) Temperature rise of winding (Measured by resistance)	
Note: The allowable temp rise during testing shall be reduced by 1 ⁰ K for every 250m above 1000m as per IS 2026 part II.	
(xviii) Noise Level at Rated Voltage & Frequency	Less than 75db for ONAN Less than 80db at full load
(xix) Transformer Oil	As per IS:335 (latest edition), with pouring temperature -10 ⁰ C

1.15 100 KVA, 415 V DIESEL GENERATOR SETS

TABLE 1.15 (a) Technical Particulars Alternator

S.No.	Item	Quantity
a.	Alternator net continuous output at site conditions, after deducting power requirement of auxiliaries	100 kVA
b.	Power factor	0.8 lagging
c.	Overload capacity for one (1) hour in twelve consecutive hours of operation	10%
d.	Rated voltage	415 V
e.	Rated Frequency	50 Hz
f.	Number of phases	Three (3)
g.	Winding connections	Star (Y)
h.	Design max ambient temperature	40 Deg. C
i.	Type of insulation	
	a. Armature winding	Class H
	b. Field winding	Class H
	c. Connections	Class H
	d. Core connections	Class H

	e. e) Type of enclosure	Screen protected IP 23
j.	Permissible voltage variation for satisfactory operation at rated KVA	±10%
k.	Permissible frequency variation	± 5%
l.	Permissible combined voltage and frequency variation (Absolute sum)	10%
m.	Method of Neutral grounding	Solidly earthed
n.	Efficiency	Better than 90%

TABLE 1.15 (b) TECHNICAL PARTICULARS OF CURRENT TRANSFORMERS

a.	Type	Cast resin insulated bar or wound type
b.	Specification & standards	As specified herein and as per IS: 2705
c.	Number of phases	Single Phase
d.	Secondary CT	5 Amp.
e.	Rated Burden	15 VA for metering & 15 VA for Protection
f.	Accuracy Class	1 (Metering) 5P10 (Protection)
g.	Rated continuous thermal Current at specified ambient temperature	Same as rated primary current
h.	Rated short time thermal current	25 KA for (1) one second or the maximum let through current of the previous (upstream) protective devise.
i.	Rated dynamic current	65 KA (peak) or the maximum current of

		the previous (upstream) protective device.
j.	Class of insulation	Class 'H'
k.	One (1) minute power frequency withstand voltage	
	i) Between all terminals connected together and all parts to be earthed	2 kV
	ii) Between contacts terminal with contacts closed and all remaining terminals connected together	2 kV

TABLE 1.15 (c) TECHNICAL PARTICULARS OF THE RELAYS

S.No.	Item	Specification
a.	Type	Flush mounted, tropicalised drawout.
b.	Specifications and standards	As specified herein and as per IS:3231
c.	Current coil rated current	5 A, AC
d.	Potential coil rated voltage	110 V AC/ 24 V DC
e.	Operating time class	As needed for instantaneous relay
f.	Control supply	24 V DC
g.	Class of insulation	'H'
h.	One (1) minute power frequency tests voltage	
	i) Between all terminals connected	2 kV

	together and all parts to be earthed	
	ii) Between contacts terminal with contacts closed and all remaining terminals connected together	2 kV
	iii) Between circuits to be connected in use	2 kV
	iv) Between contacts in open position	1 kV

TABLE 1.15 (c) TECHNICAL PARTICULARS OF THE INDICATING INSTRUMENTS

S.No.	Item	Specification
a.	Type	Flush mounted,
b.	Specifications and standards	As specified herein and as per IS: 1248
c.	Accuracy	± 1 percent
d.	Size	96 mm x 96 mm
e.	Finish	Parallax free dull black with white dial and black markings
f.	1 (One) minute power frequency test voltage	2 kV

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4 **Technical Specifications**

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-1 **Surge Arrestors**

SECTION 4

CHAPTER – 1

SURGE ARRESTORS

CONTENTS

S.No	DESCRIPTION	PAGE NO.
1.0	SCOPE	1
1.1	STANDARDS	1
1.2	GENERAL REQUIREMENT	2
1.3	ARRESTOR HOUSING	3
1.4	FITTINGS & ACCESSORIES	4
1.5	SURGE MONITOR	4
1.6	TESTS	5
1.7	NAME PLATE	5
1.8	DRAWINGS AND INSTRUCTION MANUALS	6
1.9	TECHNICAL PARTICULARS	6

SECTION 4

CHAPTER – 1

SURGE ARRESTORS

1.0 SCOPE

- 1.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, transportation up to site, testing & commissioning of 216 kV, 120 kV, 30 kV, 10 kV, Station class-3 heavy duty, gapless metal (zinc) oxide Surge Arrestors complete with discharge counter, leakage current ammeter, insulating bases & clamps suitable for Construction of 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification.
- 1.0.2 Components having identical rating shall be interchangeable.
- 1.0.3 The performance of the equipment shall be guaranteed as per **Section-5 – "Guaranteed and Other Technical Particulars"**.

1.1 STANDARDS

- 1.1.1 The design, manufacture and performance of Surge Arrestors shall comply with IEC 60099-4/IS:3070 Part-3 and other specific requirements stipulated in the specification. Unless otherwise specified, the equipment, material and processes shall confirm to the latest applicable Indian standards or International Standards as listed here under:-

TABLE-1.0

IS:2071-1993 (Part-1)	Methods of High Voltage Testing General Definitions & Test Requirements
IS:2071-1974 (Part-2)	Test Procedures
IS:2629-1985	Recommended Practice for hot dip galvanizing on Iron & Steel
IS:2633-1986	Method for Testing uniformity of coating of zinc coated Articles.
IS:3070-1993 (Part-3)	Specification for surge arrestor for alternating current systems.

	Metal-Oxide lightning Arrestors without gaps
IS:4759-1996	Specification for hot dip zinc coating on Structural Steel and Other allied products.
IS:5621-1980	Hollow Insulators for use in Electrical Equipment
IS:6209-1982	Methods of Partial discharge measurement.
IS:6745	Method for determination of mass of zinc coating on zinc coated iron and steel articles
ANSI/IEEE-C.62.11 (1982)	Metal oxide, Surge Arrestor for AC Power Circuits
IEC 60099-4	Surge Arrestors
	Electrical Power technical standards of Nepal.

1.2 GENERAL REQUIREMENT

- 1.2.1 The metal oxide gap less Surge Arrestor without any series or shunt gap shall be suitable for protection of substation equipment and 100 MVA, 30 MVA, Power transformers, associated equipment from voltage surges resulting from natural disturbance like lightning as well as system disturbances.
- 1.2.2 The surge arrestor shall draw negligible current at operating voltage and at the same time offer least resistance during the flow of surge current.
- 1.2.3 The surge arrestor shall consist of non-linear resistor elements placed in series and housed in electrical grade porcelain housing of specified creepage distance.
- 1.2.4 The assembly shall be hermetically sealed with suitable rubber gaskets with effective sealing system arrangement to prevent ingress of moisture.
- 1.2.5 The surge arrestor shall be provided with line and earth terminals of suitable size. The ground side terminal of surge arrestor shall be connected with 25x6 mm galvanized strip, one end connected to the surge arrestor and second end to a separate ground electrode. The bidder shall also recommend the procedure which shall be followed in providing the earthing/system to the Surge Arrestor.
- 1.2.6 The surge arrestor shall not operate under power frequency and temporary over voltage conditions but under surge conditions, the surge arrestor shall change over to the conducting mode.

- 1.2.7 The surge arrester shall be suitable for circuit breaker performing 0-0.3sec.-CO-3min-CO- duty in the system.
- 1.2.8 Surge arrestors shall have a suitable pressure relief system to avoid damage to the porcelain housing and providing path for flow of rated fault currents in the event of arrester failure.
- 1.2.9 The reference current of the arrester shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.
- 1.2.10 The Surge Arrester shall be thermally stable and the bidder shall furnish a copy of thermal stability test with the bid.
- 1.2.11 The arrestors shall be suitable for mounting on steel structures/supporting structures. The supplier shall furnish the drawing indicating the dimensions, weights etc. of the surge arrestors for the design of supporting structure and foundations.
- 1.2.12 The arrester shall be capable of handling terminal energy for high surges, external pollution and transient over voltage and have low losses at operating voltages.
- 1.2.13 The arrester shall meet the line discharge requirement of class 3 for 245/145/36kV of IEC on two successive operations.

1.3 ARRESTOR HOUSING

- 1.3.1 The arrester housing shall be made up of completely vitrified porcelain. The porcelain used shall be homogenous, free from laminations, cavities and other flaws of imperfections that might affect the mechanical and dielectric quality. The glazing of porcelain shall be of uniform brown colour, free from blisters, burrs and other similar defects.
- 1.3.2 Arrestors shall be complete with insulating bases, fasteners for stacking units, surge counters with leakage current meters and terminal connectors.
- 1.3.3 Porcelain housing shall be so coordinated that external flashover shall not occur due to application of any impulse or switching surge voltage upto the maximum design value for arrester. The arrestors shall not fail due to arrester porcelain contamination. The arrestors housing shall be designed for pressure relief class as given in Technical Parameters of the specification.
- 1.3.4 Sealed housings shall exhibit no measurable leakage.

1.4 FITTINGS & ACCESSORIES

- 1.4.1 The surge arrester shall be complete with all required fittings & accessories including insulating bases, fasteners for stacking units together, surge counters with leakage current meters and terminal connectors.
- 1.4.2 The terminals shall be non-magnetic, corrosion proof, robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The top metal cap and base of surge arrester shall be galvanized. The line terminal shall have a built in clamping device which can be adjusted for both horizontal and vertical takeoff. Connectors shall be suitable for "Quad/Twin ACSR Moose –31.77mm Φ ". Connectors as appropriate shall be suitable for horizontal/vertical takeoff.
- 1.4.3 Grading corona control rings if necessary shall be provided on each complete arrester pole for proper stress distribution.
- 1.4.4 The earthing connection will be made through Surge Arrester base and Surge monitor to Ground.

1.5 SURGE MONITOR

- 1.5.1 A self contained discharge counter suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit. Leakage current meter with suitable scale range to measure leakage current of surge arrester shall also be supplied within the same enclosure. The number of operations performed by the arrester shall be recorded by a suitable cyclometric counter and surge monitor shall be provided with an inspection window.
- 1.5.2 Surge monitor shall be mounted on the support structure of the surge arrester at a suitable height so that the reading can be taken from ground level through the inspection window and length of connecting leads upto grounding point and bends are minimum.

1.6 TESTS

1.6.1 Test on Surge Arrestors

The Surge Arrestors offered shall be type tested and type test reports shall be submitted and shall be subjected to routine and acceptance tests in accordance with IEC 60099-4. Surge arrestor monitor shall be connected in series with the test specimen during residual voltage and current impulse tests to establish its performance. Additional routine test with 100 A and 10kA, current impulse (8/20 micro sec) shall also be performed on surge monitor. Surge monitor shall also be tested for water dip test at 1.5 meter for 30 minutes and no water vapors shall be visible on monitor glass.

Galvanization Test

All Ferrous parts exposed to atmospheric condition shall have passed the type tests and be subjected to routine and acceptance tests in accordance with IS:2633 & IS 6745.

1.7 NAME PLATE

1.7.1 The name plate attached to the arrestor shall carry the following information :

- Rated Voltage
- Continuous Operation Voltage
- Normal discharge current
- Pressure relief rated current
- Manufacturers Trade Mark
- Name of Sub-station
- Year of Manufacturer
- Name of the manufacture
- Name of Client
- Purchase Order Number along with date

1.8 DRAWINGS AND INSTRUCTION MANUALS

1.8.1 The successful bidder shall furnish to the employer the following drawings and literature for approval before inspection/dispatch:

- a) Outline dimensional drawings of Surge Arrestor and all accessories.
- b) Assembly drawings and weights of main component parts.
- c) Drawings of terminal clamps.
- d) Arrangement of earthing lead.
- e) Minimum air clearance to be maintained of line components to ground.
- f) Name plate
- g) Insulating base
- h) Surge monitor
- i) Instructions manual
- j) Drawing showing details of pressure relief valve
- k) Volt-time characteristics of surge arrestors
- l) Detailed dimensional drawing of porcelain housing i.e. internal diameter, external diameter, thickness, height, profile, creepage distance, dry arcing distance etc.

1.9 TECHNICAL PARTICULARS

1.9.1 Surge Arrestor Technical Particulars for 220/132/33 kV Substations

TABLE-1.1

i.	Type	Heavy duty, station class, Gapless Metal oxide, outdoor		
ii.	Arrestor rating (kV rms)	216	120	30
iii.	Maximum Continuous Operating voltage (kV rms)	168	102	25
iv.	Standard Nominal Discharge Current	10 kA (8/20 micro impulse shape)		
v.	Line discharge class	Class-3		
vi.	Degree of protection	IP 55		

vii.	Max. Steep current impulse residual voltage at 10 kA (kV _p)	650	380	110
viii.	Max. Lightning Impulse residual voltage at 10 kA (kV _p)	600	330	90
ix.	Max. switching surge residual voltage at 1 kA (kV _p)	500	280	NA
x.	Partial discharge at 1.05 COV not greater than	50pC		
xi.	Max. discharge capability corresponding to rated voltage	5Kj/kV		
xii.	Low current long duration test value	2400 μs		
xiii.	High current short duration test value (4/10 μ second wave)	100kA		
xiv.	Minimum Corona Extinction Voltage (kVrms)	156	105	NA
xv.	Maximum partial discharge at 1.05*Continuous Over Voltage(COV)	50 pC		
xvi.	Prospective symmetrical fault current for pressure relief test for (0.2 sec) kA	40	31.5	25

1.9.2 Insulator Housing

TABLE-1.2

Power frequency withstand test voltage (wet) (kV rms)	552	330	90
Lightning impulse withstand/tests voltage (kVp)	1260	780	204
Pressure Relief Class	Class 'A'		
Creepage distance not less than (mm)	6125+20%	3625+20%	900+20%
Cantilever Strength (Kg)	350	350	350

Package-KC2

Koshi Corridor 220/132/33 kV Substations (Basantapur-Baneshwar-Tumlingtar- Inaruwa Substations)

Part II-Section VI: Employer's Requirements

Section-4

Chapter-2

Capacitive Voltage Transformers /Voltage Transformers

SECTION 4**CHAPTER –2****CAPACITIVE VOLTAGE TRANSFORMERS/VOLTAGE TRANSFORMERS****CONTENTS**

S.NO	DESCRIPTION	PAGE NO.
2.0	SCOPE	1
2.1	STANDARDS	1
2.2	VOLTAGE TRANSFORMER (VT)/CAPACITIVE VOLTAGE TRANSFORMERS(CVT)	2
2.3	RATING PLATE	4
2.4	TERMINAL CONNECTOR	4
2.5	BUSHING	4
2.6	TESTS	4
2.7	GUARANTEED AND OTHER TECHNICAL PARTICULARS	4
2.8	TECHNICAL PARTICULARS	5

SECTION 4

CHAPTER - 2

CAPACITIVE VOLTAGE TRANSFORMERS/VOLTAGE TRANSFORMERS

2.0 SCOPE

- 2.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, transportation up to site, Testing & commissioning of 220 kV and 132 kV CVTs and 33 kV voltage transformers (Electromagnetic type) as per IEC 60044-5/IS – 3156 & IEC 186 and per technical requirement covered under this specification complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification.
- 2.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.
- 2.0.3 Components having identical rating shall be interchangeable.
- 2.0.4 The performance of the equipment shall be guaranteed as per **Section-5 – "Guaranteed and Other Technical Particulars"**.

2.1 STANDARDS

The VT and CVT shall confirm to the following Nepal/Indian/International standards:

TABLE-2.0

IEC 60044-2	Inductive Voltage Transformer
IEC 60044-5	Voltage/Capacitive voltage transformers Standards
IS : 3156 – 1992 (Part I – 3)	Specification for voltage transformer
IS : 335 – 1993	Specification for new insulating oil
IS : 5621 – 1980	Hollow insulator for use in electrical equipment
IS : 27071 – 1974	Method of HV testing
IS : 2633 – 1986	Methods for testing uniformity of coating of Zinc coated articles
IS : 4253 – 1980	Specifications for gaskets
IS : 5561 – 1970	Electric power connector (heavy duty) electric
IS : 1554 – 1988 (Part – I)	PVC insulated (Heavy duty) electric cables
IS : 9348	Specification for coupling capacitors and capacitor

	Divider
IS : 11322	Specification for partial discharge measurement in instrument transformer.
IEC-60358	Coupling Capacitors and Capacitor divider
IEC-186	Voltage transformer

2.2 VOLTAGE TRANSFORMER (VT)/CAPACITIVE VOLTAGE TRANSFORMERS(CVT)

2.2.2 General

- i) CVT comprising of a capacitor divider unit and electromagnetic unit shall be single phase oil filled, hermetically sealed, self cooled, outdoor type and suitable for direct line connection without any fuse or isolating switch. The secondary terminals of potential unit high frequency coupling terminals and the earthing terminals shall be brought at separately and housed in a water proof cabinet. The electromagnetic voltage transformer unit of CVT whose primary is to be fed by the intermediate tapping of capacitor divider shall be of oil immersed, self cooled design and shall be suitable for metering, protection and synchronization. The primary winding shall be connected through a compensating reactor to compensate the voltage increase at intermediate tapping within the range of rated burden. Each CVT shall be provided with a suitable damping device so that Ferro resonance oscillation due to saturation of iron core or any inductance connected in parallel with it and initiated by either overvoltage on the network side shall be near zero. A device such as spark gap may be incorporated for limiting overvoltage which may appear across one or more of CVT components.
- ii) The VT shall be vacuum filled with oil after processing and hermetically sealed with stainless bellow or other suitable type of device (acceptable to Employer) for absorbing variations in the volume of oil due to change of temperature of oil to eliminate breathing and to prevent air and moisture from entering the tanks. Method adopted for hermetic sealing shall be described in the offer or during detailed engineering and shall be subject to approval of the Employer. Oil filling

and / oil sampling cocks, if provided to facilitate factory processing shall be permanently sealed before dispatching the VT.

- iii) The VT shall be so constructed that it can be easily transported to site within the allowable transport limitations and in horizontal position if the transport limitations so demand.

2.2.2 Primary Winding

The primary winding shall be of suitably insulated electrolytic copper wire. Type of insulation used to be described in the offer.

- i) The rating and diagram plate specified elsewhere in this specification shall also indicate the above re-connection arrangement.

2.2.3 Secondary Winding

- i) Suitably insulated copper wire of electrolytic grade shall be used for secondary winding and type of insulation used shall be described in the offer. The secondary winding of the Voltage transformer shall be protected by MCBs for each core.
- ii) The VT secondary terminals shall be brought out in a weather proof terminal box. The MCBs meant for protection of secondary winding shall also be located in the terminal box. The terminal box shall be provided with removable gland plate and glands suitable for 1100 volts grade, PVC insulated, PVC sheathed multi core 2.5 sq mm to 10 sq mm. stranded copper (vermin proof) and suitable arrangement shall be provided for drying of air inside the terminal box. The dimensions of the opening of the terminal box shall be adequate to enable easy access and working space with the use of normal tools.
- iii) Polarity shall be marked on each Voltage transformer at the secondary terminals in the terminals box.
- iv) The VT shall be provided with a rating plate with dimensions and markings as per IS: 3156. The marking shall be punched.
- v) The primary terminals shall be of standard size of 30 mm x 80 mm length for all VTs. The primary terminal shall be of heavily tinned electrolytic copper of 99.9% purity. The minimum thickness of tinning shall be of 15 microns.

- vi) For external connections of secondary windings, terminal studs shall be provided with at least three nuts, plain and spring washers. The studs, nuts and washers, shall be of brass, properly nickel plated. The size of the studs shall be 6 mm outside diameter. A length of at least 15 mm shall be available on the studs for inserting the leads.

2.3 RATING PLATE

- 2.3.1 Each VT shall be riveted with a non –corrosive & non –rusting rating plate made of brass / anodized aluminum with all particulars marked as per IS – 3156 & IEC –186 amended up to date. Another similar plate showing connection diagram shall be provided on each VT. Purchase order number and date shall be clearly written on both the plates. Name of client, customer & consultant shall be mentioned.

2.4 TERMINAL CONNECTORS

- 2.4.1 All the Voltage transformers required shall be provided with appropriate rigid type connectors suitable for Quad/Twin ACSR “Moose – 31.77 mm Φ ”. Connectors shall be suitable for horizontal/vertical takeoff with double conductor per phase.

2.5 BUSHING

- 2.5.1 Bushing shall be of high grade & homogeneous porcelain and shall comply with the requirement of IS-5621. Make of bushing shall be got approved from the Employer before commencement of supplies.

2.6 TESTS

- 2.6.1 Each VT/CVT shall comply with the type tests as stipulated in latest edition of applicable IS/IEC. Reports of all type tests carried out on the offered equipment shall be supplied. VT & CVT's offered shall be subjected to routine and acceptance tests in accordance with applicable Standards.

2.7 GUARANTEED AND OTHER TECHNICAL PARTICULARS

- 2.7.1 Guaranteed & other technical particulars as called for shall be furnished with the tender. Any other particulars considered necessary by the supplier may also be given in addition to those listed. Incomplete tender will be rejected out rightly.

2.8 TECHNICAL PARTICULARS

TABLE-2.1

SL.NO	DESCPTION			
(i)	Rated voltage kV (rms)	220	132	33
(ii)	Max System Voltage kV (rms)	245	145	36
(iii)	Rated frequency	50(Hz)		
(iv)	System Earthing	Solidly Earthed		
(v)	Short circuit level for one second kA (rms)	40 kA	31.5 kA	25 kA
(vi)	Rated primary operating voltage	220 / $\sqrt{3}$ (kV)	132/ $\sqrt{3}$ (kV)	33/ $\sqrt{3}$ (kV)
(vii)	Rated secondary voltage			
	• Winding No.1	110/ $\sqrt{3}$		
	• Winding No. 2	110/ $\sqrt{3}$		
	• Winding No. 3	110/ $\sqrt{3}$		
(viii)	Class of accuracy of Each secondary winding			
	• Winding No.1	3P		
	• Winding No.2	0.2		
	• Winding No.3	3P		
(ix)	Temperature rise	As per IS 3156 & IEC 60044-2& 60044-5		
(x)	Voltage factor	1.5 for 30 sec. , 1.2 Continuous		
(xi)	Rated Insulation level			
	a) Rated voltage kV	220	132	33
	b) 1.2 /50 micro sec. impulse withstand voltage (kV peak)	1260	780	204
	c) One minute dry power frequency Withstand voltage (kV peak)	552	330	90
(xii)	Rated burden (VA)			

	• Wdg I	50		
	• Wdg II	30		
	• Wdg III	50		
(xiii)	Standards reference range Of frequency for which the Accuracy's are valid	96 % to 102 % for protection and 99 % to 101 % for measurement		
(xiv)	One minute power frequency test Withstand voltage for secondary winding (kV rms)	3		
(xv)	Partial discharge level (Pico coulombs)	<10		
(xvi)	Rated Capacitance (picco-farad)	4400 (+10% to -5%)	4400 (+10%to -5%)	NA
(xvii)	Minimum Corona extinction Voltage (kVrms)	156	105	
(xviii)	Maximum Radio interference voltage for frequency between 0.5 to 2 MHz (at 156 kVrms)	1000	500	
(xix)	Equivalent resistance over entire carrier frequency range (ohms) for CVT	<40	< 40	< 40

Insulator Housing

TABLE-2.3

Voltage Level (kV)	220	132	33
Power frequency withstand test voltage (wet) (kV rms)	552	330	84
Lightning impulse withstand/tests voltage (kVp)	1260	780	204
Creepage distance not less than (mm)	6125+20%	3625+20%	900+20%
Cantilever Strength (Kg)	350	350	350

Package-KC2

Koshi Corridor 220/132/33 kV Substations (Basantapur-Baneshwar-Tumlingtar- Inaruwa Substations)

Part II-Section VI: Employer's Requirements

Section-4

Chapter-3 Current Transformer

SECTION 4

CHAPTER – 3

CURRENT TRANSFORMER

CONTENTS

S.NO	DESCRIPTION	PAGE NO.
3.0	SCOPE	1
3.1	STANDARDS	1
3.2	CONSTRUCTION FEATURES	2
3.3	TERMINAL CONNECTORS	4
3.4	TERMINALS BOX	4
3.5	CO-ORDINATION	5
3.6	TEMPERATURE RISE	5
3.7	INSULATING OIL	5
3.8	RATING PLATE	5
3.9	TESTS	6
3.10	GUARANTEED AND OTHER TECHNICAL PARTICULARS	6
3.11	DRAWINGS AND MATERIALS	6
3.12	BUSHING	7
3.13	FITTINGS & ACCESSORIES	7
3.14	MATERIALS AND WORKMANSHIP	8
3.15	TECHNICAL PARTICULARS	8

SECTION 4

CHAPTER - 3

CURRENT TRANSFORMER

3.0 SCOPE

- 3.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, Transportation upto site, Testing & commissioning of 230 kV, 132 kV and 33 kV current transformers (CTs) for outdoor substation. The CTs are required for the protection and metering purposes for Construction 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification.
- 3.0.2 Components having identical rating shall be interchangeable.
- 3.0.3 The performance of the equipment shall be guaranteed as per **Section-5 – "Guaranteed and Other Technical Particulars"**.

3.1 STANDARDS

- 3.1.1 The CTs shall confirm to the following Indian/International standards as amended upto date where specified otherwise:-

TABLE-3.0

IEC 60044-1	Specification, operation and maintenance for current transformers
IS: 2705-1992(Part I, II, III, IV)	Specification for current transformers
IS:335-1993	Insulating oil
IS: 5621-1980	Hollow insulators
IS: 2071-1974(Part II)	Method of HV testing
IS: 2633-1986	Method for testing uniformity of zinc coating
IS: 4253-1980	Gaskets

IS:-5561-1970	Electric power connectors
IS: 1554-1988(Part I)	PVC insulated (Heavy duty) electric cables
IEC 185	Old edition of Current Transformers

3.2 CONSTRUCTION FEATURES

- 3.2.1** The 220/132/33 kV CTs shall be out door type, Single phase, oil immersed, self cooled & hermetically sealed suitable for the services indicated. VA burden, accuracy class, accuracy limit factor etc. required for 220/132/33 kV CTs shall be worked out by bidder as per the system requirements. CTs shall be of live tank for 220 kV & 132 kV, dead tank/live tank for 33 kV. The characteristics shall be such as to provide satisfactory performance for burden ranging from 25% to 100% of rated burden over a range of 10% to 100% of rated current in case of metering CTs and upto the accuracy limit/knee point voltage in case of relaying CTs.
- 3.2.2** The core of the CTs shall be non-aging, high grade silicon laminated steel of low hysteresis loss & high permeability to ensure high accuracy at both normal & over currents and shall be of low reactance type so as to produce undistorted secondary current under transient conditions at all the ratios. The cores to be used for protective relaying purposes shall be of specified accuracy. The magnetization curve for the cores shall be furnished after the selection of CTs. The saturation factor of this core shall be low enough as not to cause any damage to the measuring instruments in the event of maximum short circuit current.
- 3.2.3** The primary winding (bar/wound type) should be of electrolyte high conductivity copper. Sufficient area of cross section shall be provided to cater for the short time as well as continuous thermal current ratings under site conditions. The main insulation shall be of paper of oil combination having good mechanical strength with superior electrical properties and good aging qualities to ensure long trouble free service. The rated extended primary current shall not be less than 15% of the rated primary current.

- 3.2.4 The secondary winding shall be high conductivity copper of suitable cross section. The copper wire shall have enamel insulation and paper insulation may also be provided to enhance reliability. For obtaining different ratios, either the secondary winding may be suitably tapped or a number of identical primary windings with series parallel arrangement may be provided. The rating of the secondary winding shall be one ampere for all protections except where the CTs are delta connected. It shall be 0.577 A.
- 3.2.5 The CTs shall be hermetically sealed with steel bellows or other suitable type of device (acceptable to Employer) for absorbing variations in the volume of oil due to change of temperature of oil to eliminate breathing and to prevent air & moisture from entering into the tank. It will be ensured that shape of external parts is such that the rain water does not accumulate. The CTs shall be provided with oil level gauge marked with maximum & minimum levels. Background of oil level gauge shall be snow white for clear visibility of oil. Pressure relief valve shall be provided for releasing abnormal pressure. A filling plug at the top and drain valve at the bottom shall be provided. Suitable no of cable glands for 4C, 6 mm² copper PVC cables shall be provided. All ferrous parts including nuts, bolts, washers etc. shall be hot dip galvanized. All necessary lifting lugs & fixing lugs with bolts nuts etc. shall be provided.
- 3.2.6 The equipment shall be suitable for fixing on supporting structures. The CTs shall be provided with terminal connectors suitable for connections with other equipments at site. The corresponding parts of similar items shall be interchangeable in every respect. The connectors shall be bimetallic if connection is required between aluminium and copper.
- 3.2.7 The upper tank shall be of high quality steel/light alloy which will serve as upper termination and carry primary terminals which shall be of sufficient cross-section suitable for mounting terminal connectors. The upper tank shall also serve as an expansion chamber or contain suitable provisions for taking care of the effects of

temperature variations on oil. A pressure relief valve shall also be provided in the upper tank for safety against abnormal pressure rise inside the CT.

- 3.2.8 The lower tank shall be of welded steel plate construction. The base construction shall be suitable for mounting on raised steel structures to be provided by the contractor and shall have fixing lugs and lifting holes/lugs of adequate strength. The dimensions of the base plate of supporting structure shall be as per requirement for fixing the CT. Necessary provisions shall also be made on the lower tank for two independent earthing connections with GI flat.

3.3 TERMINAL CONNECTORS

All the current transformers required shall be provided with appropriate rigid type connectors suitable for QUAD/TWIN ACSR "Moose– 31.77 mm Φ ". Connectors appropriate shall be suitable for horizontal/vertical takeoff with twin conductor per phase.

3.4 TERMINALS BOX

The leads from the secondary shall be brought out near the bottom of CT and connected to terminals in the terminals box. The terminals box shall be of weather proof construction with locking arrangement. An engraved diagram of terminal connections with various taps unaffected by weather conditions throughout the life of the equipment shall be mounted permanently on the inside of the door. A proper seal shall be provided all around the door to check the ingress of moisture/dust into the terminal box. The internal arrangement of the terminal box shall permit convenient handling of connectors to the outgoing PVC insulated and steel wire armoured copper cables of 6 mm² size entering from below. The distance between top of the secondary terminal & door of terminal box should not be less 2 inches. The secondary of all CTs shall be fitted with shorting links in the terminal box before dispatch. Further the shorting terminals shall be provided in the terminal box, so that any cable can be disconnected/ratio changed and C.T. earthed. All terminal of control

circuits are to be wired up to marshalling box plus 20% spare evenly distributed on all terminal blocks.

3.5 CO-ORDINATION

The characteristics of the CTs e.g. VA burden, accuracy class, ALF, minimum knee point voltage, maximum exciting current, secondary winding resistance etc. for protection CTs shall be calculated by the bidder for the protection schemes supplied and these shall be subject to the approval of Employer. Similarly the particulars of CTs for metering requirement shall be approved by the Employer as per the requirements of metering at various feeders.

3.6 TEMPERATURE RISE

The maximum temperature attained by any part of the equipment in service at site under full load conditions and exposed continuously to the direct rays of the sun shall not exceed the permissible limits fixed by the application standard, when corrected for the difference between the ambient temperature at site & the ambient temperature specified by the IEC 60044-1 & IS 2705 standard.

3.7 INSULATING OIL

The insulating oil shall comply with the requirement of IS:335-1993 as amended up to date with the characteristics as stipulated in Table I therein. In addition, the oil shall be subjected to agency test in accordance with the procedure laid down in ASTM-D-1934 and after accelerated aging shall have the characteristics as stipulated in Table-2 of this Standard.

3.8 RATING PLATE

Each CT shall be riveted with a non-corrosive & non-rusting engraved rating plate made of brass/anodized aluminum with all particulars marked as per IS-2705 & IEC-60044-1 amended up to date. Another similar plate showing connection diagram

shall also be provided on each CT. Employer Order number and date shall be clearly written on both the plates along with name of Employer and manufacturer.

3.9 TESTS

3.9.1 Each CT shall comply with the type test as stipulated in latest edition of IEC 60044-1, IS-2705, Part I to IV or IEC-185. Reports of all the type tests carried out on the offered equipment shall be supplied.

3.10 GUARANTEED AND OTHER TECHNICAL PARTICULARS

The technical particulars shall be furnished with the tender. Any other particulars considered necessary by the supplier may also be given.

3.11 DRAWINGS AND MATERIALS

The tender shall supply all the relevant drawings of the equipment including dimensional drawings, sectional view drawings, drawings showing inside details of tank, terminals box, secondary terminals, insulator, flange etc. as detailed below. The tender shall also supply illustrated and descriptive literature of offered equipment.

- a) General arrangement of CT
- b) Burden(VA) calculations for each core
- c) Magnetizing characteristic, ratio and phase angle error curves & composite curves of CT, CT resistance, knee point voltage etc.
- d) Secondary terminal arrangement of transformer, terminals box, etc.
- e) Type test report
- f) Sectional view drawing of CT.
- g) Mounting arrangement
- h) Earthing

3.12 BUSHING

Bushings shall be of high grade homogeneous porcelain & shall comply with the requirement of IEC 60044-1,IS-5621. Make of bushing shall be got approved from the Employer before commencement of supplies. These shall be rated for the altitude of operation.

3.13 FITTINGS & ACCESSORIES

A list of fittings and accessories required to be incorporated/supplied with the CTs is given below:

- a) Primary terminals
- b) Terminal connectors for connections from line to the CT primary
- c) Oil level gauge
- d) Pressure relief valve
- e) Expansion chamber with steel bellows or other suitable type of device (acceptable to Employer) for absorbing variations in the volume of oil due to change of temperature of oil.
- f) Weather proof secondary terminal box fitted with hinged door and complete with terminals and shorting links, lugs/holes and CT secondary details engraved on inside of cover.
- g) Lifting lugs/holes.
- h) Fixing lugs with bolts, nuts and washers for holding down the CTs on the supporting steel structures.
- i) Rating and connections diagram plates, indicating all the CT particulars such as VA, class, ALF, knee point voltage with exciting current, secondary winding resistance, taps, purpose and warning sign not to open CT.
- j) Oil filling plug and drain valve.
- k) Two earth connections on tank of suitable size to connect to the grounding grid.
- l) Any other fittings/accessories not included above but which is required shall be supplied with the CTs.

3.14 MATERIALS AND WORKMENSHP

3.14.1 All material used in the manufacturing of equipment shall be new and of best quality obtainable of their respective kinds & the whole of the work shall be of the highest class well finished and of approved design & make. Casting shall be free from blow holes, flaw cracks & other defects & shall be smooth, close grained of the true form & dimension. All machined surfaces shall be true & smooth finished. Electrolytic, 99.99% pure copper should be used and it should not be re-conditioned.

3.15 TECHNICAL PARTICULARS

TABLE-3.1

i.	Rated Voltage	220 kV
ii.	Rated frequency	50 Hz.
iii.	System neutral earthing	Solidly Earthed
iv.	Installation	Outdoor
v.	Current rating(A)	2000-1000-500/1-1-1-1-1
vi.	a).Rated fault currentcurrent for 1 second (kA)	40
	b).Rated dynamic short circuit current	100 kA
vii.	Rated insulation level (Standard Values)	
	a) LightningImpulse withstand voltage (Peak) kV	1260

	b) One minute power frequency withstand voltage (kV rms)	552
viii.	Type of insulation	Class A
ix.	Rated continuous thermal current	120% of the rated current
x.	Accuracy Class of CT cores	
xi.	1. core-1 2. core-2 3. core-3 4. core-4 5. core-5	PS PS 0.2 PS PS
xii.	Maximum temperature rise over maximum ambient temperature	As per IEC
xiii.	ISF for metering core	<5
xiv.	Power frequency withstand voltage for secondary winding for 1 minute	3kV
xv.	Max. Corona excitation voltage (kV)	156
xvi.	Max.RIV for frequency between 0.5 to 2 MHz (μ Volt)	1000 at 156 kV
xvii.	Cantilever Strength	350 Kg
xviii.	Max. Partial discharge level (pC)	10

TABLE-3.2

i.	Rated Voltage	132 kV
----	---------------	--------

ii.	Rated frequency	50 Hz.
iii.	System neutral earthing	Solidly Earthed
iv.	Installation	Outdoor
v.	Current rating(A)	1200-600-300/1-1-1-1-1
vi.	a). Rated short circuit current for 1 second (kA)	31.5
	b). Rated dynamic short circuit current (kA)	78.75
vii.	Rated insulation level (Standard Values)	
	a) Lightning Impulse withstand voltage (Peak) kV	780
	b) One minute power frequency withstand voltage (kV rms)	330
viii.	Type of insulation	Class A
ix.	Rated continuous thermal current	120% of the rated current
x.	Accuracy Class of CT cores	
xi.	1. core-1	PS
	2. core-2	PS
	3. core-3	0.2
	4. core-4	PS
	5. core-5	PS
xii.	Maximum temperature rise over maximum ambient temperature of 37°C	As per IS:2705

xiii.	ISF for metering core	<5
xiv.	Power frequency withstand voltage for secondary winding for 1 minute	5 kV
xv.	Max. Corona excitation voltage(kV rms)	105
xvi.	Max.RIV for frequency between 0.5 to 2 MHz	500 at 92kV
xvii.	Cantilever Strength	350 Kg
xviii.	Max. Partial discharge level (pC)	10

TABLE-3.3

i.	Rated Voltage	33 kV
ii.	Rated frequency	50 Hz.
iii.	System neutral earthing	Solidly Earthed
iv.	Installation	Outdoor
v.	Current rating(A)	600-300/1-1-1-1
vi.	a). Rated short circuit current for 1 second (kA)	25
	b). Rated dynamic short circuit current (kA)	62.5
vii.	Rated insulation level (Standard Values)	204
	a) Impulse withstand voltage (Peak) kV	
	b) One minute power frequency withstand voltage (kVrms)	90

viii.	Type of insulation	Class A	
ix.	Rated continuous thermal current	120% of the rated current	
x.	Accuracy Class of CT cores	Feeder Bay	Transformer Bay
xi.	1. core-1	PS	PS
	2. core-2	0.2	0.2
	3. core-3	5P20	5P20
	4. core-4	PS	PS
xii.	Maximum temperature rise over maximum ambient temperature.	As per IEC	
xiii.	ISF for metering core	<5	
xiv.	Power frequency withstand voltage for secondary winding for 1 minute	5 kV	
xv.	Max. Partial discharge level (pC)	10	
xvi.	Max.Cantilever Strength (Kg)	350	

Insulator Housing

TABLE-3.4

Voltage Level(kV)	220	132	33
Power frequency withstand test voltage (wet) (kV rms)	552	330	90
Lightning impulse withstand/tests voltage (kVp)	1260	780	204
Creepage distance not less than (mm)	6125+20%	3625+20%	900+20%

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-4 **245/145/36 kV Isolator And Isolator** **With Earth Switch**

SECTION 4**CHAPTER – 4****245/145/36 kV ISOLATOR AND ISOLATOR WITH EARTH SWITCH****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
4.0	SCOPE	1
4.1	STANDARDS	1
4.2	TYPE & RATINGS	2
4.3	CONSTRUCTIONAL FEATURES	3
4.4	MAIN CONTACTS	4
4.5	POST INSULATORS	4
4.6	CONNECTORS	5
4.7	OPERATING MECHANISM	5
4.8	SPACE HEATER & LIGHTING IN THE CUBICLE	7
4.9	BEARINGS	7
4.10	INTERLOCKS	8
4.11	AUXILIARY SWITCHES	8
4.12	ISOLATOR MOUNTING STRUCTURE	9
4.13	EARTHING SWITCHES	10
4.14	WIRING	10
4.15	DESIGN, MATERIALS AND WORKMANSHIP	11
4.16	TESTS	12
4.17	CABLE GLANDS	12
4.18	DRAWING AND LITERATURE	12
4.19	NAME PLATES	13
4.20	SPARES	14
4.21	OPERATING HANDLE	14
4.22	COMPLETENESS	15
4.23	TECHNICAL PARTICULARS	15

SECTION 4

CHAPTER - 4

245/145/36 kV ISOLATOR AND ISOLATOR WITH EARTH SWITCH

4.0 SCOPE

- 4.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, Transportation upto site, testing & commissioning of the outdoor type 245/145/36 kV gang operated isolators and isolator cum earthing switches complete in all respects with insulators, bimetallic connectors, arcing contacts, operating mechanism, interlocks, auxiliary switches, indicating devices, supporting structures, fixing details etc. with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification.
- 4.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.
- 4.0.3 Components having identical rating shall be interchangeable.
- 4.0.4 The performance of the equipment shall be guaranteed as per **Section-5 – "Guaranteed and Other Technical Particulars"**.

4.1 STANDARDS

- 4.1.1 The isolators shall comply in all respects to the latest applicable Nepal/Indian/International standards as listed hereunder:

TABLE-4.0

i)	IEC 62271-102	Standards for high Voltage Switchgear
ii)	IS 209:1992	Zinc ingot
iii)	IS 456:1978	Code of practice for plain and reinforced concrete
iv)	IS 802:1977	Code of practice for use of structural steel in overhead transmission line towers. Part-I/Part-II, material loads and permissible stress.

iv)	IS 1363 : 1992	Hexagon head bolts, screws & nuts of product grade.
v)	IS 1852 : 1985	Rolling and cutting tolerances for hot rolled steel products.
vi)	IS 2062 : 1992	Steel for general structural purpose
vii)	IS 2071: 1981	High voltage test technique
viii)	IS 2544 : 1973	Porcelain post-insulators for system with nominal voltage greater than 1000V
ix)	IS 2629 : 1985	Recommended practice for hot-dip galvanizing on iron and steel.
x)	IS 2633 1986	Methods for testing uniformity of coating of zinc coated articles.
xi)	IS 3063 : 1994	Fasteners single and rectangular section spring washers.
xii)	IS 3716 : 1994	Application guide for insulation coordination.
xiii)	IS 5350 : 1970	Dimensions of indoor and outdoor porcelain post insulators and post insulators and post insulator unit for system with nominal voltage greater than 1000 V.
xiv)	IS 5561:1970	Electric power connectors
xv)	IS: 6639: 1972	Hexagonal bolts for steel structures.
xvi)	IS : 6745 : 1972	Method for determination of mass of zinc coating on zinc and steel articles
xvii)	IS 9921 : 1981	Alternating current dis-connectors (isolators) and earthing switches for voltages above 1000 V.
xviii)	IS : 2063 : 1987	Classification of degrees of protection provided by enclosures of electrical equipment.
xix)	IEC : 694	Common specifications for high-voltage switch gear and control gear standards.

4.2 TYPE & RATINGS

4.2.1 All Isolators required shall be centre break, double pole, single throw, gang operated, with one control cabinet, outdoor type, silver plated contacts with pressure release mechanism for main contacts with horizontal operating blades & insulator posts arranged vertically. Isolators with earth switch shall be provided in addition to above one vertical break, earthing blade per pole suitable for fixing on either side of the poles.

4.2.2 All Isolators blades shall have rotating blade feature and pressure relieving mechanism. All Isolators shall move sufficiently from their fully closed position to the fully open position so that the break is distinct and clearly visible from the ground level. The isolator blades shall be suitable for locking in the open/closed position and shall not fall to the closed/open position in case the operating shaft gets disconnected.

4.2.3 It must be specifically ensured that the moving contacts (Blades) after its entry into the fixed contacts shall rotate through 90° . The equipment offered by the bidder shall be designed for a normal current rating specified in technical particulars of the specification and suitable for continuous service at the system voltage specified herein. The isolators offered shall not be required to operate under load but they shall be capable at the system voltage specified i.e. 245/145/36 kV as appropriate to handle make and break:

- (i) Magnetization currents of 220/132, 132/33 kV, 100, 30 MVA Power Transformers and capacitive currents of bushing, bus bars, connections, very short length of cables & currents of voltage transformers and dividers.
- (ii) The capacitive charging currents of unloaded transmission lines as indicated in the technical particulars.

4.3 CONSTRUCTIONAL FEATURES

4.3.1 Insulators shall be of porcelain and conform to IS-2544. The Insulator stack shall comprise of minimum number of post insulators or single piece long rod type. Pressure due to the contacts not transferred to the insulators after the main blades are fully closed.

4.3.2 The base channels & other structural steel members such as operating pipes, handles, phase coupling rods, operating mechanism boxes, bolts, pins etc. shall be of requisite strength and hot dip galvanized to ensure operational stability. All castings except current carrying parts shall be made of malleable cast iron & cast steel.

4.3.3 Arcing horns shall be provided to protect the insulators.

4.4 MAIN CONTACTS

All Isolators shall have heavy duty, self aligning, silverplated contacts or with silver inserts. The various parts should be accordingly finished to ensure interchangeability of similar components. The switch blades forming the moving contacts shall be made from tubular section of hard drawn aluminum having suitable dia. and shell thickness. Main contacts shall be self aligning and self cleaning.

4.4.1 These contacts shall be liberally dimensioned so as to withstand safely the highest short circuit currents and over voltages that may be encountered during service at site. The surface of the contacts shall be rendered smooth and silver plated of thickness not less than 25 micros and it should be of high quality and shaped so as to ensure strong wiping and self cleaning operation. In nut shell, the male and female contact assemblies shall be of substantial construction and design of these assemblies shall ensure:-

- a) Electro dynamic withstand ability during short circuits without any risk of repulsion of contacts.
- b) Thermal withstand ability during short circuits.
- c) Constant contact pressure even when the live parts of the insulator unit stacks are subjected to tensile stresses due to linear expansion of connected bus-bar or flexible conductors either because of temperature variation or strong winds.
- d) Wiping action during closing and opening.
- e) Self alignment assuring closing of the switch without minute adjustments.

4.5 POST INSULATORS

4.5.1 The post insulators shall conform to IS-2544-1973 (amended to date) and IS-5350-1971 (amended to date). The insulators selected shall be for use in highly polluted atmosphere and shall be specifically suited to meet the particular requirement of torsion strength and cantilever loads which they will be called upon to resist during service and at the rated voltage. Pressure due to contact shall not be transferred to the insulators after the main blades are fully closed.

- 4.5.2 The Electrical and Mechanical values for the complete stack should in no way be less than those specified in IS for effectively earthed system.

4.6 CONNECTORS

- 4.6.1 Each Isolators shall be provided with appropriate number (6 number minimum) of Bimetallic connectors suitable for Quad/Twin ACSR “Moose- 31.77 mm Φ ” Conductor, as appropriate for a particular application.
- 4.6.2 The maximum length of the jumpers that may be safely connected or any special instructions considered necessary to avoid undue load on the post insulators should be stated by bidders in their offer.

4.7 OPERATING MECHANISM

- 4.7.1 The 245/145/36 kV isolators shall be motor operated and remote controlled from the control room. The motor operated isolators shall also be suitable for local manual operation and shall have controls for electrical operation. The Isolators shall also be provided with manual operating mechanism. These shall be provided with ‘ON’ and OFF’ indicators and padlocking arrangements for locking in both the end positions, to avoid un-intentional operation. The isolating distance should also be visible for Isolators.
- 4.7.2 Operating mechanism shall provide a quick, simple and effective operation. The degree of protection shall be IP-55.
- 4.7.3 The manual operating handles shall be mounted on the base of supporting structure. Guide bearings shall be provided as necessary at a height of 1100 mm above the ground level. All brackets, angles, guides, guide bearings or other member necessary for attaching the operating mechanism and operating handles to the supporting structure and foundations shall be supplied as an integral part of each Isolator. All bearings shall be weather protected by means of covers & grease retainers.

- 4.7.4 The ganging of operating mechanism shall be provided with sufficient adjustment to allow for final alignment of the Isolator blades for simultaneous operation. Adjustable stops shall be provided to prevent over travel in both directions.
- 4.7.5 The Isolator and associated operating mechanism shall be such that Isolator cannot come out of their open or closed positions by gravity, wind pressure, vibrations, reasonable shocks, or accidental touching of connecting rods of the operating mechanism. Isolators shall be capable of resisting in closed position, the dynamic and thermic effects of maximum possible short circuit current at its terminals. They shall be so constructed that they do not open under the influence of the short circuit current. The operating mechanism should be of robust construction, easy to operate by a single person and conveniently located for local operation in the switchyard. All the three phases are required to be opened or closed simultaneously. The mechanism should be adjustable type and shall further be suitable for fitting necessary interlocks and auxiliary switches and shall be provided with terminal boxes for control and supply cables.
- 4.7.6 The operating mechanism electrically operated shall comprise one control cabinet for each isolator equipped with requisite electrical devices and necessary terminal blocks for termination of inter pole wiring.
- 4.7.7 The control cabinet of the mechanism shall be made of 12 SWG (2.64 mm thick) sheet steel duly hot dip galvanized or casting. Hinged door shall be provided with pad locking arrangement. Sloping rain hood shall be provided to cover all sides. 15 mm thick neoprene or better type of gaskets shall be provided to ensure degree of protection of at least IP55 as per IS:2147. The cabinet shall be suitable for mounting on support structure with adjustment for vertical alignment. Details of these arrangements shall be furnished along with the tender or during detailed engineering.
- 4.7.8 DUTY REQUIREMENTS

Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current. The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation for bus transfer current switching capacity as per IEC 62271-102.

4.8 SPACE HEATER & LIGHTING IN THE CUBICLE

- 4.8.1 The cubicle shall be provided with a space heater of suitable rating along with a thermostat. It shall be operated from 230 V Single Phase, 50 Hz supply. There shall be a double pole, MCB whose rating shall match with the space heater.
- 4.8.2 A CFL type lamp of 11 W rating shall also be provided for lighting. 5/15 A, socket of reputed makes along with switch shall also be provided. No fuse shall be acceptable and instead of it, MCBs shall be provided where ever required.

4.9 BEARINGS

- 4.9.1 The design and construction of the various bearings shall embody all the features required to withstand climatic condition specified, so as to ensure dependable and effective operation even after long periods of inactive action of the Isolators. All bearings in the current path, except those specifically designed as 'high pressure contacts, should be shunted by flexible copper conductors of adequate cross-section. Bearing housings should be weather proof. Facilities should be provided for lubrication of the bearings.
- 4.9.2 All bearings shall be filled with first fill of grease and provided with nipples for servicing.
- 4.9.3 Thrust bearing /double roller or ball bearings shall be provided for the rotating Insulator. These shall be protected from the weather by means of covers and grease retainers. Bearing pressure shall be kept low to ensure long life and ease of

operation.

- 4.9.4 All bearings must be of reputed and well known make and shall be subject to the approval of the Employer to its entire satisfaction.

4.10 INTERLOCKS

- 4.10.1 Isolators shall be provided with padlocking facility to lock them in fully open & fully closed positions. Padlocks with keys shall be supplied with Isolators.
- 4.10.2 Isolators shall be provided with electrical as well as mechanical interlocking feature. It should not open when the associated circuit breaker is in closed position. It may be in the form of bolt interlock comprising a coil of latch-in type to lock the Isolator driving shaft and thus prevent Isolator operation in the latch-in condition. It shall be possible to release the latch by energizing the coil when certain preset conditions of the interlocking scheme are fulfilled. Further, a separate bypass switch shall be provided on local cabinet to facilitate emergency manual operation of Isolator. The interlock should of robust design of some reputed 'make' & contained in weather proof & dust tight housing of IP-54.
- 4.10.3 Manual operating mechanism through crank and reduction gear shall be provided for the earth switch. The operation of earth switch will be gang operated. The operation of earth switch shall also be electrically inter-locked with circuit breaker and isolator to prevent closing of earth switch when CB or isolator are closed and vice versa.
- 4.10.4 The individual interlocking arrangement shall be provided and the interlocking coil shall be suitable for continuous operation from DC supply.

4.11 AUXILIARY SWITCHES

- 4.11.1 Isolators shall be provided with 110 V. D.C. auxiliary switches for their remote position indication on control board and for electrical interlocking with other equipment.
- 4.11.2 The switches shall have normally open and normally closed contacts. All contacts should be brought out on terminals including spare ones. The auxiliary switches shall be of robust construction, reputed make and housed in weather-proof and dust tight

covers mounted on the respective operating mechanism. It shall be possible to change normally closed contacts into normally open contacts and vice versa at site. The auxiliary switches shall strictly conform to IS:9921 in all respects. The auxiliary switches & auxiliary circuits shall be capable of carrying current of at least 10 A continuously and breaking of the current equivalent to at least 6A at 110 V DC with circuit time constant not less than 20 ms.

4.12 ISOLATOR MOUNTING STRUCTURE

- 4.12.1 All isolators shall be suitable for mounting on galvanized steel structure of minimum height of 2.5 meters. The mounting structures shall be fabricated out of steel conforming to IS-2062 and designed in accordance IS-808. The structure shall be galvanized as per IS-2633, IS-2629 etc.
- 4.12.2 All Isolators shall be mounted rigidly in an upright position on their own supporting structures and not on the line or bus bar structures. Details of the supporting structures shall be supplied with the bid. The Isolators should have requisite fixing fixtures ready for mounting them and such structures.
- 4.12.3 All the equipment including the Isolators, supporting channels inter connecting pipes for the poles as well as the stacks on the same pole, down pipe, G.I. rods, operating mechanism shall be included in the scope of supply. Provision shall also be made for proper grounding of the down pipe rods when such rod handles are required for manual operation.
- 4.12.4 The vertical down pipe/operating pipe for Isolators shall be 'B' class G.I. Pipes of 32 mm outer dia. (minimum), hot dip Galvanized. The pipe/phase coupling pipe for Isolators shall be 'B' class G.I. Pipe of 19 mm outer dia.(minimum), hot dip galvanized. The base channels for isolator will also be hot dip Galvanized.
- 4.12.5 The frame of each Isolator shall be provided with reliable earthing terminal at two ends for connection to earthing conductor suitable for specified fault current.

Note: All mild steel components shall be properly galvanized as the humidity at site is condensing in nature. On each structure provision shall be made to earth it at two points.

4.13 EARTHING SWITCHES

- 4.13.1** Earthing switch shall be locally/manually operated. It shall be constructional interlocked with the isolator so that the earthing switch can be operated only when the isolator is open and line is de-energized.
- 4.13.2** The switch shall be of the same current carrying capacity as the main blades. Each earthing switch shall be provided with flexible copper strips for connections to ground mat. These blades shall have the same short time current rating as the earth blade.
- 4.13.3** The earthing switch shall be of non-ferrous material and the design shall match the quality with that of the main isolating switch except that high pressure contacts are not required.
- 4.13.4** The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts.
- 4.13.5** The frame of each isolator & earthing switch shall be provided with two reliable earth terminals for connection to the earth mat.
- 4.13.6** Earth switch shall consist of three earthing links per isolator which will normally rest against the frames when the connected isolator is in closed position.
- 4.13.7** Earthing switch shall be capable of discharging trapped charges of the associated line.

4.14 WIRING

- 4.14.1** The auxiliary wiring shall consist of suitable colour/marked P.V.C. (non inflammable) insulated electrolytic copper wires conforming to IS-694 and IS-1554 (Part-1). The control wiring shall be of 2.5 mm² size. The cables for remote operation position indication and interlocking shall be P.V.C. insulated having copper conductors. The control terminal blocks of 1100 V rated shall be of current rating of 45 A.

4.14.2 The internal wiring shall be terminated with solder less crimping type of tinned copper lugs. Not more than two leads shall be terminated in one terminal. Double compression chromium plated cable glands shall be provided. The terminal blocks shall be mounted on the mounting rails in vertical position only, such that sufficient space is available to terminate external cables. At least five spare terminals shall be provided.

4.14.3 A complete wiring diagram of the interlocking circuit and auxiliary switches should be furnished by the bidder.

4.15 DESIGN, MATERIALS AND WORKMANSHIP

4.15.1 The successful bidder shall ensure full responsibility for the co-ordinated and adequate design. All materials used in the construction of the equipment shall be of the appropriate class, well finished and of approved design and make. All similar parts should be accurately finished and interchangeable.

4.15.2 All ferrous parts shall be made of malleable cast iron or cast steel and hot dip galvanized in accordance with IS-2633. Special attention shall be paid to give tropical treatment to all the equipment as it will be subjected during service to extremely severe exposure to atmospheric moisture and to long periods of high temperature. All current carrying parts shall be of non-ferrous metal or alloys and shall be designed to limit sharp points/edges and similar shape faces.

4.15.3 The temperature rise for the various parts shall be as per relevant IS.

4.15.4 Due to condensing type of humidity in Nepal the equipment is very much prone to rust. The manufacture must ensure that galvanized is properly done to mitigate such eventualities.

4.16 TESTS

4.16.1 Each Isolator, earthing switch and Insulator shall strictly comply with the requirements of all the type tests and shall be subjected to all routine and acceptance tests stipulated in the relevant standards IEC 62271-102/IS-9921 (Part-4).

4.17 CABLE GLANDS

4.17.1 Double compression type, chrome plated brass cables glands for terminating multicore control cables shall be provided with the auxiliary switch boxes.

4.18 DRAWING AND LITERATURE

4.18.1 All the dimensioned drawings along with illustrated and descriptive literature for all equipment offered must be submitted after the award of the contract as below: -

- (i) The drawings showing the outline dimensions of the Isolator and isolator with E/S, level adjustment devices & bearing arrangement for rotating post.
- (ii) Drawings showing details of main contacts and jumpering devices.
- (iii) Drawing showing equipment of electrical interlock.
- (iv) Control & wiring diagram of interlocking mechanism (Both Electrical and Mechanical).
- (v) Drawings giving complete dimensional details with make, type, reference catalogue no. and details of Electrical & Mechanical characteristics of the insulators offered for isolators.
- (vi) Detailed Mechanical drawing of driving mechanism, operating pipes and coupling pipes.
 - Foundation drawings of the supporting structures of Isolator.
 - Dimensioned drawing and bill of material for supporting structure.
- (vii) The bidder may submit any other drawings, pamphlets, brochures, leaflets necessary in addition to the drawings stated above for clarification.
- (viii) Complete bill of material shall be given in all the drawings including therein the dimensions, the material used, the No. of such items provided, surface treatment given to the same etc.

- (ix) Considering the above the following drawings are the minimum to be provided with necessary details for isolators and isolators with earth switches.
- General arrangement for isolator and isolator with earth switch.
 - Main contact Assembly
 - Earth Switch Contact Assembly
 - Operating mechanism box for the main switch. Detailed wiring, schematic and general arrangement drawings are to be provided, for both the above switches.
 - Mechanical Interlock between earth switch and main switch.
 - Name Plate details
 - Terminal connector details
 - Details of post type Insulators

4.19 NAME PLATES

4.19.1 Isolators and associated operating devices shall be provided with a name plate which contains the information in accordance with Table-1 of IS:9921 (Part-5)-1985. The Aluminium name plate of 0.56 mm should be with engraved letter size of 2 mm and be anodized with white etched letters and black back ground. The name plate shall also contain the purchase order no. & date, Specification No. and the name of the Employer, client, project, etc. The name plate shall be weather proof and corrosion proof. The name plate shall be visible in the position of normal service & installation.

4.19.2 Typically the name plate should be provided in the following format for the isolator, isolator with earthing switch and for the operating device.

- Manufacturer
- Designation of type
- Serial number
- Rated voltage
- Altitude of operation(m)
- Lightning impulse withstand voltage (kV)
- Normal current (A)

- (viii) Short time withstand current (kA) for 1 Sec.
- (ix) Short circuit making current (kA)
- (x) Auxiliary voltage
- (xi) Mechanical terminal load (N)
- (xii) Total mass (Kg)
- (xiii) Auxiliary motor
 - a) Motor details
 - b) Volts Watts =
 - c) Short time (Operating period) =
 - d) Motor current (A) =

4.20 SPARES

4.20.1 A list of spare part for isolators & isolator with earth switch, and operating mechanism with recommended quantities for five years of normal operation shall be submitted. A spare parts catalogue depicting various parts of the equipment alongwith part number shall be supplied. Unit prices of post insulators, auxiliary switch box for main isolator, fixed contacts assembly and moving blade assembly for electrical interlock & bimetallic connectors etc. must be quoted alongwith recommended spares.

4.21 OPERATING HANDLE

4.23.1 For hand operation of the isolators & isolators with earth switches; the operating handle (galvanized) shall be provided with each isolator & isolator with earth switch. Besides it any other tools & plants required for the safe operation and maintenance of the equipment shall also be supplied by bidder.

4.22 COMPLETENESS

4.22.1 All fittings, apparatus and accessories which may not be specifically mentioned in the specification but which are usual or necessary for the equipment of similar plant, shall be specified and shall be deemed to be included in the specification and shall be furnished by the bidder.

4.23 TECHNICAL PARTICULARS

4.23.1 The isolators and the isolators with earthing switch shall conform to the following technical requirements:-

Since the Switchyards are located at an Altitudes of differently of Baneshwar (1440Mtrs) ,Tumlingtar (440 Mtrs) and Basantapur (2470 Mtrs) above MSL , the equipment shall be suitable for increased insulation level with an Altitude correction factor of 1.2 times the normal values and shall be suitable for operation under prescribed conditions.

Further the equipment being supplied shall be suitable for operation under sub Zero Temp with ICE/Snow considerations .The equipment shall be suitable for working in the temperature variation between (-5 Deg) to (+40 Deg) without reporting any malfunction.

TABLE-4.1

S.No.	Description	Parameter
1.	Rated voltage kV (r.ms)/Highest System Voltage kV	220/245
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Number of poles	3
5.	Installation	Outdoor
	Type	Three phase, centre break, triple pole, single throw, gang operated, with one control cabinet with/without earth switch.

6.	Rated current (Amp.)	TumlingtarSubstation	Basantapur Substation	Baneshwar Substation	Inaruwa Substation
		2500	2500	2500	2500
7.	a) Rated lightning impulse withstand voltage between line terminals and ground [kV(peak)]	1260			
	b) Between terminals with Isolator contacts open [kV(peak)]	1440			
8.	One min. power frequency withstand voltage in kV (rms)				
	a) between line terminals kV (rms) and earth (Kv rms)	552			
	b) Between terminals with isolator contacts open Across the isolating distance kV (rms)	636			
9.	Rated fault current rating for 1 sec (kA)	40			
10	Rated dynamic short circuit current (kA)	100			
11	Temperature rise	As per IS: 9921(part II)-1982			
12	Rated mechanical load	As per IS: 9921/IEC			

13	Operating mechanism of I. Mode of operation of isolator II. Operating motor voltage III. Mode of operation of earthing switch	A.C Motor operated 415V, AC Manual
14	Operating time	12 Sec. or less
15	i) Number of auxiliary contact of each isolator ii) Earth Switch	12NO + 12 NC for Isolator and 2 pairs to make before breakcontact 8 NO + 8 NC for ES
16	Phase to phase spacing	Minimum 4500 mm
17	Metal for rotating blade Material for fixed contact	Aluminium HDE copper
18	D.C. Supply voltage for Interlocks	110 V / 220 V (For Inaruwa Substation)
19	No. of terminal in control cabinet(including inter pole cabinet)	All contacts and control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.
20	Minimum Corona extinction voltage in open and close position (kVrms)	156
21	Maximum RIV for frequency between 0.5 to 2 MHz in close and open position (micro volt)	1000 at 156 kVrms
22	Mechanical Endurance Class	M2 for isolator , M0 for Earth Switch

TABLE-4.2

S.No.	Description	Parameter
1.	Rated voltage kV (r.ms)/highest System Voltage kV	132/145
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Number of poles	3
5.	Installation	Outdoor
	Type	Three phase, centre break, triple pole, single throw, gang operated, with one control cabinet with/without earth switch.
6.	Rated current (Amp.)	1250
7.	Rated lightning impulse withstand voltage	
	a) Between the terminals and ground [Kv(peak)]	780
	b) Between the terminals with contacts open	900
8.	One min. power frequency withstand voltage in kV (rms)	
	a) Across the isolating distance kV (rms)	378
	b) To earth between poles	330
9.	Rated short circuit current rating for 1 sec (kA)	31.5

10.	Rated dynamic short circuit current (kA)	80
11.	Temperature rise	As per IS: 9921(part II)-1982, IEC 694
12.	Rated mechanical load	As per IS: 9921/IEC
13.	Operating mechanism of I. Mode of operation of isolator II. Operating motor voltage III. Mode of operation of earthing switch	A.C Motor operated 415V AC Manual
14.	Operating time	12 Sec. or less
15.	Number of auxiliary contact of each isolator	12NO + 12 NC for Isolator and 2 pairs to make before breakcontact 8 NO + 8 NC for Earth Switch
16.	Phase to phase spacing	Minimum 3000 mm
17.	Metal for rotating blade Material for fixed contact	Aluminium HDE copper
18.	D.C. Supply voltage for Interlocks volts	110 V
19.	No. of terminal in control cabinet(including inter pole cabinet)	All contacts and control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.
20.	Minimum Corona extinction Voltage in open and close position (kVrms)	105
21.	Maximum RIV for frequency	500 at 92 kVrms

	between 0.5 to 2 MHz in close and open position (micro volt)	
22.	Mechanical Endurance Class	M2 for isolator , M0 for Earth Switch

TABLE-4.3

S.No.	Description	Parameter
1.	Rated voltage kV (r.ms)/Highest System Voltage kV	33/36
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Number of poles	3
5.	Installation Type	Outdoor Three phase, centre break, triple pole, single throw, gang operated, with one control cabinet with/without earth switch.
6.	Rated current (Amp.)	600
7.	Rated lightning impulse withstand voltage	
	a) Across isolating distance [kV(peak)]	234
	b) Between terminals and ground	204
8.	One min. power frequency withstand voltage in kV (rms)	
	a) Across the isolating distance kV (rms)	96
	b) Between terminals and	90

	ground	
9.	Short circuit current rating for 1 sec (kA)	25
10.	Rated dynamic short circuit current (kA)	62.5
11.	Temperature rise	As per IS: 9921(part II)-1982,IEC 694
12.	Rated mechanical load	As per IS: 9921/IEC
13.	Operating mechanism of i. Mode of operation of isolator ii. Operating motor voltage iii. Mode of operation of earthing switch	A.CMotor operated 415V AC Manual
14.	Operating time	12 Sec. or less
15.	Number of auxiliary contact of each isolator	10 NO + 10 NC for Isolator and 2 pairs to make before breakcontact 8 NO + 8 NC for Earth Switch
16.	Phase to phase spacing	Minimum 1500 mm
17.	Metal for rotating blade Material for fixed contact	Aluminium HDE Copper
18.	D.C. Supply voltage for Interlocks	110 V
19.	No. of terminal in control cabinet(including inter pole cabinet)	All contacts and control circuits are to be wired up to control cabinet plus 24 spare terminals evenly distributed.

20.	Endurance Class	M2 for isolator and M0 for earth switch
-----	-----------------	---

Package-KC2

Koshi Corridor 220/132/33 kV Substations (Basantapur-Baneshwar-Tumlingtar- Inaruwa Substations)

Part II-Section VI: Employer's Requirements

Section-4

Chapter-5

245/145/36kv SF6 (Gas) Circuit Breakers For Outdoor Application

SECTION 4**CHAPTER – 5****245/145/36kV SF₆ (GAS) CIRCUIT BREAKERS FOR OUTDOOR APPLICATION****CONTENTS**

S.NO	DESCRIPTION	PAGE NO.
5.0	SCOPE	1
5.1	PARTICULARS OF THE SYSTEM	1
5.2	STANDARDS	2
5.3	OUTDOOR CIRCUIT BREAKERS	3
5.4	DESIGN FEATURES	11
5.5	INSULATOR SUPPORTS	13
5.6	CONTROL CONNECTIONS AND WIRING	13
5.7	TERMINAL CONNECTORS	15
5.8	INTERLOCKS	15
5.9	AUXILIARY AND CONTROL EQUIPMENT	15
5.10	NAME, INSTRUCTION PLATES & MARKING	15
5.11	COMPLETENESS OF EQUIPMENT	16
5.12	TESTS	17
5.13	ERECTION TOOLS AND SPECIAL MAINTANCE TOOLS/EQUIPMENT	17
5.14	DRAWINGS, LITERATURE AND INSTRUCTIONS MANUAL	18
5.15	TECHNICAL PARTICULARS	19

SECTION 4

CHAPTER – 5

245/145/36 kV SF₆ (GAS) CIRCUIT BREAKERS FOR OUTDOOR APPLICATION

5.0 SCOPE

- 5.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, transportation upto site, testing & commissioning of the outdoor type 245/145/36 kV SF₆ Gas filled CBs, complete with motor operated spring charged/pneumatic operating mechanism, unitized air compressed system, air receiver, gas monitoring instruments, operating mechanism, terminal connectors, hotdip galvanized supporting structures with foundation bolts/copper piping/connectors/valves, cable glands inter connecting cables complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification.
- 5.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.
- 5.0.3 Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.
- 5.0.4 Components having identical rating shall be interchangeable.
- 5.0.5 The performance of the equipment shall be guaranteed as per **Section-5 – "Guaranteed and Other Technical Particulars"**.

5.1 PARTICULARS OF THE SYSTEM

- 5.1.1 The Circuit Breakers to be provided under the specification are intended to be used on 3 phase, AC, 50 Hz, earthed system. The nominal system voltage and the

corresponding highest system voltage, short time current rating, basic impulse level etc. corresponding to standard values, are given in the technical parameters.

5.2 STANDARDS

5.2.1 All the material and equipment shall comply in every respect with the latest edition of IEC-62271-1,62271-100,62271-110,IEC-60376& IEC-694, IS:13118 or any other equivalent Indian Standards or International Standards. The equipment, material & processes shall confirm to the latest applicable National/International standards as listed hereunder:-

TABLE-5.0

IS:209	Specification for Zinc
IS:694	PVC insulated cables for working voltage upto and including 1100 V.
IS:802	Use of structural steel in Over head Transmission Lines-Code (Part-1/Sec-1) of Practice Part-I: Materials, Loads & Permissible stresses
IS:802	Section 1 : Material & Loads(Part-2/Sec-2) 2 : Permissible stresses
IS:808	Dimensions for Hot Rolled steel Beams, Columns, channel and Angle sections
IS:1363	Hexagonal nuts
IS:1554 (Part-I)	Specification for PVC insulated (Heavy Duty) Electric Cable working voltage upto & including 1100 V.
IS:1852	Rolling & cutting tolerances of hot Rolled steel products.
IS:2016	Plain washers
IS:2062	Structural steel
IS:2071	Methods of High Voltage Testing
IS:2099	Bushings for alternating voltage above 1000 V
IS:2629	Recommended Practice for Hot Dip galvanization for Iron & Steel
IS:2633	Testing of Uniformity of Coating of Zinc coated Articles
IS:2825	Pressure vessels for unit compressor system
IS:3063	Single Coil Rectangular section spring washers for Bolts & Nuts
IS:3716	Application Guide for Insulation coordination

IS:4379	High pressure cylinder for SF ₆ gas
IS:5561	Specification for Electric Power connectors
IS:6639	Hexagonal Bolts for steel structures
IS:6745	Determination of weight of Zinc coating on Zinc coated Iron & steel articles
IS:7285	Seamless manganese steel cylinders for permanent and high pressure liquefiable gases
IS:12063	Classification of Degree of protection provided by Enclosures of Electrical Equipment
IS:13118	Specification for High Voltage alternating Current Circuit Breakers
IEC Pub.No.376	Specifications and acceptance of new sulphurhexafluoride
IEC 60427	Synthetic Testing of High Voltage alternating Current Circuit Breakers
IEC : 694	High Voltage switchgear and control gear
	Electrical Power technical standards of Nepal.

5.3 OUT DOOR CIRCUIT BREAKERS

5.3.1 The 245/145/33 kV circuit breakers offered shall be SF₆ gas filled suitable for outdoor installation under the specified climatic conditions in Nepal. The circuit breakers shall be operated by either pneumatic mechanism or spring charged mechanism. The breakers shall be supplied as complete three identical single phase for 245 kV level and three phase , three pole Gang operated unit for 145kV,36kV level with all connectors, operating mechanism, control cabinets, piping, inter pole cable and cable accessories, pressure gauges, density monitors, the auxiliary equipment and all internal wiring installed and terminated in the apparatus box/switch cubicle for ready installation at site on receipt at destination. All equipment connections and cabling shall be designed and arranged so as to minimize the risk of fire and any damage that may be caused in the event of fire.

5.3.2 The frames of equipments shall be provided with a reliable earthing terminal for specified fault current. The diameter of clamping screw or bolt shall be at least 12 mm. The circuit breakers shall provide rapid and smooth interruption of current under all conditions completely suppressing undesirable phenomenon even under

the most severe and persistent short circuit conditions when interrupting small current including leading or lagging reactive currents.

5.3.3 SF₆ Gas Filled Circuit Breakers

5.3.3.1 Construction Features

245 kV SF₆ Gas filled circuit breakers shall consist of three identical singlephase units with independent operating mechanism units using SF₆ gas confirming to IEC-376 at single pressure and puffer type interrupting arrangement. 245 kV circuit breakers are meant for single pole re-closure. The interrupting chambers of poles shall be electrically connected and breaker shall have common operating device for 3 poles. SF₆ gas confirming to IEC-376 shall be used in the interrupting units at such a pressure that the breaker does not require any complex auxiliary circuit for pressure and temperature control, special heating system and special compressors etc. Suitable gas filling and pressure monitoring arrangements alongwith the safety plug shall be provided for each interrupting unit sealed. Pole discrepancy (special features) including relay timers etc. shall be provided to minimize pole discrepancy & to avoid single phasing shall be provided.

5.3.3.2 245 kV circuit breakers one central control cabinet for each breaker and one control box for each pole and 145kV, 36kV breakers have one central control cabinet. Breakers shall be provided with all the required electrical devices mounted therein and the necessary terminal blocks for termination of inter pole wiring. The necessary interpole cabling at site shall be done by the contractor based on the schematic wiring diagram and termination schedule to be supplied by the successful bidder. Terminal shall be of stud type with two nuts.

5.3.3.3 Insulation of phase to earth of the circuit breaker shall be independent of SF₆ gas pressure. Suitable measures shall be adopted in the individual interrupting unit to achieve requisite degree of dryness of SF₆ gas and to absorb its decomposition products. SF₆ gas filling should not develop dangerous over-pressure inside the interrupting unit within the temperature rise limits to be encountered in service.

SF₆ gas filled in the interrupting units should work in the closed circuit without causing any exhaust to the open air after performing opening or closing operations. Time period in terms of number of operations on fault, number of years of normal service after which SF₆ gas filling needs replacement shall be stated in the tender. SF₆ gas duly filled in each circuit breaker pole shall be included in the scope of supply and the complete specifications of the SF₆ gas proposed to be utilized shall be stated in the tender. SF₆ gas filled cylinder should be adequate for filling gas at least in 3 No. complete breakers. The equipment for filling and detecting leakage of SF₆ gas for proper maintenance of circuit breaker shall be quoted in the schedule of requirement. The same shall also be taken into consideration for bid evaluation. In case purging of breaker before filling with SF₆ gas is desirable, the required equipment shall also be offered as a part of the maintenance equipment. The equipment shall be complete with necessary pipes, couplings, flexible tubes and valves for coupling to the circuit breaker. An operation counter shall also be provided in the Mechanism Box. SF₆ (gas) pressure loss in the breaker shall not be more than 1% per year under normal operating conditions.

5.3.3.4 Sufficient SF₆ gas shall be provided to fill all the circuit breakers installed. In addition to this 20% of the total gas requirement shall be supplied in separate cylinders as spare requirement. The pressure loss in the breaker shall not be more than 1% per year under normal operating conditions.

5.3.3.6 Circuit Breaker Operation

5.3.3.6.1 Each circuit breaker shall be remote controlled from the control room but provision shall be made for local electrical and manual spring charged motor operation also. For remote and local electrical operation, 110 Volts D.C. shall be available and the electrically operating coils (closing and shunt tripping) shall be so designed that they operate the circuit breaker satisfactorily within a control voltage variation of 70% to 110% of the normal for shunt trip coils and 85% - 110% of the normal for closing coils

5.3.3.6.2 Duty Requirements

The Circuit breaker shall be capable of performing their duties without opening resistors. The circuit breaker shall meet the duty requirements for any type of fault or fault location also for line switching when used on a 245/145/36 kV effectively grounded system , and perform make and break operations as per the stipulated duty cycles satisfactorily. The breaker shall be capable of interrupting the steady state and transient magnetizing current corresponding of power transformers and line/cable charging currents.

5.3.3.7 Spring Charged Mechanism

5.3.3.7.1 Breaker shall be provided with spring operation mechanism. Spring operated mechanism shall be complete with motor. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism, a complete operating unit shall be provided. On availability of power supply to the motor, a continuous sequence of the closing and opening operation shall be possible with the energy contained in the operating mechanism. Breaker operation shall be independent of the motor which shall be used for charging the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it requires not more than 30 sec for full charging of the closing spring. Closing action of circuit breaker shall compress the opening spring ready for tripping. Provision shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position. The spring operating mechanism shall have adequate energy stored in the operating spring to close & latch to Circuit Breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is desired from the operating mechanism.

5.3.3.7.2 Two independent trip coils and one closing coil shall be provided on each pole of 245 kV & 145 kV C.B. and one trip coil and one closing coil for 36kV level C.B from reliability consideration. It is intended to have continuous type of pre-closing and post-closing trip circuit supervision through auxiliary relays for each trip coil for this purpose. The trip coils shall, therefore, be designed keeping in view this requirement. It shall be possible to lock out the circuit breaker operating marshalling box in the open as well as close position of the breaker. The operating mechanism shall be trip free as per IEC-62271-1, 62271-100/IS: 13118 and shall have electrically operated anti pumping features. A mechanical position indicator for ON/OFF condition of the circuit breaker shall also be provided on each breaker/pole.

Handle shall be provided for hand charging the closing spring with each breaker.

5.3.3.8 Pneumatic Mechanism

5.3.3.8.1 Each breaker shall have its own unit compressor system for supply of compressed air in case of pneumatic operated breaker.

5.3.3.8.2 The pneumatic operating mechanism shall consist of pilot or auxiliary and main valves for closing and opening operations of the circuit breaker. The pilot valves shall be suitable for operations either electrically by electrical solenoids or by local control push buttons. The accessories shall include an intake filter stop valve, drain valve, breaker position indicator, auxiliary contacts, space heater, a set of terminal blocks etc.

5.3.3.8.3 The compressed air stored in the local air receiver shall be sufficient to carry out at least 2 CO operations and the charging time to restore the pressure shall be sufficiently short to complete the rated operating sequence viz. O-0.3 Sec. CO-3 min.-CO in respect of circuit breakers. The operating mechanism shall be suitable for the rated operating sequence viz. O-0.3 sec.-CO-3min-CO with minimum auto closure lock out setting.

5.3.3.8.4 The compressed air mechanism shall be capable of operating the circuit breaker under all duty conditions with the air pressure immediately before operation between 85% and 105% of the rated supply pressure. The make/break time at this supply pressure shall not exceed the specified make/break time within any value of trip coil supply voltage as specified. The operating mechanism shall be such that it shall not be possible for any leakage of air from the pneumatic equipment to build up a pressure in the closing cylinder.

5.3.3.8.5 The compressed air cabinet and connections especially those between ceramic and metallic component shall be completely air tight for pressure upto 1.5 times the rated pressure for breaker operation. Any gasket used for these joints shall have a long life under climatic conditions specified. Necessary arrangements for draining the condensed moisture from the lower points in the pneumatic system shall be incorporated.

5.3.3.8.6 The unit compressor system of the breaker shall consist of one compressor which shall charge the local air receiver vessel of each of the three poles of the SF₆ circuit breaker either directly or through main receiver vessel located outdoor near the breaker. The compressor shall be provided with static absorption filter of automatic regenerating type, to ensure dry air. The compressor shall be capable of charging the pressure from atmospheric pressure in short time. The bidder shall indicate clearly in the tender the charging time of the receivers starting from atmospheric conditions. All pressure vessels shall be equipped with safety valves.

5.3.3.9 Marshalling Box

5.3.3.9.1 All the central equipment immediately connected with the operation of 245 kV circuit breaker shall be an outdoor type, weather/vermin and splash proof, having suitable number of hinged doors so as to afford easy access for all equipments mounted inside.

5.3.3.9.2 Marshalling box shall be fabricated from heavy gauge M.S. sheet at least 3 mm thick. The locking arrangement with lock(s) shall be provided on the front door to

check unauthorized operation. The cubicle shall be hot dip galvanized construction so as to be suitable for use under tropical conditions at site. The cabinet shall meet IP-55 requirement & contain the following equipments in addition to any other equipment required for satisfactory operation of the circuit breakers:-

1. Control selector switch for local/remote electrical operation with a neutral position.
2. Control switch for local electrical operation.
3. Control knob for local operation of motor operated spring charged device in the absence of DC supply.
4. Pressure switch with alarm contacts for signaling high/low pressure for SF₆.
5. Relief and drain cock.
6. Circuit breaker mechanical ON/OFF position indicator.
7. Anti pumping relay.
8. Trip and closing coils.
9. Indicating lamps for various operations.
10. Space heater complete with a MCB and a thermostat to prevent moisture condensation.
11. Safety valves.
12. MCBs for controlling AC & DC supplies.
13. 5/15 A, Power Socket with MCB.
14. 11 W, CFL with a MCB.
15. Double compression, chrome plated, (heavy duty) brass, Cable glands for various power and control cables.
16. Operation counter.
17. Rating and diagram - plate incorporating the year of manufacture, specification No., Purchase Order Number and date, name of client, consultant, customer, project etc.

18. Any other item to complete the equipment.
19. All fixtures, nuts & bolts etc. for mounting the apparatus box either on the circuit breaker supporting structure or on a nearby plinth shall be supplied. Apparatus box shall be equipped with requisite number of cable glands for power and control cables.
20. Pole discrepancy relay

Note: The marshalling Box should be located at convenient height for the easy access & operations.

5.3.3.10 Auxiliary Switches

Besides the auxiliary switches utilized by the manufacturer in the circuit breaker control/trip supervision relays, at least 10 numbers additional each of normally open and normal closed contacts shall be provided.

5.3.3.11 Mountings

5.3.3.11.1 The circuit breakers shall be self supporting type. However, if necessary, for the purpose of obtaining minimum ground clearance of 2.5 meter from the nearest live part of the circuit breakers, the same shall be mounted on raised steel structures, which shall be included in the scope of supply. The bidder shall supply the following information and data for design/ checking of foundations in addition to furnishing detailed drawings of foundations showing arrangement of reinforcement etc.

1. Dead weight per pole and of complete circuit breaker.
2. Static bending moments about the foot of each pole and for complete circuit breaker.
3. Static shear force at the foot of each pole and for complete circuit breaker.
4. Impact loading, if any, during operation of breaker.

5.3.3.11.2 The above data shall represent static reactions for the worst wind or operation conditions. Necessary connecting materials such as clamps, bolts, nuts,

washers etc. and fixing bolts for mounting the equipment on the supporting structures, wherever required, shall be supplied.

5.4 DESIGN FEATURES

5.4.1 Contact System

5.4.1.1 The design of contact system of the circuit breakers shall be such to provide easy access to the contacts system while undertaking maintenance and replacement jobs. Auxiliary arcing contacts may be provided to protect the main contacts from damage during circuit breaker operation. Main contacts shall be the first to open and last to close so that contact burning and wear are the least.

5.4.1.2 In the event of leakage of SF₆ gas to a value which cannot withstand dielectric stresses specified in the open condition, it may be clearly stated whether the contacts will remain in the open condition or self close.

5.4.1.3 Main contacts shall have ample area and contact pressure for carrying the rated current and short time rated current without excessive temperature rise which may cause pitting or welding.

5.4.2 Temperature Rise

The maximum temperature and temperature rise attained by various parts of circuit breaker, when in service, under continuous full load conditions and exposed continuously to the direct rays of the sun and air shall not exceed the permissible limits specified in the IEC-62271-1, 62271-100/IS-13118.

5.4.3 Recovery Voltage & Power Factor

The circuit breaker shall be capable of interrupting rated power with recovery voltage equal to the rated maximum line to line service voltage at rated frequency and at a power factor not exceeding 0.15.

5.4.4 Asynchronous Switching

The breaker shall be capable of satisfactory operation even under conditions of phase opposition that may rise due to faulty synchronizing. The maximum capacity/power

which the breakers can satisfactorily interrupt under phase opposition shall be stated in the tender.

5.4.5 RESTRIKING VOLTAGE

5.4.5.1 Capability of the breaker for interrupting at different frequencies shall be indicated in the tender or shall be furnished during detailed engineering. The complete data for the frequency, amplitude factor etc., for the rate of rise of restriking voltage shall be furnished in the tender as required as per latest edition of IEC-62271-1, 62271-100/IS:13118.

5.4.5.2 The measures adopted for ensuring proper operation at high rate of rise of restriking voltage and for limiting the actual voltage values across the breaker poles shall be described in the tender. The type, characteristics and rating of the resistor used, if any, to shunt the breaking contacts and of the auxiliary switching devices used for interrupting the resistor current shall be clearly stated.

5.4.6 LINE CHARGING CURRENTS INTERRUPTING, CABLE CHARGING CURRENT BREAKING & SHUNT CAPACITOR BANK SWITCHING CAPACITY

5.4.6.1 The circuit breaker shall be designed so as to be capable of interrupting line charging, cable charging and shunt capacitor bank switching currents of values not less than those given in IS-13118 (higher values preferred) without undue rise in the voltage on the supply side and without any re-strike and without showing signs of undue strains. The guaranteed over voltages which shall not be exceeded while interrupting the specified currents shall be stated in the tender.

5.4.6.2 The expected over voltage caused while interrupting the above charging currents shall be provided.

5.4.7 TRANSFORMER CHARGING CURRENT BREAKING CAPACITY

5.4.7.1 The breakers shall be capable of interrupting inductive currents, such as those occurring while switching off unloaded transformers, without giving rise to undue over voltages and without restrike. The maximum over voltage value which will not be exceeded under such conditions shall be stated in the tender.

5.4.7.2 The offered SF₆ breaker shall be suitable for switching off unloaded (3 Nos. 33.33 MVA Single Phase Auto Transformers) 100 MVA, 245/145/36 kV ONAN/ONAF/OFAF Transformer on HV & LV sides.

5.4.8 BREAKING CAPACITY FOR KILOMETRIC FAULT

The interrupting capacity of the breaker for kilometric faults (short line faults) shall be stated in the tender. The details of test conducted for ascertaining the capabilities of the breaker under kilometric faults conditions shall also be stated in the tender.

5.4.9 AUTOMATIC RAPID RECLOSING

245kV circuit breaker shall be suitable for Single pole auto reclosing and 145kV and 36kV breakers shall be suitable for 3 phase auto reclosing.

5.5 INSULATOR SUPPORTS

5.5.1 The insulation level of the external insulator support is given in technical particulars and shall be suitable for installation in moderately contaminated atmosphere with medium temperature and condensing type humidity. The porcelain used shall be homogeneous, and free from cavities or other flaws. These shall be designed to have ample insulation, mechanical strength and rigidity for satisfactory operation under conditions specified above.

5.5.2 All bushings of identical ratings shall be interchangeable. The puncture strength of the bushing shall be entirely free from rapid disturbances when operating at a voltage upto 10% above rated voltage and shall also be free from external and internal corona.

5.6 CONTROL CONNECTIONS AND WIRING

5.6.1 All connections and wiring shall be suitable for tropical atmosphere. Apparatus/marshalling box connections shall be insulated and shall be neatly and

securely fixed to the panel. All box wiring shall be of a suitable self- extinguishing type using FRLS cables and held in position by non-rusting metal cleats.

- 5.6.2 Where 400 volts connections are taken through junction boxes or marshalling boxes, they shall be adequately screened and "415 Volts- DANGER" notices must be affixed to the outside of the junction boxes or marshalling boxes.
- 5.6.3 All box wiring shall be in accordance with relevant IS. All wires on apparatus box and all multicore cables shall have ferrules which shall bear the same number on both ends. Ferrules shall be of white insulating materials and shall be provided with glossy finish to prevent adhesion. They shall be clearly and durably marked in black and shall not be affected by dampness or Sun.
- 5.6.4 Ferrule numbering shall be in accordance with relevant IS. The same ferrule number shall not be used on wires in different circuits on the same apparatus box.
- 5.6.5 Wiring shall in general be accommodated on the sides of the box and the wires for each circuit shall be separately grouped.
- 5.6.6 Where equipment/components are mounted in the marshalling box, the metal cases shall be separately earthed by means of copper wires or strips having adequate cross-section, typically of 25x6 mm² copper strip.
- 5.6.7 Multi core cables shall be so bound that each wire may be traced without difficulty to its cable and terminal connection. The internal wiring in the Marshalling Box shall be with stranded copper tinned wire.
- 5.6.8 All terminal boards shall be suitably mounted to give easy access to terminations and to enable ferrule number to be read without difficulty. Terminal board rows shall be spaced adequately and not less than 100 mm apart to permit convenient access to wires terminators. Terminal boards shall have pairs of terminals for incoming/outgoing wires. Insulating barriers shall be provided between adjacent connections. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals. 20% spare terminals shall be provided.

5.6.9 Instead of fuses, MCB's shall be provided.

5.7 TERMINAL CONNECTORS

5.7.1 Bimetallic terminal connectors suitable for Quad/Twin "ACSR Moose- 31.77 mm Φ " conductor per phase as per requirement shall be supplied. Each terminal connector shall be suitable to receive horizontal and vertical connections of the transmission conductor or station bus bars.

5.7.2 Each circuit breaker pole & control cabinet shall be provided with required number of grounding terminals and clamps for receiving ground connections.

5.8 INTERLOCKS

5.8.1 Necessary interlocks to prevent the closing or opening of the breaker under low gas pressure, and devices for initiating alarm shall be provided. Before the breaker trip circuit is blocked, it should be got automatically tripped, and should stay so safely.

5.9 AUXILIARY AND CONTROL EQUIPMENT

5.9.1 The rated continuous current of auxiliary and control equipment shall be 10 A with temperature rise not exceeding the limits given in IEC-640 or equivalent ISS. The rated short time withstand current shall be 100 A for duration of 30 ms and rated insulation level of 2 kV A.C. for 1 minute.

5.9.2 Auxiliary contacts shall be suitable of making & breaking at least 2 A at 110V DC with a circuit time constant of not less than 20 ms.

5.10 NAME, INSTRUCTION PLATES & MARKING

5.10.1 All name plates, instructions plates, warning signs and any marking whatsoever on the equipment and its parts and accessories should be in English Language. The name plate information shall be as given in Table XI of IS: 13118. The name plate shall have letter height of 4 mm & line 0.3 mm thick and the following data be engraved.

- a) Name of Manufacturer
- b) Type of Breaker
- c) Month, year of Manufacturer.
- d) Rated voltage
- e) Rated Current
- f) Lightning Impulse withstand voltage
- g) Short circuit breaking current along with duration
- h) Operation sequence
- i) Gas Pressure
- j) Closing & Trip coil DC Control voltage
- k) Spring charging motor voltage, & wattage
- l) Heater supply voltage
- m) Weight of circuit breaker
- n) Frequency
- o) Purchaser's Name & Purchaser order No.
- p) Altitude of operation

5.10.2 In order to facilitate sorting and erection at site, every part of the plant and equipment shall be suitably marked. These markings shall be in conformity with those given on the assembly drawings.

5.11 COMPLETENESS OF EQUIPMENT

5.11.1 Any fittings, accessories or apparatus which may not have been specifically mentioned in this specification but which are usually necessary for the satisfactory operation of the equipment shall be deemed to have been included in this specification. All foundation bolts shall be included in the scope of supply. Earthquake dampers, if necessary shall also be provided on the equipment without any extra cost.

5.12 TESTS

5.12.1 Latest Type Test Reports of the equipments and components shall be submitted and shall be subjected to routine tests according to relevant standards and such other tests including type, acceptance tests as may be required to ensure that all equipment and components are satisfactory and in accordance with the specification. No equipment shall be dispatched from the manufacturer's works before the relevant tests reports have been approved by the purchaser.

5.12.3 Additional Tests :

1. Speed curves for each breaker shall be obtained by a suitable operation analyzer/travel recorder to ascertain breaker contact movement during opening, closing, auto reclosing and trip free operation under normal and limiting operating conditions (control voltage, pneumatic/hydraulic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. this test shall also be performed at site.
2. Measurement of dynamic contact resistance measurement for arcing and main contacts shall be performed. Signature of dynamic contact resistance measurements shall be taken as reference for comparing the same during operation and maintenance in order to ascertain the healthiness of contact.

5.13 ERECTION TOOLS AND SPECIAL MAINTANCE TOOLS/EQUIPMENT

5.13.1 The bidder shall separately quote for a set of tools required for initial erection and subsequent maintenance and special tests for the circuit breakers as called for in the schedule of prices.

5.13.2 The brief detail of maintenance tools/equipments is given as under and one set shall be supplied for each substation under the Contract. Necessary coverings and instructions for safe keeping of these equipments over long periods shall be supplied.

5.13.3 SF₆ GAS FILLING AND EVACUATING EQUIPMENT (PORTABLE)

The capacity of this plant shall be such that it shall not take appreciable time for filling or evacuation of breaker. The required vacuum for complete evacuation shall be attained with the help of this plant.

The SF₆ gas shall comply with IEC 60376, 60376A and 60376B and shall be suitable in all respects for use in the switchgear under the operating conditions.

The high pressure cylinders in which the SF₆ gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations.

SF₆ gas shall be tested for purity, dew point, air, hydrolysable fluorides and water content as per IEC 60376, 60376A and 60376B and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF₆ gas in stipulated copies as indicated in Chapter-GTR. Gas bottles should be tested for leakage during receipt at site.

5.13.4 SF₆ GAS LEAK DETECTOR

The SF₆ gas leak detector shall meet the following requirements:

- (a) The detector shall be free from induced voltage effects.
- (b) The sending probe shall be such that it can reach all the points on the breakers where leakage is to be sensed.

5.14 DRAWINGS, LITERATURE AND INSTRUCTIONS MANUAL

5.14.1 The bidder should submit with his tender dimensioned drawings of the equipment offered along with illustrate and descriptive literature.

5.14.2 Further the successful bidder shall furnish 6 prints of the following drawing for each type of breaker for approval of the client

- a) General out line drawings showing dimensions, front and side elevations and plan of CB along with control panel.
- b) Sectional view drawings.
- c) Mounting details.

- d) Assembly & subassembly of the breaker arcing chamber, contacts operating mechanism etc.
- e) Wiring diagram showing local and remote scheme of breaker including alarms indicating devices, instruments etc.
- f) Foundation plane indicating weights of various components and impact loading.

5.14.3 After the approval of drawing by the client, the contractor shall submit 6 (Six) prints of approved drawings.

5.15 TECHNICAL PARTICULARS

TABLE-5.1

S.No	Parameters/Standards	For 220 kV			
1.	Rated Voltage (kV rms)	220/245			
2.	Rated frequency (Hz)	50			
3.	System neutral earthing	Solidly Earthed			
4.	Type of arc quenching medium	SF ₆ (Gas)			
5.	Number of poles	1 pole/phase			
6.	Rated normal current (A)	Tumlingtar Substation	Inaruwas Substation	Basantapur Substation	Baneshwar Substation
		2500	2500	2500	2500
7.	Installation	Outdoor			
8.	Rated short circuit current breaking capacity at rated voltage (kA rms)	40			
9.	Rated short circuit making current (kA rms)	100			
10.	Rated short circuit current duration (seconds)	1			
11.	First pole to clear factor	1.3			
12.	a) Total break time for any current upto the rated breaking current with limiting	65			

S.No	Parameters/Standards	For 220 kV
	conditions of operating & quenching media pressure (ms)	
	b) Rated break time(ms)	60
13.	Closing time (ms)	100
14.	Standard value of rated transient recovery voltage for terminal fault	As per IEC
15.	Rated operating duty cycle	0-0.3 sec-CO-3 Min-CO
16.	Auto reclosing	Single phase & Three phase auto reclosing.
17.	Rated insulation level	
	a) 1.2/50 micro second lightning impulse withstand voltage between line terminals and ground between terminals with contact open	1260
	b) One minute power frequency withstand voltage between line terminals and ground and ground between terminals with contact open (kV rms)	552
18.	Minimum corona extinction voltage in open and close position (kV rms)	156
19.	Maximum radio interference voltage for frequency between 0.5 to 2 mhz in open and close position (micro volt)	1000 at 156 kV rms
20.	Maximum line charging current (rms)	125 Amps
21.	Rated cable charging breaking current capacity (rms)	250 Amps
22.	Difference in instants of closing/opening of	

S.No	Parameters/Standards	For 220 kV
	contacts	
	a) Within a pole(ms)	2.5
	b) Between poles for opening(ms)	3.3
	c) Between poles for closing(ms)	5
23.	Maximum noise level upto 50 m distance from the base of CB (dB)	140
24..	Temperature rise	As per limits specified in IEC
25.	Set of trip coils	2
26.	Operating mechanism	
	a) Type	Spring/Pneumatic
	b) Charging	Motor charging & manual charging
	c) Max. actuating force required for manual charging of spring	Not to exceed 250 N
	d) Supply voltage	230V, 50 Hz, AC supply
27.	Permissible supply tolerance variation in case of motor charging	70%-110% of rated supply
28.	a) Type of tripping	Trip free
	b) No. of Auxiliary contacts	10 No. and 10 NC on each pole
	c) Number of auxiliary contacts (Over and above for Control/Supervision)	10NO & 10 NC
	d) Auxiliary contacts continuous current rating	10 A
	e) Auxiliary contacts breaking capacity	2 A
29.	Minimum Creepage distance (mm)	6125+20%
30.	Control circuit voltage	110V DC / 220 V DC(Inaruwa Substation)

S.No	Parameters/Standards	For 220 kV
31.	Maximum corona extinction voltage	156 kV
32.	Circuit breaker class	C2, M2 as per IEC 62271-100
33.	CLEARANCES	
a	Phase to Phase spacing in the switchyard i.e. Available interpole spacing for breaker (mm)	4500

TABLE-5.2

S.No	Parameters/Standards	For 132 kV
1.	Rated Voltage (kV rms)	132/145
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Type of arc quenching medium	SF ₆ (Gas)
5.	Number of poles	1 pole/phase
6.	Rated normal current (A)	1250
7.	Installation	Outdoor
8.	Rated short circuit current breaking capacity at rated voltage (kA rms)	31.5
9.	Rated short circuit making current (kA rms)	78.5
10.	Rated short circuit current duration (seconds)	1
11.	First pole to clear factor	1.3
12.	a) Total break time for any current upto the rated breaking current with limiting conditions of operating & quenching media pressure (ms)	65

S.No	Parameters/Standards	For 132 kV
	b) Rated Break time (ms)	60
13.	Closing time (ms)	100
14.	Standard value of rated transient recovery voltage for terminal fault	As per IEC
15.	Rated operating duty cycle	0-0.3 sec-CO-3 Min-CO
16.	Auto reclosing	Three phase auto reclosing.
17.	Rated insulation level	
	a) 1.2/50 micro second lightning impulse withstand voltage between line terminals and ground between terminals with contact open	780
	b) One minute power frequency withstand voltage between line terminals and ground and ground between terminals with contact open (kV rms)	330
18.	Minimum corona extinction voltage in open and close position (kV rms)	105
19.	Maximum radio interference voltage for frequency between 0.5 to 2 MHz in open and close position (micro volt)	500 at 92 kV rms
20.	Maximum line charging current (rms)	125 Amps

S.No	Parameters/Standards	For 132 kV
21.	Rated cable charging breaking current capacity (rms)	160 Amps
22.	Difference in instants of closing/opening of contacts <ul style="list-style-type: none"> a) Within a pole(ms) b) Between poles for opening(ms) c) Between poles for closing(ms) 	2.5 3.3 5
23.	Maximum noise level up to 50 m distance from the base of CB (dB)	140
24.	Temperature rise	As per limits specified in IEC
25.	Set of trip coils	2
26.	Operating mechanism <ul style="list-style-type: none"> a) Type b) Charging c) Max. actuating force required for manual charging of spring d) Supply voltage 	Spring/Pneumatic Motor charging & manual charging Not to exceed 250 N 230V, 50 Hz, AC supply
27.	Permissible supply tolerance variation in case of motor charging	70%-110% of rated supply
28.	a) Type of tripping	Trip free
	b) No. of Auxiliary contacts	10 No. and 10 NC on each pole
	c) Number of auxiliary contacts (Over and above for Control/Supervision)	10NO & 10 NC
29.	Minimum Creepage distance (mm)	3625+20%

S.No	Parameters/Standards	For 132 kV
30.	Control circuit voltage	110V DC
31.	Circuit breaker class	C2, M2 as per IEC 62271-100
32.	CLEARANCES	
a)	Phase to Phase spacing in the switchyard i.e. available interpole spacing for breaker (mm)	3000

TABLE-5.3

S.No	Parameters/Standards	For 33kV
1.	Rated Voltage (kV rms)	33/36
2.	Rated frequency (Hz)	50
3.	System neutral earthing	Solidly Earthed
4.	Type of arc quenching medium	Vacuum/SF ₆ (Gas)
5.	Number of poles	3
6.	Rated normal current (A)	600 A
7.	Installation	Outdoor
8.	Rated short circuit current breaking capacity at rated voltage (kA rms)	25
9.	Rated short circuit making current (kA rms)	62.5
10.	Rated short circuit current duration (seconds)	3 sec
12.	a) Total break time for any current upto the rated breaking current with limiting conditions of operating & quenching	105

S.No	Parameters/Standards	For 33kV
	media pressure (ms). b) Rated break time (ms)	100
13.	Closing time (ms)	100
14.	Standard value of rated transient recovery voltage for terminal fault	As per IEC
15.	Rated operating duty cycle	0-0.3 sec-CO-3 Min-CO
17.	Rated insulation level	
	a) 1.2/50 micro second lightning impulse withstand voltage between line terminals and ground between terminals with contact open	204
	b) One minute power frequency withstand voltage between line terminals and ground and ground between terminals with contact open (kV rms)	84
18.	Minimum corona extinction voltage in open and close position (kV rms)	NA
19.	Maximum radio interference voltage for frequency between 0.5 to 2 MHz in open and close position (micro volt)	NA
20.	Maximum line charging current (rms)	10 Amps

S.No	Parameters/Standards	For 33kV
21.	Rated cable charging breaking current capacity (rms)	50 Amps
22.	Difference in instants of closing/opening of contacts a) Within a pole(ms) b) Between poles for opening(ms) c) Between poles for closing(ms)	NA
23.	Maximum noise level up to 50 m distance from the base of CB (dB)	140
24.	Temperature rise	As per limits specified in IEC
25.	Set of trip coils	1
26.	Operating mechanism	
	a) Type	Spring
	b) Charging	Motor charging & manual charging
	c) Max. actuating force required for manual charging of spring	Not to exceed 250 N
	d) Supply voltage	230V, 50 Hz, AC supply
27.	Permissible supply tolerance variation in case of motor charging	70%-110% of rated supply
28.	a) Type of tripping	Trip free
	b) No. of Auxiliary contacts	8 NO. and 8 NC
	c) Number of auxiliary contacts (Over and above for Control/Supervision)	10 NO & 10 NC
29.	Minimum Creepage distance (mm)	900+20%
30.	Control circuit voltage	110V DC
31.	Circuit breaker class	C2, M2 as per IEC 62271-100

S.No	Parameters/Standards	For 33kV
32.	CLERANCES	
a)	Phase to Phase spacing in the switchyard i.e. available interpole spacing for breaker (mm)	1500

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-6 **Power Transformers**

SECTION 4
CHAPTER – 6
POWER TRANSFORMERS
CONTENTS

S.NO	DESCRIPTION	PAGE NO
6.0	SCOPE	1
6.1	INTRODUCTION	2
6.2	SPECIFIC TECHNICAL REQUIREMENTS (STANDARD CONDITIONS)	2
6.3	PERFORMANCE	14
6.4	AUXILIARY POWER SUPPLIES	15
6.5	DRAWINGS INCORPORATING THE FOLLOWING PARTICULARS SHALL BE SUBMITTED WITH THE BID	16
6.6	MISCELLANEOUS	16
6.7	PARALLEL OPERATION	16
6.8	NAME/RATING PLATE	16
6.9	STANDARDS & CODES	16
6.10	GENERAL DESIGN CONSTRUCTIONAL FEATURES	18
6.11	PAINTING	19
6.12	DETAILED DESCRIPTION	19
6.13	TANK	19
6.14	TANK COVER	21
6.15	CONSERVATOR TANK	21
6.16	UNDER CARRIAGE	22
6.17	CORE	23
6.18	INTERNAL EARTHING	25
6.19	WINDING	26
6.20	INSULATING OIL	27
6.21	VALVES	28
6.22	BUSHING	29

6.23	COOLING ARRANGEMENTS	30
6.24	MOTORS	31
6.25	COOLER CONTROL	32
6.26	MARSHALLING BOX AND MAIN CONTROL PANEL	33
6.27	ON LOAD TAP CHANGER (OLTC)	35
6.28	AUTOMATIC VOLTAGE CONTROL	40
6.29	VOLTAGE REGULATING RELAYS	41
6.30	ON-LINE DISSOLVED GAS ANALYSIS (DGA) & MOISTURE METER	42
6.31	ANTI-EARTHQUAKE CLAMPING DEVICE	43
6.32	FITTINGS	43
6.33	CONTROL CONNECTIONS, ALARMS AND WIRING TERMINAL, BOARD AND FUSES	47
6.34	RADIO INTERFERENCE AND NOISE LEVEL	50
6.35	NITROGEN INJECTION FIRE PROTECTION CUM EXTINGUISHING SYSTEM (NIFPES) FOR 33.3 MVA AUTO AND 30 MVA POWER TRANSFORMER	51
6.36	TESTS	57
6.37	TEST WAIVER, PROCEDURES AND COSTS	59
6.38	STAGE INSPECTION	59
6.39	TEST ON ASSOCIATED EQUIPMENT	61
6.40	SEQUENCE OF TESTING ON ASSEMBLED TRANSFORMER	62
6.41	WITNESSING OF TESTS AND EXCESSIVE LOSSES	62
6.42	CAPITALISATION OF LOSSES AND LIQUIDATED DAMAGES FOR EXCESSIVE LOSSES	62
6.43	REJECTION	63
6.44	DRAWINGS & INSTRUCTIONS MANUAL	64
6.45	CENTRE OF GRAVITY	66
6.46	TOOLS & TACKLES	66
6.47	GUARANTEED TECHNICAL PARTICULARS	66

SECTION 4

CHAPTER - 6

POWER TRANSFORMERS

6.0 SCOPE

- 6.0.1 These specifications are intended to cover design, engineering, manufacture, inspection and testing at manufacturer's works before dispatch, supply, transportation, insurance, dispatch & delivery for project site in Nepal, handling, storage & preservation at site, complete work of site assembly, erection, dehydration, testing and commissioning & remedial action, if any, upto defect liability period of following type of oil immersed core type Transformers complete with RTCC and OLTC panels, all accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specifications.
- 6.0.2 The scope of supply shall include all parts, accessories, auxiliaries, mountings, etc. including insulating oil required for first filling plus 10 % extra, which are necessary for satisfactory operation of the Transformers even though not individually or specifically stated or enumerated. The Transformer shall be transported filled with Nitrogen gas along with gas pressure monitoring device and gas replenishing arrangement.
- 6.0.3 Corresponding parts of the Transformers, accessories, spares, etc. shall be of the same materials, dimensions and workman-ship and shall be interchangeable.
- 6.0.4 Necessary shock absorbing device shall be provided on the Transformers to absorb the, intensity of jerks during transportation to site.
- 6.0.5 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.
- 6.0.6 Power cables, control cables & special cables, supports, cable racks, cable glands, lugs, terminals, connectors, etc. for cabling between equipment & devices covered in this section and upto UCB, Protection Panels shall be under scope of Supply.

- 6.0.7 Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.
- 6.0.8 Components having identical rating shall be interchangeable.
- 6.0.9 The performance of the equipment shall be guaranteed as per **Section-5 – “Guaranteed and Other Technical Particulars”**.
- 6.0.10 The bidder has to furnish the testing facilities available at the manufacturer’s works.
- 6.0.11 The Technical Specification for various Power Transformer transformers i.e. 100MVA, 25/30MVA are given below:

6.1 INTRODUCTION

- 1) The 100MVA Transformer Bank is to be made with 3 Nos. of 33.33 MVA $(220/\sqrt{3})/(132/\sqrt{3})/33$ kV Single phase Auto Transformers. The single phase Transformers shall be of core type, oil immersed ONAN/ONAF cooled.
- 2) The 25/33 MVA 220/33 kV 3 phase transformer shall be of core type, oil immersed ONAN/ONAF cooled.
- 3) The 25/30MVA 132/33 kV 3-phase Transformer shall be of core type, oil immersed ONAN/ONAF cooled.

6.2 SPECIFIC TECHNICAL REQUIREMENTS (STANDARD CONDITIONS)

SPECIFIC TECHNICAL REQUIREMENTS FOR 220/132 kV 100MVA AUTO TRANSFORMER

(i) Rating of Unit	Rating/Type
HV (MVA)	33.33
LV (MVA)	33.33

(ii) Single/Three Phase design	Single
(iii) Applicable standard	IEC 60076
(iv) Frequency (Hertz)	50
(v) Cooling	ONAN/ONAF
(vi) Rating at different cooling	60 % / 100 %
(vii) Rated MVA of Bank	100
(viii) Type of installation	Outdoor
(ix) Frequency	50 \pm 3%Hz
(x) Cooling medium	Mineral oil
(xi) Rated Voltage	
a) High voltage side	(220/ $\sqrt{3}$) kV
b) Intermediate Voltage side	(132/ $\sqrt{3}$) kV
(xii) Highest Continuous System Voltage :	
a) High voltage (HV)	245 kV
b) Low Voltage (IV)	145 kV
(xiii) Method of system earthing:	
a) High voltage (HV)	Neutral terminal- Solidly earthed
b) Intermediate Voltage (IV)	Neutral terminal- Solidly earthed
c)	
(xiv) Type of tap changer	OLTC

(xv) Range of tapping	Minus 5% to Plus 15% with sixteen (16) equal steps of 1.25%	
(xvi) Location of tap changer	On the 132 kV side of Series winding	
(xvii) Design of tap changer	Constant flux voltage variation type as per cl. 6.2 of IEC 60076 part-I	
(xviii) Tap Control	Full capacity - on load tap changer suitable for group / independent, remote /local electrical and local manual operation and bi-directional power flow	
(xix) Impedance at rated MVA Base on Principal tap at 75 Deg C	HV-LV : 12.5 %	
(xx) Tolerance on Impedance	AS PER IEC/ISS	
(xxi) Duty	Continuous	
(xxii) Overload Capacity	IEC 60076-7 or IS: 6600	
(xxiii) Type of insulation & insulation level for winding:	220 kV	132 kV
a) Type of insulation:	Graded	Graded
b) One minute power frequency withstand test voltage (kV RMS)	395kV	230kV
c) Impulse withstand test voltage (kVp):	950kV	550kV

(xxiv) Winding connection	Star (HV)	Star (IV)
Material	Copper	Copper
(xxv) Vector group:	YNao	
(xxvi) Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency	1.6 wb/m ²	
(xxvii) Short circuit level of the system to which Transformer is to be connected	40 kA for HV, 31.5 KA for LV sec.	
(xxviii) Short circuit withstand capacity	40 kA for HV, 31.5 KA for LV for for 2 sec+	
(xxix) Terminal details		
a) 220 kV Termination	ACSR“Moose” conductor for connecting to bushing terminals.	
b) 132 kV Termination	ACSR“Moose” conductor for connecting to bushing terminals.	
(xxx) Rail		
a. Shorter Axis:	1676 mm	
b. Longer Axis:	1676 mm	
(xxxi) Tan delta of winding	Less than 0.005 at 20 deg C	
(xxxii) Maximum Temperature Rise for various types of cooling over an ambient of 50 deg C		
a) Temperature rise of top		

oil(Measured by Thermometer)	50 ⁰ C		
b) Temperature rise of winding(Measured by resistance)	55 ⁰ C		
Note: The allowable temp rise during testing shall be reduced by 1 ⁰ K for every 250m above 1000m as per IS 2026 part II.			
(xxxiii) Noise Level at Rated Voltage & Frequency	Less than 75db for ONAN Less than 80db at full load		
(xxxiv) Transformer Bushings			
Type	HV- Oil Impregnated Paper (OIP) condenser type LV-Oil Impregnated Paper (OIP) condenser type Neutral- Porcelain and oil communicating type		
	HV	LV	Neutral
Rated Voltage	245kV	145kV	36kV
Rated current	1250A	1250A	800A
Lighting Impulse withstand voltage (kVp)	1260kV	780 kV	204kV
One minute power frequency withstand voltage (kV RMS)	552kV	330kV	90kV
Corona Extinction voltage	HV-156 kV _{rms}		
Ten Delta of Bushing (for HV and LV)	Less than 0.004 at 20 ⁰ C		
Minimum Total Creepage Distance	For HV: 6125 mm +20% For LV: 3625 mm + 20%		
Note: The arcing distance of the busing shall be increased by 15% at all the substations to account for the high altitude as per IEC 60137-2003.			

(xxxv) Transformer Oil	As per IS:335 (latest edition), with pouring temperature -10°C
(xxxvi) Max partial discharge at $1.5 U_m/\sqrt{3}$	100 pC

SPECIFIC TECHNICAL REQUIREMENTS FOR 220/33 kV 25/30 MVA 3-PHASE TRANSFORMER

(i) Rated MVA of the Transformer	25/30 MVA ONAN/ ONAF
(ii) Type of installation	Outdoor
(iii) Service	Continuous
(iv) Frequency	50 Hz
(v) Cooling medium	Mineral oil
(vi) Rated Voltage	
a) High voltage side	220 kV
b) Low Voltage side	33 kV
(vii) Highest Continuous System Voltage :	
a) High voltage (HV)	245 kV
b) Low Voltage (LV)	36 kV
(viii) Method of system earthing:	
a) High voltage (HV)	Neutral terminal- Solidly earthed
b) Low Voltage (LV)	Neutral terminal- Solidly earthed
(ix) Type of tap changer	OLTC
(x) Range of tapping	Plus 5% to minus 15% with sixteen (16) equal steps of 1.25%, Tap changer to be located at neutral end of HV winding

(xi) Tap Control	Full capacity - on load tap changer suitable for group / independent, remote / local electrical and local manual operation and bi-directional power flow	
(xii) Impedance at rated MVA Base on Principal tap	HV-LV : 12.5 %	
(xiii) Impedance at rated MVA Base on Max and Minimum Voltage tap	HV-LV (Max Voltage tap) : 13.51% HV-LV (Min Voltage tap): 12.1%	
(xiv) Tolerance on Impedance	As per IEC	
(xv) Type of insulation & insulation level for winding:	220 kV	33 kV
a) Type of insulation:	Graded	Uniform
b) One minute power frequency withstand test voltage (kV RMS)	395kV	70kV
c) Impulse withstand test voltage (kVp):	950kV	170kV
(xvi) Winding connection	Star (HV)	Star (LV)
Material	Copper	Copper
(xvii) Vector group:	Ynyn0	
(xviii) Type of cooling	ONAN /ONAF	
(xix) Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency	1.6 wb/m ²	
(xx) Short circuit level of the system to which	40 kA for HV, 25 KA for LV for 1 sec.	

Transformer is to be connected	
(xxi) Short circuit withstand capacity	40 kA for 2 sec
(xxii) Terminal details	
a. 220 kV Termination	ACSR“Moose” conductor for connecting to bushing terminals.
b. 33 kV Termination	ACSR“Moose” conductor for connecting to bushing terminals.
(xxiii) Rail	
a. Shorter Axis:	1676 mm
b. Longer Axis:	1676 mm
(xxiv) Ten delta of winding	Less than 0.005 at 20 deg C
(xxv) Maximum Temperature Rise for various types of cooling over an ambient of 50deg C	
a) Temperature rise of top oil(Measured by Thermometer)	
b) Temperature rise of winding(Measured by resistance)	50 ⁰ C 55 ⁰ C
Note: The allowable temp rise during testing shall be reduced by 1 ⁰ K for every 250m above 1000m as per IS 2026 part II.	
(xxvi) Overload Capacity	As per IEC 60076-7 or IS: 6600
(xxvii) Noise Level at Rated Voltage & Frequency	Less than 75db for ONAN Less than 80db at full load
(xxviii) Transformer Bushings	
Type	HV- Oil Impregnated Paper (OIP) condenser type

	LV- Oil Impregnated Paper (OIP) condenser type Neutral- Porcelain and oil communicating type		
	HV	LV	Neutral
Rated Voltage	245kV	36 kV	36kV
Rated current	1250A	800 A	800A
Lighting Impulse withstand voltage (kV _p)	1260kV	204kV	204 kV
One minute power frequency withstand voltage (kV RMS)	552kV	90 kV	90kV
Minimum creepage distance	6125mm +20%	900 mm+20%	900mm+20%
Corona Extinction voltage	HV-156 kV _{rms}		
Tan Delta for bushings	Less than 0.004 at 20 ⁰ C		
Note: The arcing distance of the busing shall be increased by 15% at all the substations to account for the high altitude as per IEC 60137-2003.			
(xxix) Transformer Oil	As per IS:335 (latest edition), with pouring temperature -10 ⁰ C		
(xxx) Maximum partial discharge level at 1.5 pu	100 pico-coulomb		

SPECIFIC TECHNICAL REQUIREMENTS FOR 132/33 kV 25/30MVA 3-PHASE TRANSFORMER

(i) Rated MVA	25/30MVA ONAN/ONAF
(ii) Type of installation	Outdoor
(iii) Service	Continuous
(iv) Frequency	50 Hz \pm 3%
(v) Cooling medium	Mineral oil

(vi) Rated Voltage		
High voltage side	132 kV	
Low Voltage side	33 kV	
(vii) Highest Continuous System Voltage :		
High voltage (HV)	145 kV	
Low Voltage (LV)	36 kV	
(viii) Method of system earthing:	Neutral terminal- Solidly earthed	
(ix) Type of tap changer	OLTC	
(x) Range of tapping	Plus 5% to minus 15% with sixteen (16) equal steps of 1.25%. Tapping shall be located at the neutral end of the HV	
(xi) Tap Control	Full capacity - on load tap changer suitable for group / independent, remote / local electrical and local manual operation and bi-directional power flow	
(xii) Impedance at rated MVA and on principal/ tap	12.5 %/	
(xiii) Type of insulation & insulation level for winding:	132 kV	33 kV
d) Type of insulation:	Graded	Uniform
e) One minute power frequency withstand test voltage (kV RMS)	230kV	70kV
f) Lighting Impulse withstand test voltage (kVp):	550kV	170kV
(xiv) Winding connection	Star	Star

(xv) Material	Copper	Copper
(xvi) Vector group:	YNd11	
(xvii) Type of cooling	ONAN /ONAF	
(xviii) Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency	1.6 wb/m ²	
(xix) Short circuit level of the system to which Transformer is to be connected	31.5 kA for HV and 25 KA for LV side for one sec.	
(xx) Short circuit withstand capacity	31.5 kA for HV and 25 KA for LV for 2 sec	
(xxi) Terminal details		
a) 132 kV Termination	ACSR“Moose” conductor for connecting to bushing terminals.	
b) 33 kV Termination	ACSR“Moose” conductor for connecting to bushing terminals.	
(xxii) Rail		
a) Shorter Axis:	1676 mm	
b) Longer Axis:	1676 mm	
(xxiii) Ten delta of winding	Less than 0.005 at 20 deg C	
(xxiv) Maximum Temperature Rise for various types of cooling over an ambient of 50deg C		
a) Temperature rise of top oil(Measured by Thermometer)		

b) Temperature rise of winding(Measured by resistance)	50 ⁰ C	55 ⁰ C	
Note: The allowable temp rise during testing shall be reduced by 1 ⁰ K for every 250m above 1000m as per IS 2026 part II.			
(xxv) Overload Capacity	As per IEC 60076-7 or IS: 6600		
(xxvi) Noise Level at Rated Voltage & Frequency	Less than 75db for ONAN Less than 80db at full load		
(xxvii) Transformer Bushings			
Type	HV- Oil Impregnated Paper (OIP) condenser type LV- Porcelain and oil communicating type Neutral- Porcelain and oil communicating type		
	HV	LV	Neutral
Rated Voltage	145kV	36kV	36kV
Rated current	800A	800A	800A
Lighting Impulse withstand voltage (kV _p)	780kV	204kV	204 kV
One minute power frequency withstand voltage (kV RMS)	330 kV	90kV	90kV
Minimum creepage distance	3625mm+20%	900mm+20%	900mm+20%
Corona Extinction voltage	HV-320kV _{rms}		
Ten Delta	Less than 0.004 at 20 ⁰ C		
Note: The arcing distance of the busing shall be increased by 15% at all the substations to account for the high altitude as per IEC 60137-2003.			
(xxviii) Transformer Oil	As per IS:335 (latest edition), with pouring temperature -10 ⁰ C		

(xxix) Maximum partial discharge level at 1.5 pu	100 pico-coulomb
--	------------------

6.3 PERFORMANCE

- 6.3.1. The Transformers shall be capable of operating at full load for at least ten (10) minutes during total failure of auxiliary power supply to cooling fans and pumps without exceeding winding hot spot temperature exceeding 140°C. It shall also be capable of operating for 20 minutes in the event of failure of oil circulating pumps or blowers associated with all unit coolers except one unit cooler without exceeding winding hot spot temperature exceeding 140°C. Necessary calculations in this regard shall be submitted during design stage.
- 6.3.2. The maximum flux density in any part of the core and yoke at normal voltage and Frequency shall be such that the flux density under 10% over voltage condition shall not exceed 1.76 Tesla with limiting value as (6.3.3) below.
- 6.3.3. The maximum flux density in any part of the core and yoke at rated MVA, voltage and frequency shall not exceed 1.9 tesla at the lowest tap position under 10% continuous over voltage & frequency condition.
- 6.3.4. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120⁰ C under normal operating condition and 130°C under most extreme operating condition.
- 6.3.5. The insulation of core to bolts and core to clamp plates shall withstand a voltage of 2kV (rms) for 1minute.
- 6.3.6. The insulating oil shall be virgin high grade inhibited, conforming to IEC 60296.
- 6.3.7. It shall withstand and give desired performance, without injurious heating for combined voltage and frequency fluctuations. It shall withstand over fluxing conditions of 110, 125 and 140% for continuous, 1 minute and 5 seconds respectively.
- 6.3.8. Transformers shall be designed to achieve suppression of harmonic voltage especially the third & fifth so as to eliminate wave form distortion and any possibility of high frequency disturbances, inductive effects or circulating currents between neutral points of different

Transformers reaching such a magnitude as to cause interference with communication circuits.

- 6.3.9. It shall be capable of being loaded upto 150% of rated load as per IS 6600/ IEC 60076-7. There shall be no limitation for overloading imposed by bushing, tap changer etc or any other associated equipment.
- 6.3.10. Transformer shall be capable of withstanding for two second without damage to any external short circuit, with the short circuit MVA available at the terminals.
- 6.3.11. Transformer shall under exceptional circumstances due to sudden disconnection of the load, be capable of operating at the voltage approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal for a period of 5 seconds.
- 6.3.12. The transformer may be operated continuously without danger on any particular tapping at the rated MVA $\pm 10\%$ of the voltage corresponding to the tapping.
- 6.3.13. The thermal ability withstand short circuit shall be demonstrated by calculation.
- 6.3.14. Transformers shall be suitable for continuous operation at rated output with a frequency variation of up to $\pm 3\%$ from normal frequency of 50 Hz without exceeding the specified temperature rise.
- 6.3.15. The transformer shall be so designed that the current density of all the windings and the regulating winding at the lowest tap should not exceed 250 A/sq.cm.
- 6.3.16. The thermal ability of the Transformer to withstand the short-circuit shall be demonstrated by calculations. The duration of the symmetrical short circuit current to be used for the calculation of the thermal ability to withstand short circuit shall be 2 seconds.

6.4 AUXILIARY POWER SUPPLIES

The following Auxiliary power supplies shall be available at site:

- i) AC, 3 phase 400 volts 50 Hz. earthed
- ii) AC, 1 phase 230 volts 50 Hz. earthed
- iii) 110 volts DC ungrounded.

6.5 DRAWINGS INCORPORATING THE FOLLOWING PARTICULARS SHALL BE SUBMITTED WITH THE BID

- i. General outline drawing showing shipping dimensions and overall dimensions, net weights and shipping weights, quality of insulating oil, spacing of wheels in either direction of motion, location of coolers, marshalling box and tap changers etc.
- ii. Height of centre line of HV and LV connectors of transformers from the rail top level.
- iii. Dimensions of the largest part to be transported.
- iv. GA drawings/details of various types of bushing.

6.6 MISCELLANEOUS

- 6.6.1. Padlocks along with duplicate keys as asked for various valves, marshalling box etc., shall be supplied by the contractor, wherever applicable.
- 6.6.2. Foundation bolts for wheel locking devices of Transformer shall be supplied by the Contractor.

6.7 PARALLEL OPERATION

The transformers Banks shall be capable of satisfactory parallel operation with each other if connected between the high voltage and low voltage bus-bar.

In case of Transformer Banks, the Single phase Autotransformers shall be interchangeable with each other without affecting Normal Operation/Parallel Operation of the Transformer Bank(s).

6.8 NAME/RATING PLATE

Transformer rating plate shall contain the information as given in clause 7 IS-2026 (Part-I). The details on rating plate shall be finalized during the detailed engineering.

6.9 STANDARDS & CODES

- 6.9.1 The equipment, materials and service covered by this specification shall conform to the latest applicable provision of the following IEC/ Indian/International standards:

TABLE 6.1.3: STANDARDS

IS:2026 (Part I to IV)	Power Transformer
IS:6600	Guide for loading of oil immersed transformers
IS:335	New insulating oil for transformers, Switchgears
IS:3639	Fittings and accessories for power Transformers
IS:2099	High voltage porcelain bushings
IS:2705	Current Transformers
IS:3347	Dimensions for porcelain Transformer/Bushings
IS:3202	Code of practice for climate proofing of electrical equipment
IS:2147	Degree of protection
IS:2071	Method of high voltage testing
IS:3637	Gas operated relays
IS:1271	Classification of insulating materials for electrical machinery and apparatus in relation to their stability in services
IS:5	Colour for ready mixed paints
IS:10028	Code of practice for selection, installation and maintenance of transformers, Part I, II and III
IS:5561	Electric Power Connectors
C.B.I.P. Publication	Manual on Transformers
IS 8478	OLTC
IEC 60076	Power transformer
IEC 60137	Insulating bushings for alternating voltages above 1 kV
IEC 60156	Insulating liquids - Determination of the breakdown voltage at power frequency – Test method
IEC 60296	Specification for unused mineral insulating oils for transformers and switchgear
IEC 60551	Determination of transformer and reactor sound levels
IEC 60616	Terminal and tapping markings for power transformer
IEC 60722	Guide to the lightning impulse and switching impulse testing of power transformers and reactors

6.10 GENERAL DESIGN CONSTRUCTIONAL FEATURES

- 6.10.1 All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions without distortion or deterioration or the setting up of undue stresses which may impair suitability of the various parts for the work which they have to perform.
- 6.10.2 Similar parts, particularly removable ones, shall be interchangeable.
- 6.10.3 Pipes and pipe fittings, screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Steel bolts and nuts exposed to atmosphere shall be galvanized.
- 6.10.4 Nuts, bolts and pins used inside the transformers and tap changer compartments shall be provided with lock washers or locknuts.
- 6.10.5 Exposed parts shall not have pockets where water can collect.
- 6.10.6 Internal design of transformer shall ensure that air is not trapped in any location.
- 6.10.7 Material in contact with oil shall be such as not to contribute to the formation of acid in oil. Surface in contact with oil shall not be galvanized or cadmium plated.
- 6.10.8 Labels, indelibly marked, shall be provided for all identifiable accessories like relays, switches, current transformers etc. All label plates shall be of in-corrodible material.
- 6.10.9 All internal connections and fastenings shall be capable of operating under overloads and over-excitation, allowed as per specified standards without injury.
- 6.10.10 Transformer and accessories shall be designed to facilitate proper operation, inspection, maintenance and repairs.
- 6.10.11 No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors will be accepted.
- 6.10.12 Schematic Drawing of the wiring, including external cables shall be put under the prospane sheet on the inside door of the transformer marshalling box.

6.11 PAINTING

- 6.11.1 The interior of all transformer tanks and other oil filled chambers and internal structural steel work shall be cleaned of all scale and rust by shot-blasting. These surfaces shall be painted with not less than two coats of heat resistant, oil insoluble and insulating varnish. Steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of a glossy oil and weather resisting non fading, paint of shade No. 631 as per IS:5.
- 6.11.2 Metal parts not accessible for painting shall be made of corrosion resistant material.
- 6.11.3 Interior surfaces of mechanism chambers and marshalling kiosks shall receive three coats of paint after proper cleaning. The final coat shall be of a light coloured anti-corrosion paint.
- 6.11.4 All paints shall be carefully selected to withstand heat, rain and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.
- 6.11.5 In case finish paint chips off or crinkle during transit or installation, the contractor shall arrange for repainting transformer at site at his cost. The paint for repainting shall be supplied by the contractor.

6.12 DETAILED DESCRIPTION

The detailed description of various parts of the Transformer is as follows:

6.13 TANK

- 6.13.1 The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of adequate thickness and tested quality. The tank and the cover shall be of welded construction.
- 6.13.2 Lifting lugs or eyes shall be provided on the Transformer tank for handling during assembly or dismantling. These lugs or eyes shall also be used for lifting of the complete Transformer with the help of crane during handling. A minimum of four jacking pads shall be provided in accessible position in tank to enable raising or lowering of complete Transformer (with oil) and changing the plane of rotation of wheels using hydraulic jacks.
- 6.13.3 Tank shall be designed to permit lifting (without any distortion) by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided

- for this purpose. The Transformer design shall be such that the tank will not be split between lower and upper connections for untanking.
- 6.13.4 All beams, flanges, lifting lugs, braces and permanent parts attached to the tank, shall be welded and where practicable, they shall be double welded.
- 6.13.5 The tank shall have sufficient strength to withstand without distortion, filling under vacuum and continuous internal gas pressure of minimum 0.35 Kg/ cm² with oil at operating level. The main tank body of the transformer, excluding tap changing compartments and radiators, shall be capable of withstanding pressure of 760 mm of Hg.
- 6.13.6 Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, testing of earth connection, terminals etc. The design shall be such that water shall not collect near the gasketed joints. At least two openings, one at each end of the tank shall be provided.
- 6.13.7 The tank cover shall be fitted with pockets for a thermometer and for the bulbs of oil. & winding temperature indicator. The thermometer pockets shall be fitted with a captive screwed top to prevent ingress of water. The pockets for the oil temperature indicator shall be located in the zone of maximum oil temperature and it shall be possible to remove the instrument bulbs without lowering the oil in the tank.
- 6.13.8 All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions. Special attention shall be given to the methods of making the hot oil-tight joints between the tank and the cover as also between the tank cover and the bushings and all outlets to ensure that the joint can be remade satisfactorily and with ease, with the help of semi-skilled labour. Where compressible gaskets are used, steps shall be provided to prevent over-compression.
- 6.13.9 Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.

6.14 TANK COVER

The transformer top shall be provided with a detachable tank cover with bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

6.15 CONSERVATOR TANK

- 6.15.1 The conservator tank shall have adequate capacity between the highest and lowest visible levels to meet the requirement of expansion of the total cold oil volume in the transformer & cooling equipment from the minimum ambient temperature to 90 deg C.
- 6.15.2 A conservator complete with sump and drain valve (so placed as to drain the conservator completely) shall be provided in such a position of the Transformer so as not to obstruct the electrical connections to the Transformer and bolted so appropriately that it can be easily removed for clearing purpose.
- 6.15.3 One prismatic oil level gauge & one magnetic oil level gauge, the latter with low level electrically insulated alarm contacts and a dial showing minimum, maximum, and normal oil levels shall be fitted at a height readable from the Transformer base level. Taps or valves shall not be fitted to the oil gauges.
- 6.15.4 The conservator tank shall be fitted with flexible diaphragm.
- 6.15.5 Transformer shall be provided with thermo siphon fitters to prolong the life of transformer.
- 6.15.6 The oil pipe from the base of the conservator tank shall project into the conservator for a distance of not less than 50 mm so as to form a water trap.
- 6.15.7 The oil connection from the Transformer tank to the conservator vessel up to the Buchholz relay shall be arranged, at a rising angle of 3 to 9 degrees to the horizontal & shall consist of 80 mm inside diameter pipe.
- 6.15.8 The conservator shall be provided with a valve to cut off the oil supply to the Transformer after providing a straight run of pipe for at least a length of 5 times the internal diameter of the pipe on the tank side and at least 3 times the internal diameter of the pipe on the conservator side of the Gas & Oil actuated (Buchholz) relay. Isolating valve shall be provided on both sides of the Buchholz relay.

- 6.15.9 The conservator vessel shall be fitted with a breather in which silica gel is the dehydrating agent and designed in such a way so as to ensure the following:-
- 6.15.10 The passage of air is through the silica gel.
- 6.15.11 The external atmosphere is not continuously in contact with the silica gel.
- 6.15.12 The moisture absorption indicated by a change in colour of the tinted crystals can be easily observed from distance.
- 6.15.13 The breather shall be mounted approximately 1400 mm aboveground level. In addition to the silica gel breather, an oil resistant synthetic diaphragm seal/bag/air cell shall be installed on the conservator to prevent direct contact between oil & air. The magnetic oil level gauge provided with the conservator should have contacts for giving alarm when the air cell gets damaged or sinks.
- 6.15.14 Instead of silica gel breather as specified, the Supplier may furnish the details of other alternative method considered to be more efficient & effective for breathing for consideration of the Employer along with relative merits of the offered method.

6.16 UNDER CARRIAGE

- 6.16.1 The transformer tank shall be supported on steel structure with detachable forged steel flanged bidirectional wheels suitable for moving the transformer completely filled with oil. A 1676 mm convenient track gauge for motion in both longitudinal and transverse directions shall be installed by the Employer for which necessary drawing indicating rail size, track gauge dimension, embedment details showing fixing of rails in concrete shall be provided by the supplier. Means shall be provided for locking the swivel movements in positions, parallel to and at right angles to the longitudinal axis of the tank. Suitable stoppers for the track wheels shall also be supplied. Flanged wheels shall be spaced accordingly. Wheels shall be provided with suitable bearings which will resist rust and corrosion and shall be equipped with fittings for lubrication.
- 6.16.2 The necessary arrangement for clamping of the wheels with the rails, capable of being put on and off easily, shall also be provided by the supplier.

- 6.16.3 Jacking pads shall be provided on the transformer. It shall be possible to change the direction of the wheels through 90 degree when the transformer is lifted on jacks to permit movement of the transformer both in longitudinal and transverse directions.
- 6.16.4 A set of hydraulic jacks (4 Nos.) for lifting the transformer shall be supplied by the supplier, for the transformer i.e. for 33.33 MVA transformer.
- 6.16.5 Pulling eyes along with adequate capacity equipment for haulage & turning of Transformer by 90 degrees shall be provided by the supplier to facilitate haulage of the Transformer and these shall be suitably braced in vertical direction so that bending does not occur when the pull has vertical components.

6.17 CORE

- 6.17.1 The magnetic circuit shall be constructed from high grade cold rolled non-ageing grain oriented silicon steel lamination known as HI-B Grade or superior grade.
- 6.17.2 The laminations shall be free of all burrs and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil.
- 6.17.3 The core shall be clamped by epoxy resin clamps having sufficient strength and rigidity to withstand the short circuit forces, if the core bolts are used to clamp the core. The insulation for the core to bolts and core to clamp plates shall be designed to withstand a voltage of 2 kV AC for one minute. The frame work and clamping arrangement shall be earthed in accordance with clause no. 6.19.3
- 6.17.4 The completed core and coil shall be so assembled that the axis and the plane of the outer surface of the core stack shall not deviate from the vertical plane by more than 25 mm.
- 6.17.5 All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting, drilling and welding. Adequate care shall be exercised in the selection, treatment and handling of core steel to ensure that the laminations are flat and the finally assembled core is free from distortion. Laminations shall be coated with a durable baked enamel/fiber glass insulation coating which shall be inert to the action of hot Transformer oil.

- 6.17.6 The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.
- 6.17.7 The core clamping structure shall be designed to minimize eddy current loss.
- 6.17.8 The framework and clamping arrangements shall be securely earthed.
- 6.17.9 The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.
- 6.17.10 Oil ducts shall be provided where necessary to ensure adequate cooling. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.
- 6.17.11 The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angle to the plane of the lamination which may cause local heating. The supporting frame work of the cores shall be so designed as to avoid the presence of pockets which would prevent complete emptying of the tank through the drain valve or cause trapping of air during filling.
- 6.17.12 The construction is to be of 'core' type. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coil assembly shall be so fixed in the tank that shifting will not occur during transport or short circuits. All parts of the cores shall be of robust design capable of withstanding any shocks to which they may be subjected during lifting, transport, installation and worst forces during service.
- 6.17.13 The magnetization characteristics of the Transformer for impressed voltage upto 1.8 p.u. shall be furnished during design stage.
- 6.17.14 Adequate lifting lugs shall be provided to enable the core and winding to be lifted. The method of supporting the core structure in the tank and method of lifting weight of core and coil assembly shall be subject to Employer's approval. When lifted, the weight shall be carried from the base so that it does not subject core structure to undue stress. The drawing showing the arrangement of supporting the core and coil including their lifting arrangement shall be furnished for approval during design stage.

6.18 INTERNAL EARTHING

- 6.18.1 All internal metal parts of the transformer, with the exception of individual laminations, core bolts and their individual clamping plates shall be earthed.
- 6.18.2 The top clamping structure shall be connected to the tank by a copper strap. The bottom clamping structure shall be earthed by one or more of the following methods:
- 6.18.3 By connection through vertical tie-rods to the top structure.
- 6.18.4 By direct metal to metal contact with the tank base.
- 6.18.5 By a connection to the top structure on the same side of the core as the main earth connection to the tank.
- 6.18.6 Earthing of core clamping structure
- 6.18.7 It shall be ensured that all the laminations of the core shall be at earth potential. Shorting bridge piece shall be provided at core duct location. One point shall be taken out from the core at the top and shall be shorted to the tank at the tank cover. The core and clamp earthing shall be done outside the tank and no internal earthing arrangement shall be provided.
- 6.18.8 The magnetic circuit shall be connected to the clamping structure at one point only and this shall be brought out of the top cover of the transformer tank through a suitably rated insulator. A disconnecting link shall be provided on transformer tank to facilitate disconnections from ground for IR measurement purpose. The connection to the link from the core shall be on the same side of the core as the main earth connection. Magnetic circuits having an insulated sectional construction shall be provided with a separate link for each individual section.
- 6.18.9 Earthing of coils clamping rings
- 6.18.10 Where coil clamping rings are of metal, each ring shall be connected to the adjacent core clamping structure on the same side of Transformer as the main earth connections.
- 6.18.11 All earthing connections with the exception of those from the individual coil clamping rings shall have a cross-sectional area of not less than 0.8 sq.cm. Connections inserted between laminations of different sections of core shall have a cross-sectional area of not less than 0.2 Sq. cm

6.19 WINDING

- 6.19.1 Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.
- 6.19.2 All low voltage windings for use in the circular coil concentric winding shall be wound on a performed insulating cylinder for mechanical protection of the winding in handling and placing around the core.
- 6.19.3 Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. The conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents & temperatures along the windings. No strip conductor wound on edge shall have a width exceeding six times its thickness.
- 6.19.4 Materials used in the insulation and assembly of the windings shall be insoluble, non catalytic and chemically inactive in the hot transformer oil and shall not liable to soften, ooze out, shrink or collapse or the otherwise affected under the operating conditions.
- 6.19.5 Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive be used which will seal the coil and prevent evacuation of air and moisture and impregnation by oil.
- 6.19.6 Winding and connections shall be braced to withstand shocks during transport or short circuit.
- 6.19.7 Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil. Steel bolts, if used, shall be suitably treated.
- 6.19.8 Terminals of all windings shall be brought out of the tank through bushings for external connections.
- 6.19.9 The completed core and coil assembly shall be dried in vacuum at not more than 0.5mm of mercury absolute pressure and shall be immediately impregnated with oil after the drying

process to ensure the elimination of air and moisture within the insulation. Vacuum may be applied in either vacuum over or in the transformer tank.

- 6.19.10 The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.
- 6.19.11 Coils shall be made of continuous smooth high grade electrolytic copper conductor, shaped and braced to provide for expansion and contraction due to temperature changes. Excessive current densities shall be avoided.
- 6.19.12 Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turns shall have additional protection against abnormal line disturbances.
- 6.19.13 The insulation of winding shall be designed to withstand voltage stress arising from surge in transmission lines due to atmospheric or transient conditions caused by switching etc.
- 6.19.14 Tapings shall not be brought out from inside the coil or from intermediate turns and shall be so arranged as to preserve as far as possible magnetic balance of the transformer at all voltage ratios.
- 6.19.15 Magnitude of impulse surges transferred from HV to LV windings by induction and capacitance coupling shall be limited to B.I.L. of LV winding.

6.20 INSULATING OIL

- 6.20.1 The insulating oil for the transformers shall be of EHV grade, generally conforming to IS: 335. No inhibitor shall be used in oil.
- 6.20.2 The quantity of oil required for the first filling of the transformer shall be stated in the bid. The bidder shall quote the price of transformer complete with first filling of oil plus 10% extra. However, the rate of transformer oil in US\$ per liter shall be quoted separately also. The transformer oil shall be supplied in non returnable containers/drums.
- 6.20.3 The design and materials used in the construction of the transformer shall be such as to reduce the risk of the development of acidity in the oil.
- 6.20.4 The contractor shall dispatch the transformer filled with oil or in an atmosphere of Nitrogen. In the former case, the contractor shall take care of the weight limitation on

transport and handling facility at site. In the later case necessary arrangement shall be ensured by the contractor to take care of pressure drop of Nitrogen during transit and storage. A gas pressure valve with necessary pressure gauge and adopter valve shall be provided.

6.21 VALVES

- 6.21.1 Valves shall be of forged carbon steel upto 50 mm size and of gun metal or of cast iron bodies with gun metal fittings for sizes above 50 mm. They shall be of full way type with screwed ends and shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.
- 6.21.2 Each valve shall be provided with an indicator to show the open and closed positions and shall be provided with facility for padlocking in either open or closed position. All screwed valves shall be furnished with pipe plugs for protection. Padlocks with duplicate keys shall be supplied along with the valves.
- 6.21.3 All valves except screwed valves shall be provided with flanges having machined faced drilled to suit the applicable requirements. Oil tight blanking plates shall be provided for each connection for use when any radiator is detached and for all valves opening to atmosphere. If any special radiator valve tools are required, the Contractor shall supply the same.
- 6.21.4 Each transformer shall be provided with following valves on the tank :
- Drain valve so located as to completely drain the tank.
 - Two filter valves on diagonally opposite corners, of 50 mm size.
 - Oil sampling valves not less than 8 mm at top and bottom of main tank.
 - One 15 mm air release plug.
 - Valves between radiators and tank.
 - Drain and filter valves shall be suitable for applying vacuum as specified in the specifications.

6.22 BUSHING

- 6.22.1 All porcelain used in bushings shall be homogeneous, anti-fog, non-porous, uniformly glazed to brown colour and free from blisters, burns and other defects.
- 6.22.2 Stress due to expansion and contraction in any part of the bushing shall not lead to deterioration.
- 6.22.3 Bushing shall be designed and tested to comply with the latest edition of applicable standards. IS-2099 & IS-3347 (Part-III/Section-I) and to operate in foggy conditions.
- 6.22.4 Liquid/oil-filled bushings shall be equipped with liquid level indicators and means for sampling and draining the liquid. The angle of inclination to vertical shall not exceed 30 degree. Tap for capacitance test shall be provided for condensers.
- 6.22.5 The bushings shall have puncture strength greater than the dry flash over value. Further, the spacing between the bushing shall be adequate to prevent flash over under all conditions of operation.
- 6.22.6 Bushing flanges shall not be of re-entrant shape which may trap air. Bushing turrets shall be provided with vent pipes which shall be connected to route any gas collection through the Buchholz relay.
- 6.22.7 Bushings for voltage for 72.5 kV and above shall be condenser type.
- 6.22.8 Bushing rated for 400 A and above shall have non-ferrous flanges and hardware.
- 6.22.9 Clamps and fittings made of steel or malleable iron shall be galvanized. All bolt threads shall be greased before erection.
- 6.22.10 Bushing shall be so located on the transformers that full flashover strength will be utilized. Minimum clearances as required for the BIL shall be realized between live parts and live parts to earthed structures.
- 6.22.11 All applicable routine and type tests certificates of the bushings shall be furnished for approval.
- 6.22.12 Bushing shall be supplied with bimetallic/terminal connector/clamp suitable for fixing to bushing terminal and the ACSR "Moose" conductors. The connector/clamp shall be rated to carry the bushing rated current without exceeding a temperature rise of 55Deg C over an

ambient of 40DegC. The connector/clamp shall be designed to be corona free at the maximum rated line to ground voltage.

- 6.22.13 Weather proof outdoor type 36 kV class porcelain bushings shall be provided for HV & LV side neutral terminal of each single phase Transformer. The neutral terminals shall be suitable for connection to a copper bar through a bimetallic clamp. The copper bar neutral conductor shall connect the neutral bushing of three single phase Transformers for neutral formation and shall be supported with pin insulators of suitable rating. A neutral CT shall be mounted in the arm of the copper bar neutral conductor after neutral formation on Y-phase of the Transformers bank. The Transformer manufacturer shall supply complete neutral equipment comprising of tank mounted neutral C.T. copper bar neutral conductor with supporting pin insulator of suitable rating, neutral bushings and terminal clamps, etc.

The neutral for the Transformer bank shall be formed outside the Transformer tanks through a copper conductor of adequate section. The neutral terminals of the Transformer bank shall be suitable for connection to station ground mat through bimetallic connector. All the necessary equipment comprising of copper conductor interconnection with supporting insulators, Current Transformers with its mounting arrangement etc. for formation of neutral outside the Transformer tanks including connection to the ground - mat risers shall be in the scope of supply of the contractor.

- 6.22.14 Bushing of identical voltage rating shall be interchangeable.
- 6.22.15 The insulation class of high voltage neutral bushing shall be properly coordinated with the insulation class of the neutral of the low voltage winding.
- 6.22.16 Each bushing shall be so co-ordinate with the transformer insulation that all flashover will occur outside the tank.

6.23 COOLING ARRANGEMENTS

- 6.23.1 2x50% unit coolers shall be provided. Relevant calculations in this regard shall be submitted by the contractor at the time of detailed design engineering. Each unit cooler shall be provided with its own cooling fans, oil pumps and other accessories.

- 6.23.2 Cooling Fans: The motor blowers shall be direct driven suitable for continuous outdoor operation and complete with necessary air dusting. These shall be mounted independently from the radiator and in the case, these are radiator mounting type, use shall be made of some anti vibration means. Care shall be taken that the blower unit is capable of being removed without disturbing the radiator structure. The blades shall be suitably painted and shall not be of hollow sections. Suitably painted wire mesh guards with mesh not greater than 25mm shall be provided to prevent accidental contact with the blades.
- 6.23.3 Oil Pumps: The oil cooler shall be provided with a motor driven oil pump of the submerged motor type and shall of the adequate capacity. It shall be possible to remove the pump & motor from the oil circuit without having to lower the level of oil in the Transformer or coolers and without having to disturb the provision made for fixing the pump. The capacity of oil pump shall be decided considering the max. output of Transformer & total head which may occur in service and also the head variation resulting from the changes in the viscosity of the oil. One standby oil pump for cooling shall be provided.
- 6.23.4 For mixed type cooling, the pump shall be of axial flow type to permit oil circulation when pump is idle.
- 6.23.5 Under no circumstances, the degree of forced circulation creates a static electrification hazard in any part of a transformer under any operating condition.
- 6.23.6 Complete oil piping shall be provided for connecting Transformer to the oil coolers and oil pumps. A suitable expansion piece shall be provided in each oil pipe connection between the Transformer and the separately mounted oil coolers. The drain valves/plugs shall be so provided that each piping section can be drained independently. Complete piping for connecting heat exchangers to the cooling water system shall also be in the scope of supply.

6.24 MOTORS

- 6.24.1 The motor shall be squirrel cage totally enclosed weather proof type suitable for direct starting and for continuous running from 400/230 volts, three phase/single phase 50 C/S supply. The motors shall comply with IS as applicable for continuous rated machine.

- 6.24.2 All motors shall be capable of continuous operation at frequency 50Hz with variation of ± 5 % and 400/230 V AC ± 10 % variation of the normal voltage without injurious overheating.
- 6.24.3 All motors shall have ball or roller bearing with hexagonal nipples for greasing. In case of vertical spindle, motor shall have bearing capable of withstanding thrust, due to weight of the moving parts.
- 6.24.4 Varnished cambric or glass insulator shall be used for connections from stator winding to the terminal suitable for external wiring. The motor terminals shall be of stud type and totally enclosed.
- 6.24.5 Each motor shall be provided with a three pole electrically operated contactor and with control gear of suitable design for both manual and automatic starting and stopping. Additional terminals for remote control of motors shall be provided. Over-load and single phasing protection shall be provided. MCCBs shall be provided for the main supply. The equipment shall be mounted in the marshaling box.

6.25 COOLER CONTROL

- 6.25.1 All connection shall be so arranged as to allow either individual or collective operation of the motors, Alarm indication (audio and visual) for failure of fans and to indicate failure of power supply shall be provided.
- 6.25.2 The control equipment shall be installed in the marshaling box in readily accessible position.
- 6.25.3 The alarm indication for failure of power supply and failure of individual fans be provided through independent non trip alarm scheme conforming to the following:-
- The closing of an initiating contact shall actuate a buzzer and will be accompanied by a flag indication on the concerned auxiliary relay.
 - The closing of an initiating contact shall glow a lamp, which will not reset until the fault has cleared.
 - It shall be possible to silence the buzzer by pressing 'Accept' push button. If after canceling the alarm but before resetting the visual signal, the same fault persists the buzzer shall be suppressed.

- d. If after canceling the alarm but before resetting the visual signal, some other fault takes place, the alarm accompanied by flag indication on appropriate auxiliary relay shall taken place.
- e. If after canceling the alarm and after resetting the visual signal, the same fault appears or some other fault take place, the alarm, flag indication and non-trip lamp indication shall reappear as usual.
- f. The non-trip alarm acceptance shall be by means of push button and resetting of visual signal may also preferably be done through a push button.
- g. Means shall be provided for test checking the lamp and alarm circuit at frequent intervals.
- h. The equipment shall be suitable for 110 Volts DC operations.

6.25.4 Static facia annunciator conforming to the foregoing requirements of non-trip alarm scheme too would be acceptable.

6.26 MARSHALLING BOX AND MAIN CONTROL PANEL

- 6.26.1 Sheet steel(minimum 3 mm thick) , vermin proof, well ventilated and weather proof marshalling box with water-tight hinged and padlocked door of a suitable construction shall be provided for the transformer ancillary apparatus. The box shall have slopping roof and the interior and exterior painting shall be in accordance with the specification. Padlock along with duplicate keys shall be supplied for marshalling box. The degree of protection shall be IP-55.
- 6.26.2 The schematic diagram of the circuitry inside the marshalling box be prepared and fixed inside the door under a propane sheet.
- 6.26.3 To prevent internal condensation, an approved type of metal clad heater controlled by a thermostat and water tight, single pole, iron-clad rotary switch mounted on the outside of the box, shall be provided.
- 6.26.4 The marshalling box shall accommodate the following equipment along with their completely wired repeat contacts:
 - a. Protection and control equipment for the cooling system.

- b. Oil & Winding Temperature indicators of each phase of HV & LV windings mounted at the height of not more than 1600 mm from the ground level.
 - c. Terminal boards & ground plates for incoming & outgoing cables and for Current Transformer secondary's and control equipment.
 - d. Illumination lamp and 5 Amp, 240 V, 3 pin socket with switch.
- 6.26.5 All incoming cables shall enter the marshalling box from the bottom and the gland plate shall not be less than 450 mm from the base of the box. The gland plates & associated compartment shall be sealed in a suitable manner to prevent the ingress of moisture from the cable trench.
- 6.26.6 The main control panel for a bank of three single phase Transformers shall have the Provision for accommodating 2 nos. 415 V, 3 phase AC incoming feeders, 2 Nos, 110 V DC incoming feeders and required number of outgoing feeders to the marshalling box of individual single phase Transformers. Necessary MCCBs/MCBs shall be provided in the incoming and outgoing circuits by the supplier. The incoming AC & DC cables from Station Auxiliary Board and DC Distribution board shall be provided and terminated. The outgoing AC & DC cables between main control panel and individual single phase marshalling boxes shall be provided by the supplier. The power cables, control cables/instrument cables between main control panel and individual marshalling boxes & for taking the signal to Station Auxiliary board and Protection panels shall be provided by the supplier.
- 6.26.7 Temperature Indicating devices
All transformers shall be provided with a dial type thermometer for indicating oil temperature. The indicator shall be fitted with a pointer to register maximum temp recorded and adjustable set of mercury contact for alarm and trip.
- 6.26.8 In addition, all the transformers shall be provided with a dial type Hot Spot winding temperature indicator in HV, MV & LV windings. The indicator shall have a pointer to register maximum temperature reached and four sets of adjustable mercury contacts for alarm, trip, automatic control of fans & remote indication. The static remote repeater (for winding temperature indicator) suitable for flush mounting shall be installed on remote tap charge control cubicle.

- 6.26.9 The temperature indicators shall be housed in marshaling box.
- 6.26.10 The alarm (mercury) and trip (mercury) contact of WTI & OTI shall be adjustable between 40°C to 100°C. The temperature difference between opening & closing of these mercury contacts shall not be more than 10oC.
- 6.26.11 The mercury contacts used for controlling cooling plant motors shall be adjustable to close between 40°C and 100°C. The temperature differential between opening & closing of this mercury contact shall be between 10°C to 15°C.
- 6.26.12 All contacts should be accessible on removal of the cover adjustable to scale. It shall also be possible to move the pointers by hand for checking the operation of contacts and associated equipment.
- 6.26.13 In addition each transformer shall be provided with a dial type thermometer for indicating the ambient temperature.

6.27 ON LOAD TAP CHANGER (OLTC)

- 6.27.1 Each transformer shall be provided with an on load tap changer for varying it effective transformation ratio while the transformer is ON Load and without providing phase displacement. The salient features of the OLTC shall be as under:
1. All the auto-transformers shall be running in parallel and their tap changers shall be controlled by keeping any of them as master and others as followers.
 2. The tap changing mechanism should be suitable for remote control operation from remote control panel in the control room in addition to being capable of local manual as well as local electrical operation.
- 6.27.2 Tap Changing Switch shall be provided on LV side in sixteen (16) equal steps of 1.25% for variation of voltage from minus 5% to plus 15%.
- 6.27.3 In case of Transformer Bank, all the auto-transformers in Transformer Banks shall be running in parallel and their tap changers shall be controlled by keeping any of them as master and others as followers.

- 6.27.4 The on circuit switch handle shall be so located as to be easily operated by a man standing on the Transformer floor and shall be provided with a locking arrangement along with tap position indicator.
- 6.27.5 It shall not be possible to leave the tap changer in an intermediate position or leave the tap changer in different position for a bank: of three single phase Transformers. This shall be accomplished by means of electrical interlocking circuit.
- 6.27.6 The On Load Tap Changer (OLTC) shall be of high speed resistor type principle, make MR or ABB Sweden. The on load changer shall be vacuum technology include the following:
1. An oil immersed tap selector and arcing switch or arc suppressing tap selector, provided with reactor or resistor for reduction of make and breaks arcing voltages, overloads and short circuits.
 2. OLTC in addition to the requirement of 8.3 of IEC 60214 for on load tap changers, tap-changing equipment shall be capable of carrying the same currents, due to external short-circuit, as the transformer windings with they are associated.
 3. The contract life of the moving and fixed contacts of the on-load tap selector switch at the 600,000 operations minimum. The mechanical life shall be more than 800,000 operations. The number of operations between each maintenance period shall be 300,000 operations. The type test reports to support these figures shall be attached to the bid.
 4. Motor driven mechanism
 5. Control and Protection devices
 6. Local tap changer position indicator
 7. Manual operation device
- 6.27.7 The on-load tap changer shall be designed so that the contacts do not interrupt arc within the main tank of transformer. The tap changer selector and arcing switch or arc suppressing tap selector switch shall be located in one or more oil filled compartments. The diverter switch should be provided with gas vent and Buchholz relay. It shall be designed so as to prevent the oil in tap selector and diverter switch compartments

from mixing with the oil in transformer tank. The tap changer shall be capable of permitting parallel operation with other transformer of the same type.

- 6.27.8 The transformer shall give full load output on all taps without exceeding the limit of permissible temperature rise in oil and winding. The manual operating device shall be so located on the transformer that it can be operated by a man standing at the level of transformer track. It shall be strong and robust in construction and shall be capable of giving satisfactory service under site conditions including frequent operations. It shall not be possible to operate the electric drive when the manual operating gear is in use.
- 6.27.9 Necessary interlocks blocking independent control when the units are in parallel shall be provided.
- 6.27.10 The controls shall be so arranged as to ensure that when a tap change operation has commenced, it shall be completed independently of the operation of control relays or switches. Local or remote control switch shall cause one tap movement only until, the control switch is returned to the off position between successive operations. Under abnormal conditions such as may occur when the contactor controlling one tap change sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units. Limit switches shall be provided to prevent over running of mechanism.
- 6.27.11 The transformer and the tap changing equipment shall be designed to permit full rated operation with tap changing equipment temporarily installed in any intermediate position. Details of out of step protection provided for the taps should be furnished in the tender.
- 6.27.12 The control scheme for the tap changer shall be provided for independent auto/ non-auto control of the tap changer when the transformers are in independent service.
- 6.27.13 In addition provisions shall be made to enable parallel control also so that the tap changers of two or more transformers will be operated simultaneously when one unit is in parallel with another so that under normal conditions the tap changer will not become out of step and this will eliminate circulating current. Additional features like

“Master / Follower” and visual indication, during the operation of motor shall also be incorporated.

- 6.27.14 A mechanical tap position indicator shall be provided on the tap changer in addition to remote indication equipment in the control room on remote control cubicle of OLTC. Necessary interlocks, for independent control when the units are in parallel shall be provided.
- 6.27.15 The whole motor drive unit comprising the motor and its control gear including contactors, indicator, local electrical push buttons, five digit operation counters, handle for manual control etc. as well as terminals for the control and indication wiring shall be housed in a dust proof kiosk mounted on a tap changer. A heating element with thermostat and switch shall also be provided in kiosk, for ensuring trouble free operation of the drive in cold weather. Arrangement shall be made for padlocking the kiosk. Tap position indication shall be visible by number appearing in a small glass window on the front of the kiosk. For remote indication an instrument type indication of digital type shall be provided, on a panel.
- 6.27.16 Any enclosed compartment not oil filled shall be adequately ventilated. All contactors, relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation, fungi etc.
- 6.27.17 The oil in the compartments of the main tap changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of a pipe connection from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay. A separate Buchholz relay with trip contacts shall be provided for the On-Load Tap Changer chamber.
- 6.27.18 Each compartment in which the oil is not maintained under conservator head shall be provided with a suitable direct reading oil level gauge.
- 6.27.19 A permanently legible lubrication chart shall be fitted with the driving mechanism chamber.

- 6.27.20 Local electrical control switches and the local operating gear shall be clearly labeled in suitable manner to indicate the direction of operation of tap changer.
- 6.27.21 The prices shall include necessary indoor and outdoor equipment except for power and control cables (between the tap changer and control room). Complete particulars of the on load tap changer gear including, the capacity of the motor shall be stated in the tender.
- 6.27.22 The remote control panel of OLTC gear to be installed in the control room should match in colour and dimensions with the Employer's transformer control panel for which details would be furnished to the successful bidder.
- 6.27.23 In addition to the fittings, auxiliaries and accessories considered necessary by the Employer the following items shall be provided.
- 6.27.24 For Local Electrical Control
1. Raise/ lower selector switch with a intermediate 'OFF' position.
 2. Auxiliary transformer (if necessary) along with MCB's and links.
 3. Step by step contactor
 4. Thermal over-load relay for the motor
 5. Reversing contactor
 6. ON/OFF automatic trip air circuit breaker for motor supply
 7. Local /remote change-over selector switch.
- 6.27.25 For Remote Electrical Independent Control
1. All equipment listed in (ii) above.
 2. Tap position indicator for mounting on control panel in the control room.
 3. Signal lamp and buzzer, for indicating "Tap Change in Progress".
 4. Raise lower switch push button type with intermediate off/position for remote control.
 5. Emergency stop button (push button type) with visual indication.
 6. Visual and alarm indication for non completion of operation within pre-set time.
 7. Provision of interlocking system for blocking independent control when the units are to run in parallel by providing interlockable phase sequence selector switch.

8. All audio-visual indications should be brought to the Remote Tap Changer Cubicle (RTCC) panel.
9. A voltage chart along with HV & LV and tap position.
10. Space Heater with thermostat & switch to avoid condensation of moisture.
11. Suitable 11 W, CFL along with switch.

Note: - All equipment and their connections in RTCC panel should be properly marked. The buzzer/bell (Industrial type) should be provided.

6.27.26 For Simultaneous Parallel Operation of Transformers

1. All equipment listed in (III) above.
2. Out of step relay along with auxiliary relays, contactors and other equipment including a buzzer and signal lamp to indicate the out of step indication when transformers in one of pair of group of rating in parallel are one tap out of step and also to trip the circuit breaker.
3. Control selector switch to enable to run a transformer as Master/Follower or independent in a group.
4. Selection switches for individual/parallel operation.
5. D.C. supply, Isolators, D.C. supply, 'ON' indication & DC failure, booster alongwith cancellation.

6.28 AUTOMATIC VOLTAGE CONTROL

6.28.1 Automatic control shall be suitable for control of transformers in parallel.

6.28.2 Following methods of control shall be provided.

1. Automatic Independent – It shall be possible to select automatic independent control for each transformer irrespective of the method of control selected for any other of the associated transformers.
2. Automatic parallel- It shall be possible to select any transformer for master or follower control.

3. Interlocking shall be provided to not operate any tap changer by supervisory, remote or local electrical hand control while the equipment is switched for automatic operation.

6.29 VOLTAGE REGULATING RELAYS

- 6.29.1 Automatic voltage control shall be initiated by a voltage regulating relay of an approved type and suitable for flush mounting. The relay shall operate from the nominal reference voltage stated in the schedule of requirement derived from a circuit mounted LV voltage transformer having Class 1.0 or 0.5 accuracy to IEC 60186 and the relay voltage reference balance point shall be adjustable.
- 6.29.2 The relay bandwidth shall preferably be adjustable to any value between 1.5 times and 2.5 times the transformer tap step percentage, the nominal setting being twice the transformer tap step percentage.
- 6.29.3 The relay shall be insensitive to frequency variation between the limits of 47 Hz and 51 Hz. The relay shall be complete with a time delay element adjustable between 10 to 120 seconds. The relay shall also incorporate an under voltage blocking facility which renders the control inoperative if the reference voltage falls below 80% of the nominal value with automatic restoration of control when the reference voltage rises to 85% of nominal value.
- 6.29.4 On each transformer the voltage transformer supply to the voltage regulating relay shall be mounted for partial or complete failure. The specified indicating lamp and alarm will be inoperative when the circuit breaker controlling the lower voltage side of the transformer is open and also that when the tap changer is on control other than automatic control.
- 6.29.5 The voltage regulating relays shall be equipped with in line compensation facility for impedance or load current based compensation.
- 6.29.6 The voltage regulating relays AVRs shall be suitable for parallel, slave/follower and independent mode of operation and shall communicate with the other relays fitted with the transformer to operate in parallel.

6.30 ON-LINE DISSOLVED GAS ANALYSIS (DGA) & MOISTURE METER

6.30.1 The equipment shall be provided for Multi-Gas online dissolved gas monitoring of 33.33 MVA, $(220/\sqrt{3})/(132/\sqrt{3})$ kV transformer required for detection of incipient faults in transformers as per relevant standards. Transformer shall be fitted with online DGA which shall continuously monitor PPM value of dissolved gases at regular intervals.

6.30.2 Technical Parameters:

The equipment must be capable to measure following fault indicating gases

- i. Methane(CH_4)
- ii. Acetylene(C_2H_2)
- iii. Ethylene(C_2H_4)
- iv. Ethane(C_2H_6)
- v. Hydrogen(H_2)
- vi. Carbon Monoxide(CO)
- vii. Carbon Dioxide(CO_2)

6.30.3 The equipment shall also be able to measure Moisture (H_2O) content in transformer oil.

6.30.4 Humidity range shall be considered as 10 to 95 %.

6.30.5 The Accuracy of equipment shall be $\pm 5\%$ or \pm Lowest detection level (LDL), (whichever is greater)

6.30.6 The Repeatability of equipment shall be $\pm 2\%$ or ± 2 ppm, (whichever is greater)

6.30.7 The oil temperature range of the equipment shall be -10°C to 120°C and external temperature range shall be -5°C to 50°C .

6.30.8 The equipment should not use any Carrier Gases or calibration gases.

6.30.9 The equipment shall be required to measure gas concentration and compare it with relevant IEC standard or user defined configuration for the alarm. The dissolved gases shall be displayed in PPM or as a percent of alarm setting.

6.30.10 The sampling rates measurement frequency shall be configurable from hourly to daily.

6.30.11 The equipment shall be built of memory to store results for minimum six month irrespective of sampling rate at the lowest interval.

6.30.12 The equipment should have LCD display at local unit to provide test result instantly.

- 6.30.13 Suitable provision shall be made at the display unit to give alarm and trip signal.
- 6.30.14 All the results shall be suitably communicated (IEC 61850 protocol) to the remote computers (HMI) located in control room & integrate into the SCADA system and locally through laptop via RS-232/ RS-485, USB.
- 6.30.15 Suitable software shall be provided for Fault Diagnosis i.e. Key gases, Ratios (Rogers/IECstandard), Duval's Triangle, Church Monogram and Cellulose Degradation etc.
- 6.30.16 The detecting, measuring and digital display unit shall be provided in a dust and weather proof enclosure with degree of protection IP-55.
- 6.30.17 The equipment shall be suitable to operate on $230 \pm 10\%$ V AC, 50Hz supply.
- 6.30.18 The Transformer shall be fitted with the relevant oil and gas actuated relay equipment conforming to IS: 3637/ relevant IEC standards having contacts which shall close oil surge or low level conditions.

6.31 ANTI-EARTHQUAKE CLAMPING DEVICE

To prevent transformer movement during earthquake, a clamping device shall be provided for fixing the transformer to the foundation. The contractor shall supply necessary bolts for embedding in the concrete after transformer is placed on foundation. The arrangement shall be such that the transformer can be fixed to or unfastened from these bolts as desired.

6.32 FITTINGS

The following fittings shall be provided on the transformers:

1. Conservator with isolating valves, oil filling hole with cap and drain valve. The drain valve of 15 mm size for conservator vessels of dia. Up to 650 mm and of 25 mm size for conservator vessel dia. above 650 mm. The conservator vessel shall be fitted with constant oil pressure diaphragm oil sealing system to prevent oxidation and contamination of oil due to contact with air. The requirement of the system are as given below:

- a. Contact of the oil with atmosphere shall be prevented by using a flexible oil resistant nitrile rubber air cell.
 - b. Diaphragm of conservator shall be able to withstand the vacuum during installation/maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve in the pipe connecting main tank with the conservator.
 - c. The connection of the air cell to the top reservoir is by an airproof seal preventing entrance of air into the conservator.
 - d. The magnetic oil level gauge provided with the conservator shall have contacts for giving alarm when the air cell gets damaged or sinks.
2. Magnetic type oil level gauge (150 mm dia.) with low oil level alarm contacts. Prismatic/toughened glass oil level gauge.
 3. Maintenance-free Dehydrating breather shall be provided at a level of 1300 mm above ground level & Each silica gel breathe shall be equipped with a condition based self-learning microprocessor control unit for optimal maximization controlled regeneration on the silica gel during phase when the transformer exhaling and LED status condition. The function shall be tested via a test button or silica gel free breather is also accepted.
 4. A double float type Buchholz relay with isolating valve, bleeding pipe and a testing cock, the test cock shall be suitable for a flexible (pipe connection for checking its operation). A 5 mm dia. Copper pipe shall be connected from the relay test cock to a valve located about 1.25 meters above ground level to facilitate sampling of gas with the transformer in service. Interconnection between gas collection box and relay shall also be provided. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden oil surge. These contacts shall be wired up to transformer marshalling box. The relay shall be provided with shut off valve on the conservator side as well as on the tank side.

5. Pressure relief device

A pressure relief device of sufficient size capable of resealing shall be provided for rapid release of any pressure that may be generated within the tank and which may result in damage to the equipment. The device shall be spring loaded and shall be calibrated to operate at a set pressure of oil. The device shall be capable of resetting itself automatically to its original condition after release of excess pressure. The device shall be designed to eliminate any chattering of the valve during operation. The device shall be provided with suitable alarm & trip contacts. The device shall operate at a static pressure of less than the, hydraulic test Pressure for the Transformer tank.

A necessary air equalizer connection through a pipe connecting the pressure relief device to the conservator along with necessary alarm contacts shall be provided for relieving or equalizing the pressure in the pressure relief device. A suitable pipe shall be provided for draining the oil from the pressure relief device down to the oil pit.

6. Air release plugs in the top cover.

7. Inspection cover, access holes with bolted covers for access to inner ends of bushing, etc.

8. Winding temperature (hot spot) indicating device for local mounting complete in all respects. Winding temperature indicator shall have three sets of contacts to operate at different settings :

9. To provide winding temperature 'high alarm'

10. To provide temperature too high 'trip'

11. Dial thermometer with pocket for oil temperature indicator with one set of alarm and one set of trip contacts and maximum reading pointer.

12. Lifting eyes or lugs for the top cover, core and coils and for the complete transformer.

13. Jacking pads.

14. Haulage lugs.

15. Protected type mercury/alcohol in glass thermometer and a pocket to house the same.

16. Top and bottom filter valves on diagonally opposite ends with pad locking arrangement on both valves.
17. Top and bottom sampling valves.
18. Drain valve with pad locking arrangement.
19. Rating and connection diagram plate.
20. Two earthing terminals each capable of carrying short circuit current of the Transformer for 4 seconds shall be provided at bottom at two comers of the Transformer tank. The earthing terminals shall be suitable for bolted connection and connection to the earth mat risers, provided by the Employer.
21. Bi-directional flagged rollers with locking and bolting device.
22. Marshalling Box (MB)
23. Shut off valve on both sides of flexible pipe connections between radiator bank and transformer tank.
24. Cooling Accessories :
25. Requisite number of radiators provided with :
26. One shut off valve on top
27. One shut off valve at bottom
28. Air release device on top
29. Drain and sampling device at bottom
30. Lifting lugs.
31. Air release device and oil drain plug on oil pipe connectors.
32. Terminal marking plates for Current Transformers and Main Transformer.
33. On Load tap changer with following as per arrangement of similar equipment for main transformer.
34. Buchholz Relay.
35. Pressure Relief Valve with trip contacts.
36. Remote Tap changer Control Panel.
37. Any other equipment recommended or suggested by the manufacturer of OLTC.
38. One number ladder with provision for anti-climbing device.

Note:

- (i) The fittings listed above are indicative and any other fittings which are generally required for satisfactory operation of the transformer are deemed to be included in the quoted price of the transformer.
- (ii) The contacts of various devices required for alarm and trip shall be potential free and shall be adequately rated for continuous, making and breaking current duties at 110 volts D.C. (nominal).

6.33 CONTROL CONNECTIONS, ALARMS AND WIRING TERMINAL, BOARD AND FUSES

- 6.33.1 The Transformer manufacturer shall supply complete control equipment for the Transformers and sufficient contacts for its auxiliaries including cooling fans and various annunciations/alarms shall be provided. The control equipment for the Transformers shall be housed in the respective marshalling boxes of weather proof construction. The supplier shall take care the provision of Auxiliary supplies to marshalling box by providing necessary MCCB, cables etc. The Transformer supplier shall make provision for repeat indications of winding temperature of all the phases of 220 kV & 132 kV windings, oil temperature, Buchholz relay status, pressure relief device status, AC/DC supply status etc.
- 6.33.2 The control equipment to be provided with the Transformer shall also include (but not be limited to) necessary supply distribution arrangement consisting of switch fuse units contactors, overload relays, remote/local control switch, start/ stop push buttons etc
- 6.33.3 Provision shall be made in the Transformer control panels for annunciation alarms & trips for the following (but not be limited to) abnormal conditions for which sufficient number of contacts shall be provided on the initiating relays/devices:

Alarms

- 1. H. V. Winding temperature 'High'
- 2. L. V. Winding temperature 'High'
- 3. Oil temperature 'High'
- 4. Buchholz relay 'Alarm'
- 5. Oil level 'Low'

6. Oil flow 'Low'
7. Water flow "Low"
8. Differential pressure 'Low'
9. Power supply "Failure"
10. Oil pump motor 'Over Loaded'
11. Water leakage in coolers

Trips

1. H. V. Winding temperature 'Very High'
2. L. V. Winding temperature 'Very High'
3. Oil temperature 'Very High'
4. Buchholz relay 'Trip'
5. Pressure relief device operated

- 6.33.4 Normally no fuses shall be used anywhere. Instead of fuse, MCBs (both in AC & DC circuits) shall be used. Only in cases where a MCB cannot replace a fuse due to system requirements, a HRC fuse can be accepted.
- 6.33.5 All wiring connections, terminal boards, fuses MCB's and links shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation and the bare ends of stranded wire shall be sweated together to prevent seepage of oil along the wire.
- 6.33.6 Panel connections shall be neatly and squarely fixed to the panel. All instruments and panel wiring shall be run in PVC or non-rusting metal cleats of the compression type. All wiring to a panel shall be taken from suitable terminal boards.
- 6.33.7 Where conduits are used, the runs shall be laid with suitable falls, and the lowest parts of the run shall be external to the boxes. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.
- 6.33.8 When 400 volt connections are taken through junction boxes or marshalling boxes, they shall be adequately screened and 400 volts Danger Notice must be affixed to the outside of the junction boxes or marshalling box. Proper colour code for Red, Yellow, Blue wires shall be followed.

- 6.33.9 All box wiring shall be in accordance with relevant IS. All wiring shall be of stranded copper (48 strands) of 1100 Volt grade and size not less than 2.5 sq.mm.
- 6.33.10 All wires on panels and all multi-core cables shall have ferrules which bear the same number at both ends, as indicated in the relevant drawing.
- 6.33.11 At those points of interconnection between the wiring carried out by separate contractors, where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment.
- 6.33.12 The same ferrule number shall not be used on wires in different circuits on the same panels.
- 6.33.13 Ferrules shall be of white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil.
- 6.33.14 Stranded wires shall be terminated with tinned Ross Courtney terminals, claw washers or crimped tubular lugs. Separate washers shall be suited to the size of the wire terminated. Wiring shall, in general, be accommodated on the sides of the box and the wires for each circuit shall be separately grouped. Back of panel wiring shall be arranged so that access to the connecting items of relays and other apparatus is not impeded.
- 6.33.15 All circuits, in which the voltage exceeds 125 volts, shall be kept physically separated from the remaining wiring. The function of each circuit shall be marked on the associated terminal boards.
- 6.33.16 Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of stranded copper wire or strip having a cross section of not less than 2 sq. mm where strip is used, the joints shall be sweated. The copper wire shall have green coloured insulation for earth connections.
- 6.33.17 All wiring diagram for control and relay panel shall preferably be drawn as viewed from the back and shall show the terminal boards arranged as in services.
- 6.33.18 Terminal board rows should be spaced adequately not less than 100 mm apart to permit convenient access to external cables and terminations.

- 6.33.19 Terminal boards shall be placed with respect to the cable gland (at a minimum distance of 200 mm) as to permit satisfactory arrangement of multicore cable tails.
- 6.33.20 Terminal boards shall have pairs of terminals for incoming and outgoing wires. Insulating barriers shall be provided between adjacent connections. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals. The terminals shall be adequately protected with insulating dust proof covers. No live metal shall be exposed at the back of the terminal boards. CT terminals shall have shorting facilities. The terminals for CTs should have provision to insert suitable plugs and with isolating links. 20% spare terminals shall be provided.
- 6.33.21 All fuses shall be of the HRC cartridge type and these shall be properly labelled, wherever these cannot be replaced by MCB as normally only MCB's shall be used.
- 6.33.22 All interconnecting wiring, as per the final approved scheme between accessories of transformer and marshalling box is included in the scope of this specification and shall be done by the Transformer supplier.
- 6.33.23 The schematic diagram shall be drawn and fixed under a transparent prospane sheet on the inner side of the marshalling box cover.
- 6.33.24 As a rule, the fuses shall be replaced by Miniature Circuit Breakers (MCBs) in the control and other supplies.
- 6.33.25 To avoid condensation in the MB, a space heater shall be provided with an MCB and thermostat.
- 6.33.26 Suitable 11W, CFL light shall be provided in the Marshalling Box for lightning purpose.

6.34 RADIO INTERFERENCE AND NOISE LEVEL

Transformers shall be designed with particular care to suppress at least the third and fifth harmonic voltages so as to minimize interference with communication circuits. Transformer noise level, when energized at normal voltage and frequency shall be as per NEMA stipulations.

6.35 NITROGEN INJECTION FIRE PROTECTION CUM EXTINGUISHING SYSTEM (NIFPES) FOR 33.3 MVA AUTO AND 30 MVA POWER TRANSFORMER

The contractor shall provide the nitrogen injection fire protection cum extinguishing system. The fire protection system using nitrogen as fire quenching medium is required for the 33.3 MVA 220/132 kV auto transformer and 30 MVA 220/33kV and 132/33kV transformer. NIFPES shall act as fire preventer by preventing transformer oil tank explosion and possible fire in case of internal faults. In the event of fire by external causes such as bushing fire, OLTC fires, fire from

Surrounding equipment etc, it shall act as a fast and effective fire fighter. NIFPES shall accomplish its role as fire preventer and extinguisher without employing water and/or carbon dioxide. Fire shall be put out within max. 3 minutes of system activation and within max. 30 seconds of commencement of nitrogen injection.

6.35.1 Activation of NIFPES

Mal-functioning of fire prevention/extinguishing systems is their major shortcoming which leads to interruption in power supply. The contractor shall ensure that the chances of malfunctioning of NIFPES are practically nil. To achieve this objective, the contractor shall work out his scheme of activating signals which, while preventing mal-operation, should not be too rigorous to make the operation of NIFPES impracticable in case of actual need. Transformer isolation shall be the mandatory pre-requisite for activation of the system in automatic mode or remote mode in the control room. In addition, at least following electrical-signals shall be provided in series for activating NIFPES.

6.35.2 Auto Mode

a) For prevention of fire:

i) Differential relay operation

ii) Buchholz relay paralleled with pressure relief valve

iii) Tripping of all connected breakers is a pre-requisite for initiation of system activation.

b) For extinguishing fire:

i) Fire detector

ii) Buchholz relay paralleled with pressure relief valve

iii) Tripping of all connected breakers is a pre-requisite for initiation of system activation.

Manual Mode (Local/Remote): Tripping of all connected breakers is pre- requisite for initiation of system activation.

Manual Mode (Mechanical): Tripping of all connected breakers is a pre- requisite for initiation of system activation.

6.35.3 General description of NIFPES

Schematic of the system

NIFPES should be a standalone dedicated system for oil filled transformer. It should have a fire extinguishing (F.E.) cubicle placed on a plinth at a distance of 6-10 mtrs from the transformer. The F.E. cubicle may be connected to the transformer oil tank (near its top) and to the oil pit (of capacity approx. equal to 10% of transformer oil tank) from its bottom through oil pipes with gate valves. The F.E. cubicle should house a pressurized nitrogen cylinder connected to the transformer oil tank (near its bottom). Cable connections are to be provided from signal box placed on the transformer to the control box in the control room and from control box to F.E. cubicle. Fire detectors placed at the top of transformer are to be connected in parallel to the signal box. The signal box may be connected to a Pre-stressed non-return valve fitted between the conservator tank and Buchholz relay. Control box is also to be connected to relay panel in control room for system activation signals.

6.35.4 Operation

On receipt of all activating signals, drain of pre-determined quantity of oil commences thus removing high temp top oil layer. Simultaneously nitrogen is injected under high pressure at a pre-fixed rate, stirring the oil thus bringing the temperature of top oil layer down. Nitrogen occupies the space created by oil drained out and acts as an insulating layer between the tank oil and fire on top cover. Pre-stressed non-return valve blocks oil flow from conservator tank, thus isolating it & preventing aggravation of fire.

6.35.5 System components

Broadly, NIFPES shall consist of the following components. It is emphasized that all components, irrespective of their exclusion in the details given below, necessary for fast reliable and effective working of NIFPES shall be considered within the scope of supply.

6.35.6 Fire extinguishing cubicle

It shall be made of 3 mm thick steel sheet, painted dark red from inside and outside with hinged split doors fitted with high quality tamper proof lock. It shall be complete with the base frame and the following:-

- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer. 12
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for oil drain and pre-determined regulated nitrogen release.
- Pressure monitoring switch for back-up protection for nitrogen release.
- Limit switches for monitoring of the system.
- Flanges on top panel for connecting oil drain and nitrogen injection pipes for transformer.
- Panel lighting (CFL type)
- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

6.35.7 Control box

Control box for monitoring system operation, automatic control and remote operation, with following alarms indication, light switches, push buttons, audio signal, line fault detection suitable for tripping and signaling on 110V DC supply.

- System on
- PNRV open
- Oil drain valve closed
- Gas inlet valve closed
- PNRV closed
- Fire detector trip
- Buchholz relay trip

- Oil drain valve open
- Extinction in progress
- Cylinder pressure low
- Differential relay trip
- PRV operated
- Transformer trip
- System out of service
- Line fault fire detector
- Line fault differential relay
- Line fault buchholz relay
- Line fault PRV
- Line fault transformer trip
- Line fault PNRV
- Auto / Manual/Off
- Extinction release on
- Extinction release off
- Lamp test
- Visual/Audio alarm
- Visual/Audio alarm
- Visual/audio alarm for DC supply fail

6.35.8 Pre-stressed non return valve (PNRV)

PNRV is to be fitted in the conservator pipe line between conservator and Buchholz relay. It shall have the proximity switch for remote alarm, indication and with visual position indicator the valve will not isolate conservator during, normal flow of oil during filtration or filling, Locking plates shall be provided with handle for pad locking to ensure no movement for valve position during service and filter position . The PNRV should be of the best quality because malfunction of PNRV shall be of serious consequence as its closing leads to stoppage of breathing of transformer.

6.35.9 Fire detectors

The system shall be complete with adequate number of fire detectors fitted on the top of oil tank, OLTC/OFF circuit tap changer for heat sensing each fitted with two no. cable glands (water proof/weather proof).

6.35.10 Signal box

It shall be fitted on the transformer for terminating cable connections from PNRV and fire detectors and for further connection to the control box.

6.35.11 Cables

Fire survival copper cables, able to withstand 750 degree C, Fire retardant low smoke (FRLS) cable 12 core x 1.5 mm sq. for connection between transformer signal box/marshalling box to control box and control box to fire extinguishing cubicle shall be used. Fire retardant low smoke cable 4 core x 1.5mm sq. for connection between control box to DC supply source and fire extinguishing cubicle to AC supply source, signal Box/marshalling box to pre-stressed non return valve connection on transformer shall be used.

6.35.12 Pipes

Pipes, complete with connections, flanges, bends tees etc. shall be supplied alongwith the system.

6.35.13 Other items

- A. Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations.
- B. Flanges with dummy piece in conservator pipe between Buchholz relay and conservator tank for fixing PNRV.
- C. Fire detector brackets on transformer top cover.
- D. Spare potential free contacts for system activating signals i.e. differential relay buchholz relay, pressure relief valve, transformer isolation (master trip relay).
- E. Pipe connections between transformer to fire extinguishing cubicle and fire extinguishing cubicle to oil pit.

- F. Cabling on transformer top cover for fire detectors to be connected in parallel and inter cabling between signal box to control box and control box to fire extinguishing cubicle.
- G. Mild steel oil tank with moisture proof coating and sheet thickness of minimum 5 mm, with watertight cover, to be placed in the oil pit. This tank shall be provided with the manhole, air vent pipe through silica gel breather, drain valve and a spare gate valve at the top.
- H. The capacity of tank shall be 10,000 liters and shall be provided as each Substation. The location of the tank shall be approved by the employer. All the Transformers to be fitted with NISPEF at that Substation. shall be connected through suitable piping arrangement to this common tank.
- I. DC-DC converter 220-110V DC (optional, incase 110V, supply is not available.)
- J. Gate valves on oil drain pipe and nitrogen injection pipe should be able to withstand full vacuum. A non-return valve shall also be fitted on nitrogen injection pipe between transformer and gate valve.
- K. The F.E. cubicle shall be painted with post office red color (shade 538 of IS-5). All the exposed parts i.e. pipes, supports, signal box etc shall be painted with enameled paint.
- L. Civil works of Fire extinguishing cubicle

6.35.14 Interlocks

It shall be ensured that once the NIFPES gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also PNRV shall get closed only if all the connected breakers are open.

Technical particulars

I.	Fire extinction period	
	On commencement of nitrogen injection	Max. 30 Seconds
II.	From the moment of system activation to	Max. 3 Minutes
III.	Complete cooling	14
IV.	Fire detectors heat sensing temperature	141Deg C

V.	Heat sensing area	800mm radius
VI.	Pre-stressed non return valve setting	Minimum 40 liter per minute for normal operation and minimum 60 liter per minute for abnormal operation
VII.	Min. Capacity of nitrogen cylinder	10 m ³ gas at pressure of 150kg/cm ² upto 60000 liter oil capacity of tank and 20m ³ gas at pressure of 150kg/cm ² above 60000 liter.
VIII.	Power Source (Control Box)	110V DC
IX.	Fire extinguishing cubicle for lighting	230V AC

6.36 TESTS

6.36.1 Bidders have to offer the already type tested transformers as per relevant IEC/IS or any other equivalent international standards. The type test report should not be earlier than 10 years as on the date of bid opening. If the transformers offered are not type tested or in case of incomplete type test reports, the successful bidder shall undertake to repeat the type test at his own expenses.

6.36.2 The Transformers shall be completely factory tested before dispatch in accordance with the IEC/ IS standards and with such other tests as may be necessary to ensure that the equipment is satisfactory and is in accordance with this specification. No equipment shall be dispatched from the manufacturers work before the relevant test reports have been approved by the Employer.

6.36.3 Routine Tests

Routine tests on transformers shall include tests stated in latest issue of IS: 2026. These tests shall also include but shall not be limited to the following:

1. Measurement of winding resistance.
2. Voltage ratio on each tapping and checking of voltage vector relationship.
3. Impedance at principal, minimum & maximum tapping position
4. Magnetic balance test.
5. Load losses.
6. No load losses and no load current.

7. Insulation resistance for 60 seconds and 15 seconds (R60/R15) and polarization index i.e. Insulation Resistance for 10 minutes and one minute (R10/R1).
8. Induced over voltage withstand test.
9. Separate source voltage withstand test (applied potential).
10. Tan delta measurement and capacitance of each winding to earth (with all other windings earthed) & between all windings connected together to earth.
11. Measurement of acoustic noise level.
12. Measurement of Zero sequence impedance.
13. Lighting Impulse Test for 220/132, 220/33 kV Transformers and 132/33kV Transformer
14. Di-electric Tests
 - a. For 220/132 Transformers, 220/33 kV Transformers and 132/33kV Transformers
 - Short duration AC
 - Separate source AC
 - Long Duration AC

6.36.4 Type Tests

The transformer shall be subjected to the following type tests (in case the offered transformers are not type tested or the complete type test was not conducted as per the IEC/IS standards) as per the IS 2026 in the presence of the Employers representative:

1. Lightning Impulse voltage Test

This test shall be carried out in accordance with clause 12 of the latest issue of IS: 2026 (Part-III).

2. Temperature Rise Test along with Dissolved gas analysis test.

The temperature rise test shall be carried out in accordance with IS: 2026 Part-II. The Temperature rise shall not exceed the values stated elsewhere in the specification. Test shall be carried out by feeding 1.1 time the total guaranteed losses at 75⁰C at highest current tap.

3. Test on OLTC

4. All routine and type test shall be carried out free of cost.

6.36.5 Special Test:

Short Circuit Test: Short circuit test on one unit of each rating shall be conducted in the presence of employer's representative or if short circuit test on an identical unit of transformer has already been conducted the same shall be submitted for consideration. However, short circuit calculations shall be submitted to prove the withstand capability of transformer for short circuit forces.

6.37 TEST WAIVER, PROCEDURES AND COSTS

- 6.37.1 The Employer, at his discretion, may waive impulse tests provided type test reports of impulse voltage withstand tests carried out on **an identical units** in any Government accredited Laboratory in India within last 5 years are furnished by the manufacturer.
- 6.37.2 No load losses and exciting current shall be measured at rated voltage, rated frequency and at 90% and 110% of rated voltage, both before and after the lightning impulse tests.
- 6.37.3 The method of test loading shall be described in the test report for determination of both average and hottest spot temperature. Where the winding temperature equipments are specified, data shall also be included for calibration of hottest spot temperature indicator.
- 6.37.4 Resistance of each winding of each phase shall be measured at principal and at all the taps and corrected to 75 °C.
- 6.37.5 Impedance voltage shall be measured at principal and at all taps,
- 6.37.6 No load Loss Measurement at 400 Volt.

6.38 STAGE INSPECTION

The Employer reserves the right for stage inspection at the time of manufacturing of the transformers at various stages, to ensure that internal details are in accordance with specifications approved manufacturer drawings for which the supplier would give 15 days prior notice and the supplier would not go ahead with further production schedule without obtaining concurrence from the Employer.

a) Core:

Bidders will offer the core for inspection and approval by the Employer during the manufacturing stage.

Following tests shall be carried out:

- (i) Measurement of flux density.
- (ii) No load loss measurement by providing dummy coils at 90%, 100% and 110% rated voltage and frequency.
- (iii) Physical inspection for quality of workmanship.

b) Windings:

- (i) Measurement of cross-sectional area for current density.
- (ii) Measurement of weight of bare copper/ cover by resistance methods.
- (iii) Test may be carried out on sample of copper for assessing its quality.

c) Tests on Transformer Tank

- (i) **Vacuum Test:** One transformer tank of each size shall be subjected to the vacuum pressure of 760 mm of mercury. The tanks designed for full vacuum shall be tested at an internal pressure of 3.33 KN/m² (25 mm of mercury) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in C.B.I.P. Manual and as mentioned below on Transformers (Revised 1999) without affecting the performance of the transformer.

Horizontal length of flat plate (mm)	Permanent Deflection (mm)
Upto & including 750	5.0
751-1250	6.5
1251-1750	8.0
1751-2000	9.5
2001-2250	11.0
2251-2500	12.5

2501-3000	16.0
above 3000	19.0

- (ii) **Pressure Test:** One transformer tank of each size together with its radiators, conservator vessel and other fittings shall be subjected to pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 KN/m² square (5 1b/sq.in) whichever is lower measured at the base of the tank and will be maintained for one hour. The permanent deflection of flat plates after the excess pressure has been released shall not exceed the value specified in C.B.I.P. Manual on Transformers (Revised 1999) and as mentioned above.
- (iii) The pressure relief device shall be subjected to increasing oil pressure. It shall operate before reaching the test pressure specified above. The operating pressure shall be recorded. The device shall seal off after the pressure in excess has been relieved (routine test).
- (iv) **Oil leakage test:** All tanks and oil filled compartments shall be tested for oil tightness by oil of a viscosity not greater than that of insulating oil to IS:335, at the specified ambient temperature and subjected to a pressure equal to the normal pressure plus 35 KN/m² square (5 1b/sq.in) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours, during which time no leakage shall occur.

6.39 TESTS ON ASSOCIATED EQUIPMENT

Porcelain bushings, bushing current transformers, wherever provided, winding temperature indicating devices, dial thermometers, Buchholz relays, ON LOAD tap changer, coolers, control devices, insulating oil and other associated equipment shall be tested by the supplier in accordance with relevant IS. If such equipment is purchased by the supplier from a sub-vendor, he shall have them tested to comply with these requirements.

6.40 SEQUENCE OF TESTING ON ASSEMBLED TRANSFORMER

Unless otherwise agreed, the sequence of testing shall be as follows:

1. Ratio and vector group
2. Winding resistance measurement
3. Insulation resistance measurement
4. Separate source voltage withstand test
5. Measurement of Iron losses
6. Load losses and impedance voltage measurement
7. Temperature rise test
8. Induced voltage withstand test
9. Tests on OLTC
10. Magnetic balance test

6.41 WITNESSING OF TESTS AND EXCESSIVE LOSSES

- 6.41.1 The Employer and/or his representative reserve the right to witness any or all tests, or to accord waiver at its sole discretion.
- 6.41.2 The Employer reserves the right to reject the Transformer if losses exceed the declared losses beyond tolerance limits as per IS or if temperature rise of oil and winding exceed the values specified elsewhere.

6.42 CAPITALISATION OF TRANSFORMER LOSSES

- 6.42.1 The transformer losses will be capitalized as follows for evaluation purpose:
- a) No load losses: **US\$ 4684 per kW**
 - b) Load losses: **US\$ 1180 per kW**
 - c) Loss associated with cooling fan load (Auxiliary losses) : US\$ 393 per kW

6.42.2 Guaranteed Values Not Reached

If the individual losses of a power transformer as measured during test exceeds the values guaranteed in the Bid, then for each kilowatt of losses in excess of the losses guaranteed, an amount at the rates of twice the rates of specified in clause 6. 42.1 for no load losses, load losses and cooling fan load shall be deducted from the Contract Price of the successful Bidder.

6.42.3 Performance Guarantee

The performance figures quoted on Technical Data Sheet shall be guaranteed within the tolerances permitted by relevant standards listed under this Technical Specifications, and shall become a part of the successful Bidder's Contract. In case of loss capitalization, no tolerance shall be permitted for the guaranteed value. The transformer will be rejected, if the measured no-load and load losses (excluding fan loss) exceed the guaranteed value by over 15 % provided that the total losses do not exceed 10% as specified.

6.42.4 Bidders shall indicate the guaranteed values of no load losses at rated voltage & rated frequency and load losses & Auxiliary losses at rated output, rated voltage & rated frequency will be indicated in the Guaranteed Technical Particulars. If the bidders quote unrealistic and unachievable guaranteed transformer loss values (no-load or load losses), then the Employer may ask the bidder to submit technical justifications to Substantiate such guaranteed losses. If the justifications are not satisfactory, the proposed transformers shall be rejected and the bid shall be considered non-responsive.

6.43 REJECTION

The Employer may reject any transformer if during tests or service any of the following conditions arise:

- 1) No load loss exceeds the guaranteed value by 15% or more.
- 2) Load loss exceeds the guaranteed value by 15% or more.

- 3) Impedance value exceeds the guaranteed value by + 10% or more.
- 4) The difference in impedance values of any two phases during single phase short circuit impedance test exceeds 2% of the average value guaranteed by the vendor.
- 5) Oil or winding temperature rise exceeds the specified value.
- 6) Transformer fails on power frequency voltage withstand test.
- 7) Transformer is proved to have been manufactured not in accordance with the agreed specification.

6.44 DRAWINGS & INSTRUCTIONS MANUAL

6.44.1 Drawings

- a. The contractor shall furnish, within 4 months after issuing of Letter of Award, six copies each of the following drawings/documents incorporating name of project and transformer rating for approval.
 1. Detailed overall general arrangement drawing showing front and side elevations and plan of the transformer and all accessories including radiators and external features with details of dimensions, spacing of wheels in either direction of motion, net weights and shipping weights, crane lift for untanking, size of lugs and eyes, bushing lifting dimensions, clearances between HV and LV terminals and ground, quantity of insulating oil etc.
 2. Foundation plan showing loading on each wheel and jacking points with respect to centre line of transformer.
 3. GA drawings/details of bushing and terminal connectors.
 4. Name plate drawing with terminal marking and connection diagrams.
 5. Wheel locking arrangement drawing.
 6. Transportation dimensions drawings.
 7. Interconnection diagrams.
 8. Over fluxing withstand time characteristic of transformer.
 9. GA drawing of marshalling box.

10. Control scheme/wiring diagram of marshalling box, OLTC and interconnection between OLTC, RTCC and marshalling box.
 11. Technical leaflets of major components and fittings.
 12. As built drawings of schematics, wiring diagram etc.
 13. Setting of oil temperature indicator, winding temperature indicator.
 14. Completed technical data sheets.
 15. Details including write-up of tap changing gear.
 16. H.V. cond. bushing.
 17. Bushing Assembly.
 18. Bi-metallic connectors for connection to ACSR "MOOSE" (as per site requirement) conductor of 33.33 MVA transformers.
 19. GA of LV cable Box.
 20. Radiator type Assembly.
 21. Detailed calculations showing short circuit withstand capability due to radial and axial forces during short circuit. Also calculations for thermal withstand capability during short circuit.
- b. All drawings/documents, technical data sheets and test certificates/results/calculations shall be furnished.
 - c. Detailed calculations showing circuit withstand capability due to radial and axial forces during short circuit. Also calculations for thermal withstand capability during short circuit.
 - d. Any approval given to the detailed drawings by the Employer shall not relieve the contractor of the responsibility for correctness of the drawing and in the manufacture of the equipment.

6.44.2 Instructions Manual

Six sets of the instruction manuals shall be supplied atleast four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection, operation and maintenance of the transformer.

6.44.3 Completeness of Equipment

- a. All fittings and accessories, which may not be specifically mentioned in the specification but which are necessary for the satisfactory operation of the plant, shall be deemed to be included in the specification and shall be furnished by the contractor without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not, without any financial liability to the Employer under any circumstances.
- b. All deviations from this specification shall be separately listed under the requisite schedules, in the absence of which it will be presumed that all the provisions of the specification are compiled by the bidder.

6.45 CENTER OF GRAVITY

The center of gravity of the assembled Transformer shall be low and as near the vertical centre axis as possible. The Transformer shall be stable with or without oil and with or without bushings. If the center of gravity is eccentric relative to track either with or without oil, its location shall be shown in the outline drawing.

6.46 TOOLS & TACKLES

Hydraulic jacks of suitable capacity and all the necessary tools and tackles required for normal operation shall be supplied by the Contractor.

6.47 GUARANTEED TECHNICAL PARTICULARS

The bidder shall give the GTPs of transformer along with the tender.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-7 **Earthing System**

SECTION 4
CHAPTER – 7
EARTHING SYSTEM

CONTENTS

S.NO	DESCRIPTION	PAGE NO
7.0	SCOPE	1
7.1	STANDARDS	1
7.2	DESCRIPTION	2
7.3	GENERAL EQUIPMENT	3
7.4	EARTHING CONDUCTOR LAYOUT	4
7.5	EARTHING PIT	4
7.6	TECHNICAL PARTICULARS	4

SECTION 4**CHAPTER - 7****EARTHING SYSTEM****7.0 SCOPE**

- 7.0.1** These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, transportation up to site, testing & commissioning of material of earthing system for Construction of 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. It shall be the bidder's responsibility to assess the exact quantity of complete material required for the earthing system.

7.1 STANDARDS

- 7.1.1** The equipments / material of the earthing system shall confirm to the following Indian/equivalent international Standards:-

TABLE-7.0

IS : 3043	Codes of Practice for Earthing
IS : 2026 – 1992	Steel for general structural purposes
IS: 808- 1991	Dimensions for hot rolled steel beam, column and angle Sections.
IS : 816 – 1992	Code of practice for use of metal arc welding for general construction in mild steel
IS: 1364- 1992	Hexagon head bolts, Screws and nuts of product grades A & B
IS : 1599 – 1992	Methods for bend test
IS : 1608 – 1991	Method for tensile testing of steel products.
IS: 2629 – 19990	Recommended practice for hot dip galvanizing on iron &Steel.
IS : 209 – 1992	Zinc ingot

IEEE STD 80 -2000

IEEE Guide for safety in AC Substation Grounding

7.2 DESCRIPTION

7.2.1 The contractor shall prepare the design of ground mat , earthing electrode etc. for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar as per layout given in Drawings in accordance with the latest Edition of IS : 3043, ANSI / IEEE- 80-2000 for 1 second duration of fault current as per protection systems provided..The earthing design for extension of 2 No. of 220 kV line bays at Inaruwa shall match the existing system. The same shall be got approved before procuring the material. The bidder shall make arrangement to supply grounding material (flat, pipes, round etc.) as per design approved by the employer/NEA for laying the ground mat in outdoor yard area which is extended 2m beyond fencing including grounding of fencing in the outdoor yard etc. The grounding of the equipment and devices both in the control room and outdoor yard area shall be with G.S flats of required sizes, ground electrodes etc. The earthing terminal for lightning arrestors shall be directly connected to pipe electrodes in treated earth pits as per IS: 3043. The earthing lead from the neutral of the power transformer shall be directly connected to two pipe electrodes in treated earth pits as per IS: 3043. Two ground connections shall be arranged for all the equipments and devices, as per IE rules/standards.

The tentative size of the flats for ground mat to be used shall be as follows:

TABLE-7.1

S.No.	Item	Specification
a.	Control room	MS flat 50 x 10 mm ²
b.	Outdoor yard	MS flat 50 x 10 mm ²
c.	Riser	50 x 6 mm ²
d.	Earthing electrodes	3 m long x 40 mm dia MS rod
e.	Earthing Electrode for treated earthing pits	25 mm dia x 3 meter long G.I pipe

The bidder shall design the Earthmat on the basis of fault level of switchgear.

7.3 GENERAL EQUIPMENT

- a) The noncurrent carrying parts of equipment / devices is to be connected to grounding mat by 50 x 6 mm² G.S flats.
- b) The conductor laid below ground level shall be mild steel black flat and that above ground level shall be galvanized mild steel flat.
- c) The various structures in outdoor yard shall also be grounded as per standards by using 50x6mm²sizes of G.S flats to the main ground mat.
- d) All joints of grounding flat between themselves & grounding electrodes should be over lap welded. The length of weld shall be atleast double the width of grounding flat.
- e) The earth conductors shall be free from pitting, laminations, rust, scale and other electrical& mechanical defects.
- f) The connections between earth leads and equipment shall normally be of bolted type.
- g) A layer of crushed rock of 20 mm thickness and atleast 150 mm deep shall be spread over the switchyard area and 1.5 m beyond the periphery of grounding conductor , The crushed rock shall also placed outside, along the periphery of the fencing when the fencing is connected to the main grounding system. The supply of crushed rock is in the scope of bidders. The resistivity of crushed rock is to be 3000 Ohm-Meter (Approximate).
- h) A ground mat of fine mesh shall be provided below operating mechanism of isolator.
- i) For transformer neutral earthing and lightening arrester earthing, treated earth pits shall be provided with 25-mm Dia, 3-meter long G.I pipe.

The contractor shall design the earth mat on the basis of fault level of switchgear.

7.4 EARTHING CONDUCTOR LAYOUT

Earthing conductors buried in ground shall be laid minimum 600 mm below ground level or otherwise decided during detailed engineering. A minimum earth cover of 300 mm shall be provided between earth conductor and the bottom of trench /foundation/ underground pipes at Crossings. Earthing conductor along their run in cable trenches etc. shall be supported by suitable welding /cleating at interval of 750 mm to 1000 mm.

7.5 EARTHING PIT

Earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building. Earth pit shall be made and electrodes shall be embedded below permanent moisture level.

7.6 TECHNICAL PARTICULARS

TABLE-7.2

S.No.	Item	Description
a.	50 x 10 mm ² MS flat for earthing mat	As per drawing prepared by the Contractor for each sub – station with complete BOQ
b.	Equipment earthing with 50 x 6 mm ² GI /flat complete with clamps accessories	--- do ---
c.	25 mm dia. G.I pipe ,3 meter long with suitable arrangements for fixing earth strip	---do---

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-8

Lightning Protection

SECTION 4
CHAPTER – 8
LIGHTNING PROTECTION

CONTENTS

S.NO	DESCRIPTION	PAGE.NO
8.0	SCOPE	1
8.1	DESCRIPTION	1
8.2	GENERAL REQUIREMENT FOR SUBSTATION CONTROL ROOM BUILDING	1
8.3	LIGHTNING PROTECTION OF OUTDOOR SWITCHYARD BY SHIELD WIRES	2
8.4	DRAWING/DOCUMENTS	3

SECTION 4

CHAPTER – 8

LIGHTNING PROTECTION

8.0 SCOPE

- 8.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, transportation up to site, Testing & commissioning of material for lightning protection of for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. It shall be the bidder's responsibility to assess the exact requirement of complete material.

8.1 DESCRIPTION

- 8.1.1 Direct stroke lightning protection and Lightning masts with supporting structure shall be provided in outdoor switchyards and for substation control room building. The layout drawings of substation indicate the tentative arrangement. The final arrangement shall be decided after approval of the direct stroke lightning protection scheme of each substation. Method of protection for outdoor switchyard shall generally to be followed as per procedure laid down by Mr. Razevig. The Aluminum Clad Steel shield wires 7/4.15 mm are connected to ground wire peaks of the columns of the bus bar, galvanized mild steel pipes in the transformers yard area and terminal gantries. The lightning protective scheme for control room building shall be as per guidelines laid down in IS: 2309.

8.2 GENERAL LIGHTENING PROTECTION REQUIREMENT FOR SUBSTATION CONTROL ROOM BUILDING

- 8.2.1 The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

- 8.2.2 Conductors of the lightning protection system shall not be connected with the conductors of earthing system above ground level.
- 8.2.3 Down conductors shall be cleated on the structures at 2000 mm interval.
- 8.2.4 All joints in the down conductors shall be of welded type. Lightning conductor on roof shall not be directly cleated on surface. Supporting blocks of PCC/insulating material shall be used for conductor fixing. The conductor hardware accessories of the lightning protection system shall be non- deteriorating & non-corrosive type.
- 8.2.5 Down conductors shall be as short & straight as practicable and shall follow direct path to earth. Down conductor shall not be connected to other earthing conductors above ground level.
- 8.2.6 Connection between each down conductor and rod electrodes shall be made via test joint (Pad type compression clamp) located approximately 1500 mm above ground level. Lightning conductor shall not pass through or run inside G.I. cable conduit and metal enclosures of electrical equipment.
- 8.2.7 All metallic structure within a vicinity of 2000 mm of the conductors shall be bonded to the conductors of lightning protection system.

8.3 LIGHTNING PROTECTION OF OUTDOOR SWITCHYARD BY SHIELD WIRES

- 8.3.1 The protection zone provided by shield wires shall include bus-bar, switchgear and transformers and shall be checked as follows:

The sectional plane of the protected zone along one earth wire is bounded by an arc, the centre of which, both from the ground and from earth wire is equal to twice the height of the earth wire. The arc touches the ground at a distance of $\sqrt{3} \times$ Height of ground wire from the foot of earth wire. The angle between the tangents to the boundary line is $2 \times 30^\circ$ at the point of intersection.

- 8.3.2 The sectional plane of the protection zone with two earth wires is separated by a distance $< 2 \times$ height of ground wire and the outer boundary lines arc as for one earth wire. The sectional plane of the protected zone between two wires is bounded by an arc the centre of which is at twice the height of earth wire above

the ground and midway between two wires. The radius is the distance between the earth wires and the midpoint.

8.3.3 The additional lightning cum lighting masts shall only be provided if required.

8.4 DRAWING/DOCUMENTS

8.4.1 The following drawings & documents shall be furnished by the contractor for approval/reference.

- a) Lightning protection drawing of the control room along with B.O.Q.
- b) Lightning protection drawing of outdoor switchyard with complete B.O.Q.
- c) Calculations & protection zones of the electrical equipment i.e. bus-bar, CBs, CTs, Isolators etc.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-9

Substation Automation and Control System

SECTION 4**CHAPTER – 9****SUBSTATION AUTOMATION AND CONTROL SYSTEM****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
9.0	GENERAL	1
9.1	SYSTEM DESIGN	3
9.2	BAY LEVEL FUNCTIONS	6
9.3	GATEWAY	18
9.4	SYSTEM HARDWARE	19
9.5	SOFTWARE STRUCTURE	23
9.6	TESTS	25
9.7	SYSTEM OPERATION	28
9.8	POWER SUPPLY	29
9.9	DOCUMENTATION	29
9.10	TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES	31
9.11	MAINTENANCE	34
9.12	RELIABILITY AND AVAILABILITY	34
9.13	SPARES	37
9.14	LIST OF EQUIPMENTS	37
9.15	TENTATIVE LIST FOR VARIOUS FEEDERS/BAYS AND SYSTEMS	38
9.16	LIST OF ANALOG AND DIGITAL INPUTS	41
9.17	APPENDICES	49

SECTION 4

CHAPTER – 9

SUBSTATION AUTOMATION PROTECTION SYSTEM

9.0. GENERAL

9.0.1. The scope covers the design, engineering, manufacture, testing at Manufacturer's works before dispatch, packing and forwarding, transportation, insurance, handling, delivering at site, proper storage at site, transportation up to site, supervision for erection testing and commissioning of the 220/132/33kV Substation Automation System along with Bay level Control Units complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification for 220/132/33kV substations at Tumlingtar, Baneshwar, Basantapur and Inaruwa - Package KC-2.

9.0.2. The Substation Automation System (SAS) shall be an integrated system to carry out control, monitoring, protection, metering and communication functions of all 220Kv, 132kV and 33kV feeder. SAS shall have an extreme range of SACADA functions. SAS will be based on IEC 61850 and IEC 60870-5-104 protocol. All devices shall be compatible to above protocol and have the capability to link with National Load Dispatch Centre. The SAS shall contain the following main functional parts:

- a. Intelligence Electronic Devices (IED s) for control and monitoring at Bay Level called by Bay Control Units (BCU) Located in Control Panels of respective feeders.
- b. Tri-vector Meter (0.2 accuracy class) Should be provided in all the Line 220 kV bays and Multi- function meter shall be provided in transformer bays, both Tri-vector meter & Multi-function meter should be able to interface with substation automation & data acquisition system on IEC 61850 communication Protocol.
- c. Station Human Machine Interface (HMI) Main and Stand by.
- d. Redundant Managed Switched Ethernet Local Area Network communication infrastructure with hot standby.

- e. Gateway for remote control via industrial grade hardware (to LDC) through IEC60870-5-104 protocol.
- f. Gateway for remote supervisory control (to LDC), should be able to communicate with LDC on IEC 60870-5-104 protocol.
- g. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Appendix-II for data exchange with LDCs coming in future in Nepal.
- h. Supply of necessary furniture for accommodating the HMI Main and Stand by, printers, display units etc are in the scope of the contractor.
- i. Peripheral equipment like printers, display units, key boards, mouse etc.
- j. Time synchronization shall be done by using GPS.
- k. A dedicated UPS to feed the power of SAS system (Size of UPS shall be decided based on the load assuming 3 hr Power Backup with 50% redundancy).
- l. All necessary Software's required with license shall be provided to NEA and purchased licenses in the name of NEA.

9.0.3. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions.

9.0.4. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

9.0.5. The communication gateway shall facilitate the information flow with Load Dispatch Center. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

9.1. SYSTEM DESIGN

9.1.1. General System Design

The Substation Automation System (SAS) shall be suitable for operation, control and monitoring of the complete substation including future extensions if any as shown in Single Line Diagrams for Tumlingtar, Baneshwar, Basantapur and Inaruwa Substations. The systems shall be of the state-of-the art suitable for operation under electrical environment present in extra high voltage substations, follow the latest engineering practice, and ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff. The offered SAS shall support remote control and monitoring from Load Dispatch Center via gateways. The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training. The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signaling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records. Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

9.1.2. System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence. Functions shall be decentralized, object-oriented and located as close as possible to the process. The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level. At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the equipment without any need for additional interposition or transducers. Each bay control IED shall be

independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station. The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in HDPE pipes. Data exchange is to be realized using IEC 61850 protocol with a 50% redundancy managed Ethernet switched communication infrastructure.

The communication shall be made in **fault tolerant ring in redundant** mode, excluding the links between individual bay IEDs to switch **wherein the redundant connections are not envisaged**, such that failure of one set of fiber shall not affect the normal operation of the SAS. However, **failure of fiber** shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers.

At station level, the entire station shall be controlled and supervised from the station

HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times. Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. LDC (Load Dispatch Centre), station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level. The station level contains the station-oriented functions, which cannot be realized at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with Load Dispatch Centre. The GPS time synchronizing signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided. The SAS shall contain the functional parts as described in Para1.1.2 above.

9.1.3. Functional Requirements

The high-voltage apparatus within the station shall be operated from different places:

- a. National Control Centre
- b. Station HMI.
- c. Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time. The operation shall depend on the conditions of other functions, such as interlocking, synchrocheck, etc. (see description in "Bay level control functions").

9.1.4. Select-Before-Execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

9.1.5. Command supervision Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

In addition to software interlocking hardwired interlocking are to be provided for:

- a. Bus Earth switch Interlocking.
- b. Disconnecter interlocking.

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails. A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

9.1.6. Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

9.1.7. Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

9.1.8. User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely. It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi activation of these additional functions should be possible). The Functional requirement shall be divided into following levels:

- a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions
- b. System Level Functions

9.2. BAY LEVEL FUNCTIONS

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- a. Bay control functions including data collection functionality in bay control unit.
- b. Bay protection functions
- c. Separate IEDs shall be provided for bay control function and bay protection function.

9.2.1. Bay control functions

9.2.1.1. Overview of Functions

- a. Control mode selection
- b. Select-before-execute principle
- c. Command supervision:
 - i. Interlocking and blocking
 - ii. Double command
- d. Synchrocheck, voltage selection
- e. Run Time Command cancellation

- f. Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- g. Operation counters for circuit breakers and pumps
- h. Hydraulic pump/ Air compressor runtime supervision
- i. Operating pressure supervision through digital contacts only
- j. Breaker position indication per phase
- k. Alarm annunciation
- l. Measurement display
- m. Local HMI (local guided, emergency mode)
- n. Interface to the station HMI.
- o. Data storage for at least 250 events
- p. Extension possibilities with additional I/O's inside the unit or via fiber optic communication and process bus.

9.2.1.2. Control mode selection

a) Bay level Operation:

As soon as the operator receives the operation access at bay level, the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED.

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

9.2.1.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control devices. These features are:

- a. Settable voltage, phase angle, and frequency difference.
- b. Energizing for dead line - live bus, live line - dead bus or dead line dead bus with no synchro-check function.
- c. Synchronizing between live line and live bus with synchro-check Function

9.2.1.4. Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control.

9.2.1.5. Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

9.2.2. Bay protection functions

9.2.2.1. General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection. IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Each IED should contain an event recorder capable of storing at least 250 time-tagged events. The Fault recorder function shall be as per Chapter 10 Control Relay and Protection Panels and give alarm if 70 % memory is full.

9.2.2.2. Bay Monitoring Function:

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (V) and current (I), Energy Meter function shall be calculated in the Bay control/protection unit.

9.2.3. System level functions

9.2.3.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes. The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit. The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

9.2.3.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds. Threshold limit values shall be selectable for alarm indications.

9.2.3.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms.

The tentative list for various feeders and systems are given below:

9.2.4. Station HMI

9.2.4.1. Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object. Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

9.2.4.2. Presentation and dialogues

General

The operator station HMI shall be redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks. The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log. An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator. The following standard pictures shall be available from the HMI:

- a. Single-line diagram showing the switchgear status and measured values
- b. Control dialogues with interlocking **or** blocking **information** details.

This control dialogue shall tell the operator whether the device operation is permitted or blocked.

- (i) Measurement dialogues
- (ii) Alarm list, station / bay-oriented
- (iii) Event list, station / bay-oriented
- (iv) System status

9.2.4.3. HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out. The object status shall be indicated using different status colors for:

- a. Selected object under command
- b. Selected on the screen
- c. Not updated, obsolete values, not in use or not sampled
- d. Alarm or faulty state
- e. Warning or blocked
- f. Update blocked or manually updated
- g. Control blocked
- h. Normal state

9.2.4.4. Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram. In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all

other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the “execution” of the command the operated switching symbol shall flash until the switch has reached its new position. The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level. After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

9.2.4.5. System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

9.2.4.6. Event list

The event list shall contain events that are important for the control and monitoring of the substation. The event and associated time (with 1ms resolution) of its occurrence has to be displayed for each event. The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it. A printout of each display shall be possible on the hard copy printer. The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall also be obtainable from a printed event log. The chronological event list shall contain:

- a. Position changes of circuit breakers, isolators and earthing devices

- b. Indication of protective relay operations
- c. Fault signals from the switchgear
- d. Indication when analog measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.
- e. Loss of communication.

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- (i) Date and time
- (ii) Bay
- (iii) Device
- (iv) Function e.g. trips, protection operations etc.
- (v) Alarm class

9.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated. The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- a. The date and time of the alarm
- b. The name of the alarming object
- c. A descriptive text
- d. The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent). Filters for selection of a certain type or group of alarms shall be available as for events.

9.2.4.8. Object picture

When selecting an object such as a circuit breaker or isolator in the single-line diagram, the associated bay picture shall be presented first. In the selected object picture, all attributes like

- a. Type of blocking
- b. Authority
- c. Local / remote control
- d. LDC / SAS control
- e. Errors etc.,

Shall be displayed.

9.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- a. Breaker and disconnector
- b. Transformer tap-changer

9.2.4.10. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus) within a certain user authorization group. Each user shall then be given access rights to each group of objects, e.g.:

- a. Display only
- b. Normal operation (e.g. open/close of switchgear)
- c. Restricted operation (e.g. by-passed interlocking)
- d. System administrator

For maintenance and engineering purposes of the station HMI, the following authorization levels shall be available:

- (i) No engineering allowed
- (ii) Engineering/configuration allowed
- (iii) Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

9.2.4.11. Reports

A. The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- (i) Trend reports:
 - a. Day (mean, peak)
 - b. Month (mean, peak)
 - c. Semi-annual (mean, peak)
 - d. Year (mean, peak)
- (ii) Historical reports of selected analogue Values:

- a. Day (at 15 minutes interval)
 - b. Week
 - c. Month
 - d. Year
- B. It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory. Following printouts shall be available from the printer and shall be printed on demand:
- a. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
 - b. Weekly trend curves for real and derived analogue values.
 - c. Printouts of the maximum and minimum values and frequency of, occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.
 - d. Provision shall be made for logging information about breaker status like number of operation with date and time indications **along with the current value it interrupts (in both condition i.e. Manual opening and fault tripping)**
 - e. Equipment operation details shift wise and during 24 hours.
 - f. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.
 - g. Printout on adjustable time period as well as on demand system frequency and average frequency.
 - h. Reports in specified formats which shall be handed over to successful bidder.
The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.

9.2.4.12. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends – input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided. It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

9.2.4.13. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc.

9.2.4.14. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

9.2.4.15. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

9.2.4.16. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

9.3. GATEWAY

9.3.1. Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations; The Substation Automation System shall have communication ports as follows:

(a) Two ports for Remote Control Centre/National Load Center

(b) Two ports for Load Dispatch Centre

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centers (LDC & RSCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

9.3.2. Load Dispatch Centre and Remote Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the Load Dispatch centre/Remote Control centre. The communication channels provided by Employer will consist either of microwave, optical fibre, VSAT or leased line, the details of which shall be provided during detailed Engineering.

9.3.3. Interface equipment:

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre. However, the communication channels available for this purpose shall be intimated to successful bidder during Detailed Engineering. The modem for both ends should be standalone type complete in all respects including power supply to interface with communication channel..

9.3.4. Communication Protocol

The communication protocol for gateway to LDC must be open protocol and shall support IEC 60870-5-101 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI , gateways to remote station etc;.

9.4. SYSTEM HARDWARE:

9.4.1. Redundant Station HMI, and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade. It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features. The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

- a. Storage of all analogue data (at 15 Minutes interval) and digital data including alarm , event and trend data for Thirty (30) days,
- b. Storage of all necessary software,
- c. 500GB space for OWNER'S use. Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

9.4.2. HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the equipment with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, uncluttering etc.

9.4.3. Visual Display Units/TFT's (Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 32" diagonally in size and capable of colour graphic displays. The display shall accommodate resolution of 1280 X 1024 pixels.

9.4.4. Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface. The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc. All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing. All printers shall be continuously online.

9.4.5. Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit **in form of DVD RW** the unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rock ridge and Joliet File systems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software.

9.4.6. Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS One switch shall be provided to connect all IEDs in one diameter of each bays of 220 kV , 2 adjacent 132 kV bays and 4 adjacent 33kV bays to communication

infrastructure. **Each switch shall have at least 50% spare ports for connecting bay level IEDs and one spare port for connecting station bus.**

9.4.6.1. Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of external input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the equipment. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours. One no. Bay level unit shall be provided for supervision and control of each 220 kV, 132 and 33kV (a bay comprises of one circuit breaker, associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service. **The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel/ switch gear panel for respective bay.** The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

9.4.6.2. Input/output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all equipment information (i.e. data coming directly from the equipment or from switchgear interlocking devices) and transmit commands for operation of the equipment. The measured values of voltage and current shall be from the secondary of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state each bay unit shall consist minimum 25% redundant I/O for future use. A separate Bay Level Unit shall be provided with minimum 48 Digital Inputs , 8 Analogue Inputs, 16 digital output and 8 analogue output for the control and monitoring of State of ACDB , DCDB, Battery Bank and Chargers , , Fire and Alarm System , DG Sets Local Temperature state, Lighting states etc.

9.4.7. Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays of in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

9.5. SOFTWARE STRUCTURE

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

9.5.1. Station level software

9.5.1.1. Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

9.5.2. Bay level software

9.5.2.1. System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronizing with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

9.5.2.2. Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library. The application software within the control/protection devices shall be programmed in a functional block language.

9.5.2.3. The contractor shall provide a network management system software for following management functions:

- a. Configuration Management
- b. Fault Management
- c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

- (a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
- (b) Maintain a graphical display of SAS connectivity and device status.
- (c) Issue alarms when error conditions occurs
- (d) Provide facility to add and delete addresses and links

9.5.2.4. The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

9.6. TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

9.6.1. Type Tests:

9.6.1.1. Control IEDs and Communication Equipment:

I. Power Input:

- a. Auxiliary Voltage
- b. Current Circuits
- c. Voltage Circuits
- d. Indications

II. Accuracy Tests:

- a. Operational Measured Values
- b. Currents
- c. Voltages
- d. Time resolution
 - Insulation Tests:
 - Dielectric Tests
 - Impulse Voltage withstand Test

III. Influencing Quantities

- a. Limits of operation
- b. Permissible ripples
- c. Interruption of input voltage

IV. Electromagnetic Compatibility Test:

- a. 1 MHZ. burst disturbance test
- b. Electrostatic Discharge Test
- c. Radiated Electromagnetic Field Disturbance Test
- d. Electrical Fast transient Disturbance Test
- e. Conducted Disturbances Tests induced by Radio Frequency Field
- f. Magnetic Field Test
- g. Emission (Radio interference level) Test.
- h. Conducted Interference Test

V. Function Tests:

- a. Indication
- b. Commands
- c. Measured value Acquisition
- d. Display Indications

VI. Environmental tests:

- a. Cold Temperature
- b. Dry Heat
- c. Wet heat
- d. Humidity (Damp heat Cycle)
- e. Vibration
- f. Bump
- g. Shock

Note:- Manufacture shall produce the report of these type test for verification of information

9.6.1.2. Factory Acceptance Tests and Site Acceptance Tests:

The supplier shall submit a test procedure for factory acceptance test (FAT) and site tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted. The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. **During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.** If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

9.6.1.3. Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. **The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.**

9.6.1.4. Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

9.6.1.5. Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. **The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.**

9.7. SYSTEM OPERATION

9.7.1. Substation Operation

9.7.1.1. Normal operation

Operation of the system by the operator from the remote LDC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device (mouse). The coloured screen shall be divided into 3 fields:

- a. Message field with display of present time and date
- b. Display field for single line diagrams
- c. Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided. All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the

background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and
- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully. Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed. The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

9.8. POWER SUPPLY:

Power supply to substation Automation System shall be derieved from substation DC supply at 110 V/220 V. Inverter of suitable capacity shall be provided to Station HMI and its peripheral devices like printer etc; Incase of power failure, necessary safeguard software shall be built for proper shutdown and restart.

9.9. DOCUMENTATION

9.9.1. The following documents shall be submitted for employer's approval during detailed engineering:

- (i) System Architecture Drawing

- (ii) Hardware Specification
- (iii) Functional Design Document
- (iv) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

9.9.2. The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in “dxf” format.

- a. List of Drawings
- b. Substation automation system architecture
- c. Block Diagram
- d. Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
- e. Calculation for power supply dimensioning
- f. I/O Signal lists
- g. Schematic diagrams
- h. List of Apparatus
- i. List of Labels
- j. Logic Diagram (hardware & software)
- k. Control Room Lay-out
- l. Test Procedure for Factory Acceptance Test (FAT)
- m. Product Manuals (Buyers Guide, Design Guide etc.)
- n. Assembly Drawing
- o. Operator’s Manual
- p. Complete documentation of implemented protocols between various elements

- q. Listing of software and loadable in CD ROM
- r. Other documents as may be required during detailed engineering

Six sets of hard copy and two sets of CD ROM containing all the as built documents/drawings shall be provided.

9.10. TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

9.10.1. Training

Contractor or its designated manufacturer personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in India. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer. The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

The contractor shall provide training for PMC and NEA personnel (Max 5 persons from NEA) comprehensively covering following courses.

TABLE-1.4

S. No.	Name of Course
1.	SAS Hardware
2.	SAS Software
3.	SAS Application Software

9.10.2. Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

- a. System Hardware Overview: Configuration of the system hardware.
- b. Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
- c. System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
- d. System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
- e. Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.
- f. Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

9.10.3. Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

- a. System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
- b. Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures
- c. System Initialization and Failover: Including design, theory of operation, and practice
- d. Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,
- e. Software Documentation: Orientation in the organization and use of system software documentation.
- f. Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

9.10.4. Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

- a. Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
- b. Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.

- c. Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.
- d. Software Generation: Generation of application software from source code and associated software configuration control procedures.
- e. Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.
- f. Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

9.11. MAINTENANCE

9.11.1. Maintenance Responsibility during the Guaranteed Availability Period

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational.

9.12. RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- a. Mechanical and electrical design
- b. Security against electrical interference (EMI)
- c. High quality components and boards
- d. Modular, well-tested hardware
- e. Thoroughly developed and tested modular software
- f. Easy-to-understand programming language for application programming

- g. Detailed graphical documentation and application software
- h. Built-in supervision and diagnostic functions
- i. Security
 - (i) Experience of security requirements
 - (ii) Process know-how
 - (iii) Select before execute at operation
 - (iv) Process status representation as double indications
- j. Distributed solution
- k. Independent units connected to the local area network
- l. Back-up functions
- m. Panel design appropriate to the harsh electrical environment and ambient conditions
- n. Panel grounding immune against transient ground potential rise.

9.12.1. Outage terms

9.12.1.1. Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/ system other than Substation Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

9.12.1.2. Actual outage duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/4th of an hour. Time less than 1/4th of an hour shall be counted as having duration of 1/4th of an hour.

9.12.1.3. Period Hours (PH)

The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leap year).

9.12.1.4. Actual Outage hours (AOH)

The sum of actual outage duration within the reporting period $AOH = \sum AOD$

9.12.1.5. Availability:

Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

9.12.2. Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved. The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test. After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

9.13. SPARES

9.13.1. Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

9.13.2. Availability Spares:

In addition to mandatory spares as listed in Chapter “Mandatory Spares” section project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

9.14. LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

- a. Station HMI
- b. Redundant Station HMI (in Hot-standby mode)
- c. Bay level units along with bay mimic as detailed in chapter.
- d. Bay Level Unit for Auxiliary system (as per requirement)
- e. Disturbance Recorder Work Station(Maintenance HMI)
- f. Colour Laser Printer (For Reports & Disturbance records)
- g. Dot matrix printers - (one each for Alarms and log sheets)

- h. Furniture as site requirement finalized during detailed engineering.
- i. All interface equipment for gateway
- j. Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
- k. Remote workstation including HMI and along with one printer
- l. Modems as per requirement.
- m. GPS system, UPS , Ethernet Switch , Printer Server , KVM Extender , Fiber Optic Cable with ST connector
- n. Any other equipment as necessary.

9.15. TENTATIVE LIST FOR VARIOUS FEEDERS/BAYS AND SYSTEMS

The tentative list for various feeders and systems are given below:

9.15.1. TUMLINGTAR – 220/132/33KV SUBSTATION:

a. 220kV Side:

- (i) Bus bar Scheme: One and Half Breaker Scheme.
- (ii) 2 Nos. of 220 kV Outgoing line bays
- (iii) 2 Nos. of 220 kV bay for Main Power Transformer.
- (iv) 2 Nos. of 100 MVA Power Transformers (6 Nos. +1 Nos.) 33.3 MVA 220/132 kV Single phase Auto Transformer).

b. 132kV Side:

- (i) Bus bar Scheme: Double bus with bypass isolator Scheme.
- (ii) 2 Nos. of 132 kV incoming/Outgoing Transformer bay.
- (iii) 1 No of Bus Coupler Bay.
- (iv) 2 Nos. of 25/30 MVA, 132/33 kV Power Transformers.

c. 33kV Side:

- (i) Bus bar scheme: Single bus with bus sectionalizer.
- (ii) 2 Nos. of 33kV Transformer bay for 132/33kV transformers with full equipment.
- (iii) 1 No. Line Bay for NEA use.
- (iv) 1 No. 33kV Bus Sectionalizer Bay.
- (v) 1 No. of Station transformer bay.
- (vi) 1 No. 400 KVA, 33/0.4kV Three Phase Station Transformer.

9.15.2. BANESHWAR – 220/33 KV SUBSTATION:

a. 220kV Side:

- (i) Bus bar Scheme: One and Half Breaker Scheme.
- (ii) 1 Nos. of 220 kV Incoming line bays with full equipment for Tumlingtar-Basantapur line.
- (iii) 1 Nos. of 220 kV Outgoing line bays with full equipment for Baneshwar-Basantapur line.
- (iv) 2 Nos. of 220 kV bay for Main Power Transformer with full equipment.
- (v) 2 Nos. of 25/30 MVA, 220/33 kV Three Phase Power Transformers.

b. 33kV Side:

- (i) Bus bar scheme: Single Bus with Bus sectionalizer.
- (ii) 2 Nos. of 33kV Transformer bay for 220/33kV transformer with full equipment.
- (iii) 1 No Line Bay for NEA use.
- (iv) 1 No 33kV Bus Sectionalizer Bay
- (v) 1 No of Station transformer bay.
- (vi) 1 No 400 KVA, 33/0.4kV Three Phase Station Transformer.

9.15.3. BASANTAPUR – 220/132/33 KV SUBSTATION:**a. 220kV Side:**

- (i) Bus bar Scheme: One and Half Breaker Scheme.
- (ii) 4 Nos. of 220 kV Incoming line bays
- (iii) 2Nos. of 220 kV Outgoing line bays
- (iv) 2 Nos. of 220 kV bay for Main Power Transformer
- (v) 2 Nos. of 100 MVA Power Transformers (6Nos. +1 Nos.) 33.3 MVA 220/132 kV Single phase Auto Transformer)

b. 132kV Side:

- (i) Bus bar Scheme: Double bus with bypass isolator.
- (ii) 1 No. of Bus Coupler Bay.
- (iii) 2 Nos. of Transformer bay for 100 MVA, 220/132 kV Transformer with full equipment
- (iv) 1 No. of 132 kV Transformer bay for 25/30MVA, 132/33kV Transformer with full equipment.
- (v) 1 No. 25/30 MVA, 132/33kV Three Phase Power Transformers.

c. 33kV Side:

- (i) Bus bar scheme: Single Bus.
- (ii) 1 No. of 33kV Transformer bay for 132/33kV transformer with full equipment.
- (iii) 1No Line Bay for NEA use.
- (iv) 1 No of Station transformer bay.
- (v) 1No 400 KVA, 33/0.4kV Three Phase Station Transformer.

9.16. LIST OF ANALOG AND DIGITAL INPUTS

This prepared list is preliminary in nature as per requirement during detail design same can be revised up to $\pm 20\%$.

Basic Monitoring requirements are:

- a. Equipment & Switchgear status indication
- b. Measurements (V, I, P, Q, f)
- c. Event
- d. Alarm
- e. Winding temperature of transformers
- f. ambient temperature
- g. Status and display of 415V LT system, 110V/220V & 48V DC system, D.G.Set.
- h. Status of display of Fire protection system and Air conditioning system (NA).
- i. Acquisition of all counters in Communication panels through potential free contacts from Communication Panel or independently by counting the receive/send commands.
- j. Acquisition of alarm and fault record from protection relays
- k. Disturbance records
- l. Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- m. Tap-position of Transformer

9.16.1. List of Inputs

The list of input for typical bays is as below

(As applicable):-

9.16.2. Analogue inputs

TABLE-1.5

i. For line	
Current	R Phase Y phase B phase
Voltage	R-Y phase Y-B phase B-R phase
ii. For transformer	
Current	R phase Y phase B phase
WTI (for transformer)	
Tap position (for transformer only)	
iii. For bus coupler	
Current	R phase Y phase B phase
iv. Common	
a. Voltage for one and a half Circuit breaker scheme bus wherever applicable	
Voltage	R-Y phase
	Y-B phase
	B-R phase
b. Frequency for one and a half Circuit breaker scheme Bus	
c. Ambient temperature (switchyard)	

1. Voltage R-Y, Y-B, B-R of Main Switch Board section-I

2. Current from LT Station transformer-I
3. Voltage of 110V/220 V DCDB-
4. Voltage of 48 V/220 V DCDB-
5. Current from 110V/220 V Battery set-
6. Current from 48 V Battery set-
7. Current from 110V Battery charger-
8. Current from 48V Battery charger-

9.16.3. Digital Inputs

The list of input for various bays/SYSTEM is as follows (as applicable) :

9.16.4. Line bays

1. Status of each pole of CB.
2. Status of Isolator, Earth switch
3. CB trouble
4. CB operation/closing lockout
5. Pole discrepancy operated
6. Trip coil faulty
7. LBB operated
8. Bus bar protection trip relay operated
9. Main breaker auto reclosure operated
10. Tie/transfer auto reclosure operated
11. A/r lockout
12. Tie/transfer bkra/r lockout
13. Direct trip-I/II sent
14. Direct trip-I/II received

15. Main I/II blocking
16. Main I/II-Inter trip send
17. Main I/II-Inter trip received
18. O/V STAGE – I operated
19. O/V STAGE – II operated
20. FAULT LOCATOR FAULTY
21. MAIN-I/II VT FUSE FAIL
22. MAIN-I PROTN TRIP
23. MAIN-II PROTN TRIP
24. MAIN-I PSB ALARM
25. MAIN-I SOTF TRIP
26. MAIN-I R-PH TRIP
27. MAIN-I Y-PH TRIP
28. MAIN-I B-PH TRIP
29. MAIN-I START
30. MAIN-I/II Carrier aided trip
31. MAIN-I/II fault in reverse direction
32. MAIN-I/II ZONE-2 TRIP
33. MAIN-I/II ZONE-3 TRIP
34. MAIN-I/II weak end infeed operated
35. MAIN-II PSB alarm
36. MAIN-II SOTF TRIP
37. MAIN-II R-PH TRIP
38. MAIN-II Y-PH TRIP

- 39. MAIN-II B-PH TRIP
- 40. MAIN-II start
- 41. MAIN-II aided trip
- 42. MAIN-I/II fault in reverse direction
- 43. Back-up o/c operated
- 44. Back-up e/f operated
- 45. 110V DC-I source fail
- 46. SPEECH CHANNEL FAIL
- 47. Communication Protection Channel-I FAIL
- 48. Communication Protection Channel-II FAIL

9.16.5. Transformer bays (as applicable):

- 1. Status of each pole of CB, Isolator, Earth switch
- 2. CB trouble
- 3. CB operation/closing lockout
- 4. Pole discrepancy operated
- 5. Trip coil faulty
- 6. LBB operated
- 7. Bus bar protection trip relay operated
- 8. REF OPTD
- 9. DIF OPTD
- 10. OVERFLUX ALARM (LV)
- 11. OVERFLUX TRIP (LV)
- 12. OVERFLUX ALARM (HV)
- 13. OVERFLUX TRIP (HV)

14. HV BUS VT ½ FUSE FAIL
15. LV BUS VT ½ FUSE FAIL
16. OTI ALARM/TRIP
17. PRD OPTD
18. OVERLOAD ALARM
19. BUCHOLZ TRIP
20. BUCHOLZ ALARM
21. OLTC BUCHOLZ ALARM
22. OLTC BUCHOLZ TRIP
23. OIL LOW ALARM
24. back-up o/c (HV) operated
25. back-up e/f (HV)operated
26. 110v DC-I source fail
27. TAP MISMATCH
28. GR-A PROTN OPTD
29. GR-B PROTN OPTD
30. back-up o/c (LV) operated
31. back-up e/f (LV)operated

9.16.6. Busbar Protection

1. Bus bar main trip
2. Bus bar Transfer trip
3. Bus bar zone-I CT open
4. Bus bar zone-II CT open

5. Bus transfer CT Operated
6. Bus transfer bus bar protection operated
7. Bus protection relay fail

9.16.7. Auxiliary system

1. Incomer-I On/Off
2. 415V Bus-I/II U/V
3. DG set breaker on/off
4. Alarm/trip signals as listed in Section: DG set
5. LT transformer- Buchholz Alarm & trip
6. LT transformer- WTI Alarm & trip
7. LT transformer- OTI Alarm & trip
8. Communication Panel exchange fail
9. Time sync. Signal absent
10. Alarm/trip signals as listed in Section: Battery and Battery charger
11. 110V/220 V DC- earth fault
12. 48v DC- earth fault
13. Alarm/trip signals as listed in Section: Fire protection system
14. The exact number and description of digital inputs shall be as per detailed
15. Engineering requirement Apart from the above mentioned digital inputs, minimum of 100 inputs shall be kept for NEA use in future.

9.16.8. Integration of SCADA system:

Augmentation and integration of work related to SCADA System.

The 220/132 bays under present scope at Inaruwa, Basantapur and Tumlingtar Substations and 220/33 kV bays at Baneshwar Substations shall be integrated by the

contractor into existing SCADA system of Siemens 'SINAUT Spectrum"(version 4.3.2) installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located in Siuchatar, Kathmandu). The integration shall include all software and Hardware required at the Control Centre as well as necessary data base, display generation and upgrades for proposed control and monitoring of station and Network Analysis. The above activities shall be carried out as appropriate, in all of the 5 stations viz. Basantapur, Baneshwer, Tumlingtar, Inaruwa and the Load Dispatch Centre. The manufacturers of the existing SCADA system are:-

LDC facilities: Siemens Germany

RTU facilities: ABB, Germany

The details of existing RTU installed at existing substations and Data acquisitions principles (types of analogue/digital data) for control, monitoring of substations is enclosed at **Appendix III**.

The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101. For the present scope of work the Data shall be obtained from the Substation Automation System (based on IEC 61850) using Gateway port with communication protocol IEC 101/104 as per requirement and send to existing Inaruwa Substation through gateway port and necessary works of integration at Inaruwa and LDC Kathmandu for onward transmission of Data and Voice.

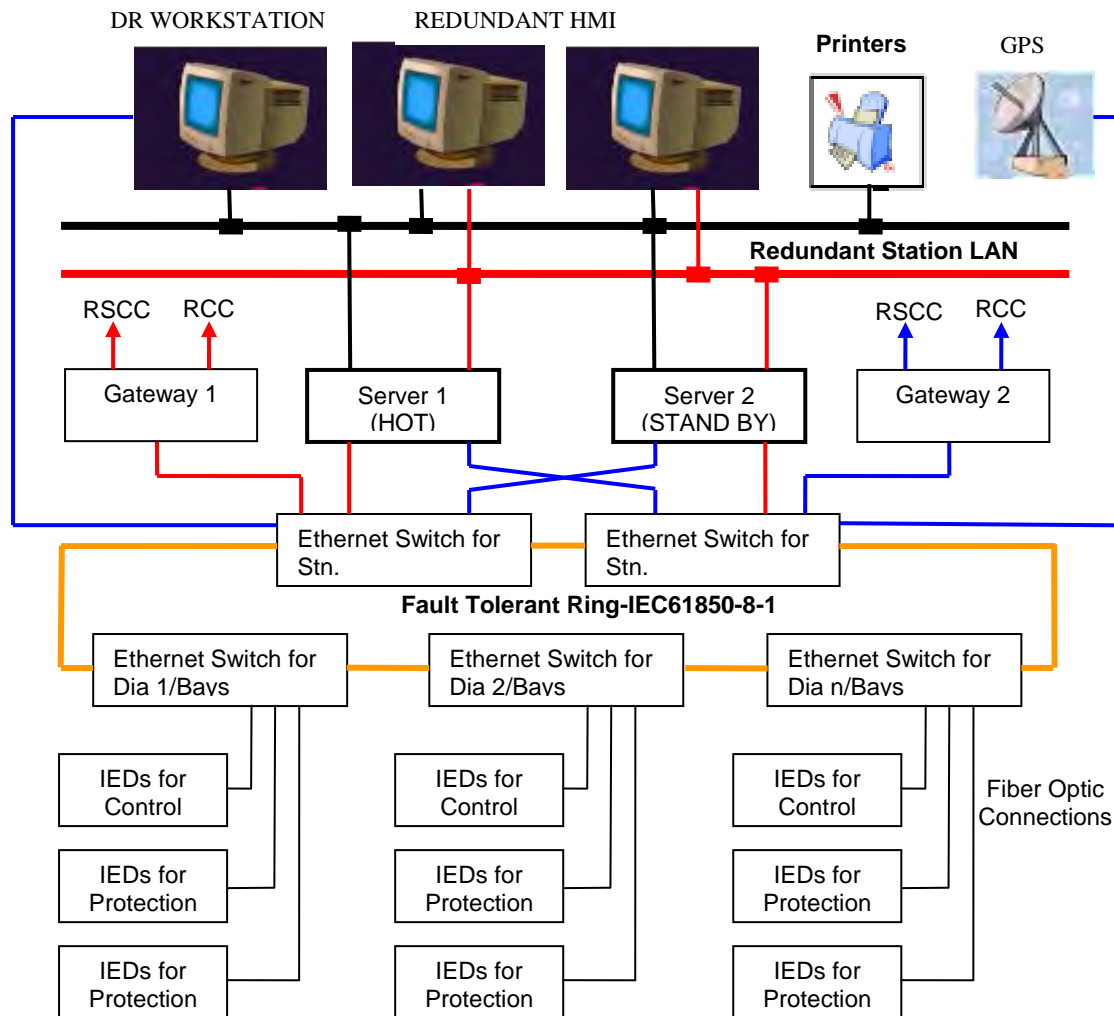
9.17. APPENDICES

Appendix-I

TYPICAL ARCHITECTURAL DRAWING

OF

SUBSTATION AUTOMATION SYSTEM

**Note:**

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-5-101 protocol.

4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.

The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

Appendix-II

List of IO Points to be transmitted to LDC (as applicable)

1. MW and MVAR for all lines, transformers ,reactors and Capacitors
2. Voltage of all buses
3. Frequency of all 220 kV Bus
4. All Breakers
5. All isolators
6. Tap Position for all transformers
7. Master protection signal for all feeders, transformers Units and Bus Bar
8. Loss of Voltage signal for Bus bar
9. All the points identified in point (5),(8) and (1) above as GPS Time stamped.
10. Temperature value per substation.
11. Any other point deemed necessary for successful commissioning of the project shall be decided during detailed engineering with no extra cost.
12. Metering Data from Energy meter.

Appendix-III

EXISTING RTU BASED SCADA & ITS DATA ACQUISITION

1.0 GENERAL INFORMATION

1.1 Remote Terminal Units

The Load Dispatch Centre (LDC) at Kathmandu controls and monitors the network of Integrated Nepal Power System (INPS) via RTUs located at its various substations.

In addition to the above, two local RTUs have been installed at the LDC: one to handle local-control-center status inputs and analog inputs and outputs; and the other for training, maintenance and testing purposes.

Manufacturers of existing SCADA system are:

LDC facilities: SIEMENS, Germany

RTU facilities: ABB, Germany

1.2 Data acquisition principles for existing Substation

The existing substations are provided with RTU for interfacing of the following supervisory controls and data acquisitions:

Remote Control

- Remote control of all 220/132/33kV circuit breakers.

Status indications

- ❖ Status indications of all 220/132kV circuit breakers, busbar and line isolators.
- ❖ Status indications of all 33kV line feeders.

1.3 Integration of SCADA of existing Substation

The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101. For the present scope of work no RTU is envisaged and the Data for SCADA purpose shall be obtained from the Substation Automation System (based on IEC 61850) using Gateway port with communication protocol IEC 101/104 as per requirement being provided at three substations

(i.e. Inaruwa , Dhalkebar & Hetauda) under present contract. The details of substation automation system is included in the separate chapter Substation Automation.

Table 1.4 : Alarms to be acquired from each type of bay

Type of Alarm	Line Bay	Transformer Bay	Coupler Bay	Busbar	Station
Main protection trip	MPT	MPT	MPT		
Back-up protection trip	BPT	BPT	BPT		
Bay fault	BFA	BFA	BFA		
Circuit breaker fault	CBF	CBF	CBF		
Auto-recloser operated	ARO				
Temperature Alarm		TAL			
Temperature Trip		TTR			
Buchholz alarm		BAL			
Buchholz Trip		BTR			
General transformer/reactor talarm		GTA			
General transformer/reactor Trip		GTT			
Busbar Voltage status				BVS	
Station urgent fault					SUF
Station none-urgent fault					SNF
Station Control disabled					SCD
RTU alarm					RTU
Communication alarm					COM
Total	5	10	4	1	5

Measurements

- ❖ Busbar voltages (separate for each busbar and section) of all 220/132/33 kV Busbars.
- ❖ Active/reactive power for
 - All 220kV & 132kV Line feeders.
 - All 220kV, 132kV and 33kV Transformer feeders.
- ❖ Single phase current measurements for all 33kV lines participating in load shedding Scheme.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-10

Control and Relay Panels

SECTION 4**CHAPTER - 10****CONTROL AND RELAY PANELS****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
10.1	SCOPE	1
10.2	STANDARDS	1
10.3	CONSTRUCTIONAL FEATURES	2
10.4	MOUNTING	4
10.5	PANEL INTERNAL WIRING	5
10.6	TERMINAL BLOCKS	6
10.7	PAINTING	7
10.8	MIMIC DIAGRAM	8
10.9	NAME PLATES AND MARKINGS	8
10.10	MISCELLANEOUS ACCESSORIES	9
10.11	EARTHING	9
10.12	INDICATING INSTRUMENTS AND TRANSDUCERS	10
10.13	ANNUNCIATION SYSTEM FOR CONTROL PANEL	12
10.14	SWITCHES	14
10.15	INDICATING LAMPS	16
10.16	POSITION INDICATORS	16
10.17	SYNCHRONISING EQUIPMENT	17
10.18	RELAYS	18
10.19	TRANSMISSION LINE PROTECTION	22
10.20	LINE OVER VOLTAGE PROTECTION RELAY FOR 220 kV & 132 kV	25
10.21	BACK-UP DIRECTIONAL OVER CURRENT AND EARTH FAULT PROTECTION SCHEME IN TRANSMISSION LINE	26

10.22	33 KV LINE PROTECTION	27
10.23	CIRCUIT BREAKER PROTECTION	27
10.24	TRANSFORMER PROTECTION	28
10.25	TRIP CIRCUIT SUPERVISION RELAY	32
10.26	TRIPPING RELAY	33
10.27	DC SUPPLY SUPERVISION RELAY	33
10.28	BUS BAR PROTECTION	33
10.29	FAULT RECORDER	35
10.30	DISTANCE TO FAULT LOCATOR	39
10.31	TIME SYNCHRONISATION EQUIPMENT	40
10.32	RELAY TEST KIT	41
10.33	TYPE TESTS	41
10.34	CONFIGURATION OF CONTROL AND PROTECTION PANELS	42
10.35	ERECTION AND MAINTENANCE TOOL EQUIPMENTS	49
10.36	TROPICALISATION	49
10.37	FALSE PANELS	50
10.38	BAY MARSHALLING KIOSKS	50
10.39	PROTECTION COUPLER	50
10.40	ENERGY METER	51
10.41	APPENDIX – I	52
10.42	APPENDIX - II	57

SECTION 4**CHAPTER - 10****CONTROL AND RELAY PANELS****10.1 SCOPE**

These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, Testing & commissioning of relay and protection panels for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. It shall be the bidder's responsibility to assess the exact quantity of complete material required for the relay and protection panels based on the various drawings during detailed engineering.

10.2 STANDARDS

The latest revision/amendments of Codes, Standards and Recommendations published by the following international organizations shall be applicable for the equipment/material covered in this Specification. In case of conflict, the vendor/manufacturer may propose equipment/material conforming to one group of Standards specified hereunder without jeopardizing the requirements of these Specifications:

CODE	DESCRIPTION
IEC 255	Electrical relays
IEC 38	IEC Standard voltages
IEC 68	Environmental testing
IEC 664	Insulation coordination for equipment within low-voltage systems
EN 50081-2	Emissivity (Industry)
EN 50082-2	Immunity (Industry)
IEC 255-6	Measuring relays and protection equipment
IEC 255-7	Test and measurement procedures for electromechanical all-or-nothing relays

IEC 68-2-3	Damp heat steady state
IEC 68-2-3	Test Db and guidance; Damp heat, cyclic
IEC 255-5	Insulation tests for electrical relays
IEC 255-22	Electrical disturbance tests for measuring relays and protection equipment:
IEC 255-22-1	1 MHz burst disturbance test
IEC 255-22-2	Electrostatic discharge test
IEC 255-22-3	Radiated electromagnetic field disturbance test
IEC 255-22-4	Fast transient disturbance test
IEC 255-11	Interruptions to and alternating components (ripple) in D.C auxiliary energizing quantity to measuring relays
IEC 255-6	Measuring relays and protection equipment
IEC 255-21	Vibration, shock, bump and seismic tests on measuring relays and protection equipment:
IEC 255-21-1	Vibration tests (sinusoidal)
IEC 255-21-2	Shock and bump tests
IEC 255-21-3	Seismic tests
IEC 255-0-20	Contact performance of electrical relays
IEC 870-3 class 2	Digital I/O, analogue I/O dielectric tests
IEC 801-5/class 3	Digital I/O surge withstand test
IEC 870-3/class2:	Radio interference test
IEC 801-4/4	Transient fast burst test
IEC 801-2/4	Static discharge
IEC 801-3/3	Electromagnetic fields

10.3 CONSTRUCTIONAL FEATURES

10.3.1 Simplex panel shall consist of a vertical front panel with equipment mounted thereon and having wiring access from rear for control panels & either front or rear for relay panels. In

case of panel having width more than 800mm, double leaf-doors shall be provided. Doors shall have handles with either built-in locking facility or will be provided with pad-lock.

10.3.2 Relay panels shall be of simplex type design as indicated. It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes is properly accommodated in the panels without congestion and if necessary, provide panels with larger dimensions. No price increase at a later date on this account shall be allowed. However, the width of panels that are being offered to be placed in control room. Should be in conformity with the space availability in the control room.

10.3.3 Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IEC 60529 (Part-1).

10.3.4 Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame ,front sheet and door frames, and 2.0mm for sides, door, top and bottom portions. There shall be sufficient reinforcement to provide level transportation and installation.

10.3.5 All doors, removable covers and panels shall be gasketed all around with neoprene gaskets. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

10.3.6 Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces true and smooth.

10.3.7 Panels shall have base frame with smooth bearing surface, which shall be fixed on the embedded foundation channels/insert plates. Anti vibration strips made of shock absorbing materials which shall be supplied by the contractor, shall be placed between panel & base frame.

10.3.8 Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.

10.3.9 Relay panels of modern modular construction would also be acceptable.

10.4 MOUNTING

10.4.1 All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush. No equipment shall be mounted on the doors.

10.4.2 Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

10.4.3 The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

10.4.4 The center lines of switches, push buttons and indicating lamps shall be not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be not less than 450mm from the bottom of the panel.

10.4.5 The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise the top lines of all meters, relays and recorders etc. shall be matched.

10.4.6 No equipment shall be mounted on the doors.

10.4.7 At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

10.5 PANEL INTERNAL WIRING

10.5.1 Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be furnished and the wiring shall be carried out internally.

10.5.2 All wiring shall be carried out with 1100V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used or internal wiring shall be as follows:

- All circuits except current transformer circuits and voltage transfer circuits meant for energy metering – Cu cable of size 1.5 sq. mm
- All current transformer circuits – Cu cable of size 4 sq. mm
- Voltage transformer circuit (for energy meters) – Cu cable of size 2.5 sq. mm

10.5.3 All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

10.5.4 Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panels.

10.5.5 Wire termination shall be made with solder less crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.

10.5.6 Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires.

10.5.7 Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

10.6 TERMINAL BLOCKS

10.6.1 All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 1100 V grade and have 10 Amps continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

10.6.2 Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

10.6.3 At least 20% spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

10.6.4 Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side - All CT circuits: minimum of two of 4 sq. mm copper cable and All CT circuits: minimum of two of 2.5 sq. mm copper cable. AC/DC Power Supply Circuits: minimum of two of 6 sq. mm copper cable. All other circuits: minimum of one of 2.5mm Sq. Copper. No. of cores shall be decided as per requirement during design engineering.

10.6.5 There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also the clearance between two rows of terminal blocks edges shall be minimum of 150mm.

10.6.6 Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of internal panel wiring. The side

of the terminal block opposite the wiring duct shall be reserved for the Employer's external cable connections if any. All adjacent terminal blocks shall also share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.

10.6.7 All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc.(except glands & lugs) for external cables shall be included the scope of supply.

10.6.8 The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting facility for CT circuits and testing facilities for protective gears.

10.7 PAINTING

10.7.1 All sheet steel work shall be phosphated in accordance with the IS:6005 "Code of practice for phosphating iron and steel".

10.7.2 Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.

10.7.3 Rust and scale shall be removed by pickling with dilute acid followed by washing with running water rinsing with a slightly alkaline hot water and drying.

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

10.7.5 The phosphate coating shall be sealed with application of two coats of ready mixed, stoved type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.

10.7.6 After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting. The exterior colour of paint shall be of a slightly different shade to enable inspection of the painting.

10.7.7 A small quantity of finished paint shall be supplied for minor touching up required at site after installation of the panels.

10.7.8 In case the bidder proposes to follow any other established painting procedure like electrostatic painting, the procedure shall be submitted for NEA's review and approval.

10.8 MIMIC DIAGRAM

10.8.1 Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.

10.8.2 Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.

10.8.3 Mimic bus colour will be decided during detailed Engineering.

10.8.4 When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.

10.8.5 Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate bus charged condition

10.9 NAME PLATES AND MARKINGS

10.9.1 All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

10.9.2 All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

10.9.3 All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

10.9.4 Name Plates shall be made of non-rusting metal or 3 plylamicoid. Name plates shall be black with white engraving lettering.

10.9.5 All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

10.10 MISCELLANEOUS ACCESSORIES

10.10.1 Plug Point: 230V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard plug, shall be provided in the interior of each cubicle with ON-OFF switch.

10.10.2 Interior Lighting: Each panel shall be provided with a fluorescent lighting fixture rated for 230 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

10.10.3 Switches and Fuses: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breakers (MCB). Selection of the main and sub-circuit MCB rating shall be such as to ensure selective clearance of sub-circuit faults. MCBs shall conform to IS: 13947. Each MCB shall be provided with one potential free contact and the same shall be wired for annunciation purpose. However voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse bases. . Fuse carrier base as well as MCBs shall have imprints of the fuse 'rating' and 'voltage'.

10.10.4 Space Heater: Each panel shall be provided with a space heater rated for 230V, single phase, 50 Hz Ac supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

10.11 EARTHING

10.11.1 All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference for earth systems under various switching conditions of

isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq. mm perforated copper with threaded holes at a gap of 50mm with a provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

10.11.2 Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.

10.11.3 All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.

10.11.4 Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. Earthing may be done in such a manner that no circulating current shall flow in the panel

10.11.5 CVT/VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

10.11.6 An electrostatic discharge arrangement shall be provided in each panel so as to discharge human body before he handles the equipments inside the panels.

10.12 INDICATING INSTRUMENTS AND TRANSDUCERS

10.12.1 Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.

10.12.2 Instruments shall have 4-digit display; display height being not less than 25 mm

- 10.12.3 Instrument shall confirm to relevant IEC and shall have an accuracy class of 1.5 or better. Watt and Var meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.
- 10.12.4 Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25mm (height).
- 10.12.5 Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC:688-1
- 10.12.6 The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.
- 10.12.7 The input to the transducers will be from sub-station current & potential transformers. The output shall be in milli ampere D.C. proportional to the input & it shall be possible to feed the output current directly to the telemetry terminal or indicating instruments.
- 10.12.8 The transducer characteristic shall be linear throughout the measuring range.
- 10.12.9 The transducer output shall be load independent.
- 10.12.10 The input & output of the transducer shall be galvanically isolated.
- 10.12.11 Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.
- 10.12.12 The transducers shall be suitably protected against transient high peaks of voltage & current.
- 10.12.13 The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 120% of the rated input current as applicable.
- 10.12.14 All the transducers shall have an output of 4-20 mA.
- 10.12.15 The response time of the transducers shall be less than 1 second.
- 10.12.16 The accuracy class of transducers shall be 1.0 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.
- 10.12.17 The transducers shall have a low AC ripple on output less than 1%.
- 10.12.18 The transducer shall have dual output.

10.13 ANNUNCIATION SYSTEM FOR CONTROL PANEL

- 10.13.1 Alarm annunciation system shall be provided in the control board by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. The annunciation equipment shall be suitable for operation on the voltages specified in this specification.
- 10.13.2 The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the control panels.
- 10.13.3 The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5 mm.
- 10.13.4 Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (350 Lux), from the location of the operator's desk.
- 10.13.5 All Trip facia shall have red colour and all Non-trip facia shall have white colour.
- 10.13.6 The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used as follows.

Hooter	Alarm Annunciation
Bell	Annunciation DC failure
Buzzer	AC supply failure

- 10.13.7 Sequence of operation of the annunciator shall be as follows :

Sl. NO.	Alarm Condition	Fault Contact	Visual Annunciation	Audible Annunciation
1.	Normal	Open	OFF	OFF

2.	Abnormal	Close	Flashing	ON
3.	Accept Push Button Pressed	Close Open	Steady On Steady On	OFF OFF
4.	Reset Push Button Pressed	Close Open	On Off	OFF OFF
5.	Lamp Test Push Button Pressed	Open	Steady On	OFF

10.13.8 Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 230 Volts AC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be provided for the cancellation of this audible alarm alone but the facia window shall remain steadily lighted till the supply to annunciation system is restored.

10.13.9 A separate voltage check relay shall be provided to monitor the failure of supply (230V AC) to the scheme mentioned in Clause above. If the failure of supply exists for more than 2 to 3 seconds, this relay shall initiate visual and audible annunciation. Visual and audible annunciation for the failure of AC supply to the annunciation system shall be provided and this annunciation shall operate on Annunciation DC and buzzer shall sound.

10.13.10 The annunciation system described above shall meet the following additional requirements :

- a) The annunciation system shall be capable of catering to at least 20 simultaneous signals at a time.
- b) One set of the following push buttons shall be provided on each control panel:
 - Reset push button for annunciation system
 - Accept push button for annunciation system
 - Lamp test push button for testing the facia windows
- c) One set of the following items shall be provided common for all the control panel (not

applicable for extension of substation) :

- Flasher relay for annunciation system
 - Push button for Flasher test
 - Three Push buttons for test of all audible alarm systems
- d) These testing circuits shall be so connected that while testing is being done, it shall not prevent the registering of any new annunciation that may land during the test.
- e) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milli seconds.
- f) In case of static annunciator scheme, special precaution shall be taken to ensure that spurious alarm condition does not appear due to influence of external electromagnetic/ electrostatic interference on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels and the static annunciator shall meet the high voltage susceptibility test , impulse voltage withstand test , high frequency disturbance test– class III and fast transient disturbance test –level III as per IEC 60255.

10.13.11 The annunciation system to be supplied for existing sub-stations shall be engineered as an extension to the existing scheme.

10.14 SWITCHES

10.14.1 Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.

The selection of operating handles for the different types of switches shall be as follows :

Breaker, isolator control switches	Pistol grip, black
Synchronising switches	Oval, black, keyed handle (one common removable handle for a group of switches or locking facility having common key)

Synchronising selector switches	Oval or knob, black
Instrument switches	Round, knurled, black
Protection transfer switch	Pistol grip, lockable and black.

10.14.2 The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip positions to "after close" and "after trip" positions respectively.

10.14.3 Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switches for AC shall be suitable for reading all line- to-line and line-to-neutral voltages for non- effectively earthed systems and for reading all line to line voltages for effectively earthed systems.

10.14.4 Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be co-ordinated to fit into all the synchronising switches. These switches shall be arranged to connect the synchronising equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

10.14.5 Lockable type of switches which can be locked in particular positions shall be provided when specified. The key locks shall be fitted on the operating handles.

10.14.6 The contacts of all switches shall preferably open and close with snap action to minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts

10.14.7 The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

10.14.8 The contact rating of the switches shall be as follows:

Description	Contact Rating in Amps			
	110 DC	220 DC	48 DC	230 DC
Make and carry Continuously	10	10	10	10
Make and carry for 0.5 sec	30	10	30	30

10.15 INDICATING LAMPS

Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting material.

10.15.1 The lamps shall be provided with suitable resistors.

10.15.2 Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if required for replacing the bulbs and lenses shall also be included in the scope of the supply.

10.15.3 The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

10.16 POSITION INDICATORS (if Applicable)

10.16.1 Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear. Their strips shall be of the same colour as the associated mimic.

10.16.2 Position indicator shall be suitable for DC Voltage as specified. When the supervised object is in the closed position, the pointer of the indicator shall take up a position in line with the mimic bus bars, and at right angles to them when the object is in the open position. When the

supply failure to the indicator occurs, the pointer shall take up an intermediate position to indicate the supply failure.

10.16.3 The rating of the indicator shall not exceed 2.5 W.

10.16.4 The position indicators shall withstand 120% of rated voltage on a continuous basis.

10.17 SYNCHRONISING EQUIPMENT

10.17.1. For sub-station equipped with sub-station Automation system, the requirement of synchronisation is specified in chapter Sub-station Automation System and the same shall prevail. For other sub-station which is not equipped with Sub-sub-station automation system following shall be applicable as per requirement.

10.17.2. The synchronising instruments shall be mounted either on a synchronising trolley or on a synchronising panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronising panel shall not be less than 144 X 144 sq.mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided

10.17.3. Synchronising check relay with necessary ancillary equipment's shall be provided which shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have an adjustable time setting range of 0.5-20 seconds. A guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in closed position long before the two systems are in synchronism

10.17.4. The synchronising panel shall be draw out and swing type which can be swivelled in left and

right direction. The synchronising panel shall be placed along with control panels and the number of synchronising panel shall be as indicated in SCHEDULES OF RATES AND PRICES. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.

10.17.5. Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

10.17.6. At existing sub-stations, the synchronising scheme shall be engineered to be compatible with the existing synchronising scheme and synchronising socket/switch on the panel. In substations, where synchronising panels are available, the bidder shall carry out the shifting of the above panels, if required, to facilitate the extension of control panel placement.

10.18 RELAYS

10.18.1 All relays shall conform to the requirements of IS:3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear. All the relays shall be directly connected to the inter bay bus using fiber optic cables and shall support peer to peer communication. The relays shall generate GOOSE messages as per IEC 61850 standards for interlocking and shall also ensure interoperability with third party relays. Each relay shall also generate an ICD file in XML format for engineering integration to a SCADA system. The relays should have a port for local communication for relay settings, modifications etc

- 10.18.2 All main protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable to these.
- 10.18.3 All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.
- 10.18.4 All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation. It is to be noted that the DC supply system at Inaruwa is 220 V. All the relays and switchgears to be supplied and installed at Inaruwa shall be compatible with operation at 220 V DC.
- 10.18.5 The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.
- 10.18.6 All protective relays, auxiliary relays and timers except the lock out relays and interlocking relays specified shall be provided with self-reset type contacts. All protective relays and timers shall be provided with externally hand reset positive action operation indicators with inscription .All protective relays which do not have built-in hand-reset operation indicators shall have additional auxiliary relays with operating indicators (Flag relays) for this purpose. Similarly, separate operating indicator (auxiliary relays) shall also be provided in the trip

circuits of protections located outside the board such as Buchholz relays, oil and winding temperature protection, sudden pressure devices, fire protection etc.

10.18.7 Timers shall be of solid-state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

10.18.8 No control relay which shall trip the power circuit breaker when the relay is de-energized shall be employed in the circuits.

10.18.9 Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance and suitable test blocks for specified protection schemes like-distance protection, bus-bar protection etc.

10.18.10 Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

- The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
- Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.
- Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.
- Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s), but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit breaker failure function, reclosing function etc.), and the alarm output signals.
- Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).

- For the current seal-in method, the seal-in shall be maintained until the circuit breaker opens, at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the sealing shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.
- Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub-harmonic conditions (e.g. reactor ring down).

10.18.11 All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.

10.18.12 The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

10.18.13 Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the NEA.

10.18.14 The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

10.18.15 All relays and their drawings shall have phase indications as R-Red, Y-yellow, B-blue

10.18.16 For numerical relays, the scope shall include the following:

10.18.17 Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. All relays to be wired up in LAN to communicate the local PC.

10.18.18 The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC 870-5-103 and 61850-protocol.

10.18.19 All the auxiliary relays shall be modular and plug-in type. No deviation shall be allowed to this clause.

10.19 TRANSMISSION LINE PROTECTION

10.19.1 The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults online. The general concept is to have two fast operating numerical distance protection schemes preferably with two different operating principals the voltage of one relay being fed from Bus PT and the voltage of the other relay from line PT, the currents of the two relays being fed from different CT cores. The main-I and main-II protections having equal performance requirement especially in respect of time as called Main-I and Main-II for 220KV transmission line.

10.19.2 The Transmission system for which the line protection equipment are required is shown in the reference drawing/document(s). The length of lines and the line parameters (Electrical Constants) shall be provided during detailed engineering.

10.19.3 The maximum fault current could be as high as 40 kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.

10.19.4 The protective relays shall be suitable for use with voltage transformers having non-electronic damping and transient response as per IEC.

10.19.5 Disturbance Recorder, Fault Recorder and Distance to fault Locator functions shall be provided, as an integral part of line protection relay shall be acceptable provided these meet the technical requirements as specified in the respective clauses.

10.19.6 Auto reclose relay function if offered as an integral part of line distance protection relay, shall be acceptable for 132kV (wherever applicable) lines, provided the auto reclose relay feature meets the technical requirements as specified in the respective clause.

10.19.7 The following protections shall be provided for each of the Transmission lines:

For 220 kV TRANSMISSION LINE

- Main-I: Non switched, carrier added, Numerical, Distance Protection scheme
- Main-II: Non switched, carrier added, Numerical, Distance Protection scheme
- Back up: Directional Over Current and Earth fault protection scheme.

For 132 kV TRANSMISSION LINE

- Main: In 132 kV line Main 1 shall be only distance protection scheme.
- Back up: Directional Over Current and Earth fault protection scheme.

SAS Carrier -inter tripping through OPGW shall also be provided for both 220 kV and 132kV lines with suitable equipments by the bidder.

10.19.8 The detailed description of the above line protections is given here under.

a. MAIN-I Numerical, communicable Distance Protection scheme:

- Shall have continuous self-monitoring and diagnostic feature.
- Shall be non-switched type with separate measurements for all phase to phase and phase to ground faults
- Shall have stepped time-distance characteristics and four independent zones (zone 1, zone-2, zone-3, Reverse Zone-4)
- Shall have mho or quadrilateral or other suitably shaped characteristics for zone-1, zone-2 and zone- 3, Reverse zone).
- Shall have following maximum operating time (including carrier and trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included) at 50 % of Zone 1 reach

For SIR 0.01-4 40ms at nearest end and 60ms at remote end.

For SIR 4 - 15 45ms at nearest end and 65ms at remote end.

(Carrier transmission line is taken as 20 ms and any reduction in carrier transmission time should reflect in reduction of operating time.

- Line Protection for 220 kV& 132KV system for remote end tripping will be done through OPGW.
- The relay shall have an adjustable characteristics angle setting range of 30 - 85degree or shall have independent resistance(R) and reactance (X) setting.
- Shall have two independent continuously variable time setting range of 0-3 seconds for zone-2and 0-5 seconds for zone-3.
- Shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)
- Shall have facilities for offset features with adjustable 10-20% of Zone-3 setting.
- Shall have variable residual compensation.
- Shall have memory circuits with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault
- Shall have weak end in-feed feature
- Shall be suitable for single & three phase tripping.
- Shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of 1 sec.
- Shall be provided with necessary self reset type trip duty contacts for completion of the scheme(Minimum number of these trip duty contacts shall be four per phase) either through built in or through separate high speed trip relays. Making capacity of these trip contacts shall be 30 amp for 0.2 seconds with an inductive load of $L/R > 10$ mill seconds. If separate high speed trip relays are used, the operating time of the same shall not be more than 10 milliseconds

- Shall be suitable for use in permissive under reach / over reach /blocking communication mode.
- Shall have suitable number of potential free contacts for inter Tripping, Auto reclosing, CB failure, Disturbance recorder & Data acquisition system.
- Include power swing blocking protection which shall
 - a. Have suitable setting range to encircle the distance protection described above.
 - b. Block tripping during power swing conditions.
 - c. Release blocking in the event of actual fault.
- Include fuse failure protection which shall monitor all the three fuses of CVT and associated cable against open circuit.
 - a. Inhibit trip circuits on operation and initiate annunciation.
 - b. Have an operating time less than 7 milliseconds
 - c. Remain inoperative for system earth faults
- The Relay shall have in built feature of broken conductor detection.
- Must have a current reversal guard feature.
- b. Main II Numerical, Communoicable Distance Protection scheme.

Main II Distance protection scheme shall have same features as Main I at para (a) above but with different measuring technique.

10.20 LINE OVER VOLTAGE PROTECTION FOR 220 kV & 132 kV

10.21.1 Monitor all three phases.

10.21.2 Have two independent stages and stage-I & II relay are acceptable as built in with line distance relays Main I & II respectively.

10.21.3 Have an adjustable setting range of 100-170% of rated voltage with an adjustable time delay range of 1 to 60 seconds for the first stage.

10.21.4 Have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200 mill seconds for the second stage.

10.21.5 Be tuned to power frequency.

10.21.6 Provided with separate operation indicators (flag target) for each stage relays.

10.21.7 Have a drop-off to pick-up ratio greater than 95%

10.21.8 Provide separate out-put contacts for each 'Phase' and stage for breaker trip relays, event logger and other scheme requirement.

10.21 BACK-UP DIRECTIONAL OVER CURRENT AND EARTH FAULT PROTECTION SCHEME IN 132 KV TRANSMISSION LINE

10.21.1 Shall have three over current and one earth fault element(s) which shall be either independent or composite unit.

10.21.2 Shall be of Numerical type

10.21.3 Shall include necessary CVT fuse failure relays for alarm purposes.

10.21.4 Directional Over current relay and earth fault relay may be built in Distance protection Relay or supplied as a separate unit.

10.21.5 Over current shall

- i. Have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting
- ii. Have a variable setting range of 50-200% of rated current
- iii. Have a characteristic angle of 30/45 degree lead
- iv. Include hand reset flag indicators or IEDs.

10.21.6 Earth fault relay shall

- i. Have IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting
- ii. Have a variable setting range of 20-80% of rated current

- iii. Have a characteristic angle of 45/60 degree lag
- iv. Include hand reset flag indicators or IEDs.
- v. Include necessary separate interposing voltage transformers or have internal feature in there lay for open delta voltage to the relay.

10.22 33 KV LINE PROTECTION

Non directional IDMT and Earth Fault Protection for **33 kV** line feeders shall have 3 over current and one earth fault element each.

10.23 CIRCUIT BREAKER PROTECTION FOR 220 KV & 132 KV

This shall include following function:

10.23.1 **AUTO RECLOSING** shall be of numerical type and its function shall be separate from Main-I and back-up protection and shall

- i. Have single phase and three phase reclosing facilities for 220 line three phase auto-reclosing facility for 132 kV lines.
- ii. Have a continuously variable single phase dead time range of 0.1-2 seconds.
- iii. Have a continuously variable three phase dead time range of 0.1-2 seconds.
- iv. Have a continuously variable reclaim time range of 5-25 seconds.
- v. Incorporate a four-position selector switch/ from which single phase/three phase/single and three phase auto reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through programming.

10.23.2 SYNCHRO CHECK

- i. Have facilities for selecting check synchronizing or dead line charging features. It shall be possible at any time to change the required feature by reconnection of links.
- ii. Be of single shot type.
- iii. Shall be acceptable as built in with line Bay Control Unit (BCU) provided for substation automation system.

- iv. Shall have priority circuit for closing, if both Circuit-Breakers in One and half Circuit breaker scheme to allow sequential closing of Circuit-Breakers.

10.23.3 LOCAL BREAKER BACK-UP PROTECTION SCHEME shall

- i. Be provided on 220 kV.
- ii. Be triple pole type.
- iii. Have an operating time of less than 15 milli seconds
- iv. Have a resetting time of less than 15 milli seconds
- v. Have three over current elements,
- vi. Have a setting range of 20-80% of rated current
- vii. Have a continuous thermal withstand two times rated current irrespective of the setting
- viii. Have a timer with continuously adjustable setting range of 0.1-1 seconds
- ix. Have necessary auxiliary relays to make a comprehensive scheme.
- x. Be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer equipment protections.

10.24 TRANSFORMER PROTECTION

All transformer protection functions may be grouped into Group-I and Group-II protections in the following manner:

Group-I Protection: Following protection functions may be provided in Group-I Transformer protection relay:

- a) Differential Protection as per clause no. 10.24.2
- b) Over fluxing Protection for HV side as per clause no. 10.24.3
- c) Direction Over current and earth fault protection for HV side as per clause no. 10.24.4
- d) Over Load Protection as per clause no. 10.24.6

Group-II Protection: Following protection functions may be provided in Group-II Transformer protection relay:

- a) REF Protection as per clause no. 10.24.4
- b) Over fluxing Protection for IV/LV side as per clause no. 10.24.3
- c) Direction Over current and earth fault protection for LV side as per clause no. 10.24.5
- d) Neutral Current Relay for Single Phase Transformer Bank 10.24.7

10.24.1 Transformer Auxiliary protection contacts (Bucholz, PRV, Oil temperature, Winding temperature, OLTC Bucholz can be wired suitably in the above protections and provide separate Flag relays/Auxiliary Relays.

10.24.2 **Numerical Transformer differential protection scheme** shall (Applicable for 220/33 kV, 220/132 kV AND 132/33 kV transformers)

- i. Be triple pole type, with faulty phase identification/ indication
- ii. Have an operating time not greater than 30 milli seconds at 5 times the rated current
- iii. Have three instantaneous high set over-current units
- iv. Have an adjustable bias setting range of 20-50%
- v. Be suitable for rated current of 1 Amp.
- vi. Have second harmonic or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetizing inrush proof feature shall not be achieved through any intentional time delay e.g. use of timers to block relay operation or using disc operated relays
- vii. Have an operating current setting of 15% or less
- viii. Include necessary separate interposing current transformers for angle and ratio correction or have internal feature in the relay to take care of the angle & ratio correction
- ix. Have a fault recording feature to record graphic form of instantaneous values of current in all three windings in 6 analogue channels for voltage transformers, during

faults and disturbances for the pre fault and post fault period. The fault recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay.

- REF protection operated
- HV breaker status
- LV breaker status
- Buchholz /OLTC Buchholz alarm / trip
- WTI/OTI/PRD alarm/trip of transformer

Necessary hardware and software for down loading the data captured by disturbance recorder to the personal computer available in the substation shall be included in the scope.

10.24.3 Over fluxing protection Relays shall (Applicable for 220/33 kV and 220/132 kV transformers)

- i. Operate on the principle of Voltage to frequency ratio and shall be phase to phase connected
- ii. Have inverse time characteristics, matching with transformer over fluxing withstand capability curve.
- iii. Provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of ' v/f ' between 100% to 130% of rated values
- iv. Tripping time shall be governed by ' v/f ' Vs. time characteristics of the relay
- v. Have a set of characteristics for various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at ' v/f ' values of 1.4 and 1.5 times, the rated values, respectively.
- vi. Have an accuracy of operating time, better than +10%.
- vii. Have a resetting ratio of 95 % or better.
- viii. Be acceptable as a built in feature of numerical transformer differential relay.

10.24.4 Numerical Restricted Earth Fault Protection shall (Applicable for 220/33 kV, 220/132 kV AND 132/33 kV transformers)

- i. Be single pole type
- ii. Be of current/voltage operated high impedance type
- iii. Have a current setting range of 10-40% of 1 Amp./ have a suitable voltage setting range.
- iv. Be tuned to the system frequency
- v. Be used for HV and LV winding.

10.24.5 Numerical Non-Directional Back-up Over Current and Earth fault protection scheme with high set feature (Applicable for 220/33 kV, 220/132 kV and 132/33 kV transformers)

- i. Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s).
- ii. The scheme shall include necessary VT fuse failure relays for alarm purposes
- iii. Over current relay shall
 - Have IDMT characteristic with a definite minimum time of 3.0 seconds at 10times setting and have a variable setting range of 50-200% of rated current
 - Have low transient, over reach high set instantaneous unit of continuously variable setting range 500%-2000 % i.e. 5 to 20 times of rated current
 - Have a characteristic angle of 30/45 degree lead
 - Include hand reset flag indicators or IEDs.
- iv. Earth fault relay shall
 - Have IDMT characteristic with a definite minimum time of 3.0 seconds at 10times setting and have a variable setting range of 20-80% of rated current.
 - Have low transient, over reach high set instantaneous unit of continuously variable setting range 500%-2000 % i.e 5 to 20 times of rated current.

- Have a characteristic angle of 45/60 degree lag
- Include hand reset flag indicators or IEDs.
- Include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay.

10.24.6 Transformer Overload Protection Relay shall

- i. Be of single pole type
- ii. Be of definite time over-current type
- iii. Have one set of over-current relay element, with continuously adjustable setting range of 50%-200% of rated current
- iv. Have one adjustable time delay relay for alarm having setting range of 1 to 10.0 seconds, continuously.
- v. Have a drop-off/pick-up ratio greater than 95%.
- vi. Be acceptable as built in feature of numerical transformer differential relay

10.24.7 **Transformer Neutral Current Protection relay** (for 1-Phase transformer bank neutral) shall have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current.

10.24.8 **The Station Transformer 33/0.4 kV shall have Non Directional Over Current protection.**

10.24.9 Further, Transformer auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature, OLTC Buchholz etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements.

10.25 TRIP CIRCUIT SUPERVISION RELAY (Circuit breaker protection)

10.25.1 The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.

10.25.2 The relay shall have adequate contacts for providing connection to alarm and event logger.

10.25.3 The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided with operation indications for each phase.

10.26 TRIPPING RELAY

10.26.1 High Speed Tripping Relay shall be instantaneous (operating time not to exceed 10 milliseconds).

10.26.2 Reset within 20 milli seconds

10.26.3 Be D.C. operated

10.26.4 Have adequate contacts to meet the requirement of scheme, other functions like auto-reclose relay, LBB relay as well as cater to associated equipment like event logger, Disturbance recorder, fault Locator, etc.

10.26.5 Be provided with operation indicators for each element/coil.

10.27 DC SUPPLY SUPERVISION RELAY

10.27.1 The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.

10.27.2 It shall have adequate potential free contacts to meet the scheme requirement.

10.27.3 The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and be provided with operation indicator/flag.

10.28 BUS BAR PROTECTION FOR 220 KV

10.28.1 The bus bar scheme shall be one and half breaker scheme.

10.28.2 Single Static Busbar Differential protection scheme shall be provided for each main bus for 220kV voltage levels. The busbar protection should be designed according to one and half breaker scheme.

10.28.3 Bus bar protection for each busbar shall incorporate a main protection and check feature.

10.28.4 Each Bus Bar protection scheme shall

- i. Have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milliseconds at 5 times setting value.
- ii. Operate selectively for each bus bar

- iii. Give hundred percent security up to 40 KA fault level for 220kV. Incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm.
- iv. Not give false operation during normal load flow in bus bars.
- v. Incorporate clear zone indication.
- vi. Be of phase segregated and triple pole type
- vii. Provide independent zones of protection.
- viii. Include individual high speed electrically reset tripping relays for each feeder
- ix. Be transient free in operation
- x. Include continuous D.C. supplies supervision.
- xi. Not cause tripping for the differential current below the load current of heaviest loaded feeder.

Contractor shall submit application check for the same.

- xii. Shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm
- xiii. Include protection 'IN/OUT' switch for each zone.
- xiv. Shall include trip relays, CT switching relays (if applicable), auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus arrangement i.e. for all the bay or breaker under this specification as well as for the future bays as per the Single line diagram of the substations.

Suitable panels to mount these in switchyard are also included in the scope of the work.

- xv. Shall incorporate continuous supervision for CT secondaries and shall render the relevant zones of protection in operative against possible open circuit and protection transferred to check zone only.

10.28.5 Built-in Local Breaker Backup protection feature as a part of bus bar protection scheme shall also be acceptable.

10.28.6 At existing Inaruwa substations, Bus-bar protection scheme with independent zones for each bus will be available. All necessary co-ordination for 'AC' and 'DC' interconnections between existing schemes (Panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relay, trip relay, flag relay and multi tap auxiliary CTs (in case of biased differential protection) required to facilitate the operation of the bays covered under this contract shall be fully covered in the scope of the bidder.

- The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

10.29 FAULT RECORDER

The Fault recorder shall be provided for the transmission line and it shall be in-built in Numerical relay and have the following features:

10.29.1 Fault recorder shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances and built in feature of line distance relay is acceptable provided the requirements of following clauses are met

10.29.2 The fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit, which is common for the entire Substation. Whenever, more than one acquisition units are connected to an Evaluation unit, necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to Evaluation unit. If there are any constraints for one Evaluation unit to accept the data from number of acquisition units under the present scope, adequate number of Evaluation units shall be supplied. In case of extension of existing substation(s), one set of Evaluation unit shall be supplied for each substation where ever Fault recorders are specified.

- 10.29.3 Fault recorder shall have 8 analog and 16 digital channels for each feeder.
- 10.29.4 Acquisition units shall acquire the fault data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.
- 10.29.5 The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.
- 10.29.6 The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.
- 10.29.7 The Evaluation unit shall consist of a desktop personal computer (including VGA colour monitor, mouse and keyboard) and printer. The desktop PC shall have Pentium - IV processor or better and having a clock speed 400 MHz or better. The hard disk capacity of PC shall not be less than 2 GB and RAM capacity shall not be less than 64 MB.
- 10.29.8 Necessary software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at the remote station through Employer's optic\ fibre/VSAT/LEASED LINE shall be provided.
- 10.29.9 Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analog and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analog channel, group of signal to be drawn on the same axis etc, listing and numbering of all analog and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and

voltage wave forms. The Fault records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)

10.29.10 The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.

10.29.11 Fault recorder acquisition units shall be suitable to operate from 110 V DC / 220V DC as available at substation Evaluation unit along with the printer shall normally be connected to 220V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Fault recorder system.

10.29.12 The acquisition unit shall have the following features:

- i. Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc and same shall be wired to annunciation system.
- ii. The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.
- iii. Scan rate shall be 1000 Hz/channel or better.
- iv. Pre-fault time shall not be less than 100 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system disturbance occurs during one post-fault runtime, the recorder shall also be able to record the same. However, the total memory of acquisition unit shall not be less than 5.0 seconds
- v. The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.
- vi. The acquisition unit shall be typically used to record the following digital channels:
 - Main CB R phase open
 - Main CB Y phase open
 - Main CB B phase open
 - Main-1 inter trip received

- Main-1 protection operated
- Main Auto reclosed operated
- Over Voltage stage 1 /2 operated
- Direct Trip received
- Main-2 inter trip received
- Main- 2/ Back Up protection operated
- Bus bar protection operated
- LBB operated of main circuit breaker
- Tie Circuit Breaker

vii. In case the Fault recorder is in-built part of line distance protection, above digital channels maybe interfaced either externally or internally.

viii. Any digital signal can be programmed to act as trigger for the acquisition unit. Analog channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

10.29.13 The printer shall be compatible with the desktop PC and shall use Plain paper. The print out shall contain the Feeder identity, Date and time (in hour, minute and second up to 100th of a second), identity of trigger source and Graphic form of analog and digital signals of all the channels. Two packets of Z-fold paper (500 sheets in each packet) suitable for printer shall be supplied.

10.29.14 Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to +0.5 seconds/day, if allowed to run without synchronisation. Further, Fault recorder shall have facility to synchronise its time generator from Time Synchronisation Equipment compliant with IEC 61850 communication standard having output in SNTP format. The recorder shall give annunciation in case of absence of synchronizing within a specified time.

10.29.15 Substations where Time Synchronisation Equipment is not available, time generator of anyone of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronized to follow the master.

10.30 DISTANCE TO FAULT LOCATOR

It shall be in-built in Numerical relay and have the following features:

10.30.1 Be electronic or microprocessor based type.

10.30.2 Be 'On-line' type

10.30.3 Be suitable for breaker operating time of 2 cycles

10.30.4 Have built-in display unit

10.30.5 The display shall be directly in percent of line length or kilometres without requiring any further calculations

10.30.6 Have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays.

10.30.7 The above accuracy should not be impaired under the following conditions:

- Presence of remote end infeed
- Predominant D.C. component in fault current
- High fault arc resistance
- Severe CVT transients

10.30.8 Shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line.

10.30.9 Built in feature of line distance relay is acceptable provided the requirements of above clauses are met.

10.31 TIME SYNCHRONISATION EQUIPMENT

- 10.31.1 The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipments to the Indian Standard Time in a substation.
- 10.31.2 Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.
- 10.31.3 It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.
- 10.31.4 Equipment shall operate up to the ambient temperature of 50 degree centigrade and 100% humidity.
- 10.31.5 The synchronisation equipment shall have 2micro second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc).
- 10.31.6 Equipment shall meet the requirement of IEC 60255 for storage & operation.
- 10.31.7 The system shall be able to track the satellites to ensure no interruption of synchronization signal.
- 10.31.8 The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.
- 10.31.9 The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following:
- Voltage signal: Normally 0-5V with 50 milli Seconds minimum pulse duration. In case any other voltage signal required, it shall be decided during detailed engineering.
 - Potential free contact (Minimum pulse duration of 50 milli Seconds.)
 - IRIG-B
 - RS232C

10.31.10 The equipment shall have a periodic time correction facility of one second periodicity.

10.31.11 Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.

10.31.12 Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit

10.32 RELAY TEST KIT

10.32.1 One relay test kit shall comprise of the following equipment as detailed here under

3 sets	Relay tools kits
2 nos.	Test plugs
1 no.	Special type test plugs for using with modular type cases (if applicable)

10.33 TYPE TESTS

10.33.1 The reports for following type tests shall be submitted by the bidder for the Protective relays, Fault locator, Disturbance recorder and Event Logger

- i. Insulation tests as per IEC 60255-5
- ii. High frequency disturbance test as per IEC 60255-4 (Appendix -E) -Class III (not applicable for electromechanical relays)
- iii. Fast transient test as per IEC 1000-4, Level III(not applicable for electromechanical relays)
- iv. Relay characteristics, performance and accuracy test as per IEC 60255
 - Steady state Characteristics and operating time
 - Dynamic Characteristics and operating time for distance protection relays and current differential protection relays

- For Disturbance recorder and Event logger only performance tests are intended under this item.
- v. Tests for thermal and mechanical requirements as per IEC 60255-6
- vi. Tests for rated burden as per IEC 60255-6
- vii. Contact performance test as per IEC 60255-0-20 (not applicable for Event logger, Distance to fault locator and Disturbance recorder)

10.33.2 Steady state & Dynamic characteristics test reports on the distance protection relays, as type test, shall be based on test programme on simulator/network analyzer / PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be/ should have been conducted based on general guidelines specified in CIGRE committee 34 reports on Evaluation of characteristics and performance of Power system protection relays and protective systems.

10.34 CONFIGURATION OF CONTROL AND PROTECTION PANELS

The following is the general criteria for the selection of the equipments to be provided in each type of panel. However, contractor can optimise the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line cannot be provided in single panel. Similarly, Group-I & Group-II protections for transformer cannot be provided in single panel.

10.34.1 CONTROL PANEL

Various types of control panels shall consist of the following

Sno	Device	Quantity
1	Ammeter	3 set for each Line, Bus Coupler, Bus section, and Transformer
2	Wattmeter with transducer	1 set for each line, transformer
3	Varmeter with transducer	1 set for each line, transformer
4	CB Control switch	1 no. for each Circuit breaker

5	Isolator Control switch	1 no. for each isolator
6	Semaphore	1 no. for each earth switch
7	Red indicating lamp	1 no. for each Circuit breaker
8	Red indicating lamp	1 no. for each isolator
9	Green indicating lamp	1 no. for each Circuit breaker
10	Green indicating lamp	1 no. for each isolator
11	White indicating lamp (DC healthy lamp)	2 nos for each feeder
12	Annunciation windows with associated annunciation relays	18 nos for each feeder
13	Push button for alarmAccept/reset/lamp test	3 nos for each control panel
14	Synchronising Socket	1 no. for each Circuit Breaker if required
15	Synchronising selector Switch	1 no. for each Circuit Breaker switch if required
16	Protection Transfer Switch	1 no. for each breaker in case of Main Transfer Bus scheme with Bypass isolator except for Bus Coupler BreakerAnd BC Breaker)-*with Bypass ISO
17	Mimic to represent SLD	Lot in all control panels
18	Voltmeter with selector	1 no for each line, transformer , bus Switch
19	Cut out, mounting and wiring for RWTI and selector switch	Lot for transformers

Notes:

- 1 For transformer feeders, all equipments of control panel shall be provided separately for HV and LV sides.
- 2 In case of incomplete diameter in Breaker and Half scheme, control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.
- 3 The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel shall be supplied.
- 4 Common synchronising switch is also acceptable in Synchronising trolley for new Substations. In this case individual synchronising selector switch is not required for each Circuit Breaker in control panel.
- 5 Each line /HV side of transformer/ LV side of transformer /Bus reactor /TBC /BC/ Bus Section shall be considered as one feeder for above purpose.

10.34.2 Configuration Of Relay And Protection Panels

The following is the general criteria for the selection of the equipments to be provided in each type of panel.

A. LINE PROTECTION PANEL

The Line Protection panel for transmission lines shall consist of following relays and protection schemes

S.No	Description	220 kV line	132kV line
1.	Main-1 Numerical Distance Protection scheme.	1 set	1 set
2.	Main-2 Numerical Distance Protection Scheme.	1 set	NA
3.	Over Voltage Relay	1 set	1 set

4.	3 phase trip relays	2 nos	2 nos
5.	1 phase trip relays	6 nos	NIL
6.	Flag relays , carrier receive relays ,aux. Relays timers etc as per scheme requirements	As required (Lot)	As required (Lot)
7.	Under voltage relay for isolator /earth switch	2 Nos	2 Nos
8.	Directional back up Over current and E/F Protection scheme	1 Set or Built in main-I & Main-II	1 Set or Built in main-I
9.	DC Supply supervision relay	2Nos.	2Nos.
10.	Fault Recorder and Disturbance to Fault Recorder	Built in Distance Protection Relay	Built in Distance Protection Relay

B. 33 KV LINE CONTROL & PROTECTION PANEL

S.No	Description	Quantity
1.	Bay Control Unit/Bay Control & Protection Unit	1 no.
2.	Numerical Non Directional Over Current and Earth Fault Relay 1No.with High Set Feature and in built LBB protection(LBB function as part of BCU is acceptable)	1 no.
3.	Electronic Trivector Meter with 0.2 Class Accuracy With RS 485, RS 232 & Front Optical port)	1 no
4.	Master Trip Relay with adequate no of contacts 1 No.and Electrical Resettable type	1 no.
5.	CB Troubles and Alarm (Part of BCU)	1 Set
6.	Metering (part of BCU)	1 Set

C. BREAKER CONTROL PANEL (for 220 kV and 132 kV Voltage level)

Each Breaker Relay panel shall consist of the following:

S.No	Description	With Auto Reclosing	Without Auto Reclosing
1.	LBB Protection Scheme (For 220 kV only)	1 Set	1 Set
2.	DC supply supervision relay	2 nos.	2 nos.
3.	Trip circuit supervision relays	6 nos.	6 nos.
4.	Auto Reclose scheme with check synchronizing and dead line charging scheme	1 Set	Not Required
5.	Flag relays, aux. relays, timers, trip relays etc. As per scheme requirements. (Acceptable as part of BCU)	Lot	Lot
6.	Electronic Trivector Meter with 0.2 Class Accuracy (With RS 485, RS 232 & Front Optical port)	1 no	1 no
7.	Metering (part of BCU)	1 Set	1 Set
8.	Emergency CB TNC Switches	1 no	1 no
9.	Energy Meter 3 phase, 4 wire, 0.2 accuracy class energy meter	1 No.	1 No.

D. BREAKER CONTROL PANEL

(for 33 kV Voltage level, Acceptable as a part of Line/Transformer relay panel)

Each Breaker Relay panel shall consist of the following:

S.No	Description	Without A/R
1.	DC supply supervision relay	2 nos.
2.	Trip circuit supervision relays	2 nos.
3.	Emergency CB TNC Switches	1 no
4.	Flag relays, aux. relays, timers, trip relays etc. As per scheme	Lot

	requirements. (Acceptable as part of BCU)	
--	--	--

E. TRANSFORMER PROTECTION PANEL (220/132 kV)

Each protection panel for Transformer shall consist of the following equipments:

S.No	Description	HV	LV
1.	Transformer Differential protection scheme	1 set	Not Required
2.	Over fluxing protection scheme	1 Set	Not Required
3.	Non Directional back-up O/C & E/F protection with high Set	1 Set	1 Set
4.	Over load protection scheme	1 no.	Not Required
5.	Restricted Earth fault protection scheme	1 no.	Not Required
6.	Three phase trip relays	2 nos.	2 nos.
7.	Trip supervision relay	2 nos.	2 nos.
8.	CVT selection relay as per scheme requirement	Lot	Lot
9.	Flag relays ,aux .relays , timers etc as per scheme relay requirements including transformer alarms and trip functions	As required (Lot)	As required (Lot)
10.	Fault Recorder	1 no.	Not Required
11.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
12.	DC Supply supervision relay	2 Nos	2 Nos
13.	Energy Meter 3 phase, 4 wire, 0.2 accuracy class energy meter	1 No.	1 No.

F. TRANSFORMER PROTECTION RELAY PANEL (220/33 kV and 132/33 kV)

Each protection panel for Transformer shall consist of the following equipments:

S.No	Description	HV	LV
1.	Transformer Differential protection scheme	1 Set	Nil
2.	Over fluxing protection scheme	1 no. *Applicable for 220/33 kV only	Nil
3.	Directional back up over current and E/F Relay with non-directional high set feature	1 Set	1 Set
4.	Non-Directional back up over current and E/F Relay with non-directional high set feature (Part of 33kV BCU is acceptable)	Nil	1 Set
5.	Over load protection scheme	1 no.	Not Required
6.	Restricted Earth fault protection scheme	1 no.	1 no.
7.	Three phase trip relays	2 nos.	2 nos.
8.	Trip supervision relay	2 nos.	2 nos.
9.	CVT selection relay as per scheme requirement	Lot	Lot
10.	Flag relays ,aux .relays , timers etc as per scheme relay requirements including transformer alarms and trip functions	As required (Lot)	As required (Lot)
11.	Fault Recorder	1 no.	Not Required
12.	DC Supply supervision relay	2 Nos	2 Nos
13.	Energy Meter 3 phase, 4 wire, ABT compliant, 0.2 accuracy class energy meter		

G. BUS COUPLER PROTECTION PANEL (for 132 kV Voltage level)

Each Bus coupler panel shall consist of the following:

S.No	Description	132 kV
1.	Non-Directional back up over current and E/F Relay with non-directional high set	1 Set
2.	Three phase trip relays	1 nos.
3.	Flag relays, aux. relays, timers, trip relays etc. As per scheme requirements. (Acceptable as part of BCU)	Lot

H. BUS BAR PROTECTION PANEL (for 220 kV and 132 kV Voltage level)

The Bus bar protection panel shall consist of the following:

S.No	Description	220 kV	132 kV
1.	Complete Bus bar Protection scheme as per Chapter 10 Clause 10.27	1 Set	1 set

10.35 ERECTION AND MAINTENANCE TOOL EQUIPMENTS

All special testing equipment required for the installation and maintenance of the apparatus, Instruments devices shall be furnished in relevant schedule.

10.36 TROPICALISATION

Control room will be normally air-cooled/air- conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.

10.37 FALSE PANELS:

While panning the Control and Relay panel in the control room building it may so happen that a few panels may get located on the floor beam, where it shall not be possible to provide opening in the floor slab for cable entry in to the panel, as such locations false panels made with similar material and manner as main control and relay panels but without having any equipment or wiring inside. This is to ensure continuous placement of panels one after the other having a aesthetic look in the control room.

10.38 BAY MARSHALLING KIOSKS

- The Bay marshalling kiosks high quality thermo plastic enclosure having IP-66/67 protection shall be supplied by the successful bidder. These kiosks should have following properties.
- Very high impact resistance.
 - High IP rating (IP 66/67) (Dust and jet water proof)
 - Wide operating temperature (-40 to 120 degree Celsius)
 - UV resistance
 - Self-extinguishing flame retardant
 - Non-Toxic (Halogen Free)
 - Good resistance to chemical and rust proof
 - Light weight
 - Totally electrical insulated.
 - Easy machining with normal tools.
 - Cable entry through IP 66 glands of various sizes and flexible conduit entry.

10.39 PROTECTION COUPLER:

- Two nos of Digital Protection Coupler (DPC) shall be used at each end of 220 kV line in Basantapur and Baneshwar Substation and One nos of Digital Protection Coupler shall be used at Tumlingtar and Inaruwa for Teleprotection Applications.

- Each DPC shall be equipped with 4 commands and all accessories, cabling etc required to interface with SDH/MUX telecommunication terminal equipment for its commissioning is in present scope of contract. The specification for the digital protection coupler shall be as per Appendix I.

10.40 ENERGY METER:

- One number each Energy meter for the record and revenue purpose is to be provided for each 220/132/33kV bays (transfer & Bus coupler bays to be excluded) at Tumlingtar and Basantapur substations and 220/33kV bays at Baneshwar substation under present scope of contract, meeting the requirement as specified at Appendix-II.

APPENDIX-I**SPECIFICATION FOR DIGITAL PROTECTION COUPLER****1.0 Digital protection coupler for protection signalling through optical fibre cable system.**

- 1.1 The Digital protection signalling equipment is required to transfer the trip commands from one end of the line to the other end in the shortest possible time with adequate security and dependability. It shall also monitor the healthiness of the link from one end to the other and give alarms in case of any abnormality. The protection signalling equipment shall have a proven operating record in similar application over EHV systems and shall operate on 48V DC (+10%, -10%). It shall provide minimum four commands. These commands shall be suitable for direct tripping, Intertripping and Blocking protection schemes of EHV lines.

The protection signalling equipment shall communicate to the remote end interfacing with SDH terminal equipment at its 2Mbps port. It shall provide suitable interfaces for protective relays, which operate at 220/110V DC. Power supply points shall be immune to electromagnetic interface.

1.2 Principle of operation

During normal operation, protection signalling equipment shall transmit a guard signal/code. In case Protection signalling equipment is actuated by protective relays for transmission of commands, it shall interrupt the guard signal/code and shall transmit the command code to the remote end. The receiver shall recognize the command code and absence of the guard code and will generate the command to the protective relays.

All signal processing i.e. generation of tripping signal and the evaluation of the signals being received shall be performed completely digital using Digital Signal Processing techniques.

1.3 Loop testing

An automatic loop testing routine shall check the teleprotection channel.

It shall also be possible to initiate a loop test manually at any station by pressing a button on the front of the equipment.

Internal test routine shall continuously monitor the availability of the protection signaling equipment.

Proper tripping signal shall always take the priority over the test procedure.

The high speed digital protection signalling equipment shall be designed and provided with following features.

- Shall work in conjunction with SDH terminal equipment.
- It shall communicate on G 703 (E1,2 Mbps)
- Full Duplex operation
- Auto loop facility shall be provided
- Shall meet IEC 60834-1 standard
- Shall be able to transmit upto 4 commands with trip counter simultaneously or sequentially in one 2Mbps channel

Bidder shall quote for protection signalling equipment suitable for 4 commands with separate trip counters for transmit and receive. With regard to trip counters alternate arrangement i.e. Laptop along with software & all accessories to download events including carrier receipt and transmit shall be acceptable. Laptop for the above shall be supplied at each substation under substation package.

High security and dependability shall be ensured by the manufacturer. Probability of false tripping and failure to trip shall be minimum. Statistical curves/figures indicating above mentioned measures shall be submitted along with the bid.

The DPC can be either housed in offered Control & Protection Panel / PLCC Panel or in separate panel.

Reports of the following tests as per clause 9.2 of Chapter 2-GTR shall be submitted for approval for protection signalling equipment and relays associated with the protection signalling equipment and interface unit with protective relay units, if any.

i) General equipment interface tests :

- a) Insulated voltage withstand tests
- b) Damped oscillatory waves disturbance test
- c) Fast transient bursts disturbance test
- d) Electrostatic discharge disturbance test
- e) Radiated electromagnetic field test
- f) RF disturbance emission test

ii) Specific power supply tests

- a) Power supply variations
- b) Interruptions
- c) LF disturbance emission
- d) Reverse polarity

iii) Tele-protection system performance tests

- a) Security
- b) Dependability
- c) Jitter
- d) Recovery time
- e) Transmission time
- f) Alarm functions
- g) Temperature and Humidity tests (As per IEC 68-2)
 - Dry heat test (50°C for 8 hours)
 - Low temperature test (-5°C for 8 hours)
 - Damp heat test (40°C/95%RH for 8 hours)

All the above tests at i, ii & iii (except temperature & humidity tests) shall be as per IEC 60834-1 and the standards mentioned therein.

iv) Relays

- a) Impulse voltage withstand test as per IEC 60255.
- b) High frequency disturbance test as per IEC 60255.

The protection signalling equipment shall be of modular construction and preferably mounted in the Relay panels. Cabling between the protection signalling equipment & Protection relays and between protection signalling equipment & Communication equipment shall be in the scope of bidder.

The input/output interface to the protection equipment shall be achieved by means of relays and the input/output rack wiring shall be carefully segregated from other shelf/cubicle wiring.

The isolation requirements of the protection interface shall be for 2kV rms.

1.4 Major technical Particulars

The major technical particulars of protection signalling equipment shall be as follows.

- i) Power supply 48V DC +10%, -10%
- ii) Number of commands 4 (four)
- iii) Operating time <7 ms
- iv) Back to back operate time without propagation delay ≤ 8 ms
- v) Interface to Protection relays

Input:

Contact Rating:

Rated voltage : 250 volts DC

Maximum current rating: 5 amps

Output:

Contact Rating:

Rated voltage : 250 volts DC

Rated current : 0.1 A DC

Other parameters : As per IEC-255-0-20

vi) Alarm contact

Rated voltage : 250 volts DC

Rated current : 0.1 A DC

Other parameters : As per IEC-255-0-20

vii) Digital communication interface: G 703(E1)

APPENDIX II**Specification for Revenue Meter & Metering (Instrument) Transformer****General:**

The units shall be suitable for operating in Outdoor environment and shall be manufactured by International Reputed ISO 9001 Company

Energy Meter

The Energy Meter shall have the following minimum requirement

Type	Electronic, 3Phase, 4wire, Wye Connection, Bi-directional
	0.1
Applicable Standard	IEC 687 (latest edition) or Equivalent
Measurement	a) Polyphase Quantities kWh, kVARh, kVAh
	b) Instantaneous Quantities Real Time, kW, kVA, PF, Volts, Amps, Frequency
Rated Current (In)	5A or 1A
Rated Maximum Current	1.2xIn
Starting Current	0.001xIn
Voltage (Phase)	110V/ $\sqrt{3}$
Frequency	50Hz
Programmable Interval length	At least 1 to 30 min
Load Profile Memory Storage	At Least 60 days of storage using 4 channels at 15min Intervals
Channels of Load Profile Data	At Least 4 channels of storage (kWh import, kWh export, kVARh Import, kVARh export)

Other Features to be Included	a) Serial communication port and Accessories
	b) Optical Port Communication (With optical Probe)
	c) Remote Download Modem (in built)
	d) Hardware Key to Prevent any Calibration and configuration change
	e) PT or CT error gain correction
	f) Non Volatile memory
	g) Inbuilt Super capacitor
	h) Meter shall be able to record and store in Non-Volatile memory the instant of Power failure and the instant of supply restoration.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-11

Fibre Optics Terminal Equipment

SECTION 4**CHAPTER - 11****FIBER OPTICS TERMINAL EQUIPMENT****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
11.0	GENERAL	1
11.1	CROSS REFERENCES	5
11.2	APPLICABLE CODES AND STANDARDS	5
11.3	DESIGN AND CONSTRUCTION REQUIREMENTS	8
11.4	DESIGN CRITERIA- GENERAL	9
11.5	INTRODUCTION	11
11.6	GENERAL NETWORK CHARACTERISTICS	13
11.7	FIBER OPTIC TRANSMISSION SYSTEM	19
11.8	MDF, DDF AND CABLING	27
11.9	PATCH CORDS	28
11.10	TELECOMMUNICATION MANAGEMENT NETWORK / NETWORK MANAGEMENT SYSTEM (AS APPLICABLE)	29
11.11	COMMUNICATION CHANNEL REQUIREMENT AND INTEGRATIONS	34
11.12	CRAFT TERMINAL	35
11.13	HARDWARE REQUIREMENTS	35
11.14	GENERAL SOFTWARE / FIRMWARE REQUIREMENTS	37
11.15	ENVIRONMENTAL REQUIREMENTS	39
11.16	PRIMARY SOURCE AC/DC POWER REQUIREMENTS	40
11.17	EQUIPMENT CONSTRUCTION, ASSEMBLY AND INSTALLATION	42
11.18	LOCATION OF EQUIPMENT, CABLE ROUTES AND ASSOCIATED CIVIL WORKS	48
11.19	INSPECTION	51
11.20	TEST PLANS AND PROCEDURES	52

11.21	TYPE TESTING	56
11.22	FACTORY ACCEPTANCE TEST	65
11.23	SITE ACCEPTANCE TESTS	69

SECTION 4

CHAPTER – 11

FIBER OPTICS TERMINAL EQUIPMENT

11.0. GENERAL

- 11.0.1. The scope covers the design, engineering, manufacture, testing at Manufacturer's works before dispatch, packing and forwarding, transportation, insurance, handling, delivering at site, proper storage at site, Factory Training, Site Training, supervision for erection testing and commissioning, Installation of Fiber Optics Based Communication equipments which includes Fibre Optic Terminal Equipment and Multiplexer Equipments complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. This Specification includes installing communication System, Telephone System, tele-protection and interface cards to interconnect with SCADA, CCTV equipment for the efficient supervision, control, operation and maintenance of the transmission system. Optical fiber communication link with its associated terminal equipments are required at 220/132/33kV substations at Tumlingtar Baneshwar, Basantapur and Inaruwa -.

In particular following components are included in the Scope:

- (i) SDH Equipment along with suitable optical line interfaces & tributary cards.
- (ii) Associated Termination equipment (Drop-insert multiplexers, subscriber line interfacing card etc.)
- (iii) Local Craft Terminal
- (iv) All cabling, wiring, Digital Distribution Frame patch facilities, equipment MDF's and interconnections to the supplied equipment at the defined interfaces.
- (v) MDF & DDF cross connects required to route and activate circuits.

- (vi) System integration of the supplied subsystems and also integration with existing communication equipment such as SDH, MUX etc.
- (vii) System integration of the supplied equipments (termination equipment system) with existing equipments for seamless transmission of communication channel
- (viii) Integration of supplied system with the User equipments such as RTUs, SCADA system, , PABX etc.
- (ix) Maintenance of the supplied system
- (x) All other associated works/items described in the technical specifications for a viable and fully functional communication network.

The Contractor is encouraged to offer standard products and designs. However, the Contractor must conform to the requirements and provide any special equipment necessary to meet the requirements stated herein.

It should be noted that preliminary design information and bill of quantity (BoQ) specified in this specifications are indicative only. The Contractor shall verify the design data during the site surveys & detail engineering and finalise the BoQ as required for ultimate design & system performance.

The Bidder's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

An analysis of the functional and performance requirements of this specification and/or site surveys, design, and engineering may lead the Contractor to conclude that additional items are required that are not specifically mentioned in this specification. The Contractor shall be responsible for providing at no added cost to the Employer, all such additional items and services such that a viable and fully functional communication equipment system is implemented that meets or exceeds the capacity, and performance requirements specified. Such materials and services shall be considered to be within the scope of the

contract. To the extent possible, the Bidders shall identify and include all such additional items and services in their proposal.

All equipment provided shall be designed to interface with existing equipment and shall be capable of supporting all present requirements and spare capacity requirement identified in this specification.

The communication equipment shall be designed and provisioned for expansions and reconfigurations without impairing normal operation, including adding and removing circuits. The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

The Bidders are advised to visit sites (at their own expense), prior to the submission of a proposal, and make surveys and assessments as deemed necessary for proposal submission. The successful bidder (Contractor) is required to visit all sites. The site visits after contract award shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the Employer well in advance. The site survey schedule shall be finalised in consultation with the Employer. The Employer may be associated with the Contractor during their site survey activities.

After the site survey, the Contractor shall submit to the Employer a survey report on each link and site. This report shall include at least the following items:

- a) Proposed routing of power, earthing, signal cables and patch cords etc.
- b) Confirmation of adequacy of Space and AC/DC Power supply requirements
- c) Proposals for new rooms/buildings if required
- d) Identification of facility modifications if required
- e) Identify all additional items required for integration for each site/location.

- 11.0.2. Telephone System (EPABX-16 lines minimum) shall be installed at substations at Tumlingtar, Baneshwar and Basantapur. The Specification of EPABX is given in Section-I, Annexure.
- 11.0.3. Closed Circuit TV (CCTV) system to be installed in all the substations. Tentative Locations of camera as detailed below and finalized during detailed engineering
- All incoming bays should cover all the isolators in the bay
 - All outgoing bays should cover all the isolators in the bay
 - Transformer bays
 - Bus coupler bays
 - Covering Entrance gate of Substation
 - Any other locations as desired by the NEA finalized during detailed engineering
- 11.0.4. The security monitoring system shall be provided with CCTV and digital video record would be able to transmit signal to upcoming Load Dispatch Centre (LDC) in future.
- 11.0.5. Time Synchronization Equipment (TSE)
- 11.0.5.1. The Time Synchronization Equipment (TSE) shall receive the co-ordinate Universal. Times (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronize equipments to the Nepal Standard Time in a substation. Time synchronization equipment shall include antenna, all special cables and processing equipment etc. It shall be compatible for synchronization of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realized through optic fibre bus. The real time clock will not drift by more than 60 s in one month.
- 11.0.5.2. Supply shall be complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification.
- 11.0.5.3. The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.
- 11.0.5.4. Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.

11.0.5.5. Components having identical rating shall be interchangeable.

11.0.5.6. The bidder has to furnish the testing facilities available at the manufacturer's works.

11.1. CROSS REFERENCES

This Materials Standard Specification shall be read in conjunction with the latest "General Specification and General Information which shall be considered as an integral part of this Technical Specification as per IEC 60331.

11.2. APPLICABLE CODES AND STANDARDS

The latest revision/amendments of Codes, Standards and Recommendations published by the following international organizations shall be applicable for the equipment/material covered in this Specification. In case of conflict, the vendor/manufacturer may propose equipment/material conforming to one group of Standards specified hereunder without jeopardizing the requirements of this Specification:

1. ANSI/ATIS T1.617 Bearer Services; Frame Relaying - ISDN DSSI; Bearer Services - Frame Relaying
2. IEC 60255-5 Insulation Coordination for Measuring Relays and Protection Equipment – Requirements and Tests
3. IEC 60255-22-1 Electrical Disturbance Tests for Measuring Relays and Protection Equipment, Part I: 1MHz Burst Disturbance Tests
4. IEC 60834-1 Tele protection Equipments of Power Systems – Performance and Testing, Part 1: Command Systems
5. IEC 60870-3 Tele control Equipments and Systems, Part 3: Interfaces (Electrical Characteristics)
6. IEC 61000-4-2 Electromagnetic Compatibility (EMC), Part 4-2: Testing and Measurement Techniques – Electrostatic Discharge Immunity Test
7. IEC 61000-4-3 Electromagnetic Compatibility (EMC), Part 4-3: Testing and Measurement Techniques Radiated, Radio Frequency, Electromagnetic Field Immunity Test

8. IEC 61000-4-4 Attachment 2, Electromagnetic Compatibility (EMC), Part 4-4: Testing and Measurement Techniques – Electrical Fast Transient Burst Immunity Test
9. IEC 61000-4-5 Electromagnetic Compatibility (EMC), Part 4-5: Testing and Measurement Techniques – Surge Immunity Test
10. IEC 61000-4-6 Electromagnetic Compatibility (EMC), Part 4-6: Immunity to Conducted Disturbances, Induced by Radio Frequency Fields
11. IEC 61000-4-12 Electromagnetic Compatibility (EMC), Part 4-12: Testing and Measurement Techniques – Oscillatory Waves Immunity Test
12. ISO/IEC 8802-3 Information Technology – Telecommunications and Information Exchange Between Systems – Local and Metropolitan Area Networks – Specific Requirements, Part 3: Carrier Sense Multiple Access with Collision Detection (CSAMA/CD) Access Method and Physical Layer Specifications
13. ITU-T G.703 Physical/Electrical Characteristics of Hierarchical Digital Interfaces
14. ITU-T G.707 Network Node Interface for the Synchronous Digital Hierarchy (SDH)
15. ITU-T G.709 Interfaces for the Optical Transport Network (OTN)
16. ITU-T G.711 Pulse Code Modulation (PCM) of Voice Frequencies, Appendix II: A Comfort Noise Payload Definition for ITU-T G711 use in Packet-Based Multimedia
17. ITU-T G.712 Transmission Performance Characteristics of Pulse Code Modulation (PCM)
18. ITU-T G.773 Protocol Suites for Q-Interfaces for Management of Transmission Systems
19. ITU-T G.775 Loss of Signal (LOS), Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) Defect Detection and Clearance Criteria for PDH Signals
20. ITU-T G.783 Characteristics of Synchronous Digital Hierarchy (SDH) Equipment Functional Blocks

21. ITU-T G.803 Architecture of Transport Networks Based on the Synchronous Digital Hierarchy (SDH)
22. ITU-T G.805 Generic Functional Architecture of Transport Networks
23. ITU-T G.813 Timing Characteristics of SDH Equipment Slave Clocks (ESC)
24. ITU-T G.821 Error Performance of an International Digital Connection Operating at Bit Rate Below the Primary Rate and Forming Part of an Integrated Services Digital Network
25. ITU-T G.823 Control of Jitter and Wander Within Digital Networks Which are Based on the 2Mbps Hierarchy
26. ITU-T G.825 Control of Jitter and Wander Within Digital Networks Which are Based on the Synchronous Digital Hierarchy (SDH)
27. ITU-T G.826 Error Performance Parameters and Objectives for International, Constant Bit-Rate Digital Paths at or Above the Primary Rate
28. ITU-T G.841 Types and Characteristics of Synchronous Digital Hierarchy (SDH) Network Protection Architectures
29. ITU-T G.957 Optical Interfaces for Equipments and Systems Relating to the Synchronous Digital Hierarchy
30. ITU-T G.958 Digital Line Systems Based on the Synchronous Digital Hierarchy for Use on Optical Fiber Cables
31. ITU-T I.233 Frame Mode Bearer Services
32. ITU-T M.2101.1 Performance Limits for Bringing into Service and Maintenance of International SDH Paths and Multiplex Sections
33. ITU-T Q.811 Lower layer Protocol Profiles for the Q3 and X Interfaces
34. ITU-T Q.552 Transmission Characteristics at 2-Wire Analogue Interfaces of Digital Exchanges

35. ITU-T T.50 International Reference Alphabet (IDA) – Information Technology – 7 Bit Coded Character Set for Information Interchange
36. ITU-T V.24 List of Definitions for Interchange Circuits Between Data Terminal Equipment (DTE) and Data Circuit – Terminating Equipment
37. ITU-T V.28 Electrical Characteristics for Unbalanced Double-Current Interchange Circuits
38. ITU-T V.35 Data Transmission at 48Kbps Using 60-108 kHz Group Band Circuits.

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

11.3. DESIGN AND CONSTRUCTION REQUIREMENTS

11.3.1. GENERAL

The Fiber optics terminal equipment shall meet, or exceed the requirements of this specification in all respects.

Manufacturer's documents and drawings as required in Drawings Schedule shall include all pertinent construction details of the equipment. All pertinent dimensions for the construction of the equipment shall be provided for NEA/WAPCOS evaluation and approval.

11.4. DESIGN CRITERIA-GENERAL

- 11.4.1. The equipment shall meet indoor ambient temperature requirements as specified in General Information.
- 11.4.2. The equipment shall be specifically designed for low to medium channel applications to be operated at the carrier level rate of STM as per the ITU-T standard G.709, and related ITU-T SDH equipment standards and proven for use in an Electric Utility Telecommunications environment. They shall be designed to provide a minimum twenty (20) years of acceptable service.
- 11.4.3. The design of the equipment shall utilize field proven solid state components and circuits in order to provide high equipment reliability.
- 11.4.4. Overall system availability (protected mode) between any two interconnected terminals for the Fiber optic terminal links shall be 99.999 percent, or greater throughout the minimum 20 year lifetime of the equipment. For determining system availability, the equipment manufacturer's Mean time between failure and mean time to repair figures (for each Fiber optic terminal) shall be used.
- 11.4.5. Equipment shall have specific plug-in interface modules (integrated in the basic equipment main unit) which shall allow for direct connection to the following:
- Protective relay commands (distance type, breaker failure type, directional earth fault relays and other relays requiring direct transfer trip contact closures).
 - External protective relay signaling equipment (interfacing with the Fiber optics terminal equipment at the 64Kbps G.703 level).
 - Numerical (microprocessor based) protective relays (interfacing with the equipment at the 64Kbps G.703 level).
 - Numerical (microprocessor based) line differential relays (interfacing with the equipment at the 64Kbps G.703 level).
 - SCADA RTU equipment (both digital and analog connections).
 - Transmission of external equipment alarms.
 - Data traffic.

h. Ethernet LANS, E1 (2Mbps) G.703 electrical, as well as normal telephone traffic.

i. E1 interface for CCTV data transmission

- 11.4.6. Optical inputs/outputs for the equipment shall operate with 1310nm or 1550nm single mode optical signals, with the following available optical transmitters / receivers, which are shown in the Table 1 below: main unit which shall allow for direct connection to the following:

TABLE 1.4.6.1 - OPTICAL WAVELENGTH AND OPTICAL UNIT OPTIONS

WAVELENGTH	OPTION
1310 nm	High Power (Laser Version)
1550 nm	High Power (Laser Version)
1310 nm	Low Power (LED Version) when available from the Fiber Optic terminal Equipment Manufacturer

- 11.4.7. Additional signal security shall be integrated in the Fiber optic terminals to assure error-free operation of the communications link, when the communications link encounters high bit-error rates.
- 11.4.8. The equipment shall be based on the supporting to future configuration of STM. All terminal equipment shelves shall be fully wired, and additional shelves provided, to support the installation of the plug-in interface modules and future channel expansion requirements, which are specified in the equipment quantity table included in the Project Scope of Work and Technical Specification.
- 11.4.9. All equipment shelves of the Fiber optic terminal equipment shall be designed for mounting on standard EIA 19-inch wide racks or equipment cabinets as described in Section 5.0 of this standard.
- 11.4.10. All modules and shelves of the terminal equipment shall have integral high voltage surge and fast transient protection as per International Standards.
- 11.4.11. The equipment shall also contain suitable EMI /RFI protection as specified as per International Standards.

- 11.4.12. The equipment shall be designed to contain a basic equipment main unit (which contains equipment shelves and units/modules for the basic multiplexing requirements), as well as plug-in interface modules.
- 11.4.13. For any Fiber optic terminal equipment type, the DC power consumption shall be less than 200 Watts DC Peak Power.
- 11.4.14. Alarm Transmission Requirements.
- 11.4.15. Each terminal shall be equipped with alarm transmission and detection equipment (Alarm Unit (AU) or equivalent) to allow transmission and reception of selected alarms (as specified in the Project Specification) on the remote end(s) of the Fiber optic link to the fiber optic remote supervisory terminals at the sites referenced in the associated Project Scope of Work and Technical Specification (for turnkey projects).
- 11.4.16. All Protective relay communication between remote stations will be transmitted through FOTS (Fiber optic transmission system) for tripping and communication
- 11.4.17. The equipment shall have extensive alarm reporting facilities to report local terminal alarms. Alarms may be reported locally (at the terminal equipment end) by use of LED indicators, or through use of a local (portable) craft terminal.
- 11.4.18. Following Annexure shall be integral part of this Chapter:

Annexure 10 (a): Network Configuration and Equipment Characteristics

Annexure 10 (b): Environment, EMI, Power Supply, Cabling and Earthing

Annexure 10 (c): Inspection, Test and Availability.

Annexure 10 (a): Network Configuration and Equipment Characteristics

11.5. INTRODUCTION

This section describes the Fiber Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

1. Fiber Optic Transmission System (FOTS)
2. Termination Equipment Subsystems

3. MDF, DDF and Cabling

The requirements described herein are applicable to and in support of network requirements. The equipment supplied shall support existing network for Power system operational requirements.

The security related requirements of the equipment shall be as per relevant agency and shall be followed/complied by the vendor.

The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security/threat check any time during the supplies of equipment.

The contractor shall ensure that the supplied equipments have been got tested as per relevant contemporary International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. From 1st April, 2013, the certification shall be got done from authorized and certified agency.

The Contractor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipments, software etc. supplied and implemented in the project shall be given for use by the Employer

In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the Contractor as per guidelines of Government department.

11.6. General Network Characteristics**11.6.1. Description**

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH) having bit rate of STM-1 (upgradable to STM-4) as identified in the BoQ. The network shall consist of overhead fibre optic links with a minimum bit rate of Synchronous Transport Module-1 (STM-1). The Contractor can propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement. The detailed BOQ is described in appendices.

11.6.2. Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS/RTUs/PMUs. The communications support requirement for SCADA/EMS/RTUs/PMUs system is for low & high speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

- a) High speed E1 channel support
- b) 64kbps & nx64kbps data channel support
- c) Low speed (300 -1200 bps) data channel support
- d) Voice (2 wires, 4 wires) channel support.
- e) Data transport supporting Network Management channels
- f) The connectivity envisaged between RTUs and Control Centre over TCP-IP using Ethernet interface or over serial interface.
- g) Network cards should be according to the standards.

11.6.3. General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

11.6.3.1. System Synchronization

The Contractor shall synchronize the existing equipments and all the new equipments under the contract using existing Master clock, if available. The Contractor shall provide the additional clocks as required under the set of clock indicated in BoQ. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. The contractor shall submit the synchronisation plan as per standard ITU-T G.811. All sync equipments proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments new & existing. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of ITU-T G.803. The synchronization plan shall clearly indicate the requirement of additional clocks with full justification.

The system equipment requiring "clock" shall be connected to the master clock using external clocking. For this purpose, appropriate interfaces(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

11.6.3.2. System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under TMN control (if provided). Such testing shall not affect the functional operation of the system.

11.6.3.3. System Upgradeability and Expandability

Equipment supplied shall be sized (though not necessarily equipped) to support system/subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate

patching facilities or termination blocks. Power supplies shall be sized for maximum equipped system capacity.

11.6.3.4. Equipment Availability

The calculated availability of each fibre optic link (E1 to E1) shall be at least 99.999%. The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the mean-time-to-repair (MTTR) of the components and subsystems comprising the FOTS. For this analysis, an MTTR of at least 4 hours shall be assumed. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations. The calculated failure rates of the units and the calculated availabilities of the equipment being offered shall be provided by the Contractor during detailed engineering.

11.6.3.5. Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Employer, prior to the completion of SAT.

11.6.3.6. Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BoQ and configuration requirements as identified in the appendices. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion.

11.6.3.7. Redundancy Requirements and Protection Schemes

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 2-1. The failure of one element shall not prevent the use of any other that has not failed.

Table 2-1

Equipment Redundancy Requirements Summary

<p>Fiber Optic transmission Equipment :</p> <p>SDH equipment</p> <p>Power Supply & Converters -----</p> <p>Common Control* Cards -----</p> <p>MUX, DROP/INSERT</p> <p>Power Supply -----</p> <p>* = Common control cards which are essentially required for operation of the equipment.</p>	<p>1:1 APS or distributed power supply</p> <p>1:1 APS</p> <p>1:1 APS or distributed power supply</p>
--	--

The offered equipment shall support at least SNCP as per standard ITU-T G.841. In case the equipment offered by the Bidder does not support the above mentioned minimum protection methods, the bidder shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to Employer. The bidders shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

11.6.3.8. Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

11.6.3.9. Software Upgrades

The Contractor shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if upgrade in the hardware/software of supplied item is required, the same shall be done by the contractor without any additional cost to the Employer.

11.6.3.10. General Site Considerations

All fiber optic links up to 175 kms transmission line length shall be implemented by the Contractor without repeaters. In order to meet the link budget requirement, the Contractor shall provide all the necessary equipments only in the end stations. The contractor may provide the optical amplifier, wave length translator, optical cards or high capacity SDH equipment with suitable rack/subrack to meet the maximum distance limit. All the provided equipments shall be monitored/managed by Craft Terminal.

11.6.3.11. Proposed Optical Fibre Characteristics

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibres conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table-2-2:

Table-2-2
Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode (DWSM)
Mode Field Diameter:	8.6 to 9.5 μm ($\pm 0.6 \mu\text{m}$)
Cladding Diameter:	125.0 $\mu\text{m} \pm 1\mu\text{m}$
Mode field Concentricity Error:	$\leq 0.6\mu\text{m}$
Core-Clad concentricity error:	$\leq 1.0\mu\text{m}$
Cladding non-circularity	$\leq 1\%$
Cable Cut off Wavelength:	$\leq 1260 \text{ nm}$
1550 loss performance	As per G.652D
Proof Test Level	$\geq 0.69 \text{ Gpa}$
Attenuation coefficient	@1310nm $\leq 0.35 \text{ dB/Km}$ @1550nm $\leq 0.21 \text{ dB/Km}$
Attenuation variation with wavelength 1285 nm - 1330 nm 1525 nm – 1575 nm	Attenuation coefficient @1310 $\pm 0.05 \text{ dB}$ Attenuation coefficient @1550 $\pm 0.05 \text{ dB}$
Point discontinuities	$\leq 0.1\text{dB}$
Chromatic Dispersion; Max.: Zero Dispersion Wavelength: Zero Dispersion Slope:	18.0 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) @ 1288-1339nm 5.3 ps/(nm x km) @ 1271-1360nm 1300 to 1324nm 0.092 ps/(nm ² xkm) maximum
Polarization mode dispersion coefficient	$\leq 0.2 \text{ ps/km}^{1/2}$
Temperature Dependence:	Induced attenuation $\leq 0.05 \text{ dB}$ (-60 deg C - +85 deg C)
Bend performance:	@1310nm (75 \pm 2 mm dia Mandrel), 100 turns; Attenuation rise $\leq 0.05 \text{ dB}$ @1550nm (30 \pm 1 mm dia Mandrel), 100

	turns; Attenuation rise ≤ 0.10 dB @1550nm (32 \pm 0.5 mm dia Mandrel), 1 turn; Attenuation rise ≤ 0.50 dB
--	---

11.6.4. Fibre Optic Link Lengths

The fiber optic route lengths are as specified in appendices. The lengths specified in appendices are the transmission line route lengths; however the actual fiber cable length shall exceed the route lengths on account of extra cable requirement due to sag, jointing & splicing, approach cabling etc. For bidding purposes the Contractor may assume an additional cable length of 5% of given route length + 1Km towards approach cable for calculating the link length. The exact cable lengths shall be determined by the Contractor during the survey. The same shall be used by the Contractor for final link design during the detailed engineering of the project.

11.7. FIBRE OPTIC TRANSMISSION SYSTEM

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-1 (upgradable to STM-4) and equipped with 2 nos. of minimum 16 port E1 interface(G.703) card, one no. of minimum 4 port Ethernet interface (IEEE 802.3/IEEE 802.3u) card supporting layer 2 switching as tributaries. The Ethernet interfaces shall support VLAN (IEEE 802.1P/Q), spanning tree (IEEE 802.1D) quality of service. Protection scheme for Ethernet traffic should be ERPS based (Ethernet ring protection scheme) as per ITU-T G.8032.

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection. Two number spare jumpers shall be provided for each equipment connection. Fiber jumpers shall be of sufficient

lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

11.7.1. SDH Equipment

11.7.1.1. Functional Requirement

There is a requirement for different types of equipment under this project which are described in this section. The BOQ is provided in the appendices. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub-rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If bidder is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, control card shall not be equipped with more than one optical interface/SFP and optical base card shall not be equipped with more than two optical interface/SFPs.

The equipment shall be configurable either as Terminal Multiplexer (TM) as well as ADM with software settings only.

SDH ADM

The aggregate interfaces shall be (at least) STM-1 towards at least two protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with a 2 nos., min.16 E-1 port electrical tributary cards & one no., min.4 port Ethernet interface card as tributaries. The equipment shall provide access to full STM-4 payload.

The offered STM-1 SDH equipment shall be upgradeable to STM-4 by changing optical line cards only. Cross connection (VC4) capability of offered SDH equipment shall be provided

according to STM-4 equipment. The contractor shall demonstrate the STM-4 upgradeability during FAT.

11.7.1.2. Redundancy and Protection

Two fibre rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibres shall be implemented.

11.7.1.3. Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Muldem's that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and one data channel. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis.

11.7.1.4. Supervision and Alarms

ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, F2/Q2 interfaces for a local craftsperson terminal interface and remote equipment monitoring is required.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the TMN.

11.7.1.5. Synchronisation

The equipment shall provide synchronisation as per Table 2-2. One 2MHz synchronisation output from each equipment shall be provided.

11.7.1.6. Electrical and Optical I/O Characteristics and General Parameters

Table 2-3 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

Table 2-3 Electrical and Optical I/O Characteristics and General Parameters	
Optical Wavelength ^{NOTE (1)}	1310/1550nm
Optical Source ^{NOTE (2)}	Laser
Optical Source Lifespan	Better than 5 X10 ⁵ hours
Optical Fibre Type	G.652 D
Optical Connectors	Type FC-PC
Transmission Quality	Per ITU-T G.821, G.823, G.826
Source Primary Power	-48 Vdc
Equipment Specifications	Per ITU-T G.783
Tributary, Electrical Interface	Per ITU-T G.703, 75 Ω
Ethernet Interface	10/100 Mbps
SDH Bit Rates	Per ITU-T G.703
Optical Interfaces	Per ITU-T G.957, G.958
Frame and Multiplexing Structure for SDH	Per ITU-T G.707
Synchronization	Per ITU-T G.813
Management Functions	Per ITU-T G.774, G.784
Protection Architectures	Per ITU-T G.841
Built In Testing and Alarms	Per ITU-T G.774, G.783, G.784

NOTE (1) Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

NOTE (2) Eye Safety for Laser Equipment: To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

NOTE (3) In case other than FC-PC connector is provided in the equipment,

suitable patch cord with matching connector are to be provided to connect with FODP.

11.7.2. Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

11.7.2.1. Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

1. Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.
2. Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.
3. Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.
4. Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed "End of Life (EOL)" parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.
5. Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.
6. Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.
7. Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.
8. Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

9. Bit Error Rate: The link budget calculations shall be done for a BER of 10^{-10} .

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fibre optic link during detailed engineering.

For finalising the FOTS system design & BOQ, above methodology shall be adopted taking into account fibre attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

11.7.2.2. Link Performance

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826.

11.7.2.3. FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP and the SDH equipment. The Contractor shall provide FC PC coupled patch cords. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage. If there is distance between FODP & Equipment the patch cords should be fitted with cable raceways

11.7.3. Termination Equipment Subsystem

The Termination Equipment Subsystem is defined to include the equipment that interfaces (adapts) the subscriber (user) to the Fibre Optic Transmission System (FOTS). A Functional description of these equipments are as follows:

11.7.4. Functional Description

The transmission network node provides subscriber interface to the transmission network and/or switching/routing. For clarity, the basic functions accomplished at the network nodal points, are described briefly as follows:

Primary Multiplexer shall be used to accomplish subscriber connectivity to the Digital Communication Network. Subscriber Line Units shall provide analog to digital and direct

digital conversion to 64 Kbps digital channel. In the CEPT standard hierarchy, thirty (30) such 64 Kbps digital channels shall be Time Division Multiplexed (TDM) resulting in a single 2.048 Mbps (E-1) digital bit stream.

Digital Drop-Insert and Branching Equipment shall be used to digitally interface a small number of channels at spur locations without requiring successive D/A and A/D conversions of the throughput channels.

The equipment shall also have an interface for external 2048 kHz synchronisation signal according to ITU-T Recommendation G.703.

11.7.5. First Order (Primary) Multiplexing

The Contractor shall be required to provide E-1 Drop & Insert Multiplexer and E-1 Channel Bank primary multiplexing in compliance with the electrical input-output characteristics provided in Table 2-4.

11.7.5.1. Drop & Insert Primary Multiplexing

Drop & Insert primary multiplexing in conformance with CEPT E-1 characteristics shall be required at locations where the subscriber requirement is minimal. The drop and insertion of up to thirty 64 Kbps channels supporting subscriber line units (SLU) shall be required at intermediate locations. The Drop & Insert Muxes supplied shall be performance and card compatible with the Channel Bank Equipment provided so that all Subscriber Line Interface cards are interchangeable.

Table 2-4

**CEPT E-1 Standard First Order Multiplexing
Electrical Input/Output Characteristics**

Applicable Standards:	CEPT per CCITT Recommendation G.702, G.703, G.711 and G.712
Number of Tributaries:	30 X 64 Kbps
Alternative Sub-rate Tributaries:	n X 64 Kbps V.36 64Kb/s V.11/V.36

Output Aggregate Rate:	2.048 Mb/s \pm 50 ppm
Interface Code:	HDB3
Impedance:	75 ohm unbalanced
Peak Level @ 120 ohm:	3.0 volts \pm 10%
Peak Level @ 75 ohm:	2.37 volts \pm 10%
Maximum Insertion Loss:	6 dB
Signal Waveform:	Per CCITT G.703
Frame Structure:	Per CCITT G.742
Jitter Performance:	Per CCITT G.823
Power Supply Voltage:	-48 Vdc

11.7.5.2. Channel Banks (Mux, Drop/Insert)

User voice and data equipment interfacing requirements are defined at the subscriber line level. Primary multiplexing in conformance with CEPT E-1 characteristics shall be used to provide first order multiplexing of up to thirty 64 Kbps channels supporting Subscriber Line Units (SLUs).

11.7.5.3. Subscriber Line Units\Subscriber Line Interface Cards

The terms Subscriber Line Interface Cards and Subscriber Line Units have been used interchangeably throughout the specification. Multiple configurations of SLUs shall be required to provide subscriber to primary multiplexer Bank interfacing for a variety of voice and data communications. In case there are changes in number or type of cards because of changes in channel requirements, the contract price shall be adjusted accordingly.

The SLU interface requirements are discussed in the following subparagraphs:

a. Voice Channels

The voice channel requirement is for (I) 4-Wire E&M trunking in support of PABX trunks & PLC VF and (II) 2-Wire telephonic interfaces. 2 wire SLUs shall be DTMF/TP optioned for 2-wire loop start or 2-wire GND start. The voice cards shall utilize ITU.T A - law companded

PCM G.711, 64 kbits/s encoding. The voice card requirements are indicated in the BoQ in appendices.

b. Sub-Channel Data Multiplexing

For this Project, the RTU data interface to the wideband telecommunications network node shall be defined at the DTE level at low-speed rates of 300, 600 and 1200 baud. The port shall be compatible with RS232C interface. The Contractor shall be required to furnish 64 Kbps SLU asynchronous dataplexing for at least 4 selectable low speed DTE interfaces whenever multiple asynchronous data circuits are required.

c. Synchronous Data

The Contractor shall provide a direct DTE interface for synchronous communications at speed of 64Kbps and compatible with CCITT G.703 Kbit/s, V.35 and X.21 interfaces. Data rate selection shall be switch selectable or programmable.

d. Nx64 kbps Synchronous Data

There is also a requirement for N x 64 kbps V.35, X.21 interfaces. The tentative quantities have been identified in the appendices. However the final BOQ shall be worked out during detailed design and contract price shall be adjusted accordingly.

11.8. MDF, DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities and MDFs interfacing to the wideband telecommunications system. Equipment and material components for MDF, DDF and cabling are also part of this procurement. It shall be the Contractor's responsibility to provide all cable support required for full supplied equipment interconnection with the MDF and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications. Special Flooring should be used for MDF and DDF.

11.8.1. Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

- i) "Normally thru" circuit routing
- ii) Circuit rerouting via patch cord assemblies
- iii) Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

11.8.2. Main Distribution Frames

The Contractor shall make provision for cross connection of subscriber services to the subscribers utilizing Krone type or equivalent and shall provide full connectivity up to and terminated on the equipment side of the appropriate DDFs and line side of MDFs. The Contractor shall terminate on the equipment side of patching facilities provided by other contracts and shall provide DSX type patching facilities supporting aggregate bit streams (i.e. dataplexers and E-1 Channel Banks). Separate Patch panels or MDFs shall be provided for Data and Voice. All cross connects shall be accomplished utilizing one, two or three pair patch cords. Patch plugs are permissible for direct one-to-one circuit "cut-thru".

11.9. PATCH CORDS

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

11.10. TELECOMMUNICATION MANAGEMENT NETWORK / NETWORK MANAGEMENT SYSTEM (AS APPLICABLE)

The Contractor shall provide a Telecommunications Management Network System (TMN) for operational support to the FOTS and associated Termination equipment subsystems. This TMN shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network from a centralized location and at each node of the network where equipment is located. This TMN system shall assist Employer/Owner in the operations and maintenance of the wideband communication resources of the including detection of degraded circuits, system performance, the diagnosis of problems, the implementation of remedial actions and the allocation or reallocation of telecommunications resources and addition/deletion of network elements.

The contractor shall supply preferably a single TMN for all the NEs (Network Elements) such as SDH equipment, Mux, Drop-Insert, DACS etc. In case a single TMN can not be provided for all the NEs, the contractor may supply separate TMNs. Each of the offered TMN shall meet the requirements indicated in this section. The bidder shall provide details of the offered TMN in the bid.

11.10.1. Applicable Standards

The TMN design concept, functional and informational architecture and physical architecture, shall be in compliance with ITU-T Recommendation M.3010. The offered TMN system shall be capable of integration to other supplier's Network Management System (NMS) upwardly through North bound interfaces. The north bound interface in the EMS shall be CORBA/TMF-814 compliant.

11.10.2. TMN Architecture

The TMN shall provide

- A. Collection of Management data from all Network Elements (NEs) supplied under this package. The minimum monitoring and control requirements for the communication equipment shall be as defined in this section.

- B. For TMN architecture ITU T M.3400, M.3020 should be applicable.
- C. Processing of above management data by using processor(s) located at control Centre and additional intermediate station processor(s), wherever required.
- D. Monitoring and control of the NEs as defined below:
 - i. TMN system at LDC (including local operator console, if applicable) shall support management of all equipments supplied and monitoring of the entire regional network supplied under this package. At a minimum functions of Network management layer (NML) and Element management layer (EML) as defined in CCITT M3010. The detailed functions are listed in TS.
 - ii. Monitoring and control of NEs using Craft Terminals as defined in this Section .
- E. Supervisory monitoring and control of the following station associated devices:
 - i. Intrusion Detection Alarms
 - ii. Power Failure
 - iii. Fire and Smoke Detection
 - iv. Environmental Control (Temperature, Humidity etc.)
- F. Communication channel support for TMN System as specified in Technical Specifications (TS).

The supplied TMN system shall be capable of handling all management functions for at least 150% of the final network elements. Further, the centralised TMN system shall also have provision for addition of at least two remote operator consoles. The TMN hardware shall be so designed that failure of a single processor/component (router, switch, converter etc.) shall not inhibit any of the functionality of the TMN at control centre. The Contractor shall submit for Employer's approval the TMN architecture describing in detail the following subsystems/features:

- a. Database used in TMN
- b. Master Processor, server/workstation, LAN, Peripherals and hardware

- c. Software and operating system
- d. Local Consoles/remote consoles
- e. Craft Terminals
- f. Data communication between NEs, Remote/Local Consoles and TMN Processor(s)
- g. Routers/Bridges
- h. Expansion Capabilities

11.10.3. Management Functions

The TMN shall support following Management functions:

11.10.3.1. Configuration Management

Configuration management is concerned with management, display, and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

- a. Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.
- b. Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.
- c. Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.
- d. Provide verification testing to support new equipment installation.

11.10.3.2. Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, and links. Minimum specific requirements that shall be satisfied include the following:

- a. Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text.
- b. Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.
- c. Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be configurable as critical alarms, major alarms and minor alarms with different colours.
- d. Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.
- e. The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.
- f. Track network equipment failure history.

11.10.3.3. Performance Management

Performance management is concerned with evaluation of the use of network equipments and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

- a. Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions. For example, BER of each link, together with other data measured at each node, shall be available on operator request (atleast for SDH).

- b. Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources (atleast for SDH). Specifically provide displays to permit the operator to:
 - i. Select/deselect network equipments, events, and threshold parameters to monitor
 - ii. Set monitoring start time and duration or end time
 - iii. Set monitoring sampling frequency
 - iv. Set/change threshold values on selected performance parameters
 - v. Generate alarm events when thresholds are exceeded.
 - vi. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.
 - vii. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs. Performance data provided is limited to what is available from the equipment Contractors.
 - viii. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.
 - ix. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

11.10.3.4.Security Management

The TMN shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. One access level of System Administrator and at least two levels of operator access shall be provided - read (view) only, and write (configure). The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the TMN system. With "read only" access level, network parameters should

only be viewed. Access to database maintenance, command control and test functions shall be available with "write " access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network. It shall be possible to define multiple domains for purposes of monitoring and control.

Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

11.11. COMMUNICATION CHANNEL REQUIREMENT AND INTEGRATION

Communication requirements for TMN system have not been considered in Appendices and the Contractor shall provide these as a part of TMN system. The Contractor shall provide all required interface cards / devices, LAN, routers/bridges, channel routing, cabling, wiring etc. and interfacing required for full TMN data transport.

The TMN data transport shall utilize the wideband communications transmission system service channel in the overhead whenever possible. This will provide inherent critical path protection

Should the configuration requirements dictate multiple TMN station processors, the TMN Master Station shall require bidirectional data transport with its station processor(s). This communications interfacing shall be via critically protected data channels. It shall be the Contractor's responsibility to provide for and equip all necessary critically protected TMN data channel support.

In case supervisory channels are not available, the Contractor shall provide suitable interfaces in their supplied equipment for transport of TMN data. The Contractor shall also be responsible for providing suitable channels with appropriate interfaces to transport the TMN data.

The NMS information of existing PDH & SDH system shall be transported through the new communication network, wherever required, up to the NMS location. The NMS information of the new SDH & PDH system being procured under the package shall be transported through the existing communication network using 64 kbps/2Mbps (G.703)

interfaces. Any hardware required for above interfacing shall be provided by the Contractor.

The bidders shall describe in the proposal the TMN data transport proposed to be used by the bidder in detail including capacity requirements and various components/equipment proposed to be used.

11.12. CRAFT TERMINAL

Each equipment (SDH equipment, Mux, Drop/Insert and DACS etc.) on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Craft Terminal Should be according to ITU-G 774 & G.826 standards for error performance and performance. Through the use of this PC and local displays/controls, the operator shall be able to:

- a. Change the configuration of the station & the connected NEs.
- b. Perform tests
- c. Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ given in the appendices.

11.13. HARDWARE REQUIREMENTS

11.13.1. Master Processor, Server/Workstation and Craft Terminal

The server/workstation and craft terminal shall have suitable processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this specification. Only reputed make like Dell, IBM, HP, Compaq make shall be supplied.

The server shall have minimum configuration of 3GHz for CISC based or 1.6GHz for RISC based processor, 2GB RAM, DVD-ROM drive, redundant 80 GB internal Hard Disk Drive, 101-Enhanced style keyboards, mouse, parallel, serial, USB(2.0) ports and hot swap

redundant power supply. VDUs shall be 17" TFT active matrix color LCD with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required. However, the internal hard disk drive for the server shall be redundant and all the data shall be mirrored. Further, the TMN software shall support data mirroring on redundant disk drives.

The workstation shall have minimum configuration of 2.4GHz for CISC or 1.4GHz for RISC based processor, 1GB RAM, DVD-RW drive, 160 GB Hard Disk Drive, 101-Enhanced style keyboards, mouse, parallel, serial and USB (2.0) ports. VDUs shall be 19" TFT active matrix color LCD with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required.

CPU enclosures shall be desktop type and shall include available expansion slots except for the Craft Terminal which shall be a laptop. The craft terminal shall have minimum configuration of 2.4 GHz, 2 GB RAM, 256 MB VRAM, DVD RW drive, 160 GB Hard Disk Drive, keyboard, mouse/trackball etc., parallel, serial/USB (2.0) ports to accommodate printers, and Internal/external Data/Fax modem and a battery back-up of at least 60 minutes. VDUs shall be 15" TFT active matrix color LCD with a minimum resolution of 1024 X 768.

11.13.2. Peripherals and hardware

TMN system shall be provided with laser printer. The laser printer shall have a minimum print speed of 17 pages per minute and a minimum resolution of 1200 x 1200 dpi. The laser printer shall have parallel and LAN ports for connecting to TMN system.

The laser printer under this specification shall be black & white and include print enhanced buffering to prevent loss of print data in the event of a print failure.

11.13.3. Local/Remote Operator Consoles (As Applicable)

The Contractor shall provide operator consoles sized and equipped to support the subsystem(s) furnished and in compliance with the specification. The console shall provide hardware interfacing for the TMN users to the software operating support systems. At a minimum, a console shall include the hardware similar to a workstation.

11.13.4. Power Supplies

The TMN system shall use 220 volts 50 Hz A.C or -48 volt D.C as available at site for its operation as available at site.

11.14. GENERAL SOFTWARE/FIRMWARE REQUIREMENTS

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

11.14.1. Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, management devices, to allocate system resources, and manage communications among the system processors. The contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

11.14.2. Applications Software

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The contractor shall make no modifications to the applications program except as provided as USER development tools.

11.14.3. Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

11.14.4. Revisions, Upgrades, Maintainability

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required. All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

All software shall be easily user expandable to accommodate the anticipated system growth, as defined in this specification. Reassembly recompilation or revision upgrades of the software or components of the software, shall not be necessary to accommodate full system expansion.

Software provided shall be compliant with national and international industry standards.

11.14.5. Database(s)

The contractor shall develop all the databases for final wideband network following the global acronyms for all stations. Database(s) to be provided shall contain all structure definitions and data for the integrated functional requirements of TMN system.

TMN operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

11.14.6. Help

All applications shall be supported by USER accessible HELP commands that shall assist the user in the performance of its tasks. HELP commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application.

Annexure 10 (b): Environment, EMI, Power Supply, Cabling and Earthling

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in an Extra High Voltage (EHV) power system environment.

11.15. ENVIRONMENTAL REQUIREMENTS

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

11.15.1. Temperature and Humidity

Most of the equipment will not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in Table 4-1.

Table 4-1
Environmental Operating Limits

Temperature Range:	(Un Controlled Environment)
Specification	0 to 45°C
Operation without damage	-10 to 55°C
Shipping/storage	-40 to 60°C
Relative Humidity, non-condensing	Upto 90%
Elevation:	
Operating	to 3,000 m
Non-operating	to 10,000 m

For each location, the Contractor is required to assess the environmental conditions for the equipment to be installed under this specification. The Contractor is responsible for all necessary enclosure, rack or equipment upgrades to ensure the proper operation of the installed equipment.

11.15.2. EMI and Electrostatic Interference

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location. Specifications provides the type of immunity tests for which the equipment shall be required to pass without failure. For the individual tests to be carried out at the different interfaces, references are made to the relevant IEC and ITU-T recommendations.

11.15.3. Vibration and Shock Resistance

As per testing requirements indicated in this specification.

11.15.4. Tropicalization

Communications equipment will often be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

11.15.5. Contaminants

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

11.16. PRIMARY SOURCE AC/DC POWER REQUIREMENTS

Facilities will be required to support both AC and DC power load requirements of telecommunications equipment as specified below:

11.16.1. Primary Source AC Power

It will be the Employer's responsibility to provide required Primary AC source Power for communications equipment installed under this specification. The Primary AC Power supplied will be 230 VAC \pm 5%, 50Hz with a frequency variance between 48.75 and 51.25 Hz. Harmonic distortion will not exceed five (3) percent.

All equipment and components provided under this specification requiring Primary AC Power, shall be designed for normal operation under the above stated tolerances for 230 VAC supply.

The Contractor shall provide in their Bid as well as in the survey report to the Employer the projected 230 VAC Primary Power load requirement per equipment and totals, by location, for equipment provided under this specification. The Contractor shall provide suitable UPS for communication equipment/module etc. requiring AC power supply at locations other than control centre.

11.16.2. -48V DC Power

Power supplies/converters for communications equipment (except computer system supplied as part of NMS which shall use 230 VAC) provided under this specification, shall use -48Vdc uninterrupted primary source power. The power supply may vary normally within the voltage range -42 to -58 Vdc and the supplied equipment shall operate satisfactorily within this range.

11.16.3. Power Distribution and Protection

The Employer will furnish only one source primary 230 VAC and/or -48 VDC power. It shall be the Contractor's responsibility for the connection and distribution of all Primary AC and -48V dc source power, in full compliance with all local and national electrical codes.

The Employer shall indicate during the survey by Contractor, on the primary source, the feeders/points that can be used by the Contractor. The Contractor shall supply & install Primary AC and -48Vdc feeder cables to Contractor-furnished distribution panels.

The Contractor shall provide required distribution panels, circuit breakers and appropriate Panel Disconnects. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

The Contractor shall provide and install all required primary power distribution sourced from the distribution panels. The Contractor shall also be responsible for Load Balancing.

The Contractor is responsible for all inter-rack (enclosure) and intra-rack (enclosure) power distribution required to support equipment supplied under this specification. The Contractor shall provide all cabling, fusing, switching and circuit breaker and surge protection required.

Partially equipped subsystems shall be installed with provision for expansion. Equipment power supplies provided under this specification, shall be sized to support fully equipped subsystems. Primary power distribution protection shall be sized to support and protect

maximum operating load potential whether or not the actual projected load shall meet that maximum load potential.

The Contractor shall provide equipment and rack safety earthing in compliance with this specification.

11.17. EQUIPMENT CONSTRUCTION, ASSEMBLY AND INSTALLATION

All equipment supplied under this specification shall be constructed, assembled and installed in accordance with the following requirements:

11.17.1. Identification

All cabling, racks/enclosures, equipment, modules and materials shall be uniquely identifiable as per the following:

11.17.1.1. Equipment

Each equipment component to the level of printed circuit card, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture and revision level. Changes to components shall be identified by an unambiguous change to the marked revision level. The Contractor shall be responsible for maintaining the master revision level list until the Contractor has complied with all requirements of this specification.

Where custom components and parts are provided, each component/part shall be marked to specifically identify that component/part. Printed circuit card cages are defined as an equipment component and as such, shall be clearly identified as stated within this specification.

Equipment chassis and printed circuit card cages having wired backplanes, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture, revision level and an additional identifier corresponding directly to the applicable backplane wiring diagram/list.

11.17.1.2.Power Distribution

Power distribution panels shall be clearly marked with their unique identifier, source feed information, and remote source feed emergency disconnect location and identity.

Power distribution panel "Main Disconnect" and circuit breakers shall be clearly marked with a unique identifier. Circuit breaker feed lists shall be clear, accurate and the feed list information shall be posted inside each distribution panel door. Wiring diagram also posted outside the panel door.

Inter-rack and intra-rack (enclosure) power distribution shall be clearly identified with source feed, voltage and power rating information. All power feed cabling shall be clearly identified near the point of termination.

All power distribution identification shall utilize heat-resistant permanent marking techniques such as stamped non-metallic tags, embossed labels, etc. Marking techniques are subject to approval by the Employer. Power distribution identifiers and information shall agree with the Contractor's power cable plant drawings.

11.17.1.3.Signal Cabling

Connectorised signal cabling/wiring requires marking with a unique identifier at each connectorised end. The signal cable/wire identifier shall include a cable identifier and the location of both terminations.

Signal cable/wiring installed on terminal blocks requires marking with the cable identifier and distant end location. The cable tag shall be clearly visible at the cable fanout point.

All signal cable, wiring and terminations shall be clearly labelled/tagged with identifiers consistent with Contractor supplied cable plant records. Marking techniques are subject to approval by the Employer.

11.17.1.4.Equipment Racks and Enclosures

All equipment racks, enclosures and equipment, including distribution frames, shall be clearly labelled with unique identifiers consistent with Contractor supplied floor plans and rack elevations.

11.17.2. Installation Hardware

Equipment racks, enclosures, cable raceways and installation hardware shall, at a minimum, comply with the following requirements:

11.17.2.1. Equipment Sub-Racks and Cabinets (Enclosures)

All equipment provided under this specification, shall be physically mounted in sub-racks and cabinets (enclosures). The Contractor shall determine and propose for the Employer approval, the type, size, weight and manner of installation for each location.

Selection of equipment sub-racks and cabinets (enclosures) shall meet the following requirements:

A. Equipment SubRack Construction

Equipment Sub Racks provided for installation in environmentally controlled facilities, shall meet the following minimum requirements:

1. Equipment Sub Racks shall be steel/aluminium fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All sub rack bolts are fastened using cage bolts All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.
2. Equipment covers shall be provided for exposed components mounted in equipment sub Racks.
3. Dust and moisture protection shall meet or exceed IP20 standards.

B. Equipment Cabinet (Enclosure) Construction

- i. Equipment cabinets (enclosures) shall be steel/ steel & Aluminium extrusion fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.
- ii. Equipment cabinets (enclosures) shall be designed free-standing but shall be mounted to the floor. Cabinets (enclosures) shall have secure fitting, lockable, full-

length front doors for access to hardware and wiring. Equipment covers for exposed components mounted inside cabinets are not required unless specifically recommended.

- iii. All doors and removable panels shall be fitted with long life rubber beading. All panels shall be fabricated from minimum 2.0mm thickness steel sheet. However, for racks with load bearing Aluminium extrusion frame, door panels and side panels may be fabricated from minimum 1.6mm thickness steel sheet and the top & bottom panels shall be fabricated from minimum 2.0mm thickness steel sheet.
- iv. Equipment cabinets (enclosures) shall be dust and moisture-proof as per IP41 specification, or better.

11.17.2.2.Cable Raceways

The Contractor is required to provide and install all additional necessary indoor and outdoor cable raceways. The cable raceways shall be in conformance with the following:

- 1) Signal cabling and power cabling shall require separate cable raceways. Signal and power cabling shall not share the same raceways and shall be installed as far apart as is practical. Adequate shielding shall be provided as required.
- 2) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
- 3) Outdoor cable raceways shall be of corrugated construction and shall be fitted with solid covers overlapping all sides of the cable raceways.
- 4) Outdoor cable raceways shall be fabricated from construction grade aluminum, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be taken. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.

- 5) Indoor cable raceways fabricated of aluminum or galvanized iron, shall not normally need special finishing or painting, unless otherwise stipulated by the Employer. Steel fabricated raceways shall require a red oxide primer coat at a minimum.

11.17.3. Signaling Distribution

The Contractor shall be responsible for all signal wiring associated with furnished equipment in accordance with the following:

- i. All signal wiring connections to the communications equipment shall be via Krone type or equivalent terminal blocks.
- ii. The Contractor shall provide subscriber level wiring and patching wherever required.

11.17.4. Lightning and Transient Voltage Protection

The Contractor shall be required to provide protection from lightning and transient voltages for all wideband communications equipment, in accordance with the following:

- i. At the outside cable plant point-of-entry of all cabling penetrations for all cabling installed by the Contractor, the Contractor shall provide lightning and transient voltage isolation for the inside plants cabling, wiring, and all terminations and equipment.
- ii. All equipment installed under this specification that requires 240VAC primary power, shall be surge protected.

11.17.5. Station Safety Earthing and Signal Grounding

For each facility, the Contractor is responsible for meeting the following substation and equipment terminal earthing requirements:

- i. All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards
- ii. Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.

- iii. Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sqmm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.
- iv. The safety earth network shall be connected to "earth ground" at the safety earth stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.
- v. The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

The Contractor shall extend the existing station earth to the equipment room using suitable G.I. earthing strip (50 x 6 mm), wherever required. .

The Contractor is responsible for providing all required earthing/grounding cable and installation. Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the Employer's approval.

The Contractor shall be responsible for determining the suitability of existing station earth for the equipment to be supplied under this contract. In case existing earthing arrangement at the site is not adequate, the Contractor shall either make improvement in the existing earthing arrangement or make new earthing as per requirement.

11.17.6. Interconnections

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor-supplied as-built drawings.

The Contractor shall supply and install all primary power cords, powerstrips, receptacles, circuit breakers, fuse panels, switches, earth fault detectors, surge protectors, distribution

cabling, and power connectors required to support all equipment enclosures and system components furnished and installed under this specification, except as specifically excluded.

Plug-type power connectors with captive fastening (such as "Twist-Lock") shall be used for interconnection of source power to the equipment enclosures or racks.

Plug-type connectors with captive fasteners (ie. DB-25, etc) shall be used for the interconnection of all inter and intra-enclosure signalling cable.

11.17.7. Finish Colors

Unless otherwise specified, finish colors for enclosures shall be gloss white enamel on the inside, and semi-gloss medium grey enamel on the outside. Only brushed aluminum trim shall be used. Employer reserves the right to approve the proposed color scheme.

11.18. LOCATION OF EQUIPMENT, CABLE ROUTES AND ASSOCIATED CIVIL WORKS

During the Site Surveys, the Contractor shall determine and propose locations for all equipment to be supplied under this contract. Further, the Contractor shall locate and identify proposed routing for all cabling between all equipment locations including existing and planned equipment not provided under this contract, but required to be connected under the scope of this contract. This subsection defines the requirements and clarifies the responsibilities of the Employer and the Contractor regarding equipment siting, intra and inter facility interconnectivity and necessary associated civil works.

11.18.1. Locations for Supplied Equipment

All transmission equipment and associated DDFs and MDFs, shall generally be colocated in the same communications room located in the Control Building whenever possible.

11.18.2. Associated Civil Works

The Contractor shall provide all required minor civil works necessary for full connectivity as required in the Contractor's scope of work as follows:

- i. All wall and floor penetrations necessary for the installation of all cabling to be performed in accordance with the requirements of this specification.

- ii. Installation of racks, cabinets, cable raceways, and cabling supplied as part of this contract.

11.18.3. Cable Trenches

A network of cable trenches and/or ducts may exist at some sites but shall require expansion and/or new construction at some stations. It shall be a responsibility of the contractor to cooperate fully with the Employer and all other on-going project contractors in the planning and efficient use of existing and new cable trenches. The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be proposed for Employer approval. The Employer shall provide any additional cable trenches required for such approved alternatives.

It may be noted that in order to utilise the existing trenches, the Contractor supplied cables may be required to be co-located with LV cables. Accordingly, the contractor shall ensure that selection and installation of cables is suitable for the purpose. The contractor shall be responsible for new building penetrations required for supplied cabling. Caution shall be taken to ensure existing equipment and site personnel are protected from dust and debris incident to the cable penetration work. Penetration shall be neatly formed and sealed for protection from moisture, dust wind and vermin intrusion.

All required fitting, supports, accessories, ducts, inner ducts, conduits, riser and any item not specially mentioned but required for lay and installation of cables in trenches shall be supplied and installed by the Contractor.

ANNEXTURE 10 (c): Inspection, Test and Availability

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

All security related features shall be demonstrated during FAT/SAT as required by the Employer.

11.18.4. Augmentation and integration work related to Communication System.

The existing FO communication link exists between Inaruwa-Dhalkebar(New)-Hetauda(new) Substations to the LDC Kathmandu. Data and voice communications from various substations and power houses flow to LDC in Inaruwa-Dhalkebar(New)-Hetauda(new) Substations to the LDC Kathmandu. The scope of work for supply, installation of approach optical fibre (as per requirement from JB to ODF box), Optical Line Termination Equipment, Digital Multiplexer, hardware accessories etc at Basantapur , Baneshwar, Tumlingtar and its integration work at Inaruwa and LDC Kathmandu for onward transmission of Data and Voice communication upto LDC Khatmandu is included in the Contract.

One number each PABX shall be supplied and commissioned at all three new substations Inaruwa, Dhalkebar & Hetauda. The technical specification is enclosed at Appendix-I.

11.19. INSPECTION

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

1. Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.
2. Inspections to be performed by the Employer will include visual examination of hardware, cable dressings and labeling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.

3. Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.
4. The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.
5. The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

11.20. TEST PLANS AND PROCEDURES

Test plans and test procedures for both factory and site acceptance tests shall be provided by the Contractor. Test plans and test procedures shall ensure that each factory and site test is comprehensive and verify all the features of the equipment to be tested. Test plans and test procedures shall be modular to allow individual test segments to be repeated upon request.

The Contractor shall submit a Test Schedule for the Employer's approval within one (1) week after the award of contract for Type Tests and three (3) months after the award of contract for all other tests. The test schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.

The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the corrections

as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

11.20.1. Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table 4-1.

Table 4-1

Factory & field Test Plan Requirements

Item:	Description:
1.	Test schedule
2.	Record-keeping assignments, procedures and forms
3.	Procedures for monitoring, correcting and retesting variances
4.	Procedures for controlling and documenting all changes made to the communications equipment after the start of testing

11.20.2. Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Fully approved test procedures shall be submitted to the Employer at least four weeks prior to the commencement of testing. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table 4-2.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

Table 4-2

Test Procedure Requirements

Item:	Description:
1.	Test Title and Revision Level, if applicable
2.	List of Standard(s) complied with
3.	Function(s) / parameter(s) to be tested
4.	Purpose of each test segment
5.	List of required test equipment
6.	Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test.
7.	Test setup including test configuration block diagrams and/or illustrations.
8.	Test procedures to be followed.
9.	Required inputs and expected outputs for each test segment
10.	Acceptance criteria for each test segment.
11.	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
12.	Format of test reports.

11.20.3. Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table 4-3.

Table 4-3**Test Record Requirements**

Item:	Description:
1.	Test Title and Revision Level, if applicable; contract references
2.	Date and time for test start and test completed
3.	Test title and reference to the appropriate section of the test procedures
4.	Description of any special test conditions or special actions taken (Includes test-case data).
5.	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6.	Test procedure modifications made during testing.
7.	Variance Report(s) tracking information and copies (if variance(s) was detected).
8.	Contractor's test engineer(s) identification, signature and remarks
9.	Employer's test witness identification, signature and remarks
10.	List of all attachments
11.	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

11.20.4. Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary.

Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer for further inspection and/or tests.

11.20.5. Test Periods Defined

The terminology used in Volume I, General Conditions of Contract and their correlation with the tests requirements described within this section is as follows:

Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)

Operational Acceptance - Successful completion of SAT

11.21. TYPE TESTING

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

- a) All equipment being supplied shall conform to type tests as per technical specification.
- b) The test reports submitted shall be of the tests conducted within last five (5) years prior to the date of bid opening. In case the test reports are older than five years (5) ago on the date of bid opening, the Contractor shall repeat these tests at no extra cost to the purchaser.
- c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and

parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives.

In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

- d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.
- e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.
- f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
- g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

11.21.1. Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. At least three samples of each of the proposed equipment shall be offered for selection, out of which one sample for each equipment shall be selected.

11.21.2. List of Type Tests

The type testing shall be conducted on the following equipment

1. SDH Equipment with all types of cards (optical card, Tributary card or any other equipment as part of repeater less links)
2. Primary Multiplexer & Drop – Insert Multiplexer with subscriber interface card

11.21.2.1. List of type test to be conducted on Telecom equipment

The type tests for SDH Equipment with all types of cards, Primary Multiplexer & Drop – Insert Mux with subscriber interface card are described below:

11.21.2.1.1. Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

1. Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

- I. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.
- II. Degree of Severity: Test shall be done at 0°C
- III. Acceptance Criteria: No degradation of performance during and after the test.

2. Low Temperature Test : Operation without Damage

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

- I. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (Post-test).

- II. Degree of Severity: Test shall be done at -10° C
- III. Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the post-test.

3. Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

- I. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test.
- II. Degree of Severity: As per table 5-1: operation to specification range.
- III. Acceptance Criteria: No degradation of performance during and after the test.

4. Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

- I. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (Post-test).
- II. Degree of Severity: Test shall be done at 55°C.
- III. Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the post-test.

5. Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-3 with the following specifications:

- I. Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.

- II. Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

6. Temperature Variation Test

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

- I. Number of cycles required is five (5)
- II. The degree of severity: temperature TL:0°C, TH: As per table 5-1 (Operation to specification range)
- III. Cycle duration for each temperature is three (3) hours.
- IV. Ramp : 1 oC/minute.
- V. Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

11.21.2.1.2. Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.

A. Immunity Tests

The list of Immunity tests are specified below in Table 4-4:

Table 4-4: Recommended Immunity Tests

S.NO	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Para-metres
1	Voltage Fluctuations	Yes	Yes	N/A	N/A	Table 11 of IEC 60870-2-1: 1995 - Level :

Table 4-4: Recommended Immunity Tests

S.NO	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Para-metres
2	Voltage dips and Interruptions	Yes	Yes	N/A	N/A	1
3	1.2/50 - 8/20 μ s surges	Yes	Yes	Yes	N/A	Table 12 of IEC 60870-2-1: 1995 - Level : 4
4	Fast transient bursts	Yes	Yes	Yes	Yes	
5	Damped oscillatory waves	Yes	Yes	Yes	Yes	
6	10/700 μ s surges	N/A	N/A	N/A	Yes	
7	Electrostatic discharge	Yes				Table 13 of IEC 60870-2-1: 1995 - Level : 4
8	Power frequency magnetic field	Yes				Table 14 of IEC 60870-2-1: 1995

Table 4-4: Recommended Immunity Tests

S.NO	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Para-metres
9	Damped oscillatory magnetic field	Yes				- Level : 4
10	Radiated electromagnetic field	Yes				Table 15 of IEC 60870-2-1: 1995 - Level : 4
11	Power Frequency voltage on control and signal lines	N/A	N/A	Yes	Yes	IEC 61000-4-16 : 2002-07 Level : 4
12	DC voltage on control and signal lines	N/A	N/A	Yes	N/A	IEC 61000-4-16 : 2002-07 Level : 4
-End of Table-						

B. Emission Tests

The list of Emission tests are specified below in Table 4-5

Table 4-5:**Recommended Emission Tests**

S. NO.	Emission test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Para- metres
1	LF disturbance voltages CCITT recommendation P.53	N/A	Yes	N/A	N/A	Table 17 of IEC 60870- 2-1: 1995 - Class : B
2	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
3	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
4	RF radiated fields CISPR 22	Yes				
-End Of Table-						

C. Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class: VW1 of Table 18.

11.21.2.1.3. Mechanical Tests

A. Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance test conditions are selected according to the vibration withstand requirements.

Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

B. Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semi-sinusoidal shape (clause 3.1.1.2).

The recommended severity shall be $A = 294 \text{ m/s}^2$, $D = 18 \text{ ms}$. Three shocks per axis per direction shall be applied to the equipment packed according to the Contractor's specifications.

Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features

(inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

11.22. FACTORY ACCEPTANCE TESTS

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on SDH Equipments, associated line & tributary cards, Termination Equipments (Primary Mux, Drop/Insert, associated Subscriber Line Interface Cards etc) and all other items for which price has been identified separately in the Bid Price Schedules.

Equipment shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer's representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system and NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general the FAT for other items shall include at least:

Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

11.22.1. Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

11.22.2. Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be

carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

Table 4-6:

Factory Acceptance Testing for Fibre Optic Transmission System

Item:	Description:
1.	Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2.	Optical output power
3.	Transmitter lightwave spectral analysis
4.	Low receive level threshold
5.	Generation of bit error rate curve
6.	Measurement of analog and digital service channel parameters as well as service channel functionality
7.	Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.
8.	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for multiplexers
9.	At a minimum tests on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544
11.	Simulation of failure conditions and failover of each redundant unit.
12.	Test of spare card slots
13.	Checks of power supply/converter voltage margins
14.	Random inspections to verify the accuracy of documentation
15.	Test of spare parts/modules/cards as per applicable tests

Table 4-7

Factory Acceptance Testing Requirements for Termination Equipment**(MUX)**

Item	Description:
1.	Physical Inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2.	Performance of supervision, alarm, control and switching systems, diagnostics, loopbacks, Craftsperson interface etc.
3.	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for the channel banks/low-level multiplexers
4.	Framing, signaling, and operational and maintenance tests consistent with applicable ITU-T requirements
5.	Simulation of failure conditions and failover of each redundant unit
6.	Test of spare card slots and test of spare parts/modules/cards as per applicable tests
7.	Checks of power supply/converter voltage margins and short circuit and overvoltage protection
8.	Random inspections to verify the accuracy of documentation

Table 4-8

FAT on Craft Terminal

1	Physical inspection of Craft Terminal hardware for conformance to approved BoQ, DRS & drawing
2	Testing of Craft Terminal to demonstrate proper operation of all functions

11.23. SITE ACCEPTANCE TESTS

The Contractor shall be responsible for the submission of all equipment & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for Telecom equipment. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for Telecom equipment installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

11.23.1. Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

11.23.1.1. Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense.

In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated.

The minimal installation testing requirements for fiber optic transmission subsystem, Termination equipment sub-system are provided in respective Tables in this section.

11.23.1.2.Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated as per RFC 2544:

- a) Ping test
- b) Throughput test
- c) Latency test
- d) Packet Loss

10% of the total links (Chosen by the Employer, generally to cover links from all configurations used) shall be tested for a duration of 12 Hours. Rest of the links shall be tested for 1 Hour. In case a link does not meet the performance requirements during 1 hour, then the duration of the test shall be increased to 12 hours.

In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects.

This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipments may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

11.23.1.3.Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the data and voice channel required to interconnect the various User's interfaces. The integrated testing for a batch shall include end-to-end testing of

back-bone network included in that batch. Integrated testing for last batch shall include testing of the entire back-bone. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during factory and field installation and communications testing have been corrected, and that the communication equipment is compatible with other equipment at all locations. The Integrated System Test shall include all fibre optic transmission equipment, termination equipment, the network management subsystem and other components.

At a minimum the following tests shall be included in the integrated testing:

- (1) Equipment configuration shall be checked to establish that it supports the channel routing.
- (2) End to end testing of all individual voice circuits
- (3) End-to-end testing of all individual Data Circuits.
- (4) Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

Table 4-9

Fibre Optic Transmission system Installation Testing

Item:	Description:
1.	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	Station power supply input and equipment power supply (DC-DC converter) output voltage measurements
3.	Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)
4.	Service channel performance
5.	Craftsperson interface, alarm and control functional performance
6.	Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional

7.	Network management interface and supervision performance
8.	Correct configuration, level setting & adjustments and termination of Input/output interfaces
9.	Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.
10.	Simulation of failure conditions and failover of protected components.

Table 4-10

Termination Equipment Sub-system Installation Testing

Item:	Description:
1.	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	Power supply/converter voltage measurements
3.	Muldem performance testing
4.	Craftsperson interface, alarm and control functional performance
5.	Rack and Local alarms
6.	Network management interface and supervision performance
7.	Channel performance
8.	Safety and signalling earthing system
9.	Simulation of failure conditions and failover of protected components.

Table 4-11

NMS Installation Testing (if Applicable)

Item:	Description:
1.	Physical inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	Workstation hardware inventory, configuration and characteristics
3.	Demonstration of proper operation of all hardware, including workstations peripherals

ANNEXTURE 10 (d): Bill of Quantities for Fibre Optic Based Communication Equipments

S.No.	Item Description	Unit	220/132/33 KV Tumling Tar S/S	220/33 KV Baneshwar SS	220/132/33 KV Basantapur S/S	Inaruwa SS	Kathmanndu LDC	Total Quantity
1.0	Transmission Equipment							
A	SDH Equipment (STM - 1 upgradable to STM-4 ADM, upto two directions)							
(I)	Base Equipment (Common cards, Cross-connect/control cards, Optical base card, Power supply cards, power cabling, other hardware & accessories including sub-racks, patch cords, DDF etc. fully equipped excluding (II) and (III) below)	No.	1	1	1	1	-	4
(II)	Optical Interface/SFP# for							
(a)	L4.1	No.	-	2	-		-	2
(b)	Optical Line Interface card (to support	No.			2	2		4

Koshi Corridor 220kV Transmission Line Project, Nepal

Package KC2: Koshi Corridor Substations

Part II-Section VI: Employer's Requirements

IFB No: KOSHI/NEA/71/72-2

S.No.	Item Description	Unit	220/132/33 KV Tumling Tar S/S	220/33 KV Baneshwar SS	220/132/33 KV Basantapur S/S	Inaruwa SS	Kathmanndu LDC	Total Quantity
	minimum 80 kms)**							
(c)	Optical Line Interface card (to support minimum 40 kms)**		2	2	-	-		4
(III)	Tributary Cards							
(a)	E1 Interface card (Minimum 16 interfaces per card)	No.	2	2	2	2	-	8
(b)	Ethernet interfaces 10/100 Mbps with Layer-2 switching (Minimum 4 interfaces per card.)	No.	1	1	1	1 1	-	4
2.0	Termination Equipment							
A1	Drop/Insert Multiplexer Base Equipment (Common cards, Power supply cards, power cabling,	No.	2	2	2		-	8

Koshi Corridor 220kV Transmission Line Project, Nepal

Package KC2: Koshi Corridor Substations

Part II-Section VI: Employer's Requirements

IFB No: KOSHI/NEA/71/72-2

S.No.	Item Description	Unit	220/132/33 KV Tumling Tar S/S	220/33 KV Baneshwar SS	220/132/33 KV Basantapur S/S	Inaruwa SS	Kathmandu LDC	Total Quantity
	other hardware & accessories including sub-racks, etc. fully equipped excluding subscriber line interface cards)					2		
A2	Subscriber Line Interface Cards							
a)	2 wire (sub/sub) voice channel cards (min 8 channels per card)	No.	1	1	1	1	-	4
b)	2 wire (sub/exchange) voice channel cards (min 8 channels per card)	No.	1	1	1	1	-	4
c)	4 wire (E&M) voice channel cards (min 8 channels per card)	No.	1	1	1	1	-	4
d)	Asynchronous Sub Channels data cards (minimum 4 channels per card)	No.	1	1	1	1	-	4
e)	Synchronous data card (NX64kbps)	No.	1	1	1	1		4

Koshi Corridor 220kV Transmission Line Project, Nepal

Package KC2: Koshi Corridor Substations

Part II-Section VI: Employer's Requirements

IFB No: KOSHI/NEA/71/72-2

S.No.	Item Description	Unit	220/132/33 KV Tumling Tar S/S	220/33 KV Baneshwar SS	220/132/33 KV Basantapur S/S	Inaruwa SS	Kathmandu LDC	Total Quantity
3.0	Equipment Cabinets							
a)	For Drop/Insert Multiplexer	No.	1	1	1	1		4
b)	For SDH Equipment	No.	1	1	1	1		4
4.0	TMN – Craft Terminal for SDH & PDH Equipments							
(a)	Hardware	Set*	-	0	1	-	-	1
(b)	Software	Set*	-	0	1	-	-	1
5.0	Synchronization Equipment							
	GPS clock including all hardware & accessories	Set	-	-	1	-	-	1
6.0	Main Distribution Frame (100 pairs)	No.	1	1	1	1		4
7.0	FODP							
	FODP (minimum 24 Fibres) : Indoor	No.	1	1	1	1	-	4

S.No.	Item Description	Unit	220/132/33 KV Tumling Tar S/S	220/33 KV Baneshwar SS	220/132/33 KV Basantapur S/S	Inaruwa SS	Kathmanndu LDC	Total Quantity
	Type, rack mounted with FCPC coupling and pig tails							
8.0	Fibre Optic approach cable							
	24 Fibre (DWSM –G.652D)	Km.	0.5	0.5	1	0.5	-	2.5
	Installation hardware set for above 24 Fibre, Fibre Optic Approach Cable	Set	1	1	1	1	-	4

Note# :Optical interface/SFP can be provided with Optical base card or Control card with the condition that control card shall not be equipped with more than one Optical interface/SFP and optical card with not more than two Optical interface/SFP. However main and protection channel shall be terminated on separate cards

Note** : Suitable Optical Interface Card(s) or any other solution such as SDH equipment with optical amplifier, wavelength translator or higher aggregate bit rate SDH equipment may be offer for the lengths to meet the link budget requirements without repeater.

Note*: Set shall include all required hardware/software for complete TMN –Craft Terminal system as specified in technical specifications.

Note ***: One set of installation hardware shall contain all installation hardware fittings as may be required for 1 km of Approach Fibre Optic cable

Table - 2
BOQ for Mandatory Spares of Communication Equipments

S.No.	Item Description	Unit	Quantity
1.0	Transmission Equipment		
A	SDH Equipment (STM- 1 ADM, upto two directions)		
(I)	Common cards, Power supply cards, power cabling, other hardware & accessories (each)	Set ^{\$\$}	1
(II)	Optical Interface/SFP for		
(a)	L1.2	No.	1
(b)	Optical Line Interface card (to support minimum 80 kms)**	No.	1
(c)	Optical Line Interface card (to support minimum 40 kms)**	No.	1
(III)	Tributary Cards		
(a)	E1 Interface card (Minimum 16 interfaces per card)	No.	1
(b)	Ethernet interfaces 10/100 Mbps with Layer-2 switching (Minimum 4 interfaces per card.)	No.	1
2.0	Termination Equipment		
A1	Drop & Insert Multiplexer Common cards, Power supply cards, power cabling, other hardware & accessories (each)	Set ^{\$\$}	1
A2	Subscriber Line Interface Cards		
a)	2 wire (sub/sub) voice channel cards (min 8 channels per card)	No.	1
b)	4 wire (E&M) voice channel cards (min 8 channels per card)	No.	1
c)	Asynchronous Sub Channels data cards, minimum 4 channels per card	No.	1

d)	Synchronous data card (NX64kbps)	No.	1
3.0	Pre Connectorized Optical Fiber Patch Cords (10 Mtrs) – Pack of Six Patch Cords	Set	1

Note\$\$: One Set means one of each type of module/unit card etc

Note** : Suitable Optical Interface Card(s) or any other solution such as SDH equipment with optical amplifier, wavelength translator or higher aggregate bit rate SDH equipment may be offered for the length to meet the link budget requirements without repeater.

Note: #The testing capacity of SDH analyser shall be provided according to offered SDH equipment.

Data Requirement Sheets

Table - 3 BOQ for Test Equipment			
S.No.	Item Description	Unit	Quantity
1.	SDH Analyser [#]	No.	1
2.	Handheld 2Mbps BER Tester	No.	1
3.	Ethernet Tester (with dual port, 10/100 ports Mbps Ethernet option, layer-1 & layer-2 functionality)	No.	1

The following sets of Data Requirement Sheets are required to be filled up by the bidders to

Table -4			
Maintenance Charges			
S. No.	Items Description	Unit	Qty
1	Maintenance Charges for Communication System for One (1) year during Warranty period	Year	1
2	Maintenance Charges for Communication System for 6 year after Warranty period	Year	1x6

aid in the evaluation process. The response shall be brief and to the point and shall be supported by the printed product description and other literature. The DRS duly filled and the relevant drawings shall also be submitted during the detailed engineering along with the relevant technical brochures.

DRS Form 01**DATA REQUIREMENTS SHEETS for****OPTICAL LINE TERMINATION EQUIPMENT (OLTE)**

Manufacturer: _____

Model #: _____

GENERAL OLTE FEATURES

Seq	Parameter:	As per Technical Specification	As per Bidder Offering
1.	SDH hierarchy level:	STM-1	
	Capacity Aggregate Bit-rate:	155 Mbps	
	CEPT E-1 Ports:	63 x E1	
2.	Minimum No. of protected (MSP) directions	Two	
3.	No. of E1 ports in E1 tributary cards	minimum 16	
4.	No. of ethernet ports in Ethernet interface tributary cards	minimum 4	
5.	Service Channel provision	Yes	
	a) Voice Channel	Minimum 1	
	b) Data Channel	Minimum 1	
6.			

	Power Supply cards of SDH equipment	1:1 APS or distributed power supply	
	Common Control* Card of SDH equipment	1:1 APS	

* = Common Control Cards which are essentially required for the operation of the equipment
DRS Form 02

DATA REQUIREMENTS SHEETS for

Primary Multiplexer/Drop & Insert Multiplexer

Manufacturer:

Model

#: _____

Configuration:

Seq.	Parameter	As per Technical Specification	As per Bidder Offering
1.	Output Aggregate Rate	2.048 Mbps +/- 50 ppm	
2.	Interface Code	HDB3	
3.	Impedance	75 ohm unbalanced	
4.	Maximum Insertion Loss	6 dB	

5.	Power Supply card of multiplexer	1:1 APS or distributed power supply	
----	----------------------------------	---	--

The detailed DRS for all equipments/items are required to be submitted along with brochures during detailed engineering.

Appendix-I

TECHNICAL SPECIFICATION OF PABX EQUIPMENT

1.1 General

This section provides the functional and performance requirements for the PABX system. The Bidder is encouraged to propose any hardware configurations better suited to the characteristics of the Bidder's standard products as long as the equipment characteristic requirements of this specification are met.

The PABX must be capable of operating in the high EMI environment of substations and power plants, and without air conditioning. The bidder shall provide performance certificate from at least one customer for satisfactory operation of one year.

The Contractor shall be responsible for the installation and implementation of the PABX provided under this procurement along with the interfaces, associated hardware & accessories. This shall include the development of the database, system tests and training of Employer staff.

The following are the minimum requirements for PABX system.

1.2 Technical Requirement

The Contractor shall be responsible for providing state of the art TDM/PCM based PABX system. The offered PABX shall be modular in nature with universal slot architecture to facilitate future expansion requirements. Expansion shall require only procurement and installation of respective interface cards.

The exchange transmission performance shall comply with the ITU-T standards. The Contractor shall provide the details of standards conforming to the product supplied. The offered PABX must be capable of interfacing with 4-wire E&M VF channels provided by Power Line Carrier System (PLCC), E1 (G.703) / Ethernet channels provided by wideband communication equipment and 2 wire LS or 4 wire E&M channels provided by primary multiplexers. The PABX shall also be designed to operate over 2 wire leased telephone land line of other telecommunication provider.

All interfacing equipment necessary for satisfactory operation and to comply with the local regulation shall be provided under this procurement.

The Contractor shall ensure that the speech level and signal-to-noise ratio are satisfactory under all conditions likely to be encountered on the system. The offered PABX shall be integrated with existing PABXs. Any interfaces required for proper matching and connection with existing PABX equipment shall be provided by the Contractor. It shall support at a minimum the following features:

- (a) SPC (Stored Program Control) type
- (b) 100% non blocking switch with PCM-TDM
- (c) Redundant processors or distributed processing architecture
- (d) 2 Wire interfaces for local subscribers & remote subscriber
- (e) 4 Wire E&M interfaces for two way trunks
- (f) Extensions should be extendable over a distance of 300meters
- (g) E1 Interface using Electrical (through copper cable) connection to existing SDH equipments.
- (h) Provision of suitable interface for VOIP connectivity (50 Nos)
- (i) Printer interface
- (j) Extensions shall support DTMF & Pulse dial phones
- (k) Extensions shall support analog phones/fax machines
- (l) Ringer/Tone card for different tones and ring generation
- (m) DID (Direct Inward dialing)
- (n) DOD(Direct Outward dialing))
- (o) Executive Override enabled
- (p) Provision of Voice mail
- (q) Call forwarding and Call pickup

- (r) Circular hunting within a defined group
- (s) Automatic call back
- (t) Calling Line Identification Presentation (CLIP) support
- (u) Howler tone for receiver-not-on-hook warning

The Contractor shall provide the suitable system for PABX configuration such as class of service, feature assignment, line and trunk access etc. Further, it shall be possible to make on-line changes to the database and shall be user friendly. In case, the bidder offers a PC based PABX configuration system, the PC/workstation shall be of reputed make (Compaq/HP/IBM/Dell) with 15" TFT Color monitor.

The Contractor shall install the telephone extensions as well as terminate the voice trunks along with requisite cable, PVC conduit/channels and other installation hardware. The PABX shall be supplied with a MDF which may be housed inside the PABX cabinet or in a separate enclosure suitable for wall mounting.

The PABX shall be able to operate on -48 Volt DC (nominal). It shall have power supply and control cards in hot-standby mode so that in case of failure of one the other takes over automatically. Alternatively, distributed power supply architecture is also acceptable.

1.3 Equipment Availability:

PABX system shall have 99.99% availability. Equipment shall be capable of providing suitable alarm indication in order to determine malfunction/fault condition.

1.4 Testing & Inspection:

The offered PABX shall be type tested as per relevant standards. The bidder shall submit the previous type test reports. The FAT & SAT for PABX shall be conducted as per requirement specified in this Section.

1.5 Factory Acceptance Tests

Factory acceptance tests shall be conducted on final assemblies of all equipment to be supplied.

Equipment/Material shall not be dispatched to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to dispatch shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's/Owner's authorised representatives.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. The factory acceptance tests shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's /supplier's) standard FAT testing program which shall be finalised during detailed during engineering. In general the FAT shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

1.6 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), along with information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

1.7 Site Acceptance Tests (SAT)

The Contractor shall be responsible for carrying out site tests and inspection for all equipment supplied in this contract as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate. The site acceptance tests shall be proposed by the Contractor in accordance with technical specifications and Contractor's(including Sub-Contractor's /supplier's) standard Site Acceptance Testing program which shall be finalised during detailed during engineering.The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-12 **A.C Distribution Board**

SECTION 4**CHAPTER – 12****A.C. DISTRIBUTION BOARD****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
12.0	SCOPE	1
12.1	STANDARDS	1
12.2	DESCRIPTION	3
12.3	CONSTRUCTIONAL FEATURES	5
12.4	PAINTING	9
12.5	BUS – BAR , SWITCHING DEVICES & CONNECTIONS	10
12.6	MOULDED CASE CIRCUIT BREAKERS (MCCB)	11
12.7	MINIATURE CIRCUIT BREAKERS (MCB)	12
12.8	RESIDUAL CURRENT – OPERATED CIRCUIT BREAKERS (RCCB) / EARTH LEAKAGE CIRCUIT BREAKERS (ELCB)	12
12.9	FUSE HOLDER /BASE	13
12.10	FUSES	13
12.11	INTERNAL WIRING	14
12.12	NAME PLATE	14
12.13	DRAWINGS & LITERATURE	14
12.14	TESTING & INSPECTION	15

SECTION 4

CHAPTER - 12

A.C. DISTRIBUTION BOARD

12.0 SCOPE

12.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, Testing & commissioning of 400 volts, 3 phase, 4 wire, AC distribution switch boards cubical indoor type complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal.

12.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.

12.0.3 Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.

12.0.4 Components having identical rating shall be interchangeable.

12.0.5 The performance of the equipment shall be guaranteed as per **Section-5 "Guaranteed and Other Technical Particulars"**. The bidder has to furnish the testing facilities available at the manufacturer's works.

12.1 STANDARDS

12.1.1 The equipment covered by this specification shall confirm to the provisions of the following Indian/International standards as amended up to date except where specified otherwise in this specification. IS: 1248- 1993- Direct acting indicating analogue electrical Maintaining instruments and their accessories:-

TABLE-12.1.1

S.No.	IS Code	Description
1.	IS: 722	Electricity meters.
2.	IS: 8623	Specifications for factory built assemblies of Switchgear and control gear for voltage up to and including 1000 V AC & 1200 V DC.
3.	IS: 4237	General requirements for switch gear and Control gear for voltage not exceeding 1000 volts.
4.	IS: 2147	Degree of protection provided enclosure for low voltage Switchgear and control gear.
5.	IS: 2516(Part-II Sec-I)	Air circuit breaker.
6.	IS: 3156	Voltage transformer.
7.	IS: 2705	Current transformer.
8.	IS: 4064	Air break switches.
9.	IS: 9224	Low voltage fuses.
10.	IS: 6875	Switches & Push buttons
11.	IS: 6005	Code of practice for phosphating of Iron & Steel.
12.	IS: 2633	Hot dip galvanizing.
13.	IS: 375-	Marketing and arrangements of bus-bars
14.	IS: 5082	Electrical grade aluminum E 912.
15.	IS:1248 -1993	Direct acting indicating analogue electrical Maintaining instrument and their accessories
16.		Electrical Power technical standards of nepal.

The Equipment and material meeting the requirement of any other Indian standards or internationally recognized standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable. Where the equipment confirms to any other standards then salient points of difference between the standards adopted and those prescribed in these specifications shall be clearly

brought out in the bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

12.2 DESCRIPTION

12.2.1 The LT Distribution Board shall be fed from 400 KVA, 33kV/400 V distribution transformer.

12.2.2 Tentatively the following minimum feeders shall be required from the AC Distribution Board, and each shall be suitably rated as per requirement.

- a. Incoming from 400 kVA, 33 kV/400 V, Station Transformer 4 wire, 3 phase supply.
- b. 3 phase, 4 wires supply for oil filtration set.
- c. Single phase supply to various 220 kV Circuit Breakers (separate feeders to each).
- d. 3 phase, 4 wires supply for indoor lighting.
- e. 3 phase, 4 wires supply for outdoor lighting.
- f. 3 phase, 4 wires for transformer Marshalling boxes.
- g. 1 phase supply to 33 kV switch gear panel board.
- h. 1 phase supply to 220 kV C&R Panels.
- i. 1 phase supply to Substation Automation System, HMI, printers etc.
- j. 1 phase supply to 220 kV isolator boxes for motor operation.
- k. 3 phase, 4 wires feeders for Battery chargers.
- l. Supply for OPGW Communication Panel.
- m. At least 20% (minimum 1) of each rating as spares.
- n. Three phase/single phase supply as per requirement with individual MCCB/MCB's to Air conditioning system, CCTV, Fire detection, alarm and control system, etc.

12.2.3 Incoming from transformer shall be provided with the following:

- a. 630 A, MCCB (with adjustable setting) with O/L & S/C releases

- b. One No. 100 mm dia. flush mounted Ammeter with range 0-600 amp with phase selector switch.
 - c. One No. 100 mm dia. flush mounting voltmeter scale range 0-500 V with fuse and selector switch, along with LED type, indicating lamps before the selector switch.
 - d. 600/1 Amp. CTS having burden 25 VA and accuracy class – I
 - e. One No. 3 phase, 4 wires unbalanced load integrating watt – load meter operable on 600/1 A CT. Each circuit as indicated above shall have switch rating and labeling as mentioned their against each and shall include bus-bar connections, terminals cable glands and legs etc.
 - f. Bus bar shall be of Aluminum and designed for 630 Amps for phases and 400A for neutral.
- 12.2.4 400 V AC switch board cubical type shall consist of feeders as above and shall have MCB of rating and labeling as per system requirement. It shall include bus-bar connections terminals, Cable glands and lugs. The aluminum bus- bar shall be designed for 630 Amps for phases and 400 Amp for neutral based current density of 85 Amp per sq. cm. The bidder shall design the ratings of MCB/MCCBs' which shall be approved by purchaser. The above detail of outgoing feeders is provisional and is subject to change during detailed engineering.
- 12.2.5 The A.C. Board shall be fitted with the following accessories:
- 1. 230 V, AC space heater with MCB and thermostat.
 - 2. Only MCB/MCCBs' as appropriate shall be provided. No fuses are allowed.
 - 3. All the feeders shall be provided with single phase ammeters. For three phase supplies an ammeter with selector switch (or in yellow phase only) shall be provided. Typical ammeter size shall be 70 mm x 70 mm. These details shall be finalized during detailed engineering.
 - 4. Necessary CTs wherever required for current measurement shall be provided. The secondary rating of each shall be 1A.
 - 5. Indicating lamps shall be of low wattage typically 2.6 W or less.

6. All the terminals for external cabling shall be suitably rated as per the size of the external cables.
7. All the indicating instruments, lamps, handles, MCCBs', MCB's shall be flush mounted.
8. Panel shall be indoor, single front, fixed type.
9. Base frame shall be of ISMC-100.
10. Phase clearances shall be as per IS.
11. Panel Paint: will be decided during detailed engineering
12. Interior & mounting plate: Glossy white
13. Bus bars to be colour coded and also the circuits taken from it.
14. Earth bus of 50 x 6mm copper strip shall project out of the panel at both ends and shall have two holes for earth connections.
15. Control Wiring: 1.5 mm² copper (48 strands), 2.5 mm² copper for CTs (48 strands)
16. Power Switch & MCCB shall be door interlocked and shall have pad locking
17. Caution Name Plates for live terminals shall be provided.

12.3 CONSTRUCTIONAL FEATURES

12.3.1 400 V Station Supply LT Board

The supply board shall comprise of:

- a. Metal enclosed, indoor /outdoor mounted, dust and vermin proof and self supporting cubicle type made –up of mild steel sections and cold rolled sheet steel of 2 mm thickness for enclosure and all load bearing members, doors & fitting plate. The Gland Plate shall be 3 mm thick, sheet steel, with double compressions, chromium plated brass glands.
- b. The board shall be stiffened properly to be free from vibration, twist and bends. The degree of protection of enclosure to be not less than IP-54 for all indoor type panels and IP-55 for all outdoor mounted panel or boards respectively as stipulated by IS: 2147.

- c. Requisite number of sheet steel enclosure for mounting circuit breakers, relays, switches, CTs and other components. Light structural members shall be jointed preferably by bolting.
- d. Separate cable / bus- bar chambers duly partitioned, removable covers and metals still frames of single front double access type having feeders located in the front and vertical bus bars and cable chamber located in the rear.
- e. Detachable or hinged type door with handle and locking arrangements and easy access for inspection and maintenance works.
- f. Bottom frame suitable for erection on flush concrete floor by means of evenly spaced grouting bolts projecting through the base channel members.
- g. Necessary facilities for entry of cable from the bottom. No access to any live part inside the panel to avoid accident. Separate cable support to avoid load on the thimble of cable as well as on the links.
- h. Synthetic rubber Gaskets all round the perimeter of cover, gland plates, removable covers and doors shall be provided.
- i. Eye bolts at the top to facilitate lifting and anti vibration pads between base frame and panel to prevent vibration.
- j. Adequate strength to withstanding all stresses imposed during handling, transportation, installation and operation without distortion or damage. The panels shall be assembled to the extent possible within transporting and handling limitations duly wired up and ready for installation in accordance with this specification.
- k. Each MCB to have separate bus –link wired up to terminal block so that by removal of link, the outgoing feeder is isolated without removing cable from the terminals.
- l. The minimum component height will be 250 mm form the ground level for case of maintenance.

- m. It must be ensured while designing the switch boards that adequate electrical clearance as required under the rules shall be provided for the various components inside the cubical.

12.3.2 Distribution Board

- a. The boards shall be fabricated out of best quality cold rolled sheet steel of 2 mm including for doors & sides and shall be fully dust and vermin proof affording a degree of protection of IP – 54 for indoor DBs and IP 55 for outdoor DBs as per IS – 2174.
- b. Distribution boards shall be provided both hinged door with handle and locking facility for switch on inter lock facility for switch on interlock of doors. Doors shall be gasketed all round with neoprene gaskets.
- c. All accessible live connections / parts shall be shrouded and it shall possible to change /replace individual MCB /Fuse units form the front of the board without danger & coming in to contact with live parts.
- d. Adequate interior cabling space and suitable removable type cable entry plates shall be provided for top/ bottom entry of cable gland plate shall be supplied undrilled. Necessary number of glands to suit the specified cable shall be provided. Cable glands shall be screwed on type and made of chromium plated brass.
- e. The DB shall have two earthing terminals for connecting to the stations earthing.
- f. The AC DBs shall be either floor mounted type. Suitable foundations channels with necessary bolts and nuts shall be provided.
- g. The danger board shall be fixed on the front of the door of DBs as per standards.
- h. Wiring inside the panel shall be carried out with 1100 V grade PVC insulated stranded copper conductors of adequate size on both ends of each wire engraved identification ferrules shall be provided.

- i. Bus bar shall be of copper adequately sized for the specified continuous current rating such that the maximum temperature of the bus bar and links does not exceed 75⁰ C.
- j. All MCBs /Isolators /switches etc. shall be flush mounted with hinged door provided with locking arrangement and an inner Bakelite sheet /fibre glass sheet shall be provided inside such accidental contact.
- k. Equipment mounted inside the panel shall be provided with individual labels with equipment designation /rating. Front of the panel shall be provided with label engraved with designation of the panel as furnished by the purchaser. Label shall be made of 3 ply lamincold /engraved PVC having white letters on black ground. Letter size shall be 4 mm minimum.
- l. Terminal blocks shall be 1100 V grade clip on type, moulded in melamine suitable for terminating incoming cable of suitable size of stranded copper conductor and outgoing circuits of approved sizes. All the terminals shall be shrouded, numbered and provided with identification strip for the feeders.
- m. MCB's shall be current limiting type magnetic and thermal release suitable for manual closing and automatic tripping under fault condition single pole MCB's shall have interrupting capacity not less than 10 kA. MCB knob shall be marked with ON/OFF indication. A trip free release shall be provided to ensure tripping on fault even if the knob is held in on position to avoid accidental contact. MCCB shall have adjustable setting, O/L & S.C. releases.
- n. Fuses if required shall be HRC cartridge type complete with fuses fittings. Fuses fittings shall incorporate fully insulated shrouded contacts. Visible indication of operation of fuses shall be provided. However, purchaser would not prefer to have fuses instead MCB's should be provided.
- o. The indoor panel shall be finalized during detailed engineering. The inside of the panel shall be glossy white.

12.4 PAINTING

- a. All sheet work shall be phosphate in accordance with following procedure and in accordance with IS: 6005, code of practice for phosphating iron and steel, with seven tank process.
- b. Oil, grease and dirt shall be thoroughly removed by emulsion cleaning.
- c. Rust and scale shall be thoroughly removed by emulsion cleaning.
- d. Rust and scale shall be removed by pickling with dilute acid followed by washing and running water rinsing with slightly alkaline hot water and drying.
- e. After phosphating, through rinsing shall be carried out by clean water followed by final rinsing with dilute solution and oven drying.
- f. The phosphate coating shall be sealed by the application of two coats of red mixed stoving type Zinc chromate primer. The coat may be 'flash dried' while the second coat shall be stove dried.
- g. After the application of the primer, two coats of finishing synthetic enamel shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The color of the finishing paint on the exterior should be got approved from the purchasers before painting. All the panels and DBs shall be painted white in the interior.
- h. Each coat of primer and furnishing paint shall be of a slightly different shade to enable inspection of painting.
- i. The final finished film thickness of paint on sheet steel shall not be less than 100 microns and shall not be more than 150 microns.
- j. Finished painted appearance shall present an aesthetically pleasing appearance free from dents and uneven surface.
- k. Adequacy quantity of finishing paint shall be supplied for minor touchup required at site after the installation of the L.T., AC station board and distribution boards.

12.5 BUS – BAR, SWITCHING DEVICES & CONNECTIONS

12.5.1 LT Station Supply Board

Bus bar system for LT station supply board shall be assembled and fully tested and certified in accordance with relevant standards i.e. IS :375 or BS : 5486 & IEC 439

The bus bars of LT station supply boards shall be of high conductivity aluminum and of uniform rectangular cross section. The size of bus bar shall be got approved from the purchaser before the procurement /fabrication. The bus bars and supporting arrangements shall be designed to withstand thermal and magnetic stresses corresponding to 10 kA fault level. All bus bars and metallic bus supports shall be insulated by heat shrunk PVC sleeves with exceptional dielectric properties to provide additional protection against accidental contact and to prevent failure in the event of accidental presence of external agents. Bus bars supports shall be arc resistant flame retardant, porcelain type or sheet moulding compound having high insulation resistance and de-moulding compound having high insulation resistance and dielectric strength to avoid ground faults of bus due to dust collection. At the bus- bar joints and tap-off points, removable shrouds (sleeves) shall be provided. Temperature rise shall not exceed the maximum allowable temperature for the equipment as specified in relevant IS/IEC specification even under over load conditions and shall be of sufficient size to limit the temperature rise not to exceed the specified value in the applicable standard inside the enclosure. Ground bus shall be provided at the bottom of each station supply board throughout the entire length of the board. This bus shall be earthed solidly by connecting to the main earthing system of the sub- station. There should be provision for earthing at both ends of the switchboard Lugs, bolts, nuts and spring washers shall be provided for earth connection.

12.5.2 Distribution Board

These shall be provided whenever required to further distribute the three phase supply taken from the ACDB. The bus bars of distribution boards shall be of electrolytic copper having 99.9 % purity as per IS-440 unless otherwise specified.

The size of the Bus bars be got approved form the purchaser during detailed engineering.

- a) All bus bars, MCBs, Switch fuse units, fuses and connection shall be of sufficient size to limit the temperature not to exceed the specified value in the relevant standard inside the enclosure while carrying full load current. All main bus bars connections and bus bar outgoing taps be tin plated and tightly clamped with through bolts to ensure maximum conductivity. All bus bars shall be rigid type. All bus bars connections shall be accessible for inspection and maintenance purpose.
- b) Bus bars supports shall be made of suitable insulating material such as sheet moulding compound, glass reinforced moulded plastic material, or cast resin etc., of thickness not less than 6 mm. Separate supports shall be provided for all three phases, anti – tracking barriers shall be incorporated.
- c) The bus bars shall be protected from Accidental contact by using highly not less than 6 mm thick.
- d) The size of neutral bus of the wall mounted type 3 phase 4 wire distribution board shall be rated as the phase bus-bars. The neutral bus should have sufficient terminals and detachable links for all the single phase outgoing and supports shall have sufficient strength to with stand thermal and electromechanical stresses for a short circuit level of 10 kA of the system.

12.6 MOULDED CASE CIRCUIT BREAKERS (MCCB)

The MCBs shall be of reputed make having proven performance record and confirming to IS – 2516 (part I & II) with minimum rupturing capacity of 10 kA The MCCBs shall be quick make quick break, independent manual type trip free mechanism . Position of knob shall be provided to test trip the MCCBs mechanically. Overload and short circuit protection for all circuits shall be provided for MCCBs. The MCCBS shall be covered with the insulating case and covers made of high strength, high resistant and flame retardant thermosetting insulating material.

12.7 MINIATURE CIRCUIT BREAKERS (MCB)

The MCBs shall be of reputed make and the characteristics of MCB shall be suitable for control & protection circuit equipment's, high pressure mercury vapour/ sodium vapour lamps / fluorescent tubes & power points etc. MCB shall be hand operated, air break, quick make, quick break confirming to applicable standards mentioned. The out-going MCBs shall be provided with overload / short circuit device for protection under overload and short circuit conditions. The MCB shall confirm to IS – 8828 (latest edition) and shall have a minimum interrupting rating of 10 kA. MCB shall be flush mounted and fitted on Zinc chromium M.S channel provided in DB construction. Single pole MCBs shall be provided for all outgoing A.C feeders.

12.8 RESIDUAL CURRENT – OPERATED CIRCUIT BREAKERS (RCCB) / EARTH LEAKAGE CIRCUIT BREAKERS (ELCB)

- 12.8.1 The RCCB/ELCB offered shall confirm to IS: 12640 and shall be suitable for particular application in conjunction with MCB and arranged for manual closing and opening and automatic tripping on earth fault condition. In case of multi-pole circuit breakers, the indication shall represent the position of all the poles. The metallic portions of the mechanism shall be either inherently resistant to or treated so as to make them resistant to atmospheric corrosion. The operating mechanism shall be trip free. The operation mechanism case shall be effectively sealed by the manufacturer to prevent access to the mechanism. The case shall be of insulating material. The temperature rise at specified parts of RCCB shall not exceed the value given in table 1 of IS: 12640.
- 12.8.2 The RCCB shall be provided with test device for testing automatic opening of the circuit breaker by an integral test device. The test device shall be arranged for external operation in such a way that the protection afforded by the cover or enclosure is not impaired. The test device shall meet the requirement of clause 7.8 of IS: 12640.

12.8.3 The preferred rated current and rated tripping current shall be any one of the values given in clause 4.4 and 4.5 of IS: 12640 meeting the operating requirement of respective MCBs.

12.8.4 The selection and application of RCCBs shall generally be in accordance with guidelines given in Annex – A (clause 2.2.10) of IS: 12640.

12.8.5 The product of rated residual current (rated tripping current) in amperes and the earth loop impedance in ohm should not exceed the value 50. The RCCB shall be so chosen that the same has lowest suitable tripping current.

12.9 FUSE HOLDER /BASE

Fuse holder unit for outgoing circuits wherever provided and approved by purchaser shall confirm to IS – 1300. Fuse holder be suitable for HRC fuse links of required rating. They shall be made up of superior grade phenolic moulding compound with non – inflammable property. Fuses holder shall be supplied with necessary cable holding screws and terminal lug fasteners and conducting portion copper carrier with extruded brass base support. Further conducting part shall be silver plated to provide long lasting shall be complete with pressure clip so formed to provide durable firm grip of male and female parts. Fuse holder shall be fully shrouded to ensure personnel safety.

12.10 FUSES

Generally fuses shall not be used anywhere. However if approved by purchaser due to specific situation the fuses shall be of reputed make and shall be HRC Cartridge type with minimum rupturing capacity of 10 kA. The fusing factor shall be greater than 1.5 and shall be provided with visible indicator for having operated. All HRC fuses shall confirm to IS: 9224. Fuses shall be dimensionally interchangeable with any other compatible make and shall be so designed to ensure non-deteriorating time current characteristics.

12.11 INTERNAL WIRING

The LTAC station supply board and the distribution boards shall be supplied with complete internal wiring. The wiring shall be carried out the 1100 V grade, PVC insulated. Stranded supply conductor cables of adequate size shall be used to suit the rated circuit current. Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire. All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded and suitable for 500 V. Stud type terminal blocks shall be used for higher current rating. Terminals shall be adequately rated for the short circuit current. Typically terminals of 'Phoenix Contact' make shall be provided which shall be approved by purchaser during detailed engineering.

12.12 NAME PLATE

Name plate shall be made of non rusting metal or engraved on PVC shall be of size 50 mm x 20 mm indicating the feeder details and shall be provided for all feeders for easy identification DB No. etc. shall be provided.

12.13 DRAWINGS & LITERATURE

After receipts of the order, the contractor shall be required to furnish 10 prints of the following drawings for approval:-

- a) General arrangements drawing of AC distribution board.
- b) Typical schematic diagram of AC distribution board.
- c) Complete assembly drawing of AC distribution boards showing plan, elevation. sectional views and location of terminal blocks cable entry details
- d) Control and wiring diagram for each module of AC distribution board including spare terminals and inter modular and inter panel wiring.
- e) Foundation plan showing location, channels, foundation bolts etc.
- f) Schematic control diagram for control interlocks, relays, instruments and space heaters.

- g) Protective relay characteristics of each type of relay
- h) Fuse characteristics curve for each type of rating
- i) Technical and descriptive literature giving details of the equipment offered.

12.14 TESTING & INSPECTION

12.14.1 All tests and inspection shall be made at the manufacturer's works unless otherwise specifically agreed upon by the manufacturer and purchaser at the time of placement of purchase order. The manufacturer shall afford to the inspector representing the purchaser, all reasonable facilities, without charge to satisfy him that the material being furnished is in accordance with these specifications. The purchaser reserves the right to get any component/material being used by the manufacturer of the L.T. board tested from any recognized test house. No material shall be dispatched without prior approval of the all the test reports and certificates by the purchaser.

12.14.2 The inspection by the purchaser or his authorized representative shall not relieve the bidder of his obligation of furnishing equipment in accordance with the specification.

TABLE-12.14.2.1

TECHNICAL PARTICULARS

1.	AC SYSTEM	3 phase, 4 wire, solidly earthed
	a. Voltage	400 volts- 15 % to +10 %
	b. Frequency	50 Hz \pm 3 %
	c. Combined variation in voltage & frequency	- 10 % to + 10 % Absolute sum
	d. Fault level	10 kA (rms)
2.	BUS BAR	
	a. Continuous	630 A Aluminum
	b. Short time (1 Sec)	10 kA rms
3.	ONE MINUTE POWER FREQUENCY WITHSTAND VOLTAGE	

	a. Power circuits	2.5 kV (rms)
	b. Control circuits	2.5 kV (rms)
4.	MOULDED CASE CIRCUIT BREAKER	
	a. Voltage	AC 3- phases –415 V (-15 to + 10 %)
	b. Frequency	50 Hz
	c. Short circuit Performance	10 kA (rms)
	d. Making capacity	2.5 times breaking capacity
	e. Operating Mechanism	Manual , trip free
	f. Temperature rise	As per IS: 2516
	g. Mechanical rise	As per IS: 2516
	h. Auxiliary contacts	4 No., 4 NC
5.	METERS	
	a. Accuracy class	1.0 or better
	b. one minute power frequency withstand voltage	2 .5 kV (rms)
6.	CURRENT TRANSFORMERS	
	a. Type	Cast resin, Bar primary
	b. Secondary circuit	1 Amp.
	c. Voltage class and Frequency	1100 V, 50 Hz
	d. Class of insulation	E or better
	e. Accuracy	
	I. Accuracy class metering CT	Class 1, 10 VA
	II. Accuracy class protection CT	5p 10 , 15 VA
	f. Short time current rating	10 kA (rms) for 1 sec.

	g. one minute power frequency withstand voltage	2.5 kV (rms)
7.	VOLTAGE TRANSFORMERS	
	I. Type	Cast resin
	II. Rated voltage	415 V \pm 10%
	a. Primary	415 V / $\sqrt{3}$
	b. Secondary	110V/ $\sqrt{3}$
	III. Accuracy class and VA burden	
	a. Metering	1.0, 10 VA
	b. Protection	3 p, 50 VA
	IV. Method of connection	
	a. Primary	Star
	b. Secondary	Star
	V. Rated voltage factor	1.1 continuous , 1.5 for 3 sec.
	VI. Class of insulation	E or better
	VII. One minute power frequency withstand voltage	2.5 kV (rms)
8.	RELAY	
	a. One minute power frequency withstand voltage	2.0 kV (rms)
9.	CUBICLE COLOUR FINISH	
	a. Interior	Glossy white
	b. Exterior	Decided during detailed engineering
10.	ACCESSORIES	
	a. Plug point with switch fuse.	

	b. Space heater with thermostat	
	c. Name plate on front of rear	
	d. Danger plate	

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-13

D.C. Battery, Battery Charger & DC **Distribution Board**

SECTION 4**CHAPTER – 13****D.C. BATTERY, BATTERY CHARGER & DC DISTRIBUTION BOARD****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
13.0	SCOPE	1
13.1	STANDARDS	2
13.2	TYPE AND RATING	4
13.3	DESCRIPTION OF BATTERY	9
13.4	D.C. DISTRIBUTION PANEL	17
13.5	TESTS	18
13.6	INSPECTION	19
13.7	DRAWINGS	20
13.8	SPARES	20
13.9	INSTRUCTIONS MANUAL	21
13.10	COMPLETENESS OF EQUIPMENT	21
13.11	TOOLS, TACKLES AND SLINGS FOR ERECTION, TESTING & COMMISSIONING	22
13.12	DEVIATIONS FROM SPECIFICATIONS	22
13.13	GUARANTEED TECHNICAL PARTICULARS	22
13.14	TECHNICAL PARAMETERS	22

SECTION 4

CHAPTER - 13

D.C. BATTERY, BATTERY CHARGER & DC DISTRIBUTION BOARD

13.0 SCOPE

13.0.1 This specification covers the design, manufacture, testing at manufacturer's works, supply, delivery, storage, transportation upto site, erection, testing and commissioning of 110 V, DC distribution board, Nickel-Cadmium (Ni-Cd) /Lead Acid DC battery, battery charger complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal.

13.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost. Components having identical rating shall be interchangeable. The performance of the equipment shall be guaranteed as per **Section-5 – “Guaranteed and Other Technical Particulars”**. The bidder has to furnish the testing facilities available at the manufacturer's works.

13.0.3 It is proposed to provide 110 V DC supply for control& Protection, indication, annunciation, emergency lighting etc. and 48 V DC supply for OPGW Communication system. DC system shall comprise of the following items.

- a) Two sets of 110 V, Ni-Cd/Lead Acid, 400 AH (or of higher rating) & 48 V, 100AH (or of higher rating) maintenance free, factory charged station batteries.
- b) Two sets Float-cum boosts charger panels for 110 V & 48 V batteries.

- c) 110 V & 48 V DC distribution panel
- d) Battery stands, interconnection cables, termination, lugs etc. to complete the system for 110 V & 48 V batteries
- e) Bidder shall furnish calculation in support of battery sizing, selection of number of cells, Float and Boost voltages during detailed engineering stage.
- f) Depth of Discharge for battery at average temperature shall be furnished during Detailed Engineering Stage.
- g) Accessories & devices required for testing, commissioning & operation for 110 V & 48 V batteries
- h) Spare parts for both 110 V & 48 V batteries.

13.1 STANDARDS

- 13.1.1 The DC battery charging equipment and control panel with their accessories shall conform to the latest amendment and edition of the following Indian Standards or IEC or Nepal or any other equivalent International Standards:

TABLE-13.1.1.1

S.No.	International Standards	Indian Standards	Description
1	IEC: 62259	-	Secondary cells and batteries containing alkaline or other non-acid electrolytes-Nickel-Cadmium prismatic secondary single Cells with partial gas recombination
2	IEC: 60623	IS: 10918	Secondary cells and batteries containing alkaline or other non-acid electrolytes- vented Nickel-Cadmium prismatic rechargeable single Cells.
3	IEEE:1106		Recommended practice for maintenance testing & replacement of Ni-Cd storage batteries for generating stations and substations
4	IEEE:1115		Recommended practice for sizing of Ni-Cd batteries for stationary applications
5		IS 13410	Glass reinforced polystar sheet modeling compounds

6		IS :1248	Voltmeter
7		IS:5	Colours for ready mix paints.
8		IS : 1248	Specification for Direct acting indicating analogue electrical measuring instruments.
9	IEC : 947-1	IS : 13947 Prt-1	Degree of protection provided by enclosures for low voltage switches gear and control gear.
10	IEC : 947-2	IS : 13947 Prt.-2	Low voltage circuit breaker
11	IEC : 947-3	IS : 13947 Prt-3	Specification for low voltage switches gear and control gear.
12	IEC : 947-4	IS : 13947 Prt-4	Contactors
13	IEC:439	IS:8623	Low voltage switch-gear and control-gear assembly
14		IS:8686	Static protective relays
15	IEC: 337	IS:6875	Control switches
16	IEC:225	IS : 3231	Electrical relays for power system protection.
17		IS : 3842	Application guide for Electrical relays for AC System
18	IEC 146	IS : 3895	Mono-crystalline semi-conductor Rectifier Cells and Stacks.
19	IEC 146	IS : 4540	Mono crystalline semi-conductor Rectifier assemblies and equipment.
20		IS:6619	Safety Code for Semi-conductor Rectifier Equipment.
21		IS:6875	Control switches (switching devices for control and auxiliary circuits including contactor relays) for Voltages upto 1000 V AC or 1200 V DC.
22		IS : 9000	Basic environmental testing procedures for electronic and electrical items.
23	IEC:60269	IS:13703 Prt-4	Low voltage fuses for protection of semiconductor devices
24		IS:1901	Visual indicating lamps
25		IS:6005	Code of practice for phosphating of Iron and Steel.
26	IEC :227	IS:694 /IS: 1554	PVC Insulated Cable for working voltages upto and including 1100 V.

13.1.2 The Equipment and material meeting the requirement of any other Nepal or internationally recognized standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable. Where the equipment conforms to any other standards then salient points of difference between the

standards adopted and those prescribed in these specifications shall be clearly brought out in the bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

13.2 TYPE AND RATING

13.2.1 The battery shall be rated for 400 AH (or of higher rating) & 100 AH (or of higher rating) capacity on 10 hours basis for to end voltage of the cell as 1.14 V. The batteries shall be of Nickel-Cadmium/Lead Acid , high discharge performance type, factory charged and shall be rated at 27⁰C and shall conform to IS: 10918. Nominal voltage of each cell shall be 1.2 V capacities at various rates of discharge and corresponding final voltages shall be in accordance with IEC 60623/IS 10918. In the normal course, the load shall be supplied by battery charger (Battery charger operating in constant voltage mode) as well as floating the battery. When AC Mains supply fails the DC load shall be supplied by the battery. After resumption of AC mains supply, the battery set shall be kept for boost charging.

- (i) It shall be the responsibility of the contractor to provide battery of adequate capacity to meet specified requirements pertaining to control, protection indication, annunciation etc., and emergency lighting. For computing battery capacity it is assumed that the battery is fully charged at the beginning of loading cycle and is discharged to a voltage of 1.14 volts per cell at the end of the loading cycle. The battery shall have minimum difference between float and boost charging voltages.
- (ii) The contractor shall specify lower optimum voltage to be maintained by charges to maintain batteries in fully charged condition, for minimum evaporation and maximum battery life for 110 V DC systems. The contractor shall also specify freshening charge requirement, if any for optimum battery life as well as boost charging cycles of the battery. Periodic discharge recharge cycle of the batteries is not envisaged.

- (iii) Suitable means shall be provided for indicating and annunciating the fully discharged condition of the battery of both 110 V and 48 V DC systems in control room.
- (iv) Bidder is REQUIRED TO SUBMIT BATTERY CAPACITY CALCULATION to confirm the adequacy of rating and if higher rating is selected, the same shall be without any extra cost to the Employer, and this should apply not only to battery, but also to all the items given in the scope above.
- (v) It shall be the responsibility of the bidder to ascertain and confirm that the rating of the boost cum float charger (or separate float & boost charger) is adequate for the associated battery offered.

13.2.2 It is not intended to specify completely herein all details of the equipment. Nevertheless the equipment shall be complete and operative in all aspects and shall conform to highest standard of engineering, design and workmanship. Any material or accessory which may not have been specifically mentioned but which is necessary for trouble free operation and maintenance of the equipment shall be deemed to be included without any extra cost to the Employer. Details in this regard shall be finalized during detailed engineering as per requirements of Employer.

13.2.3 No acid filling and initial charging should be required at site. It should be low self discharge rate and can be stored for longer period.

13.2.3.1 Construction

The cells shall have prismatic, spill-proof and valve-regulated partial recombination type of construction with partial recombination feature. The cells shall be flooded type containing sufficient reserve electrolyte. Battery shall be equipped with nickel-plated inter-cell connectors and terminals. The cells shall be housed in high-strength impact resistant & alkali-resistant containers and should be transparent / translucent to facilitate checking of electrolyte level. Container and Lid should be welded and should not cause leakage of electrolyte/gases during operation even in

case of normal mechanical/electrical abuses. O-rings of nitrile rubber with EPOXY sealing shall be used to ensure proper sealing of bushings etc. Flip-top vent plugs/valves with flame arrester feature shall be provided. The regulating valve type design shall be of self-resealing type. Construction of cells shall be to ensure proper air circulation between the cells for heat dissipation/ ventilation (by providing either insulated button separators integral with the outer surface of the cell container or by suitably designing the inter cell connectors). The containers shall be strong enough, so that excessive bulging of container does not occur during service. Cells shall be supplied in filled & charged state or otherwise electrolyte dry form & battery water separately or in liquid form shall be shipped as desired by the owner. Battery shall have provision for water top up to ensures electrolyte level does not fall below recommended level.

13.2.3.2 Electrodes

Positive and negative electrodes shall be made by encapsulating/impregnating active material in order to ensure that the battery is able to perform reliably over its life. Positive and negative electrodes shall be separated by micro porous separators. The structure of electrodes shall be elastic enough to absorb mechanical stresses & volume changes during charge/discharge cycles.

13.2.3.3 Electrolyte

The electrolyte shall be prepared from battery grade potassium hydroxide (KOH) confirming to IEC 60993. The cells shall contain sufficient reserve electrolyte for efficient heat dissipation & to reduce water topping up interval. Reserve electrolyte shall not be less than 06 ml/Ah.

13.2.3.4 Connectors

Nickel plated copper intercell connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be nickel-plated steel/stainless steel. All terminals and cell inter-connectors shall be fully insulated or have insulation shrouds.

13.2.3.5 Terminals

Separate terminals shall be provided on the end cell for connecting load through DCDB and for connecting charger leads. All terminals shall be of suitably sized nickel-plated steel. Suitable nickel-plated copper lugs shall be provided by the supplier for use of the purchaser for connecting up the load wiring. All connectors and leads shall be suitable for carrying 30-minute discharge current continuously and rated for short circuit duty of 4kA for 01 second.

13.2.3.6 Manual of Instructions

The manufacturer shall supply a copy of the instruction manual for commissioning & initial treatment of the battery and maintenance during service with every battery bank ordered.

13.2.3.7 Recombination Efficiency

In order to reduce topping-up frequency, recombination of Hydrogen & Oxygen gases evolved during charging/discharging shall be achieved by using safe and reliable technology such as catalytic conversion/valve regulation technique or both. Minimum recombination efficiency shall be 80%. Recombination efficiency test shall be done in accordance with IEC 62259. In case the batteries are operated at high temperatures & are frequently boost charged the water consumption may be higher & topping-up frequency may increase.

13.2.3.8 Battery Racks

Suitable corrosion resistant battery racks and cable supports shall be provided. Metallic racks shall be properly earthed. The bottom tier of stand shall have a ground clearance of 150mm minimum above the floor. Racks shall be made of alkali resistant powder coated steel or stainless steel or FRP to ensure corrosion resistance.

13.2.3.9 Temperature Range

Battery must be capable of continuous operation in temperatures range of -15°C to $+50^{\circ}\text{C}$ for prolonged periods. No Air-conditioning shall be provided where batteries are to be installed.

13.2.3.10 Accessories

The following accessories (BIS certified) shall be supplied with each set of battery:-

- (i) Clamp-on type digital multi-meter of AC/DC current range having ISI mark.
- (ii) Pair of gloves
- (iii) 10" Slide insulated wrench for opening terminal nuts
- (iv) Plastic/glass syringe
- (v) Alcohol thermometer
- (vi) Hydrometer for use while filling electrolyte

13.2.3.11 Charge Rate

Fully discharged batteries should be able to get recharged in 7 hours maximum to 90% of capacity. At higher temperatures, the charging time may be more. The trickle charge rate shall be 1-2 mA /Ah.

13.2.3.12 Cell Designation

The practice as per IS: 10918 (latest version) shall be followed.

13.2.3.13 Polarity Marking

The polarity of the terminals shall be marked for identification. Positive terminal may be identified by 'P' or a (+) sign or red colour mark and negative terminal may be identified by 'N' or (-) sign or blue colour mark. Marking shall be permanent and non-deteriorating.

13.2.3.14 Performance Curves

The bidder shall furnish all characteristics curves for satisfactory operation and maintenance of batteries under service conditions.

13.2.3.15 Warning Marking

The battery shall be furnished with a warning plate located at conspicuous place specifying the use of 'ALKALINE ELECTROLYTE ONLY' (in block letters) and specifying proper filling level of the electrolyte. Marking shall be permanent and non-deteriorating.

13.2.3.16 Packing

The batteries shall be securely packed in wooden crates suitable for handling during transit by rail/road and secured to avoid any loss or damage during transit. Carton boxes duly palletized shall also be acceptable.

13.2.3.17 Tests

The batteries shall be tested for type, acceptance and routine tests in line with IS: 10918& IEC: 62259 (latest versions). The owner may at their discretion to accept the batteries based on type tests already carried-out. In such cases, Type test reports for tests carried out not earlier than 05 years from bid opening date from NABL accredited labs shall be acceptable.

Note: In case Type tests are repeated, life cycle test may not be insisted upon Ni-Cd battery of the specific ratings to be ordered, as this test takes a long time (2-3 years). However, satisfactory evidence is to be furnished for having made this test on cell of any other Ah capacity of the same design.

13.2.3.18 Guarantee

The batteries shall be guaranteed for a period of 36 months from the date of commissioning.

13.3 DESCRIPTION OF BATTERY CHARGER**13.3.1 General**

- a) Solid state float-cum-boost charger or separately housed float and boost charger shall comprise of silicon controlled rectifiers (SCRs) connected in full wave bridge circuit for charging the Battery set. They should be interlocked so

that at a time only float or boost charger can be connected to the battery system. The battery and the charging equipment will normally be connected to the common bus at all times supplying loads at constant voltage. The charging equipment in addition to charging the battery shall deliver all the demands of the switchgear, protection and auxiliary equipment. In the event of AC failure the battery shall supply the entire power to the control bus and also for emergency lighting. The input supply shall be three phase 4 wire.

- b) The battery charger shall have circuit for automatic switching of the voltage, dropper diodes in stages so that the voltage at the distribution panel remains within the specified limits. Thus automatic switching of selected numbers of diodes, with the aid of DC contactors may be necessary in float and boost mode. This automatic selection and switching of dropper diodes should also be available when AC supply fails. Blocking diodes shall be provided on the output side to prevent back feeding from battery.
- c) Each battery charger shall be suitable for float charging the battery under normal conditions and boost charging the battery when it has discharged during service conditions. The changeover from float to boost mode and vice versa shall be automatic. The bidder shall arrange to provide 80% battery tap and blocking diode for DC supply during boost charging if float and boost charging voltages differ by more than 0.1 to 0.15 V per cell. The Boost Charger shall restore a fully charged condition a fully discharged battery in not more than 12 hours.
- d) The rectifier transformer shall be dry type and copper wound with required number of taps. The transformer shall be natural air cooled and its rating shall be 10% more than the continuous overloading capacity.
- e) In the float charging mode, the charger shall be designed for supplying:

- (i) The DC loads of supervision lamps and relay coils that remain energized during normal operation and the momentary closing and trip coil loads of the breakers.
 - (ii) The float charging current of the battery.
- f) Battery charging equipment complete with all accessories shall be housed in free standing type sheet steel cubicle. Sheet steel used for construction shall be 2 mm thick. The units shall be wired using 1100 V grade. PVC insulated, stranded electrolytic copper conductor wires.
- g) Battery charger shall be provided with facility for both automatic and manual control of output. A selection switch shall be provided for selecting the mode of operation – automatic or manual. Potentiometer shall be provided for auto setting of output current or voltage of charger. When operating on automatic control mode, the float charger output voltage shall remain within + 1% of the set value for A.C. input voltage variation of – 15 to +10% frequency variation of +5% a combined voltage and frequency variation of –15 to +10% and a D.C. load variation from zero to full load.
- h) The float charger shall be suitable for floating the battery anywhere between 1.4 to 1.42 Volts per cell, preferably at the optimum float voltage, while supplying the continuous D.C. load. The manufacturer has to recommend the optimum voltage for the batteries so that the battery will draw the necessary trickle charging current from the float charger.
- i) Recharging of discharged battery, after resumption of AC supply, should be possible through a boost charger capable of providing recharging voltage from 1.53 to 1.7 volts per cell so that the necessary starting current and the finishing current for the battery charging can be obtained. All the cells of the battery bank should be recharged uniformly without undercharging or overcharging any portion of the bank.

- j) The charging system should also ensure the connection of the full battery to the load bus bar, even if another AC power failure takes place, when the battery is on boost charge mode. The circuit should also provide a continuity of DC supply even during any "Ride through" period.
- k) Suitable filter circuits comprising of smoothing chokes and condenser with alarm indication shall be provided in all the chargers to limit the ripple content of the D.C. output voltage within + 2%. For protection of these necessary MCBs/ MCCBs' shall be provided.

13.3.2 Contactors

The battery charger shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. The operating coil shall be rated for 240 volts AC.

13.3.3 Thermal Overload Relay

A thermal overload relay incorporating a distinct phasing protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

13.3.4 Rectifier Transformer

The rectifier transformer shall be copper wound continuously rated, natural air cooled (N.A) type. The rating of the rectifier, transformer shall correspond to the rating of the associated rectifier assembly. The calculations for rating of transformer shall be furnished.

13.3.5 Rectifier Assembly

Full wave controlled bridge circuits, preferably full wave half controlled shall be provided for float-cum-boost charger. The rectifier assembly shall be designed to meet the duty as required by the respective charger. Rectifier shall be mounted on heat sinks. Necessary resistor and condenser network for surge suppression with semi-conductor HRC fuses shall be provided in each arm of the rectifier connection along with trip alarm indication.

13.3.6 Instruments

One AC voltmeter (with selector switch), One DC voltmeter, one AC ammeter (with shunt and selector switch) and one DC ammeter (with shunt) shall be provided for the charger. The instruments shall be flush type, dust proof and moisture resistant. The instruments shall have easily accessible means for zero adjustment. The Instruments shall be of better than 1.5 accuracy class, LED type indicating lamps shall be provided across the AC and DC supply.

13.3.7 Moulded Cases Circuit Breaker / Miniature Circuit Breakers

Manufacturer should supply the equipment by providing MCCB/MCB's of suitable rating until and unless it is essentially required to use a HRC fuse. MCCB (Moulded Cases Circuit Breaker) AC input and DC output shall be controlled by MCCB of suitable rating with HRC fuse for back-up protection in charger. They shall be suitable for 415/240 V AC and 115 V DC. MCCB shall be provided with thermo magnetic type release for over current and short circuit protection. Sufficient NC and NO contacts shall be available for interlocks & annunciation.

13.3.8 Fuses

The Employer would like to have equipment with MCCB/MCB's instead of fuses. However, if essentially used, all fuses shall be of HRC type with suitable fittings. Ratings shall be chosen by the bidder depending on the circuit requirements.

13.3.9 Blocking Diode

Blocking diode of suitable rating shall be provided in positive pole of the output circuit of each charger to prevent current flow from DC battery.

13.3.10 Alarm/Indicators

The following are the minimum requirements. However, details shall be finalized during detailed engineering, which shall be provided by manufacturer.

- I. The following alarm, indicators and metering have to be provided.
 - a. Main incoming AC supply ON (for float as well as Float-cum-boost charger)

- b. DC supply ON (for Float-cum Boost charger).
- c. Float-cum-Boost charger rectifier failure
- d. AC main failure
- e. Float-cum-Boost output DC fuse failure
- f. Filter fuse /MCB failure
- g. Earth leakage
- h. Controller card defective
- i. Float charger load limiter operated
- j. SCR 's (Silicon Control Rectifier) fail Alarm
- k. Any other annunciation recommended by manufacturer.

II. Metering the following meters shall be provided.

- a. AC incoming voltmeter with selector switch.
- b. AC ammeter with selector switch
- c. DC output voltmeter for Float-cum-Boost charger
- d. DC ammeter for Float-cum-Boost charger
- e. Milli Ammeter for measuring trickle charging current of battery.

III. In addition to above, facilities shall be there for detection of following abnormal conditions/faults.

- a) DC over voltage and under voltage
- b) Battery earth leakage
- c) Overload in float and boost charger

13.3.11 NAME PLATES AND MARKING

The name plates shall be white with black engraved letters. On top of each charger, on front as well as rear sides, larger and bold name plates shall be provided to identify the charger. Name plates with full and clear inscription shall also be provided on and inside of the panels for identification of various equipments and ease of operation and maintenance.

13.3.12 CONSTRUCTION

- a. The charger shall be indoor, floor-mounted, self-supporting sheet metal enclosed cubicle type mounted on a channel base via a neoprene gasket. The Contractor shall supply all necessary base frames, anchor bolts and hardware. The chargers shall be fabricated from 2.0 mm cold rolled steel and shall have folded type of construction. Removable gland plates for all cables and lugs for power cables shall be supplied by the contractor. The lugs for power cables shall be made of electrolytic copper with tin coat. The Charger shall be tropicalised and vermin proof. Ventilation louvers, if provided shall be backed with screens. All doors and covers shall be fitted with synthetic rubber gaskets. The charger shall have hinged double leaf doors provided on front and or backside for adequate access to the Charger internals. All charger cubicle doors shall be properly earthed. The degree of protection of charger enclosure shall be at least IP-54 as per IS: 2147.
- b. All indicating instruments, control switches and indicating lamps shall be mounted on the front side of the charger. Each charger shall be furnished completely & wired upto power cable lugs and terminal blocks ready for external connections. The control wiring shall be carried out with 1.1 kV PVC insulated, 2.5 sq.mm. Stranded copper wires. Control terminals of reputed make and type shall be suitable for connecting two wires, with 2, 5 sq. mm stranded copper conductors. All terminals shall be numbered for ease of connections and identification. Each wire shall bear a ferrule or tag on each end for identification. At least 20% spare terminal shall be provided for control circuits. The insulation of all circuits except the low voltage electronic circuits shall withstand test voltage of 2 kV for one minute. An air clearance of at least ten (10) mm shall be maintained throughout for such circuits, right up to the terminal

lugs. Whenever this clearance is not available, the live parts shall be insulated or shrouded.

- c. An earthing copper strip of adequate size shall be provided in the panel.

13.3.13 Painting

All sheet steel work shall be pretreated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scale shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be 'Class-C', as specified in IS: 6005. Welding shall not be done after phosphating. The phosphated surfaces shall be rinsed and passivity prior to application of stoved red oxide primer coating. After primer application, two coats of finishing synthetic enamel paint of shade-692 (smoke grey) of IS:5 shall be applied, unless required otherwise by the Employer. The inside of the chargers shall be glossy white. Each coat of finishing synthetic enamel paint shall be properly stoved. The paint thickness shall not be less than fifty (50) microns.

13.3.14 Accessories/Components

Each battery charger shall be provided with accessories that include, but are not limited to the following: (To be finalized during detailed engineering)

- a) Silicon controlled rectifiers connected in full wave bridge circuit with ripple control devices and transient suppression network.
- b) Double wound (copper winding) dry type transformer with taps.
- c) Automatic voltage regulator unit with manual/auto control switch.
- d) Coarse and fine control potentiometers for manual control.
- e) Selector switch for mode of charging i.e. float charging/boost charging
- f) Off-load tap changing switch for changing the taps of the transformer
- g) DC voltmeter with MCB and a three position selector switch
- h) DC ammeter with shunt
- i) Incoming MCB on AC side with alarm contacts and surge suppressors

- j) MCB on DC output side with alarm contacts
- k) Centre zero ammeter with shunt
- l) Voltage dropping diodes in load circuit during boost charging mode
- m) DC under voltage relay and earth fault relay
- n) AC/DC switching relays for alarm and indication circuit including buzzer
- o) Current limiting feature
- p) Cubicle space heater suitable for 220 V AC, 1 Ph. 50 Hz supply, with MCB and thermostat.
- q) CFL tube for cubicle internal lighting with MCB.
- r) Other items as indicated in the earlier paragraphs.

13.4 D.C. DISTRIBUTION PANEL

13.4.1 The board shall be metal clad, totally enclosed indoor floor mounted, and free-standing cubicle type. Entry for incoming and outgoing cables shall be from bottom. Bus-bars shall be made of tinned copper and insulated. The construction feature, pre-treatment, painting and other aspects shall comply with specification covered for LT AC/DC board. The frame shall be fabricated using suitable mild steel structural section or pressed and shaped cold rolled sheet steel of thickness not less than 2.0 mm. The panel shall be provided with circuits and components such as meters, relays, etc. as per the 110 V DC single line diagram enclosed. Main bus bar shall be of high conductivity tinned copper of uniform rectangular cross section provided with positive and negative bus bars of adequate size. Components such as MCBs etc. shall be of reputed make with proven performance record and suitable for DC application. The bus bars shall be insulated.

13.4.2 The DC distribution panel shall be complete with bus bars, input/output terminals, inter panel connections, internal wiring, name and rating plates, mimic diagram (at the front of the switchboard), earthing bus and space heaters etc. The terminals shall be of reputed make and will be subject to approval of Employer.

13.4.3 Emergency Lighting

In case of AC failure, DC board shall supply emergency light in the Control Room building. Necessary devices for automatic change over for emergency lighting from AC to DC supply complete with necessary relays, interlocking and indications etc. shall be provided. Details shall be approved during engineering stage.

13.4.4 An earth bus bar of 25 mm Cu. Flat (to be got approved from Employer during detailed engineering) shall be provided along the entire length of the switchboard at the bottom. Two nos. earthing terminals connected to the earth bus bar shall be provided on the external face of the board for connection to the earthing grid at the sub-station.

13.4.5 ALL OUT GOING & INCOMING FEEDERS SHALL BE THROUGH MCCB/MCB's THE ISOLATING LINKS SHALL BE PROVIDED BEFORE MCCB/MCB.

13.5 TESTS

13.5.1 Battery Charger

The type and routine tests shall be carried out on all the components of Battery Chargers as per relevant Indian Standards. Rectifier transformer shall be subjected to short circuit test in addition to type and routine tests specified in IS: 4540. Following type tests shall be carried out in the presence of the Employer's representative, if so desired by the Employer.

- a) Insulation resistance test
- b) HV test on power & control circuits
- c) Temperature rise/heat run test
- d) Regulation test at specified AC supply and load variation.
- e) Ripple measurement
- f) Load limiting feature of trickle charger
- g) Load test (efficiency and power factor measurement for both float and boost charger etc.)

- h) Checking of annunciation circuits
- i) Surge withstand and capability test

Along with the offer, the bidder shall submit the test certificates for above tests for similar chargers already supplied to other customers/ organizations.

- 13.5.2** The contractor shall have to demonstrate to the Employer that the charger conform to the specification regarding continuous rating, ripple content, voltage regulation and load limiting characteristics before dispatch and after installation at site.

The following acceptance tests shall be carried out at site:

- a. Insulation resistance test
- b. Automatic voltage Regulation operation
- c. Checking of proper annunciation system operation

- 13.5.3** Battery charging equipment shall be type tested for dead short circuits of output terminals at full D.C. voltage without blowing off any fuses MCB's/or components.

13.6 INSPECTION

- 13.6.1** All tests and inspection shall be made at the manufacturer's works unless otherwise specifically agreed upon by the manufacturer and Employer at the time of placement of purchase order. The manufacturer shall afford to the inspector representing the Employer, all reasonable facilities, without charge, to satisfy him that the material being furnished is in accordance with the specification. The Employer reserves the right to get any component/ material used by the manufacturer tested from any recognized Test House.

- 13.6.2** The inspection by the Employer or his authorized representative shall not relieve the bidder of his obligation of furnishing equipment in accordance with the specification, and if at any it is found that equipment has not been tested as desired by Employer, the same would be rejected.

13.7 DRAWINGS

The successful bidder shall be required to furnish the following drawings and catalogues.

- a) General arrangement drawing showing the proposed arrangement of cells/battery, battery charger.
- b) Charge and discharge performance curve of the battery
- c) Complete schematic diagram of charger and bill of materials.
- d) Layout drawing of battery giving details of terminal posts and arrangement of cable termination including general arrangement of cells.
- e) General arrangement drawing of the battery charger showing mounting details of various equipment and foundation details.
- f) Complete schematic diagram of charger including alarm and annunciation scheme and bill of material.
- g) Voltage vs current characteristic curve and automatic voltage regulator.
- h) Complete technical literature for battery and battery chargers.
- i) Copy of instruction manual for initial treatment and for subsequent maintenance during service.
- j) Interconnection Diagram.
- k) Any other drawing to be finalized during detailed engineering.

13.8 SPARES

13.8.1 Mandatory Spares

As, per the Price Schedule; Mandatory spares considered to be sufficient for successful operation and maintenance of equipment for a period of 5 years are listed separately in Chapter- 25 "Mandatory Spares". The bidder may review the above spares and may add the spares, which are essentially required for the satisfactory operation & maintenance of the equipment. The Bidder shall accordingly quote the itemized price of these spares in the price Schedule.

13.8.2 Recommended Spares

The bidder may recommend the spares in addition to the mandatory spares, the itemized prices of the spares shall be quoted in price Schedule.

13.9 INSTRUCTIONS MANUAL

Six sets of the instruction manuals shall be supplied atleast four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection, operation and maintenance of the transformer. The manuals shall include amongst others, the following particulars:

- a) Marked erection prints identifying the components, parts of the equipment as dispatched with assembly drawings.
- b) Catalogue, users' manual, maintenance manual for the equipments shall also be submitted.
- c) Salient technical particulars of the equipments.
- d) Copies of all final approved drawings.
- e) Detailed O&M instructions with periodical check lists and Performa etc.

13.10 COMPLETENESS OF EQUIPMENT

13.11.1 All fittings and accessories, which may not be specifically mentioned in the specification but which are necessary for the satisfactory operation of the plant, shall be deemed to be included in the specification and shall be furnished by the contractor without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not, without any financial liability to the Employer under any circumstances.

13.11.2 All deviations from this specification shall be separately listed under the requisite schedules, in the absence of which it will be presumed that all the provisions of the specifications have been complied with the bidder.

13.11 TOOLS, TACKLES AND SLINGS FOR ERECTION, TESTING & COMMISSIONING

The supplier shall provide/arrange testing instruments, tools, tackles and slings required for erection, testing and commissioning of the equipment at site. The list of testing instruments, tools, tackles & slings required to be arranged by the supplier shall be submitted along with the bid.

13.12 DEVIATIONS FROM SPECIFICATIONS

All the deviations from the specifications shall be separately listed in specified Annexure in the absence of which it will be presumed that the provisions of the specifications have been fully complied with by the bidder.

13.13 GUARANTEED TECHNICAL PARTICULARS

All Schedules annexed to the specification, shall be duly filled by the bidder separately given in **Section-III – “Guaranteed and Other Technical Particulars”**.

13.14 TECHNICAL PARAMETERS**TABLE-13.1**

A	D.C. Battery	For Station Battery	For Communication
	I. Type	Nickel-Cadmium/Lead Acid battery, completely sealed, maintenance free stationary, normal discharge performance type suitable for application in sub stations having life of not less than Ten years on float operation	
	II. Ambient temperature		
	a. Max.	37.5 ⁰ C Do...
	b. Min.	14 ⁰ C Do...

	c. No. of cells	87	38
	d. Rated voltage	110 V	48 V
	III. Minimum capacity for: 10 hr. Discharge rate to end voltage V/cell at 27 ⁰ C	400 AH	100AH
	IV. Capacity of the one hour discharge rate to end voltage V/cell at 27 ⁰ C	40 AH	10 AH
	V. Float voltage	1.4 to 1.42 V/cell	1.4 to 1.42 V/cell
	VI. Optimum float voltage	To be specified by the manufacturer	To be specified by the manufacturer
	VII. Boost voltage	1.53 to 1.7 V/Cell	1.53 to 1.7 V/Cell
	VIII. Ampere-hour efficiency	Not less than 90%	Not less than 90%
	IX. Watt-hour efficiency	Not less than 75%	Not less than 75%
	X. Self-discharge	< 1% per week	< 1% per week
	XI. Life	>10 Years	>10 Years
B.	Battery Charger	Float-cum-Boost Charger.	
	I. Type	Solid state, full wave controlled bridge rectifier (preferably half controlled type)	Solid state, full wave controlled bridge rectifier (preferably half controlled type)
	II. A.C. Input		
	a. Supply	400 V, 3 phase, 4	400 V, 3 phase, 4

		wire	wire
	b. Frequency	50 Hz	50 Hz
	c. Input voltage variation	-15% to +10%	-15% to +10%
	d. Frequency variation	+5%	+5%
	e. Combined voltage & frequency variation	-15% to +10%	-15% to +10%
	f. System Earthing	Effectively earthed	Effectively earthed
	III. D.C. Output	For Station Battery	For Station Battery
	a. Continuous D.C. load	To charge as well as supply DC load	To charge as well as supply DC load
	b. Output voltage range	0-150V	0-65V
	c. For D.C. load variation from 0 to 100% output Voltage stable within	+1% (digitally controlled)	+1% (digitally controlled)
	d. Continuous Current settings	100% (digitally controlled)	100% (digitally controlled)
	e. Ripple content	Less than 2%	Less than 2%
	IV. AC input /DC output	(to be controlled by for both float-cum-boost) MCCB/MCB &with links to isolate circuits)	

IMPORTANT NOTE

- a) The equipment shall be used >2500 M altitude (height above MSL) with Condensing Humid Atmosphere, coupled with low temperature. All components must be designed keeping this in view.
- b) Bidder must indicate with each set of battery, battery chargers, and DCDB's recommendatory spare parts for five years' operation along with unit rates.
- c) Details submitted by Bidder shall be reviewed and approved during detailed engineering.
- d) DCDB shall be provided with necessary relays to monitor and check the earth fault on the system. Alarm scheme shall also be provided for the system.

Package-KC2

Koshi Corridor 220/132/33 kV Substations (Basantapur-Baneshwar-Tumlingtar- Inaruwa Substations)

Part II-Section VI: Employer's Requirements

Section-4

Chapter-14 **Power and Control Cables**

SECTION 4**CHAPTER – 14****POWER AND CONTROL CABLES****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
14.0	SCOPE	1
14.1	STANDARDS	1
14.2	GENERAL TECHNICAL REQUIREMENT	3
14.3	CONSTRUCTIONAL REQUIREMENTS	6
14.4	CABLE ACCESSORIES FOR HT CABLES	8
14.5	TERMINATION KITS	8
14.6	REQUIREMENT OF XLPE JOINTS & TERMINATION	8
14.7	CABLE DRUMS	9
14.8	INSPECTION	10
14.9	TESTS	11
14.10	MAKE	15
14.11	TECHNICAL PARTICULARS	15

SECTION 4

CHAPTER - 14

POWER AND CONTROL CABLES

14.0 SCOPE

- 14.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, transportation up to site, Testing & commissioning of HT Power Cables, LT Power Cables & Control Cables complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. Any other cables which may be required for Power, Control and other systems but not specifically brought out here or elsewhere shall be included and spelt out in the bid.
- 14.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.
- 14.0.3 Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.
- 14.0.4 Components having identical rating shall be interchangeable.
- 14.0.5 The performance of the equipment shall be guaranteed as per **Section-5 – "Guaranteed and Other Technical Particulars"**. The bidder has to furnish the testing facilities available at the manufacturer's works.

14.1 STANDARDS

- 14.1.1 The cables under this specification shall comply with the requirements of latest edition of the following Indian/International standards including amendments:-

TABLE-14.1.1.1

S.No.	IS Codes	Description
1.	IS: 1554 (Part-I)	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 V.
2.	IS: 1753	Aluminium conductors for insulated cables.
3.	IS: 3961 Part-II	Recommended current rating for PVC insulated and PVC sheathed heavy duty cables
4.	IS: 3975	Metal steel wires, strips and tapes for armouring of cables
5.	IS: 4905	Methods for random sampling
6.	IS:5831	PVC insulation and sheath of electric cables.
7.	IS: 7098 (Part- I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto & including 1100 V.
8.	IS: 7098 (Part-II)	Cross linked polyethylene insulated PVC sheathed cable for working voltage from 3.3 kV to 33 kV.
9.	IS: 8130	Conductors for insulated electric cables and flexible cords.
10.	IS: 10418	Wooden drums for electric cables.
11.	IS: 10810	Method of tests for cables
12.	ASTMD 2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastic
13.	IEEE-383	Standard for type test of IE class of electric cables
14.	IEC-332 (Part-I)	Tests on electric cables under fire conditions.
15.	IEC-754 (Part-I)	Test on gases evolved during combustion of electric cables
16.	ASTMD – 2843	Test method for density of smoke from the burning on decomposition of plastic
17.		Electrical Power technical standards of Nepal.

14.1.2 The Equipment and material meeting the requirement of any other Indian standards or equivalent internationally recognized standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable. Where the equipment confirms to any other standards then salient points of difference between the standards adopted and those prescribed in these specifications shall

be clearly brought out in the bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

14.2 GENERAL TECHNICAL REQUIREMENT

- a) The cables shall be suitable for laying in racks, ducts, covered trenches, conduits and underground buried installation with chances of flooding by water.
- b) Cables shall be designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.
- c) The aluminum/copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be of uniformly good quality free from defects. All aluminum used in the cables shall be of H2 grade.
- d) Aluminum conductor used in power cables shall have tensile strength of more than 100N/sq mm. The conductor of control cables shall be manufactured from plain annealed copper. The entire conductor shall be multi-stranded.
- e) PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90°C and short circuit conductor temperature of 250°C.
- f) The cable cores shall be laid up with fillers between the cores wherever necessary. It should not stick to insulation and inner sheath. All the cables, other than single core unarmored cable shall have distinct extruded PVC inner sheath black in colour as per IS 5831.
- g) The fillers and inner sheath shall be of non-hygroscopic flame retardant and material shall be softer than insulation and outer sheath shall be suitable for the operation temperature of the cable.
- h) For single core armoured cables, armouring shall be of aluminum wires. For multi-core armoured cables, armouring shall be of galvanized steel as follows:

TABLE-14.2.0

Calculated nominal size & diameter of cable under armour	Type of armour
a. Up to 13 mm	1.4 mm dia. GS wire
b. Above 13 up to 25 mm	0.8 mm thick GS strip/1.6 mm dia. GS wire
c. Above 25 up to 40 mm	0.8 mm thick GS strip/2.0 mm dia. GS wire
d. Above 40 up to 55 mm	1.4 mm thick GS strip/2.5 mm dia. GS wire
e. Above 55 up to 70 mm	1.4 mm thick GS strip/3.15 mm dia. GS wire
f. Above 70 mm	1.4 mm thick GS strip/4 mm dia. GS wire

14.2.1 The gap between armour wire/strip shall not exceed one armour wire/strip space and there shall be no cross over/over-riding of armour wire/strip. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire/strip. Zinc rich paint shall be applied on armour joint surface.

- (i) Suitable chemicals shall be added to the outer sheaths of all cables to protect them from rodent and termite attack. These chemicals shall not have any harmful effect on the human being.
- (ii) The normal current rating of all PVC insulated cables shall be as per IS-3961 and should suit the duty requirements for which it is intended.
- (iii) Outer sheath shall be of PVC black in colour for power cables and grey in colour for control cables.
- (iv) Cores of the cables of up to 5 cores shall be identified by coloring of insulation. Following colour scheme shall be adopted:

1 core	-	Red, Black, Yellow & Blue
2 core	-	Red & Black
3 core	-	Red, Yellow & Blue
4 core	-	Red, Yellow, Blue & Black
5 core	-	Red, Yellow, Blue, Black & Grey

For reduced neutral conductors the core shall be black.

- (v) For cables having more than 5 cores, core identification shall be done by numbering insulation of core sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The numbers shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of same colour, which shall contrast with the colour of insulation. The colour of the insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.
- (vi) In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed over outer sheath.
- a) Cable size and voltage grade.
 - b) Sequential marking of length of the cable in metres at every one metre.
- The embossing shall be progressive, automatic, on line and marking shall be legible and indelible.
- (vii) Allowable tolerance on the overall diameter of the cables shall be $\pm 2\text{mm}$ maximum, over the declared value in the technical data sheets.
- (viii) In plant repairs to the cables shall not be accepted.
- (ix) Identification of cores: - The insulated cores of HT and LT power cables shall be identified by coloured code. The control cables shall have identification by means of indelible printing of numbers on its cores at intervals not more than 75 mm. At least 20% cores shall be kept as spares in the multicore control cables.

14.3 CONSTRUCTIONAL REQUIREMENTS

14.3.1 General

- a) 33 kV Power Cable: - The cables shall confirm to IS-7098 (Part-II)
- b) The cable shall be 33 kV (earthed system) grade, heavy duty, stranded aluminum conductor, XLPE insulated, provided with conductor screening and insulation screening, galvanized steel wire/strip armored, extruded PVC of Type ST2 outer sheathed.
- c) The conductors shall be stranded and compacted circular for all cables. The conductors shall be provided with non-metallic extruded semi conducting shielding.
- d) The cores insulation shall be with cross-linked polyethylene insulation compound applied by extrusion. It shall be free from voids and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions. It shall confirm to the properties given in Table-I of IS-7098 (Part-II).
- e) The insulation shielding shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic screening of copper. The copper screen shall be capable of carrying the single line to ground fault current for the duration specified in the data sheet. Vendor shall furnish calculation in support of selection of the size of copper screen along with bids.
- f) The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation by 'Triple Extrusion' process to ensure perfect bonding between the layers. The core identification shall be by coloured strips or by printed numerals.
- g) The inner sheath shall be applied over the laid up cores by extrusion and shall confirm to the requirements of type ST2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness.

- h) For multicore cables, the armoring shall be by galvanized steel strips. If armoring is specified for single core cables, the same shall be with H4 grade hard drawn aluminium round wire of 2.5mm diameter.
- i) The outer sheath of the cables shall be applied by extrusion over the armouring and shall be of PVC compound confirming to the requirements of type ST2 compound of IS: 5831. The thickness of outer sheath shall be as per amendment no.1 of table 5 of IS: 7098 Part-2 (Column 3 & 5 for both armoured and unarmoured cables).
- j) The dimensions of the insulation, inner sheath and armour materials shall be governed by values given in Tables 2, 3 & 4 (Method 3) of IS: 7098 Part-II).

14.3.2 PVC LT Power and Control Cables

- a) All power/control cables for use on low voltage systems shall be heavy duty type, 1100 V grade with aluminium conductor, PVC insulated, PVC inner sheathed, armoured/ unarmoured and overall PVC sheathed as detailed below.
- b) The conductors shall be stranded for both aluminium and copper cables. The minimum number of strands shall be 7 (seven) except as otherwise specified conductors. Conductors, whose nominal area will be lesser than 25 sq.mm, shall be of circular cross section only. Cables of nominal area 25 sq.mm and above may be circular or shaped Cables with reduced neutral conductor shall have sizes as per Table 1 of IS: 1554 (Part-I).
- c) The core insulation shall be with PVC compound applied over the conductor by extrusion and shall confirm to the requirements of type 'A' compound as per IS: 5831. The thickness of insulation and the tolerance on thickness of insulation shall be as per Table 2 of IS: 1554 Part-I.
- d) The inner sheath shall be applied over the laid up cores by extrusion and shall be of PVC confirming to the requirements of type ST1 PVC compound as per IS: 5831. The minimum thickness of inner sheath shall be as per Table 4 of IS: 1554 Part-I.
- e) If armouring is specified for multicore cables, the same shall be by single round galvanized steel wires where the calculated diameter below armoured

does not exceed 13 mm and by galvanized steel strips where this dimension is greater than 13 mm. The dimensions of armour shall be as per Table-5 of IS-1554 (Part-I).

- f) Control Cables shall be 1.1 kV grade, heavy duty, multicore stranded, tinned copper annealed conductor, PVC insulated, armoured extruded PVC of outer sheathed.

14.4 CABLE ACCESSORIES FOR HT CABLES

- a) The termination and straight through jointing kits for use on the systems shall be heat shrinkable type and suitable for the type of cables offered as per this specifications.
- b) The accessories shall be supplied complete in all respects and should be supplied in kit form. Each component of the kit shall carry the manufacturers' mark of origin.
- c) The kit shall include all stress grading insulating and sealing materials apart from conductor fittings and consumable items. An installation instruction sheet shall also be included in each kit.
- d) The contents of the accessories kit including all consumables shall be suitable for storage without deterioration at a temperature of 45°C with shelf life extending more than 5 years.
- e) A set of tools for making joints shall be provided (both for indoor and outdoor joints).

14.5 TERMINATION KITS

The heat shrink terminating kits shall be suitable for termination of the cables to indoor switchgear or to a weather proof cable box of an outdoor transformer or to a 4 pole structure. For outdoor terminations weather shields/sealing ends and any other accessories required shall also form part of the kit.

14.6 REQUIREMENT OF XLPE JOINTS & TERMINATION

- 14.6.1 The straight through jointing kit shall be suitable for installation on over head trays, concrete lined trenches and ducts and for underground burial with uncontrolled backfill and possibility of flooding by water and chemicals. These shall have

protection against any mechanical damage and suitably designed to be protected against rodent and termite attack. It shall meet the following requirements.

- a) Conductivity of the jointed conductor shall not be less than that of the main conductor of the cable.
- b) Joints between two conductors or conductor lugs shall have a mechanical strength not less than that of the conductor.
- c) Adequate insulation level free from voids and impurities.
- d) Adequate stress relief provision
- e) Adequate creepage paths to eliminate system tracking.
- f) Ability to withstand electromagnetic thermal stress during flow of short circuit current.
- g) Proper seals for water, dust and chemical fumes for checking their ingress under all the conditions.
- h) Inner semi-conducting layer with a smooth surface & good contacts and insulation.
- i) Outer semi-conducting layer to adhere firmly to the insulation
- j) Earth continuity connection of adequate size shall be a part of the kit.
- k) Heat shrinkable technique shall be used for termination kits.

14.6.2 This system shall be based on the use of heat shrinkable radiation vulcanized cross linked polyethylene tubes (semi-conducting and insulation grade) and skirts. These tubes shall be fitted to the cable and/or joints and set in position by shrink fitting by application of heat by a gas torch or kerosene blow lamp. The heat shrinkable tubes, designed as stress control tubing, insulating tubing and screen tubing shall meet the requirements of temperature, flexibility, stress grading, long life, resistance to corrosion and chemical etc. Complete list of various items required for making various type of joints shall be furnished with the offer.

14.7 CABLE DRUMS

14.7.1 Cables shall be supplied in non-returnable wooden or steel drums of heavy construction. For wooden drums the wood used for construction for the drum shall

be properly seasoned, sound and free from defects. Wood preservative shall be applied to the entire drum.

14.7.2 Bidder shall indicate in the offer the standard length for each size of power and control cable which can be furnished on one drum. The cable length per drum shall be subject to tolerance of + 5% of the standard drums length agreed between Employer and bidder. The Employer shall have the option of rejecting cables drums with shorter lengths.

14.7.3 A layer of water -proof paper shall be applied to the surfaces of the drums and over the outer most cables layer. A clear space of at least 40 mm shall be left between the cables and the logging.

14.7.4 Each drum shall carry the manufacturer's name, the owner's name address and contract number, item number and type, size and length of cable, net and gross weight stenciled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wordings shall be marked on one end of the reel indicating the direction in which it should be rolled.

14.7.5 Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation handling and storage. Both cable ends shall be sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation, storage and erection.

14.8 INSPECTION

14.8.1 Before dispatch, the cables offered shall be made available for inspection to a duly authorized representative of the Owner. Inspection may also be made at any stage of manufacture at the option of the Owner and the cables found unsatisfactory due to the material used or poor workmanship shall be rejected. The supplier shall guarantee free access to the places of manufacture to the Owner representative at all times when the work is in progress. The contractor shall inform the Owner in advance the time of starting of manufacture and the progress of manufacture of the cables offered by him so that arrangement can be made for inspection.

- 14.8.2 Inspection and acceptance of cables by the Owner or his authorized representative shall not relieve the contractor of his obligation of furnishing cables in accordance with the specification and shall not prevent subsequent rejection if such cables are later found to be defective.
- 14.8.3 The cables shall comply with type tests stipulated in prescribed section and the relevant standards. Test reports for all type tests shall be submitted with the tender.
- 14.8.4 All type and sizes of cables shall be subjected to routine and acceptance tests as stipulated in relevant standards without any extra cost to the Employer. Cables should not be dispatched until the test reports are duly approved by the Owner or his authorized representative, and specific instructions to dispatch the inspected items issued.
- 14.8.5 The Employer reserves the right of having any other special tests of reasonable nature carried out at site or at manufacturer's works or at any other place in addition to the aforesaid type and routine tests to satisfy himself that the cables comply with the specification, without any financial liability.
- 14.8.6 Six copies of test reports shall be supplied for approval. The reports shall indicate clearly the governing standards and the standard values specified for each test to facilitate checking of the test reports. Four bound copies of the test reports shall be submitted after approval of test reports along with the cables.

14.9 TESTS

- 14.9.1 All types and sizes of cables being supplied shall be subjected to type tests, routine tests and acceptance tests as specified below and according to relevant standards.
- 14.9.2 Employer at his discretion may ask the bidders to conduct any or all the type tests for which at least 15 days advance notice shall be given by the contractor.
- 14.9.3 Charges for Type, acceptance test and routine test shall be deemed to be included in the bid price of individual cables. All the type and routine test reports, certificates shall be submitted and got approved from the Employer before dispatch of the equipment.

14.9.4 Type Tests

Type tests shall be carried out on all the types and sizes of cables if desired or alternatively latest test certificates shall be acceptable. The following type tests shall be conducted:-

TABLE-14.7.4.1

S.No.	Test	Remarks
A.	For Conductor	
1.	Annealing test	For copper conductor only
2.	Tensile test	For aluminum conductor only
3.	Wrapping test	For aluminum conductor only
4.	Resistance test	
B.	For Armour Wires/Strips	
5.	Measurement of Dimensions	
6.	Tensile test	
7.	Elongation test	
8.	Torsion test	For round wires only
9.	Winding test	For strips only
10.	Resistance test	
11.	Zinc Coating test	For G.S. strips/wires only
C.	For PVC/XLPE Insulation & PVC Sheath	
12.	Test for thickness	
14.	Tensile strength and elongation test before aging and after aging	
14.	Aging in air ovens	
15.	Loss of mass test	For PVC insulation & PVC sheath only
16.	Hot deformation test	-do-
17.	Heat stock test	-do-
18.	Shrinkage test	-do-

19.	Cold bend/cold Impact test	-do-
20.	Colour fastness to	-do-
21.	Thermal stability test	-do-
22.	Bleeding and blooming test	-do-
23.	Hot set test	For XLPE insulation only
24.	Water absorption test	For XLPE insulation only
D.	For Completed Cables	
25.	Insulation resistance test	
26.	High voltage test	
27.	Partial discharge test	
28.	Bending test	
29.	Dielectric Power factor test	
	i) As a function of voltage	
	ii) As a function of temperature	
30.	Heating cycle test	
31.	Impulse with stand test	
32.	Measurement of eccentricity and ovality	
33.	Short circuit test	

14.9.5 Short Circuit Test

- Short circuit test on conductors shall be carried out on cables samples.
- During each short circuit test, the cable shall be subjected to thermal (rms) and dynamic (peak) short circuit current of specified duration.
- The test sample shall be subject to following tests before carrying out the short circuit test and after completion of short circuit test (when cable has cooled down to ambient temperature).
 - Conductor resistance measurement
 - High voltage test
 - Tan delta measurement

- Partial discharge measurement (for cables of 6.6 kV grade)
 - Volume resistivity.
- d) Before applying the short circuit current, the test sample shall be heated up to the specified maximum conductor temperature (70 deg C for PVC cables). This may be done by eddy current heating or by giving intermittent high current impulses as per the convenience of test station. After establishing specified conductor temp., the cable shall be subjected to short circuit test.

e) **Acceptance Criteria**

After the short circuit test the test specimen shall meet the following:

- i. No. Visual damage
- ii. HV Test
- iii. Pd test
- iv. Tan delta values as per standard
- v. Conductor resistance not more than $\pm 5\%$
- vi. Volume resistivity shall not be below the standard acceptance value.

14.9.6 Acceptance Test

Acceptance tests shall be carried out on each type and size of the cable on the cable drums selected at random.

The following shall constitute acceptance test:

- a) Annealing test
- b) Tensile test
- c) Wrapping test
- d) Resistance test
- e) Test for thickness
- f) Tensile strength and elongation test before aging and after aging
- g) Aging in air ovens
- h) Hot set test
- i) Insulation resistance test
- j) High voltage test
- k) Partial discharge test

- l) Measurement of eccentricity and ovality.

14.9.7 Routine Test

Routine test shall be carried out for each drum of cables of all type and sizes.

Following shall constitute routine tests:

- a) Resistance test
- b) Insulation resistance test
- c) High voltage test.

14.10 MAKE

All the cables shall be from experienced and reputed manufacturers, (as are approved by Employer) with proven experience in operation for power sub-stations and having capability to develop, test and timely supply cables as specified in the tender specification. The manufacturer shall have arrangements for carrying out all the tests including special tests such as flammability test, smoke generation test, HCL gas evaluation test as per the standards specified and have furnished satisfactory test results.

14.11 TECHNICAL PARTICULARS

TABLE-14.9.1

1.	L.T. POWER & CONTROL CABLES	Description
(a)	Size of Cable	As per requirement (given in the text)
(b)	Voltage rating	650/1100 V
(c)	Short circuit withstand for 1 sec.	13 kA/system requirement
(d)	Conductor for LT power cable	Copper
(e)	Conductor for control cable	Copper

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-15 **Illumination/Lighting System**

SECTION 4**CHAPTER – 15****ILLUMINATION/LIGHTING SYSTEM****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
15.0	SCOPE	1
15.1	STANDARDS	2
15.2	GENERAL REQUIREMENTS	3
15.3	TYPE AND DESCRIPTION	5
15.4	ACCESSORIES FOR LIGHTING FITTING	7
15.5	TYPE OF LIGHTING FIXTURES	12
15.6	EMERGENCY LIGHTING	12
15.7	WIRING OF LIGHTING FIXTURE AND RECEPTACLES	13
15.8	ROAD /STREET LIGHTING POLES	14
15.9	DRAWING & LITERATURE	14
15.10	INSPECTION OF TESTING	14
15.11	TECHNICAL PARTICULARS REQUIREMENTS	15

SECTION 4

CHAPTER - 15

ILLUMINATION/LIGHTING SYSTEM

15.0 SCOPE

- 15.0.1 These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, storage, transportation upto site, Testing & commissioning of lighting system comprising of lighting fixtures, complete with lamps supports & accessories, complete with distribution boxes, galvanized rigid steels/PVC conduits, lighting wires, earth wire, receptacles switch boards, switches, junction boxes, pullout boxes complete with accessories and emergency lightning in case of failure of L.T AC supply complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal.
- 15.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.
- 15.0.3 Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.
- 15.0.4 Components having identical rating shall be interchangeable.
The performance of the equipment shall be guaranteed as per **Section-5 – "Guaranteed and Other Technical Particulars"**. The bidder has to furnish the testing facilities available at the manufacturer's works.
- 15.0.5 The illumination levels in the switch yard, control room building, approach road etc. shall be as under:-
- (a) Normal Lighting

TABLE-15.0.5.1

S.No.	Particulars of locations	Average illumination level, 'Lux'
a.	Control Room	500
b.	Battery Room	200
c.	OPGW Communication Room	500
d.	Offices	500
e.	Outdoor switchyard	50
f.	Corridors	70
g.	Approach roads	20
h.	Path ways	50
i.	Store Room	100
j.	Toilets	100

15.0.6 The illumination design of outdoor switch yard, control room of the sub- station, approach road to the Sub Station and fencing etc. shall form the basis of lighting fixtures quantity. Illumination scheme shall be designed to ensure illumination intensity of 50 Lux in the outdoor switchyard. The luminaire offered shall be suitable for mounting on the switchyard structure/lighting tower.

15.0.7 Suitable number of power sockets along with plugs shall be supplied for the control room and in the switchyard for misc. uses such as for welding sets, transformer filtration sets, heaters etc.

15.0.8 Contractor shall provide the NEA one set of Lux & Glare measuring instruments.

15.1 STANDARDS

15.1.1 The lightening equipments / accessories shall comply with the latest edition of following Nepal/Indian/International standards: -

TABLE-15.1.1.1

IS 694	1490 PVC insulated cables for working voltage up to and including 1100 Volts.
IS 1534	Ballast's for fluorescent lamps part-I for switch start circuits
IS 1554	1488 PVC insulated (Heavy-duty) electric cable for working voltage up to and including 1100 volts.
IS 1569	Capacitors for use in tubular fluorescent high-pressure mercury and low pressure Sodium vapour discharge lamp circuit.
IS 1777	Industrial luminaire with metal reflectors
IS 1413	General and safety requirements for luminaires Part- I Tubular fluorescent lamps.
IS 2215	Starters for fluorescent lamps
IS 2418	Tubular fluorescent lamps for general lightning service.
IS 8828	Circuit breakers for over current protection
IS 9974	High-pressure Sodium Vapour lamps

15.1.2 The Equipment and material meeting the requirement of Nepal/Indian or any other equivalent internationally recognized standards which ensure a quality equal or better than the Nepal/Indian standard mentioned above shall also be acceptable. Where the equipment conforms to any other standards then salient points of difference between the standards adopted and those prescribed in this specification shall be clearly brought out in the bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

15.2 GENERAL REQUIREMENTS

15.2.1 The fittings shall be designed for continuous trouble free operation under atmospheric conditions as specified without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather proof and rain proof types.

- a) The fittings shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps / starters etc.
- b) Connections between different components shall be made in such a way that they will not get loose by small vibration.
- c) The utilization for each type of lighting fitting in terms of proportion of the light emitted by the bare lamps which falls on the working plane shall be furnished.
- d) All fittings shall be supplied complete with lamps suitable for operation on the supply voltage including permissible variations.
- e) The fittings and accessories shall be designed to have low temperature rises and the temperature rise above the ambient temperature shall be as indicated in the relevant standards.
- f) All mercury Vapor and Sodium vapor lamp fittings shall be complete with accessories like lamps, ballasts, power factors improvement capacitors, starters, igniters wherever applicable etc. These shall be mounted as far as possible in the fitting assembly only. If these cannot be accommodated inside, then a separate metal enclosed box shall be included to accommodate the accessories in addition to a MCB and a terminal block suitable for loop – in / loop – out connections. Outdoor type fitting shall be provided with outdoor type weather – proof box.
- g) All LED/CFL fitting shall be complete with all accessories.
- h) Each fitting shall have a terminal block suitable for loop- in / loop out and T – off connection by 650 / 1100 V, 3 core, PVC insulated Cu conductor cable of not less than 2.5 sq. mm size unless otherwise specified. Each fitting shall be complete with the internal wiring by means of stranded copper wire and terminated on the terminal block.
- i) The mounting facility and conduit knock- out for the fixture shall be as specified and shall be suitable for 20 mm or higher size conduit entry.

- j) All hardware used in the luminaire shall be suitably plated or anodized and passivated for use in the substation.
- k) Each lighting fitting shall be provided with an earthing terminal suitable for connection to an earthing conductor.
- l) All metal or metal enclosed parts of the housing shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity throughout the fixture.
- m) All surface of the fitting shall be thoroughly cleaned and degreased. The fittings shall be free from scale, rust, sharp edges and burrs.
- n) The housing shall be stove – enameled / epoxy stove enameled – vitreous enameled or anodized as indicated in the specification of the relevant fixture.
- o) When enamel is specified, it shall have a minimum thickness of 2 mills for outside surface and 1.5 mills inside surface. The finish shall be non- porous and free blemishes, blisters and fading.
- p) The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 ° over 12 mm dia mandrel.
- q) The finish of the fittings shall be such that no bright spots are produced either by direct light source or by reflection.

15.3 TYPE AND DESCRIPTION

15.3.1 Decorative Type Fittings

Decorative fluorescent fitting shall be provided with mounting / housing channel cum reflectors of CRCA sheet steel, stove enameled. Diffusers or louvers shall be provided, as required. Diffuser shall be of translucent white opal acrylic or depending upon the type of fitting. Fitting shall be suitable for the number of lamps of specified wattage, for directly mounting on ceiling / conduit suspended or for recess mounting in false ceiling, as specified. Decorative incandescent fitting when required, should be suitable for 60/100/150 W lamps, suspended or recess mounting in false ceiling. The fitting for recess mounting shall be provided with

copper anodized finished cylinder, ceiling mounting ring and translucent acrylic crystal ring.

15.3.2 Industrial Type Fittings

15.3.2.1 These fittings shall be suitable for use with incandescent / fluorescent / mercury vapour lamps as per requirements and generally as described below.

15.3.2.2 The angle or cut for fittings with filament lamp shall not exceed 70 degree and for fittings with fluorescent tubes shall not exceed 79 degree. The distribution of light shall be such that at least 80 % of the total luminous flux from the fitting shall be in the lower hemi-sphere.

15.3.2.3 Florescent lamps to be mounted in the false ceiling so as to form a continuous luminous ceiling, shall have an inside reflector of non fluorescent power neoprene gasket and wire guards as stated in above item.

15.3.3 Flood Lighting Fittings

15.3.3.1 Flood lighting weather proof fittings for illuminating outdoor yards, buildings and structures, the fittings shall be suitable for use with or up to 500 watts, HPSV lamps. In case of HPSV lamps, weather – proof, anti-corrosive painted completely wired box shall be provided to house the ballast, capacitors and fuse gear and provided with cable glands for cable entry. The housing and connector box of the fittings shall be of cast aluminium with pre-wired lamp holder and a cable box at the bottom provided with cable gland of brass. The reflector shall be of anodized, mirror polished aluminum. Heat resistant, toughened clear glass cover and necessary neoprene gaskets to make the unit weather proof shall be provided. A cast – iron base shall be provided for fixing the flood light to any structure or building. Fittings shall be capable of being rotated in both horizontal and vertical and plane and locked in any desired position. For focusing purposes, focusing knobs shall be provided on the housing to obtain desired light span.

15.3.3.2 The above flood lights shall be suitable for medium beam / long range narrow beam as per requirement.

15.3.4 Post Top Lantern Type

Post top mounting fittings for illumination of walkways, entrances to buildings and fencing of switchyard shall be provided. The fitting shall be suitable for 80 W HPSV lamps. The control gear for the HPSV lamp shall be mounted integrally in the fitting. The pole mounting piece and the canopy shall be of aluminum and finished with corrosion proof paint. The diffuser bowl shall be of opal acrylic sheet. Neoprene gasket shall be provided for weather proofing the fittings.

15.3.5 Street Lighting Fittings

15.3.5.1 Street lighting fittings shall be suitable for Sodium Vapor lamps, and shall be of the cut off, Semi cut off or non – cut –off type as specified. The fitting shall be of the top entry / side entry / post top / suspension type.

15.3.5.2 The size of threads, length of threads, socket bores of various types of fittings shall comply with relevant standards specified.

15.3.5.3 The fittings shall be designed such that the glare value is controlled below an acceptable level. The light distribution patterns of cut-off, semi-cut and non cut- off fitting shall be as per relevant standards specified.

15.3.5.4 The required control gear such as ballast and capacitor shall be provided integral with the fitting. The housing shall be of cast aluminum stove – enameled and provided with anodized, mirror or polished aluminum reflectors. The covers shall be provided for sealing the unit for outside atmosphere.

15.4 ACCESSORIES FOR LIGHTING FITTING

15.4.1 Reflectors

15.4.1.1 The reflectors shall be made of CRCA sheet steel or aluminum indicated for above mentioned fittings in the bill of quantities.

15.4.1.2 The thickness of steel / aluminum shall comply with relevant standards specified. Reflectors made of steel shall have stove enameled/ vitreous enameled / epoxy coating finish. Aluminum used for reflectors shall be anodized / epoxy stove enameled / mirror polished. The finish for the reflector shall be as indicated for the

above mentioned fittings. Aluminum paint on the reflectors of flame – proof lightening fitting is prohibited. Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflection coefficient such as to ensure the overall light output specified by the manufacturer. Reflector shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

15.4.2 Lamp / Starter Holders

15.4.2.1 Lamp holders shall comply with relevant standards. They shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with in normal installation and use.

15.4.2.2 Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the holder shall not be exposed during insertion or removal of the lamp or after the lamps has been taken out.

15.4.2.3 The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position. Lamp holders for incandescent and mercury vapor lamps shall be of bayonet type up to 100 W and Edison Screw type for higher wattage lamps.

15.4.2.4 Starter holders for fluorescent lamps shall conform to the standards specified. All material used in the construction of the holder shall be suitable for tropical use.

15.4.2.5 The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of with outstanding the shocks met within normal transit, installation and use.

15.4.3 Ballasts

- 15.4.3.1 The ballasts shall be designed, manufactured and supplied in accordance with IS: 3021 and other relevant standards. The ballasts shall be designed to have a long service life and low power loss.
- 15.4.3.2 Ballasts shall be mounted using self-locking, anti-vibration fixing and shall be easy to remove without demounting the fittings. They shall be in dusting and non-combustible enclosures.
- 15.4.3.3 The ballasts shall be of the inductive, heavy duty type, filled with thermo- setting, insulating, moisture repellent polyester compound filled under pressure or vacuum. Ballasts shall be provided with tappings to set the voltage within the range specified. End connections and taps shall be brought out in a suitable terminal block, rigidly fixed to the ballast enclosure. The ballast wiring shall be of copper wire. They shall be free from hum. Ballasts, which produce humming sound, shall be replaced free of cost by the vendor.
- 15.4.3.4 Separate ballasts for each lamp shall be provided in case of multi - lamp fittings, except in the case of 2x20 watt fittings. Only electronic ballasts shall be acceptable.

15.4.4 Starters

Starters shall have bimetal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamp and without the use of any tool. Starters shall have brass contacts and radio interference capacitor. The starters shall generally conform to the relevant standards.

15.4.5 Capacitors

The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits. The capacitors shall be suitable for operation at supply voltage and shall have a value of capacitance so as to correct the power of its corresponding lamp circuit to the extent of 0.95 lag or better. The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnation and ingress of moisture.

15.4.6 Lamps

15.4.6.1 The fluorescent lamps shall be 'Day – light color' type unless otherwise specified

15.4.6.2 They shall be provided with features to avoid blackening of lamps ends.

15.4.6.3 Mercury vapor lamps shall be of high pressure, colour corrected type.

15.4.6.4 Sodium vapour lamp shall be colour corrected type with screwed caps.

15.4.6.5 The constructional features of gas discharge lamps for special applications such as for instant start fluorescent lamps if specified shall be clearly brought out in the bid.

15.4.6.6 The lamps shall be capable of withstanding small vibrations and the connections at lead in wires and filaments / electrodes shall not break under such circumstances.

15.4.6.7 Lamp/Tube shall conform to relevant standards and shall be suitable for supply voltage and frequency specified.

15.4.7 Miniature Circuit Breakers (MCB)

15.4.7.1 The MCB's shall be of reputed make and the characteristics of MCB shall be suitable for control & protection circuit equipments of high pressure mercury vapor / sodium lamps / fluorescent tubes & plug points etc. MCB shall be hand operated, air break, quick make, quick break, conforming to applicable standards mentioned.

15.4.7.2 The outgoing MCB's shall be provided with overload / short circuit device for protection under overload and short circuit conditions. The MCB shall conform to IS- 8828 (latest edition) and shall have an interrupting rating of 9 kA. MCB shall be flush mounted and fitted on Zinc chromium plated M.S channel provided in DB construction. Single pole MCB's shall be provided for all outgoing A.C feeders.

15.4.8 Three Pin Sockets Receptacles

15.4.8.1 Decorative sockets of rating 6A & 16 A and industrial type of rating 32 A & 63 A receptacle units with switch of approved make shall be supplied and installed. Three pin sockets shall be of reputed make and having metallic contacts designed for engagement with corresponding plug pins and arranged for connections to fixed wiring. The sockets shall be of flush type and shall be provided with means for mounting in a socket outlet box. The material of the socket base shall be tough, non insulating material.

15.4.8.2 The socket outlets shall be so designed and constructed so that a pin or plugs do not establish live contact unless properly inserted. The current carrying socket contact shall be sunk below the surface of the socket outlet in a way as to make it impossible for them to be touched unintentionally. The mechanism for screening live and neutral contacts automatically shall be designed to ensure positive operation of shutters when plug is withdrawn from a socket outlet. The shutters shall not operate without insertion of the earthing pin to the socket outlet. MCB's shall be mounted on Zinc chromium plated M.S channel provided in the construction.

15.4.9 Name Plate

Name plate shall be made of non – rusting metal or engraved on PVC shall be of size 50mm x 20 mm indicating the feeders details shall be provided for all feeders for easy identification. Further, name plate indicating DB No. etc. shall be provided.

15.4.10 Switch Boxes

- a) Switch boxes shall be made of 1.6 mm thick, MS sheet with 3 mm. thick decorative, Bakelite / Perspex cover. Switch box shall be hot dip galvanized provided with earthing terminal, mounting holes and screws, specified number of conduit knockouts on both the sides and shall be suitable for surface / flush mounting.
- b) Switches shall be Piano key type single pole, quick make/quick break, suitable for operation on 240 V AC supply. It shall be reputed make subject to owner's approval.
- c) Sockets shall be of 3 pin type, suitable for 240 V AC supply and 450 V for 3 phase supply.
- d) Terminal blocks provided for all incoming and outgoing wires shall be of 650 V grades, moulded in melamine suitable for looping in and looping out of stranded copper wires used.

Note: The maker of above items shall be as approved by purchaser during detailed engineering.

15.5 TYPE OF LIGHTING FIXTURES

15.5.1 The type of lighting fixtures to be used in the indoor / outdoor areas with their type designation is given below:

TABLE-15.5.1.1

AREA	TYPE OF FIXTURE
a) Control Room	Decorative fluorescent lamp lighting fixtures surface / false ceiling mounting type, complete enclosed acrylic, control gear, mounting accessories and with 2 x 40 W/ 2x20 W fluorescent lamps.
b) Entrance	Water proof and splash proof totally enclosed lighting fixture with clear glass cover suitable for surface mounting, complete with internal wiring, control gear, mounting accessories and with 4' – 2x40 watts fluorescent lamps.
c) Battery Room	Corrosion resistant acid vapor proof lighting fixture suitable for surface mounting complete with internal wiring, control gear mounting accessories with 4' x – 2x40 watts fluorescent lamps.
d) Outdoor switchyard & road	HPSV Lamps
e) Toilets	Industrial fluorescent lamps lighting fixtures suitable for surface / mounting complete with internal wiring, mounting rail , vitreous enameled sheet steel reflector, Control gear, mounting accessories and with 4 ft 1x 40 watts fluorescent lamps.

15.6 EMERGENCY LIGHTING

15.6.1 Emergency lighting shall be considered on the following areas / rooms with corrosion resistant vapour proof lighting fixture suitable for surface mounting complete with internal wiring with 1x 60 W incandescent lamp suitable for 110 V DC.

TABLE-15.6.1.1

	Normally 'ON'	Total
a. Control Room	4	4
b. Communication room	1	1
c. Battery Room	1	1
d. Gallery/Lobby	1	1
e. Office block & Engineers room	2	2
f. Entrance	1	1
g. Corridor	1	1
h. reception	1	1
i. Store Room	1	1

15.6.2 Emergency lights will normally work on 110 V DC batteries. Facilities to switch off “Normally ON” lights individually may be considered.

15.7 WIRING OF LIGHTING FIXTURE AND RECEPTACLES

15.7.1 Area wise lighting fixture shall be controllable individually by use of single pole decorative type switch, which in turn will be fed from the outgoing circuit of sub-lighting panel. The lighting circuits will be wired with stranded copper conductor run in-side 20 mm dia. PVC conduits. The conduits will be concealed mounted with support span of min. 750 mm. Suitable GI junction boxes shall be provided as required. The internal wiring with heavy duty PVC pipes & fitting is recommended as GI conduits may get rusted in the long run. All the metal parts of junction holder shall be earthed by earth conductor not less than 14 SWG green coloured insulated copper conductor.

15.8 ROAD /STREET LIGHTING POLES

- 15.8.1 The street light poles of 8m height shall be steel tubular poles complete with fixing brackets and junction boxes mounted 1 m above ground.
- 15.8.2 The galvanized sheet steel junction box for the street lighting pole shall be completely weather proof conforming to IP: 55 poles with lockable door and with MCB. The terminal shall be stud type and suitable for 2 nos. , 16 mm² cable and double compression gland.
- 15.8.3 Wiring from junction box at the bottom of the pole to the fixture at the top of the pole shall be done by using 2.5 sq. mm copper cables.

15.9 DRAWING & LITERATURE

- 15.9.1 The contractors shall furnish the following
- Detailed illumination scheme for sub- station shall be submitted along with calculations for the approval of Employer.
 - Layout of luminaries in the control room and switchyard with light above ground & mode of fixing
 - No. of lamps fixture proposed with type & make.
 - Polar curves, utilization curve and catalogue for the same
 - Catalogue & literature of various luminaries.
 - Emergency DC lighting schemes in AC supply failure.

15.10 INSPECTION OF TESTING

The equipment and material shall be tested for routine tests as per relevant IS before dispatch. The bidder shall submit type test certificates for the test carried out on the similar equipment.

15.11 TECHNICAL PARTICULARS REQUIREMENTS**TABLE-15.11.1**

a.	Supply voltage	230 V
b.	Frequency	50 Hz
c.	Variation of voltage	± 10%
d.	Variation of frequency	± 5%
e.	Combined voltage & frequency variation	± 10%
f.	Type of internal lighting wires	Copper wiring, P.V.C. insulated 1100 V grade.
g.	Conduit	14 mm, 25mm, 32mm and 63 mm PVC medium duty pipe
h.	Earthing wire	
	i. Material	Copper
	ii. Size	8 SWG GI
	iii. Light Points	16 SWG (stranded) with green colour insulation
	iv. Power Points	14 SWG (stranded) with green colour insulation
i.	Temperature rise	As per IS:10322 (Pt-4)
j.	Lighting fixtures & accessories panel	As per IS:8623 (Part-1)

Note:

- PVC conduit & fittings shall be of fire resistant & non-inflammable type.
- All wiring shall be of 99.9% electrolytic copper of reputed make approved by purchaser.
- For emergency light the fittings shall be suitable for 110 V D.C. systems.

- d) No fuses shall be used. Instead of its MCB's/ MCCB's as appropriate of proper short circuit level should be used.
- e) To have aesthetic look the junction boxes, switches, etc. shall be of the same manufacturer. Similarly MCBs and distribution box shall also be of the same manufacturer.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-16 **Civil Works**

CHAPTER – 16

CIVIL WORKS

CONTENTS

SI. NO.	DESCRIPTION	PAGE NO.
16.0	GENERAL	1
16.1	SCOPE OF WORK	3
16.2	GENERAL AND SPECIFIC TECHNICAL REQUIREMENTS	5
16.3	DOCUMENTS FOR APPROVAL	42
16.4	EXPERTISE STAFF AND LABOUR	44
16.5	CONSTRUCTIONAL PLANTS	44
16.6	PROGRAMME FOR EXECUTION OF WORKS	44
16.7	ACCESS TO SITE AND LAND FOR TEMPORARY WORKS	44
16.8	SAFETY OF EXISTING SERVICES	45
16.9	PROTECTION OF MATERIALS FROM WEATHER	46
16.10	ARRANGEMENT OF WATER DURING CONSTRUCTION	46
16.11	CONSTRUCTION POWER	46
16.12	SANITATION AND PUBLIC HEALTH	47
16.13	STORAGE SPACE AND SHEDS	47
16.14	OFFICE OF CONTRACTOR AND EMPLOYER/PMC	47
16.15	REMOVAL OF CAMPS	47
16.16	APPOINTMENT OF SAFETY SUPERVISOR	48
16.17	SETTING OUT OF WORKS	48
16.18	GEOTECHNICAL INVESTIGATIONS	48
16.19	TOPOGRAPHICAL SURVEY	56
16.20	SITE LEVELLING AND FORMATION OF TERRACES	56
16.21	SLOPE PROTECTION WORKS	58
16.22	CATCH DRAINS	59
16.23	EXCAVATION	59

SI. NO.	DESCRIPTION	PAGE NO.
16.24	ANTIQUITIES	61
16.25	REMOVAL OF SURPLUS EXCAVATED MATERIAL	61
16.26	MATERIAL FOR FILLING/BACKFILLING	62
16.27	BACKFILLING OF EXCAVATION	62
16.28	SAND FILLING	62
16.29	COMPACTION	63
16.30	ANTI-TERMITE TREATMENT	63
16.31	DAMP PROOFING COURSE	64
16.32	CONCRETE WORK	65
16.33	CONSTRUCTIONAL TOLERANCES	76
16.34	FORMWORK, SHUTTERING AND STAGING	77
16.35	REINFORCEMENT	81
16.36	MASONRY WORK	84
16.37	PLASTERING	92
16.38	WATER PROOFING COMPOUND	95
16.39	FLOORING, SKIRTING AND DADO WORKS	95
16.40	STRUCTURAL STEEL TRUSS ROOF	111
16.41	FALSE CEILING	117
16.42	POWDER COATED ALLUMINIUM DOORS AND WINDOWS	119
16.43	PAINTING	120
16.44	PLINTH PROTECTION WORKS	124
16.45	BITUMINIOUS ROAD WORK	124
16.46	OPEN SURFACE DRAINS	125
16.47	CHEQUERED STEEL PLATE COVERS	125
16.48	CHAIN LINK FENCING	126
16.49	STEEL GATES	127
16.50	WATER SUPPLY, PLUMBING AND SANITARY WORKS	128
16.51	CAST IRON SOIL, WASTE AND VENT PIPES AND FITTINGS	133

SI. NO.	DESCRIPTION	PAGE NO.
16.52	BRICK /STONE MASONRY MANHOLES	136
16.53	SEPTIC TANK	136
16.54	SOAK PIT	136
16.55	ANTI-WEED TREATMENT AND STONE SPREADING	137
16.56	SUPPLY AND LAYING OF R.C.C. NON-PRESSURE RIPES	139
16.57	QUALITY ASSURANCE, FIELD TESTING AND CHECKING PLAN	139
16.58	MODE OF MEASUREMENT AND PAYMENT	143

CHAPTER –16

CIVIL WORKS

16.0. GENERAL

16.0.1. These Specifications cover the detailed engineering covering planning, design and preparation of all construction drawings; the supply of all materials, labour, fuel, construction plant & machinery and execution of all civil works required for successful commissioning of 220/132/33 kV substations at Tumlingtar and Basantapur and 220/33 kV Substation at Baneshwar in Nepal. The works shall include (i) Site development works covering topographical survey of identified substation sites and preparation of contour maps; geotechnical/soil investigations at each substation Site; site leveling and the formation of required number of terraces as per topography of site which shall include excavation in all types of soils, soft & hard rock, the filling required for site levelling and/or formation of terraces and disposal of surplus earth; construction of R.C.C retaining walls between the terraces; construction of stone masonry retaining/breast walls for hill slope protection; the construction of R.C.C./Stone masonry catch drains etc; (ii) construction of foundations for gantry towers/columns, lightening/lighting masts, equipment supporting structures, transformers, all other structures/equipments; (iii) construction of R.C.C. Fire Protection Wall & Oil collecting Pits including drainage of oil from transformer soak pits to central oil collecting pit with necessary manholes; (iv) construction of R.C.C. Rail-cum-Road for handling of transformers; (v) construction of control room building, D.G. Set Room building and stores with all necessary finishes, fittings & fixtures and including water supply, sanitary works, electrical works, lighting, air conditioning, firefighting arrangements etc; (vi) construction of R.C.C. Cable trenches with precast R.C.C. covers; (vii) construction of stone/brick masonry drains including the disposal of surface runoff water; (viii) Construction of chain link fencing; (ix) all internal roads and culverts;(x) laying of earth mat etc. as shown in the tender drawings attached in Section-6 of Part-2 of Specifications and as listed in the Bill of Quantities and all other civil works required for successful commissioning of substations.

16.0.2. The entire work under this contract shall be carried out in accordance with these

specifications and provisions and relevant clauses of the Specification for Building & Road works issued by the Central Public Works Department (CPWD), Ministry of Urban Development, Government of India as well as specification and guidelines of Department of Building and Department of Road, Government of Nepal. The relevant Codes of Practice including all amendments, additions and correction slips issued by Bureau of Indian Standard up to one month (i.e. 30 days) prior to prescribed date of submission of bids shall be considered applicable in this contract. The Schedule of Quantities and Rates and tender drawings shall form the part of this Contract. In case of any discrepancy, most stringent provision shall be followed with the approval of Employer.

- 16.0.3.** All civil works shall satisfy the general technical requirements specified herein under in subsequent clauses. All civil structures, buildings, foundations and other facilities shall be designed to the service conditions and loads specified elsewhere in this Specification or implied as per relevant Indian Standards/ equivalent International Standards.
- 16.0.4.** All civil works shall be designed and executed as per applicable Indian Standards/ equivalent International Standards and Codes. All materials shall be of best quality conforming to relevant Indian Standards/ equivalent International Standards and Codes.
- 16.0.5.** The Contractor shall prepare all designs and construction drawings and shall furnish all materials, labour, tools, equipment, constructional plant & machinery, fuel, transportation and all other incidental items not shown or specified but as may be required for execution of civil works in accordance with this specifications, approved construction drawings and direction of Employer/PMC.
- 16.0.6.** The works shall be carried out according to the design/drawings to be developed by the Contractor and approved by the Employer/PMC. For all buildings, structures, foundations etc., the necessary layout and details shall also be developed by the Contractor keeping in view the functional requirements of the substation and providing enough space and access for operation and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only.
- 16.0.7.** All references given herein are intended solely for the information and guidance of the contractor and shall in no way exclude the application of other clauses of the contract documents which, in the opinion of Employer/PMC, may affect the contract.

16.1. SCOPE OF WORK

16.1.1. The work to be carried out under these specifications shall include but not limited to the following works:

- (a) Detailed engineering including planning, design and preparation of all construction drawings and execution of all civil works required for 220/132/33 kV substations at Tumlingtar and Basantapur and 220/33 kV substation at Baneshwar;
- (b) To carry out topographical survey at each substation site and preparation of contour maps on specified scale & contour interval;
- (c) Carrying out geotechnical/soil investigations at each substation site for ascertaining the soil strata likely to be encountered and determining all necessary engineering properties of soil strata required for design of foundations, site development works, construction of roads etc.;
- (d) Carrying out site development work at each substation site including site leveling and formation of required number of terraces as per topography of site for locating the various facilities and components of substation which shall include excavation in all types of soils including soft & hard rock; filling with selected excavated earth for levelling & formation of terraces, compacting the filled up earth to specified density; and disposal of surplus earth; construction of R.C.C retaining walls between the terraces; construction of stone masonry retaining/breast walls on hill side of terraces for slope protection; and construction of R.C.C./Stone masonry catch drains etc.
- (e) Construction of foundations for gantry towers/columns, lightening/lighting masts, equipment supporting structures, transformers and all other structures & equipments;
- (f) Construction of R.C.C. Fire Protection Walls between transformers and construction of Central Oil Collecting Pits including underground drainage arrangement of oil from transformer soak pits to central oil collecting pit by laying R.C.C. pipes of prescribed size & quality and constructing necessary manholes etc.;

- (g) Construction of Substation Control Room-cum-Administrative building, D.G. Set Room building, Stores/Warehouses, Car Scooter parking shed with all finishes, fittings & fixtures including water supply, sanitary works, electrification & lighting, air conditioning, firefighting facilities etc including anti termite treatment. Control Room Building and other specified areas shall be provided with air conditioning to maintain prescribed temperature and humidity level. Control Room Building shall be two storied building in which ground floor shall be used for cable laying and first floor for installation of Control & Rely Panels, A.C. & D.C. Distribution boards, Batteries, Electric Workshop, Communication Equipments, Stores and other auxiliary facilities etc. Administrative block shall be a single storey building in continuation of Control Room building and shall have rooms for Officers and staff, conference room, Pantry, Reception Area, Gent's & Lady's Toilets etc. A tentative layout of Control Room-cum-Administrative building is shown in tender drawing attached in Section-6 of Part-2 of Specifications for the information and guidance of bidders. The said drawing is tentative and purely indicative and in no way final drawing. The layout of said building shall be prepared by Contractor after award of work to meet the requirements of this specifications and concerned substation and as approved by Employer/PMC.
- (h) Construction of R.C.C. Cable Trenches with R.C.C. precast covers including providing suitable crossing arrangements for cable trenches at the crossings of drains & roads and providing all necessary embedment like plates, angles etc in cable trenches for laying the cables. Edges of cable trenches and R.C.C. precast covers shall be protected against damage during laying of cables and during placing/ removal of precast R.C.C. covers by providing edge protection angles as shown in tender drawings attached in Section-6 of Part-2 of Specifications.
- (i) Construction of stone/brick masonry drains for drainage of substation and disposal of surface runoff water to any nearby natural drain/stream/river including providing necessary culverts at road crossings;

- (j) Construction of R.C.C. road-cum-rail track, Jacking pads, pulling blocks etc required for handling of transformers during installation, removal & maintenance;
- (k) Construction of all internal bituminous roads;
- (l) Finishing the yard by providing anti weed treatment and laying of stone metal after construction of all foundations, cable trenches, drains etc
- (m) Providing chain link fencing around switchyard with lockable steel gates of appropriate sizes, one for equipment and other for operational & maintenance personnel;
- (n) The execution of all necessary water supply, sanitary and area drainage works;
- (o) The execution of all necessary electrical wiring and installation of all lighting and other fittings & fixtures;
- (p) Any other work/works whether specified or not but required and necessary for successful commissioning of substations.

The above scope of work shall be read in conjunction with Section-1 of Part-2 of this specification and both are complementary to each other.

16.2. GENERAL AND SPECIFIC TECHNICAL REQUIREMENTS

- 16.2.1. Design Criteria for Civil Works:** The Contractor shall be required to prepare a detailed design criteria and basis for the design of all civil works required for substations including foundations, buildings, Road-cum-Rail track, internal roads, drainage, water supply, sanitary works and all other works in the scope of this specification bringing out the standards proposed to be used, the details of materials & loads, analysis & design methods and computer software proposed to be used and all other relevant details in conformity with this specification and related Indian Standards and submit the same to Employer/PMC for approval. The design of civil works shall be taken up only after having the approval of aforesaid design criteria & basis from Employer/PMC.
- 16.2.2.** The Contractor shall also prepare detailed proposals for geotechnical investigation, topographical survey and site levelling works including formation of terraces in conformity with this specification and related Indian Standards for the approval of Employer/PMC

bringing out details of works proposed to be carried out and methodology proposed to be used. These works shall be taken up only after the approval of aforesaid proposals by Employer/PMC.

16.2.3. Geotechnical Investigation

16.2.3.1. The Contractor shall carry out detailed geotechnical investigation at each substation site as per these specifications and related Indian Standards to arrive at sufficiently accurate, general as well as specific information about the soil profile, necessary soil parameters of the Site including engineering properties of soils required for (i) planning and design of site development works; (ii) safe and rational design and construction of foundations of the various buildings, structures and equipments and (iii) design of internal roads.

16.2.3.2. Geotechnical/Soil investigation at each substation site shall be carried out up to a depth of two times the expected maximum width of any foundation below foundation level or up to 12 m below ground level whichever is more. In case of pile foundations, the soil investigation shall be carried out up to a minimum depth of 20 meter below ground level or as per the expected length of pile whichever is more.

16.2.3.3. A detailed soil report including field data duly certified by site engineer of Employer/PMC shall be submitted by the Contractor for specific approval of Employer/PMC. The report shall contain all soil parameters including engineering properties of soils along with recommendations of Geotechnical Consultant for type of foundation, soil parameters & engineering properties of soil including safe/allowable bearing capacity of soil, soil treatment, if any, required for site development works, the design and construction of foundations and design of roads etc.

16.2.3.4. The Bidder may visit the substation sites to ascertain the site & soil conditions likely to be encountered during execution of works. Any variation in soil data shall not constitute a valid reason for any additional cost and shall not affect the terms & conditions of the contract. Field tests must be conducted covering entire substation area including all the critical locations i.e. Control Room-cum-Administrative Building, Lightning/Lighting Masts, Gantry Tower/column locations, transformers etc.

16.2.4. Topographical Survey

16.2.4.1. A preliminary topographical survey of each substation site has been carried out by the

Employer and contour maps prepared. The preliminary layout of each substation has been superimposed on contour map drawings and these drawings are attached in Section-6 of Part-2 of Specifications for the information and guidance of Bidders. However, the Employer does not take any responsibility for correctness of these drawings and any interpretation or conclusion drawn by bidders there from. The successful bidder shall be required to carry out topographical survey and prepare contour map of each substation site after award of work and the same shall form the basis of all works.

16.2.4.2. The land for construction of substations shall be handed over to the successful bidder as on where basis after award of work. The contractor shall carry out topographical survey at each substation site covering the entire area of substation and 100 m beyond substation plot and also all nearby important features like existing roads, foot tracks, natural streams, rivers, houses etc and prepare contour map on 1 : 1000 scale with 0.5 contour interval. Since contour map shall be the basis of estimation of quantities of excavation and filling required for site development work, 0.50 m contour interval shall be maintained and only for very steep topography, 1.0 m contour interval may be adopted with the approval of Employer/PMC.

16.2.4.3. The spot levels shall be taken in a grid of 3 m x 3 m as well as at all such points where there is a sudden change in levels. The spot levels shall be taken with respect to a temporary bench mark established by contractor at substation site by transferring the levels from a permanent bench mark of Survey Department of Nepal available near to substation site.

16.2.4.4. The contractor shall submit the spot levels (in grid format) in editable soft copy in excel format along with contour map of each substation site on 1 : 1000 scale with contour interval of 0.5/1.0 m in editable auto cad soft drawing as well as in hard copies for each substation.

16.2.5. Site Levelling & Formation of Terraces

16.2.5.1. Based on preliminary topographical survey of each substation site, the Employer has tentatively finalized the levels and nos. of terraces at each substation site and the same are given tender drawings attached in Section-6 of Part-2 of Specifications for the information and guidance of Bidders. The levels and nos. of terraces as given in tender

drawings are purely tentative and in no way final. These details shall be finalized by successful bidder in consultation and with the approval of Employer/PMC after award of work based on topographical maps prepared by him.

16.2.5.2. The contractor shall level the area required for construction of substation either at a single level or multiple levels depending upon the topography of site and space requirement for each substation and also ensuring minimum requirements of earth work during site levelling and formation of terraces. The number of terraces and their levels at each substation site shall be finalized by contractor in consultation and with the approval of Employer/PMC after completion of topographical survey of substation sites and preparation of contour maps and taking into account the requirement of earthwork for site levelling and formation of terraces and highest flood level. The proposal in this regard shall be submitted by the Contractor for the approval of Employer/PMC. The work of site levelling and formation of terraces shall be taken up only after approval of related drawings by the Employer/PMC.

16.2.5.3. The proposal of site levelling and formation of terraces shall be approved by the Employer/PMC during detailed Engineering stage after finalization of layout of substations and completion of work of topographical survey & preparation of contour maps.

16.2.6. Layout & Levels of Structures

16.2.6.1. The layout and levels of all structures shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by him and approved by Employer/PMC. The Contractor shall provide all assistance in terms of instruments, materials and personnel to Employer/PMC for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

16.2.7. Drainage of Substation

16.2.7.1. The Contractor shall carry out overall planning and design of both external & internal storm water drainage system for each substation including development of layout, designs and drawings of all drains including all culverts, connection of internal drains to the outfall point located outside the substation boundary wall. Invert level of drainage system at outfall point shall be decided in such a way that the water from internal drains can be easily discharged outside the substation boundary wall by gravity. Outfall point shall be

got approved from Employer/PMC before commencement of construction. While designing the drainage system, the following points shall be taken care of:

- (a) The drainage system for each substation shall be designed for one hour rain fall intensity of 25 years return period.
- (b) The surface of the switchyard shall be sloped towards drains to prevent accumulation of water.
- (c) Drains shall be constructed at suitable locations in such a way that substation is not flooded and roads are not affected due to accumulation of surface runoff water. In the substation, the maximum spacing between two drains shall not be more than 100 meter. It shall be ensured that no area is left un-drained.
- (d) Open surface drains shall have a minimum clear width (i.e. Inner) of 300mm and a minimum depth of 300mm depth at their starting points. The depth of drain shall be measured with respect to ground level of substation i.e. from bottom of switchyard stone filling.
- (e) Longitudinal slope of drains shall be kept not less than 1 in 1000.
- (f) Open surface drains shall be constructed with brick masonry or stone masonry as per the site condition. A 100 mm thick layer of 1 : 2 : 4 Plain Cement Concrete (1 cement : 2 Fine Aggregates : 4 Coarse Aggregates of 20 mm nominal size) shall be laid at the bottom of all drains over a 75 mm thick layer of Lean Concrete of proportion 1: 3 : 6 (1 cement: 3 Fine Aggregates : 6 Coarse Aggregates of 20mm nominal size). Before laying the lean concrete layer, the earth below shall be thoroughly compacted for ensuring that there is no loose pocket below drain.
- (g) The last course of brick masonry in drain walls shall be with brick on edge.
- (h) A concrete coping of 50 mm thick plain cement concrete of 1 : 2 : 4 (1 cement : 2 Fine Aggregates : 4 Coarse Aggregates of 20 mm nominal size) proportion shall be provided at top of all masonry drains for the protection of masonry.
- (i) All internal and exposed surfaces of drains shall be plastered with 15 mm thick 1 : 4 cement – sand plaster (1 Cement : 4 Coarse Sand)

- (j) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 1000 mm spacing in drain walls above ground level with suitable mild steel grating for drainage of water from stone metal layer.
- (k) The maximum velocity of water in open stone/brick masonry drains and pipe drains shall be limited to 1.80 m/sec and 2.4m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured and maintained in all drains.
- (l) Pipe drains shall be provided in areas of switchyard where movement of crane will be necessary during operating phase of the substation.
- (m) Concrete (R.C.C.) pipes of class NP-3 conforming to IS:458 shall be provided for pipe drains as well at road crossings for culverts. However, for rail crossings, R.C.C. pipes of class NP-4 conforming to IS:458 shall be provided. The internal diameter of pipes shall not be less than 450 mm. For the design of R.C.C. pipes for drains and culverts, relevant Indian Standards/equivalent International Standards shall be followed.
- (n) Pipe drains shall be provided with manholes at the spacing of not more than 30.0 m.
- (o) If the invert level of outfall point is above the invert level of last drain in the substation boundary, the sump of suitable size shall be constructed within the substation boundary and auto start pumps of adequate capacity shall be provided to pump out the water from sump to natural drain so as to ensure that there is no flooding of switchyard..
- (p) The drainage scheme and associated drawings shall be got approved from Employer/PMC before commencement of construction.

16.2.8. Road-cum-Rail Tracks and Internal Roads

- 16.2.8.1.** All the road-cum-rail tracks and internal roads as shown in the layout drawing of the substations enclosed in Section-6 of Part-2 of Specification are in the scope of this

specification. However, the exact length and requirements of road-cum-rail tracks and internal roads shall be finalized during detailed engineering based on approved layout of each substation. While planning and designing the road-cum-rail track and internal roads, the following points shall be taken care of:

- (a) Road-cum-rail track and internal roads shall be designed for the load of heaviest transformer in the substation. Designs shall be carried out as per relevant Indian Standards as well as Standards of Indian Road Congress and Department of Roads of Government of Nepal.
- (b) R.C.C. Jacking Pads of required size shall be provided in Road-cum-Rail Track at all turning points where the direction of transformer wheels is required to be changed during the installation or removal of transformer. Concrete pulling blocks of necessary capacity shall also be provided for handling of transformer during installation or removal.
- (c) The road from main gate of Substation to Control Room Building shall be 5.0 m wide bituminous road. All other internal roads within substation boundary wall shall be 3.75 m wide bituminous road. In addition, all roads shall have 1.2 m wide shoulder on either side of the road.
- (d) Minimum two layer of Water Bound Macadam (WBM) of thicknesses as per design requirements shall be provided under all roads including Road-cum-Rail Track over a prepared sub grade.
- (e) Strengthening or widening of existing roads as applicable shall be carried out with 2.5 cm thick premix carpet over a 100 mm thick (minimum) or as per design requirement, whichever is more, compacted layer of WBM (Water Bound Macadam) after filling the pot holes of existing roads with WBM material. Widening of existing roads, if required, shall be carried out as per specification of new roads.
- (f) Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Transformer shall be as short and straight as possible.

- (g) All culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed as per relevant Indian Standards/ equivalent International Standards for the load of heaviest transformer. All drawings of roads, culverts and allied structures shall be prepared by the contractor and submitted to Employer/PMC for approval.

16.2.9. Transformers Foundation and Road-cum-Rail Track

- 16.2.9.1.** The Contractor shall design, prepare construction drawings for the foundations of transformers and shall provide a R.C.C. Road-cum-Rail Track integrated with the Transformer foundations to enable installation and the replacement of any transformer unit. The road-cum-rail track system shall be suitable to permit the movement of any transformer unit fully assembled (including OLTC, bushings) with oil and shall enable the removal of any transfer unit from its foundation to the nearest road. If crossings of cable trench/drain are required, suitably designed pipe or box R.C.C. culverts shall be provided as per requirement and site conditions in accordance with relevant Indian Standards/ equivalent International Standards.
- 16.2.9.2.** Each Transformer including oil conservator tank and cooler banks etc. shall be placed on R.C.C. walls in soak pit. The clear distance of the pit walls (inner face of wall) from the Transformer's outer most faces shall be 20% of the Transformer height or 1.0 m whichever is more. The oil soak pit thus formed shall have a capacity equal to 200% volume of total oil contained in transformer of 220 kV voltage level and 130% for 132 kV or lower voltage level transformers. The walls of oil soak pit shall project 150 mm above the finished level of the switchyard so as to avoid outside water entering into the soak pit. The bottom of the soak pit shall have a uniform slope towards the sump pit. While designing the oil soak pit, the movement of the transformer shall be duly considered and taken into account in the design.
- 16.2.9.3.** The gratings for transformer soak pits shall be made of MS flat of size not less than 40 mm x 5mm placed at 30mm center to center and MS flat of minimum size of 25mm x 5mm placed at spacing of 150mm center to center, both placed at right angle to each other. The sizes of flats shall be as per design requirement and sizes specified above are the minimum sizes. Maximum length of grating shall be 2000mm and width shall not be more

than 500mm. The gratings shall be supported on structural steel beams of size not less than ISMB 150mm, which shall be supported on soak pit walls and pedestals to be raised from soak pit bottom as per design requirement. A 300 mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm shall be laid over gratings, which shall act as barrier to fire and an extinguisher for flaming oil. All structural steel components and steel gratings shall be hot dip galvanized.

16.2.9.4. Each soak pit shall be provided a sump pit of minimum size 600 mm x 600 mm and 300 mm deep in one corner and soak pit floor shall be sloped towards this sump pit for easy drainage of oil & rain water from soak pit to central oil collecting pit so that soak pit remains dry.

16.2.9.5. One or more central oil collecting pits, at a suitable location, shall be provided which shall act as main disposal tank for all adjoining transformer soak pits. The individual soak pit of transformers shall be drained into central oil collecting pit by providing a pipe line with minimum 300 mm diameter R.C.C. Pipes of NP-3 Class from transformer soak pits to central oil collecting pit. Manholes shall be provided as per requirement but spacing of manholes shall not be more than 30 m.

16.2.9.6. The transformer foundation including soak pit, road-cum-rail track and central oil collecting pits shall be of reinforced cement concrete construction and shall be designed as per relevant Indian Standards/equivalent International Standards and these specifications.

16.2.9.7. A pump of adequate capacity shall be supplied and installed by the Contractor to evacuate the rain water and oil from the central oil collecting pit.

16.2.9.8. Central Oil Collecting Pit shall be provided 900 mm high railing for safety of personnel.

16.2.10. Fire Protection Walls

16.2.10.1. Fire protection walls shall be provided between two transformer units located in close proximity for fire safety of transformers in accordance with modern engineering practice and Local Advisory Committee (LAC) recommendations. The fire protection walls shall be of R.C.C. construction. While designing the fire protection walls, the following aspects shall be duly taken care of:

16.2.10.2. Fire Resistance: The fire protection wall shall have a minimum fire resistance of 3 hours. The partitions, which are made to reduce the noise level, shall have the same fire

resistance. The walls of the building, which are used as fire protection walls, shall also have a minimum fire resistance of 3 hours.

16.2.10.3. The fire protection walls shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

16.2.10.4. Dimensions: The fire protection wall shall extend not less than 1000 mm beyond transformer's outer most faces and its cooling bank and 1000 mm above the conservator tank or safety vent. A minimum clearance of 2.0 meter shall be provided between the equipments e.g. Transformer and fire protection walls. The building walls, which act as firewalls, shall extend at least 1.0 m above the roof in order to protect the building against fire.

16.2.10.5. Materials: The fire protection wall shall be made of reinforced cement concrete as per the relevant Indian Standards/ equivalent International Standards.

16.2.11. Indoor Transformers

16.2.11.1. For indoor installation of oil filled transformers, the transformers of rating of more than 75 kVA shall be located in a vault. Transformer vaults shall have a minimum fire resistance rating of 3 hours but where transformers are protected by water spray, Halogen or Carbon dioxide systems, vaults of 1 hour rating is adequate.

16.2.11.2. A trapped floor drain shall be provided which discharges burning oil to a safe location. A fire resistant door and a noncombustible curb at least 100 mm high shall be provided at each doorway. Switchboards etc. shall be physically separated from the vaults and the latter should never be used as offices, filling cabinets, work rooms, etc.

16.2.11.3. Adequate ventilation shall be provided in the transformer vault. Self-controlled transformer shall be separated by 600 to 750 mm (minimum) to permit free air circulation.

16.2.12. Foundations and other R.C.C. Constructions

16.2.12.1. General Requirements

- (i) The work covered under this clause comprises the design, preparation of construction drawings and construction of foundations and other R.C.C. constructions for substation gantry towers/columns, lightening/lighting masts, bus supports, equipment supports, transformers, jacking pads, pulling blocks, fire protection walls, control cubicles, marshaling kiosks, auxiliary equipments,

- construction of Control Room-cum-Administrative building, D.G. Set Room building, Underground Water Storage Tank, R.C.C. cable trenches, Car/Scooter Parking shed or any other facility or foundation required for successful commissioning of substations. This clause is also applicable to the other R.C.C. constructions.
- (ii) All foundations except for external lighting poles shall be of reinforced cement concrete construction. The external lighting pole shall be embedded in plain cement concrete of proportion 1:2:4 (1 Cement : 2 Fine Aggregates : 4 Coarse Aggregates) to the designed depth. The design and construction of R.C.C. structures shall be carried out as per relevant Indian Standards.
 - (iii) The grade of structural concrete for all foundations, structures, buildings and all load bearing members shall be design mix concrete of M-25 grade conforming to IS:456 and these specifications or equivalent International Standards. Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the Employer/PMC.
 - (iv) All tests on concrete shall be conducted as per relevant Indian Standards/ equivalent International Standards.
 - (v) The plinth of switchyard foundations and buildings shall be kept not less than 300mm and 500 mm above finished ground level respectively.
 - (vi) A layer of lean concrete 1 : 3 : 6 (1 Cement : 3 Fine Aggregates : 6 Coarse Aggregates of 20 mm nominal size) of 100 mm thickness shall be provided below all foundations, underground structures, trenches etc to provide a levelling course and a base for construction.
 - (vii) The design of foundations shall be based on the approved soil data, sub-soil conditions and safe/allowable bearing capacity of soil as well as for all possible critical loads and the combinations thereof. The foundations either shallow spread footings or raft foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.
 - (viii) If pile foundations are needed, the same shall be cast-in-situ bored or under reamed pile type as per relevant Indian Standards/ equivalent International

Standards. Only R.C.C. cast-in-site bored piles shall be provided. Suitability of the adopted type of pile shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the contractor at his own cost to establish the pile design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

16.2.12.2. Foundation Depths

- | | | | |
|-----|--|---|--------|
| (a) | Minimum depth of Foundations for Gantry Towers and Lightning/Lighting Masts | : | 2.0 m |
| (b) | Minimum depth of Foundations for Equipment Supporting Structures | : | 2.0 m |
| (c) | Minimum depth of Foundation for VCB/SF6 | : | 2.0 m |
| (d) | Minimum depth of Foundation for Control Room -cum-Administrative & D.G. Set Room Buildings | : | 2.0 m |
| (e) | Minimum depth of Foundation for Fencing Posts and Minor Structures | : | 0.75 m |

16.2.12.3. Design Requirements for Foundations and other R.C.C. Structures: While designing foundations and R.C.C. structures, the following points shall be taken care of:

- (a) Dead Loads, Live/Imposed Loads, Wind Loads, Snow Loads and Special Loads and Load Combinations, as applicable, shall be considered as per IS:875 (Part-I to Part V) until and unless specified otherwise in this specification.
- (b) **Snow Loads:** Substation at Basantpur is located at an altitude of more than 2500 m and experiences snow fall during winter. Accordingly, snow load shall be duly considered in the design of buildings and all other facilities at this substation. Other substations are located on lesser altitudes and don't experience snow fall

- during winter. No snow load shall be required to be considered in the design of structures at these substations.
- (c) **Seismic Loads:** Seismic load shall be considered as per IS:1893 corresponding to Zone-V. It shall be ensured that seismic loads to be considered in designs are not less than the seismic loads corresponding to earthquake occurred in Nepal in April, 2015.
- (d) Limit state method of design as per relevant Indian Standards or any other method as per equivalent International Standards subject to the approval of Employer/PMC shall be adopted.
- (e) Cold twisted deformed bars of grade Fe-415 or Fe-500 conforming to relevant Indian Standards/ equivalent International Standards shall be used for reinforcement.
- (f) Two layers of reinforcement (on inner and outer face) shall be provided in walls & slab sections (like cable trenches, underground water tank etc) as well as in foundations irrespective of design requirements irrespective of design requirement. The minimum reinforcement as per IS:456 or equivalent International Standards shall be provided in cases where there is no design requirement.
- (g) Clear cover to reinforcement shall be as per relevant Indian Standards/equivalent International Standards. However, it shall not be less than 50 mm for foundations and 25 mm for underground structures like cable trenches, underground water tanks and similar other structures.
- (h) The detailing of reinforcement in foundations and R.C.C. structures shall be carried out as per relevant Indian Standards/equivalent International Standards.
- (i) R.C.C. water retaining structures like water storage tanks etc shall be designed as un-cracked section in accordance with relevant Indian Standards/ equivalent International Standards. However, cable trenches/storm water drains etc shall be

- designed as cracked section with limited steel stresses as per relevant Indian Standards/ equivalent International Standards.
- (j) The foundations and other R.C.C. structures shall be designed for all the critical combination of loads as per the relevant Indian Standards/equivalent International Standards. Detailed design calculations and drawings of foundations and other R.C.C. structures shall be submitted by the contractor to Employer/PMC for approval.
 - (k) Design of foundations and other R.C.C. structures shall consider any sub-soil water pressure that may be encountered.
 - (l) Necessary protection to the foundations and underground structures, if required as per the findings of soil investigation, shall be provided to take care of any special requirements for aggressive soils or sub soil water or both, black cotton soil or any other type of soil which is detrimental/harmful to the concrete or reinforcement steel.
 - (m) R.C.C. columns shall be provided with rigid connection at the base with column footings.
 - (n) All substructures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be as specified in relevant Indian Standards/ equivalent International Standards or as stipulated elsewhere in these Specifications. For checking against overturning, weight of soil vertically above the footing only shall be considered.
 - (o) Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest or co-efficient of active or passive earth pressure, whichever is applicable. However, for the design of substructures of any underground enclosures, earth pressure at rest shall be considered.
 - (p) In addition to earth pressure and sub soil water pressure etc, a surcharge load of 2.0 ton/m^2 shall also be considered for the design of all underground structures

- including cable trenches, sumps, underground water tanks, drains, substructure of any underground hollow enclosure etc for taking care of the vehicular traffic in the vicinity of the structures.
- (q) Following conditions shall be considered for the design of water tank, cable trenches, sumps, drains/trenches and other underground structures:
- (i) Full water pressure from inside and no earth pressure & sub-soil water pressure and surcharge pressure from outside.
 - (ii) Full earth pressure, surcharge pressure and sub-soil water pressure from outside and no water pressure from inside.
 - (iii) Design shall also be checked against buoyancy under empty condition due to sub-soil water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.
- (r) Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with ground water table (GWT) at highest possible level. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.
- (s) Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with GWT at highest possible level. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.
- (t) The foundations shall be proportioned so that the estimated total and differential settlement of the foundations are not greater than the settlements that the structure or equipment is designed to accommodate.
- (u) The tower and equipment foundations shall be checked for a factor of safety as per relevant Indian Standards/ equivalent International Standards for two conditions i.e. Normal condition and Abnormal condition (i.e. either with short circuit forces

- or earthquake forces whichever is more critical) against sliding, overturning and pullout.
- (v) Thickness of footing slab shall not be less than 250 mm for dry locations and 300 mm for wet locations.
 - (w) The thickness of wall of underground tanks, sumps etc shall not be less than 250 mm.
 - (x) Diameter of main reinforcement bar in foundations, water tanks, sumps etc shall not be less than 12 mm and in floor/roof slabs not less than 10mm.
 - (y) Thickness of floor/roof slabs shall not be less than 150 mm

16.2.13. Cable Trenches and Cable Trench Crossings

While designing cable trenches and their crossings, the following points shall be taken care of:

- (a) The cable trenches and pre-cast removable R.C.C. cover (with lifting arrangement) shall be constructed using RCC of M-25 grade as per relevant Indian Standards/ equivalent International Standards.
- (b) The cable trench walls shall be designed for the following loads:
 - (i) Dead load of 155 kg/m length of cable support + 75 Kg on one tier at the outer edge of tier.
 - (ii) Earth pressure + uniform surcharge pressure of 2.0 ton/m².
- (c) Cable trench covers shall be designed for self-weight of top slab + concentrated load of 150 kg at center of span on each panel.
- (d) Thickness of cable trench walls and base slab shall not be less than 150 mm and diameter of reinforcement bars shall not be less than 10 mm.
- (e) Necessary sumps shall be provided for collecting water from cable trenches and each sump shall be provided with pumps of suitable capacity. These pumps shall be supplied and installed for pumping out water collected in sump pit.
- (f) Cable trenches shall not be used as storm water drains.

- (g) The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trenches shall be such that the surface run off rainwater does not enter into the cable trenches.
- (h) Edge Protection Angles of size 45x45x5 mm with lugs shall be provided for edge protection in cable trenches and their precast covers for protection of edges/corners against breakage.
- (i) All metal parts inside the trench shall be connected to the earthing system.
- (j) Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.
- (k) The trench bed shall have a slope of 1/500 along the run and 1/250 perpendicular to the run.
- (l) Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:4 cement sand mortar.
- (m) Cable trench crossings shall be designed for critical load likely to be passed over the crossing. The cable trench crossing may be of either RCC box culvert type or RCC Hume pipes embedded in plain concrete as per design requirement and approved by Employer/PMC.
- (n) In case of pumping of water from cable trench sump pits to nearest storm water drain becomes necessary, auto start pump shall be provided at each sump pit.

16.2.14. Control Room- cum-Administrative Building

16.2.14.1. General Requirements:

- (a) The work includes detailed design & engineering and construction of Control Room-cum-Administrative Building including anti-termite treatment, DPC, plinth protection, peripheral drains, water supply, plumbing, sanitary and civil works required for firefighting, electrification, air conditioning etc.
- (b) The size of control room building shall be finalized by taking into account the present requirements as well as future expansion (i.e. nos. of bays in the scope of this specification and bays to be added in future).
- (c) The Control Room-cum-Administrative Building shall be a double storey R.C.C.

Framed structure with R.C.C Roof.

- (d) The control Room Building shall be so designed and oriented so that whole of outdoor switchyard is visible from the Control Room Building. The ground floor of control room shall be used for cable laying and first floor for installation of control & relay panels and locating other auxiliary equipments & facilities like batteries, A.C. & D.C Distribution boards, Communication Equipments, Electrical Workshop, Stores etc.
- (e) Administrative block of building shall be a single storey R.C.C. framed structure with R.C.C. roof and shall have rooms for engineers and staff, conference, pantry, reception, gents & lady's toilets etc.
- (f) As substation at Basantpur lies in snow fall area, snow load shall also be considered in the design in addition to other loads.
- (g) The auxiliary services like air conditioning, fire protection and detection system and all other miscellaneous services shall be provided in accordance with the requirements as specified in relevant section of this specification.
- (h) The building shall be constructed as per the design and drawings to be developed by the contractor and approved by Employer/PMC.
- (i) A tentative layout and size of Control Room-cum-Administrative Building for each substation is shown in the tender drawings attached in Section-6 of Part-2 of Specifications. The size and details shown in the tender drawings are tentative and indicative only and for the purpose of information and guidance of bidders. However, its size and details shall be finalized by the contractor with the approval of Employer/PMC during detailed engineering stage.
- (j) The layout of the panels in the Control Room shall be decided based on the manufacturer's drawings during detailed engineering by successful bidder in consultation and with the approval of Employer/PMC.

16.2.14.2. Design Requirements: While designing the Control Room-cum-Administrative building, it shall be ensured that it meets the following requirements:

- (a) the requirements of the relevant Indian or equivalent International standards and this specifications;

- (b) the specified climatic and loading conditions;
- (c) the requirements of the equipments and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy;
- (d) functional and economical space arrangement;
- (e) To be aesthetically pleasing;
- (f) different buildings shall show a uniformity and consistency in architectural design as far as possible;
- (g) To allow for easy access to the equipments as well as maintenance of the equipments;
- (h) Wherever access to the roof is required, R.C.C. stair case shall be provided.
- (i) Fire retarding materials which shall prevent supporting or spreading of fire and wherever required, shall be provided for walls, ceilings, doors etc.
- (j) Expansion joints, wherever required, shall be provided as per relevant standards.

16.2.14.3. Design Loads

- (i) Building structure shall be designed for the most critical combinations of dead loads, live loads, super-imposed loads, equipment loads, erection loads, wind loads, snow loads, seismic loads etc. Any other incidental load, if anticipated, shall also be duly accounted for in the design and shall be clearly mentioned. All the members of the buildings frame shall be designed for the worst combination of loads as per relevant Indian Standards/ equivalent International Standards.
- (ii) Dead loads shall include the weight of structures complete with finishes, fittings & fixtures and partitions and shall be taken as per relevant Indian Standards/ equivalent International Standards.
- (iii) Super-imposed loads in different areas shall include live loads, equipment loads, and loads due to cable trays, small pipe racks/hangers and erection, operation and maintenance, wherever these loads are expected. Equipment loads shall constitute

all loads of equipments to be supported on the building frame. The following superimposed loads shall be considered:

TABLE-16.1
SUPERIMPOSED/LIVE LOADS

Sl. No.	Area	Load
(1)	(2)	(3)
1.	For Offices& Stores	5 kN/m ²
	If higher than 5 kN/m ² (Based on requirement, especially for stores)	As per actual Requirement.
2.	For Equipment Floors	10 kN/m ²
	If higher than 100 kN/m ² (Based on Equipment Weight and Layout Plans)	As per actual Requirement.
3.	Staircases & Balconies	5 kN/m ²
4.	Toilets	2 kN/m ²
5.	Chequered Plate Covers	4 kN/m ²
6.	Corridors/Walkways	3 kN/m ²
7.	Accessible Roofs	1.5 kN/m ²
8.	Non-accessible Roofs	0.75 kN/m ²

- (iv) Wind loads shall be calculated as per relevant Indian Standards/ equivalent International Standards. The Factors affecting the wind speed shall be taken based on the site conditions.
- (v) Earthquake loads shall be calculated as per IS: 1893/equivalent International Standards and considering the earthquake intensity of earthquake experienced in Nepal in April, 2015. Seismic coefficient Method or Response spectrum method

shall be used for seismic analysis of the building for Earthquake forces as per IS: 1893 or equivalent International Standards.

- (vi) Wind forces and Seismic forces shall not be considered to act simultaneously.
- (vii) The load combinations that create maximum stresses in structure shall be considered as per relevant Indian Standards/ equivalent International Standards.
- (viii) Floors Slabs shall be designed to carry loads imposed by equipments, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, building shall be designed for live loads as specified above or loads specified in relevant Indian Standards/ equivalent International Standards whichever is higher. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

16.2.14.4. Walls and Floor/Roof Slabs

- (a) All walls shall be non-load bearing walls, in brickwork as per this specification. Minimum thickness of external walls shall be 230 mm (one brick) thick with cement sand mortar 1:6 (1 Cement: 6 Coarse Sand). Internal Partition walls in Administrative building, wherever shown in approved drawings, can be of 115 mm thick (half brick) brick masonry wall in cement sand mortar 1:4 (1 Cement : 4 Coarse Sand).
- (b) All Floor/Roof slabs shall be regular beam - slab construction. However, sunken R.C.C. slab shall be provided in toilet areas as per the requirement. The minimum thickness of floor and roof slab shall not be less than 150 mm.
- (c) False ceiling in Control Room-cum-Administrative building shall be provided as per requirement and directed by Employer/PMC.
- (d) Minimum height of skirting above finished floor level shall be 150 mm. The skirting material shall match with the floor finish.
- (e) The dado in toilets, pantry room and battery room shall be upto ceiling height.
- (f) Minimum height of the parapet walls shall be 750 mm above finished roof level.

- (g) Floor finish at ground floor shall be laid over 100 mm thick plain cement concrete 1:3:6 (1 cement : 3Fine Aggregates : 6Coarse Aggregates) below which a 100 mm thick layer of well compacted local sand shall be provided. The earth below sand layer shall also be well rammed and well compacted before laying sand layer.

16.2.14.5. Details of Roof

Roof of the building shall consist of cast-in-situ R.C.C. slab treated with a water proofing system which shall be an integral cement based treatment conforming to relevant Indian Standards/ equivalent International Standards. The water proofing treatment shall comprise the following:

- (a) Applying a cement slurry coat of neat cement using 2.75 kg/m^2 of cement admixed with water proofing compound conforming to relevant Indian Standards/ equivalent International Standards over the R.C.C. slab including cleaning the surface with wire brushes and keeping the cleaned surface wet for 24 hours before treatment.
- (b) Laying cement concrete using broken stone of size from 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with water proofing compound conforming to relevant Indian Standards/ equivalent International Standards over 20mm thick layer of cement mortar 1:5 (1 Cement: 5 coarse sand) admixed with water proofing compound conforming to relevant Indian Standards/ equivalent International Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions of walls and slabs.
- (c) After two days of proper curing, applying a second coat of cement slurry admixed with water proofing compound conforming relevant Indian Standards/ equivalent International Standards.
- (d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement : 4 coarse sand) admixed with water proofing compound conforming to relevant Indian Standards/ equivalent International Standards and finally finishing

the surface with trowel with neat cement slurry and making of 300 x 300 mm square.

- (e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All the above operations shall be carried out in order specified above and as directed by the Employer/PMC.
- (f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

16.2.14.6. Partitions: Partitions wherever provided in approved drawings, shall be made of powder coated aluminum frame with 5.5 mm thick clear glass or pre-laminated board depending upon the location of partition and as directed by Employer/PMC.

16.2.14.7. Plastering: External surfaces of buildings shall have 18 mm thick cement – sand plaster in two layers, with the under layer of 12mm thick plaster in 1:5 cement sand mortar (1 Cement : 5 Medium Sand) and the top layer 6.0 mm thick plaster in 1:4 cement sand mortar (1 Cement : 4 Fine Sand). Inside faces of walls shall be provided 12mm or 15 mm thick cement – sand plaster in 1:4 cement sand mortar (1 Cement : 4 Fine Sand). Rough faces of walls shall receive 15mm thick cement sand plaster and even faces, 12 mm thick cement sand plaster. All R.C.C. ceilings shall be provided with 6.0 mm thick cement – sand plaster in 1:3 cement sand mortar (1 cement : 3 Fine sand).

16.2.14.8. External Painting: External surfaces of the Control Room Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of Employer/PMC

16.2.14.9. Doors, Windows and Ventilators: The schedule of doors, windows and ventilators of the Control Room-cum-Administrative Building shall be as per the detailed finishing schedule in Table 16.2 and shall conform to the relevant Indian Standards/ equivalent International Standards. Rolling Steel Shutters shall be provided as per the layout and requirements of the building. Main entrance door to control room building shall be made of powder coated aluminum frame with 5.5 mm thick glazing.

16.2.14.10. Cable Trench inside Control Room Building: All cable trenches inside the Control Room Building, if any, shall be covered with minimum 6.0 mm thick steel chequered plate covers

stiffened with suitable size of stiffeners.

16.2.14.11. Plinth Protection: 750 mm wide plinth protection around the building shall be provided.

Plinth protection shall comprise 100 mm thick plain cement concrete 1:2:4 (1 cement : 2 Fine Aggregates : 4 Coarse Aggregates of 20 mm nominal size) laid over 75 mm thick well compacted stone aggregates of 40 mm nominal size with interstices filled with local sand.

16.2.14.12. Plumbing & Sanitation:

- (a) All plumbing and sanitary works shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters, these specifications and relevant Indian Standards/ equivalent International Standards. The Contractor shall arrange for all necessary formalities to be met with regards to the inspection, testing, obtaining approval and giving notices etc.
- (b) 'SINTEX' or an equivalent make PVC Overhead Water Tank(s) of adequate capacity depending on the number of users for 24 hours storage of water shall be provided. However, a minimum of 2 nos. of 1500 liter capacity tanks shall be provided. PVC Overhead tanks shall conform to relevant Indian Standards/ equivalent International Standards.
- (c) Chlorinated Polyvinyl Chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading conforming to relevant Indian Standards/ equivalent International Standards shall be used for internal piping works for water supply.
- (d) C.I. pipes with lead joints conforming to relevant Indian Standards/ equivalent International Standards shall be used for sanitary works above ground level and R.C.C. pipes shall be used for sanitary works below ground level.
- (e) Separate toilets for ladies and gents shall be provided. Common Toilet in Administrative Block shall have separate block for ladies and gents with separate entrances. Ladies Block shall have one ladies toilet with western type of WC and Gents Block shall have two WC, one with western type of WC and other with Indian type of WC with all other fitting & fixtures specified above.

- (f) Each toilet shall have the following minimum fittings:
 - (i) One WC (Western type) 390 mm high along with toilet paper roll holder and all other fittings in gents and ladies toilets;
 - (ii) Common Gent's Toilet in Administrative Block shall have a minimum two WC, one with WC (Western type) 390 mm high and other with WC (Indian Type) along with toilet paper roll holder and all other fittings;
 - (iii) Gents toilet shall also have Urinals (430 x 260 x 350 mm size) with all fittings and built-in-sensor for automatic flush after use. Toilet attached to Conference Room and common toilet in Administrative block shall have a minimum two nos. of urinals and all other common toilet shall have one urinal.
 - (iv) Common Toilet and Toilet attached to Conference Room shall have two number of Wash basin (550 x 400 mm) each with all fittings. Other toilets shall have one wash basin of same size with all fittings.
 - (v) Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing shall be provided with all washbasins.
 - (vi) CP brass towel rail (600 x 20 mm) with CP brass brackets by the side of each wash basin.
 - (vii) Soap holder and liquid soap dispenser with each wash basin.
 - (viii) One Automatic Hand Dryer in each toilet.
- (g) Water cooler for drinking water with adequate water storage facility shall be provided which shall preferably be located near the pantry room and away from the toilet block.
- (h) One no. of stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) shall be provided in pantry.
- (i) All fittings, fasteners, gratings shall be chromium plated conforming to relevant Indian Standards/ equivalent International Standards.

- (j) All sanitary fixtures and fittings shall be, in general, conforming to relevant Indian Standards/ equivalent International Standards and shall be of approved quality, type and make, manufactured by reputed manufacturers. All items brought to site must bear identification marks of the Manufacturer.
- (k) Contractor shall provide necessary nos. of septic tank and soak pit of adequate capacity to treat the sewage/sullage from the buildings.
- (l) Contractor shall undertake all other activities required to complete and commission the building.

16.2.14.13. Building Storm Water Drainage

- (a) The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.
- (b) Cast Iron Rainwater down comer pipes conforming to relevant Indian Standard / equivalent International standards with water tight lead joints shall be provided to drain off the rain water from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material. The number and size of down comer pipes shall be governed by relevant Indian Standards/ equivalent International Standards.
- (c) All drains inside the buildings shall have minimum 40 mm thick grating covers; and in areas where heavy equipment loads are envisaged, Pre-Cast R.C.C. covers shall be provided in place of steel grating.
- (d) Suitable arrangements for draining out water collected from equipment blow downs, leakages, floor washings, firefighting etc. shall be provided for each floor.

16.2.14.14. Detailed Finishing Schedule

The detailed finish schedule for Control Room Building-Cum-Administrative building is given below:

TABLE-16.2

**DETAILED FINISHING SCHEDULE
 (FOR CONTROL ROOM-CUM-ADMINISTRATIVE BUILDING)**

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
(1)	(2)	(3)	(4)	(5)	(6)
1.	Control Room	Vitrified tiles 8.0 mm thick of size 600 x 600mm	Plastic emulsion paint over prepared smooth surface by applying a 2.0 mm thick layer of Plaster of Paris	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5mm thick Glazing.
2.	Conference Room	Vitrified tiles 8.0 mm thick of size 600 x 600mm	Plastic emulsion paint over prepared smooth surface by applying a 2.0 mm thick layer of Plaster of Paris	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5mm thick Glazing.
3.	Executive/ Substation In-charge Room	Vitrified tiles 8.0 mm thick of size 600 x 600mm	Plastic emulsion paint over prepared smooth surface by applying a 2.0 mm thick layer of Plaster of Paris	White wash above False Ceiling*	Windows shall be of powder coated aluminum with 5.5mm thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5mm thick Glazing.
4	Office Rooms	Vitrified tiles 8.0 mm thick of size 600 x 600mm	Plastic emulsion paint over prepared smooth surface by applying a 2.0 mm thick layer of Plaster of Paris	White wash above False Ceiling*	Windows shall be of powder coated aluminum with 5.5mm thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5mm thick Glazing.
5.	Electrical/ Electronics Test Lab.	Vitrified tiles 8.0 mm thick of size 600 x 600mm	Plastic emulsion paint over prepared smooth surface by applying a 2.0 mm thick layer of Plaster	White wash above False Ceiling*	Windows shall be of powder coated aluminum with 5.5mm thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5mm

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
(1)	(2)	(3)	(4)	(5)	(6)
			of Paris		thick Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping. Skirting shall be of 1:3cement sand plaster.	Oil bound washable distemper on smooth surface applied with plaster of Paris putty	Oil bound washable distemper on smooth surface applied with plaster of Paris putty	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminum with 5.5mm thick glazing.
7.	Battery Room	Alkali and Acid Resistance Tile Flooring	DADO of Alkali and Acid Resistant tiles up to ceiling height	Alkali and Acid Resistance Paint	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminum with 4mm glazing.
8.	Reception/ Lobby	Vitrified tiles 8.0 mm thick of size 600 x 600mm	Plastic emulsion paint on prepared smooth surface by applying 2.0 mm thick layer of Plaster of Paris	Oil bound washable distemper on prepared smooth surface by applying 2.0 mm thick layer of Plaster of Paris	Windows shall be of powder coated aluminum with 5.5mm thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5mm thick Glazing.
9.	Corridor	Vitrified tiles 8.0 mm thick of size 600 x 600mm	Plastic emulsion paint prepared smooth surface by applying 2.0 mm thick layer of Plaster of Paris	Oil bound washable distemper on prepared smooth surface by applying 2.0 mm thick layer of Plaster of Paris	Windows shall be of powder coated aluminum with 5.5mm thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5mm thick Glazing.
10.	Portico	Cast-in-situ 52.0 mm thick. Cement concrete with metallic hardener.	Granite Stone Cladding	Oil bound washable distemper on prepared smooth surface by applying 2.0 mm thick layer of	All doors shall be glazed powder coated aluminium doors with 5.5mm thick Glazing.

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
(1)	(2)	(3)	(4)	(5)	(6)
				Plaster of Paris	
11.	Toilet	Ceramic tiles	DADO glazed tiles up to ceiling height	Oil bound washable distemper over prepared smooth surface by applying 2.0 mm thick layer of Plaster of Paris	Windows/ ventilator shall be of powder coated aluminum with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminum frame.

16.2.14.15. False Ceiling

The false ceiling shall be provided in Control Room, Conference Room and other specified areas.

16.2.14.16. Under Deck Insulation

50 mm thick insulation mat of Fiber Glass Crown - 100 or equivalent made out of fiber glass conforming to relevant Indian Standard/ Equivalent International Standard and backed with 34 gauge aluminum foil and 22gauge x 12mm wire mesh netting shall be fixed to ceiling in all air conditioned areas.

16.2.14.17. Electrification

All electrification works shall be executed as per details specified elsewhere in the technical specification & C.P.W.D. specification. All fittings & fixtures and details shall be as per relevant Indian Standards/ equivalent International Standards and shall be of approved make.

16.2.15. D.G. Set Room Building

16.2.15.1. General: The D.G. Set Room building shall be single storey reinforced cement concrete (R.C.C.) framed structure with R.C.C. roof. The work shall include design, engineering and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, electrification etc. of D.G. Set Room building. The building auxiliary services like internal

electrification, fire protection system etc shall be designed in accordance with the requirements as specified in other part/section of this Specification.

16.2.15.2. Area Requirements: A tentative size of D.G. Set Room Building is shown in tender drawing attached in Section-6 of Part-2 of Specifications for information of bidders. However, the dimensions of the building shall be decided by the contractor with the approval of Employer/PMC during detailed engineering stage depending upon the size of D.G. set and its auxiliary equipment like control panel, diesel storage tank etc, requirement of space for its maintenance and any other facility to be housed in the said building. A toilet of suitable size with WC, Washbasin and urinal shall be provided in similar way as specified for Control Room cum Administrative Building.

16.2.15.3. Design Criteria: Design basis of D.G. Set Room Building shall be same as for Control Room-cum-administrative building. In addition, it shall meet the following requirements:

- (a) The layout of building and facilities shall allow for easy access to the equipments as well as maintenance of the equipments.
- (b) G.I. ladder shall be provided for access to the roof.
- (c) The fire retarding materials shall be used for walls, ceilings, doors/windows/ventilators which shall prevent supporting or spreading of fire and shall be decided by the contractor and got approved from Employer/PMC.

16.2.15.4. Design Loads: Design Loads shall be same as for control room building. In addition, the following loads shall also be considered:

- (i) Floors shall be designed for a Live Load of 10 kN/m^2 and loads imposed during handing and maintenance of D.G. Set and any other load associated with the building. Loads imposed by Diesel Storage Tank, Cables and piping etc shall also be considered in addition to the specified live loads for floors.

16.2.15.5. Flooring: D.G. Set Room building shall be provided with Ironite Flooring. The flooring shall laid over 100 mm thick plain cement concrete (1:3:6) layer which shall be laid over a 100 mm thick compacted local sand filling and a layer of 300 mm thick well compacted stone packing (Stone Size from 25 mm to 100 mm) with interstices filled with local sand. The earth below floor shall be well rammed and compacted.

16.2.15.6. Plastering: The thickness of plaster and specifications shall be same as for Control Room-cum-Administrative building.

16.2.15.7. External Painting: It shall be same as for control room building.

16.2.15.8. Doors, Windows and Ventilators

The doors and roller shutters shall be of steel and windows/ventilators shall be of power coated aluminums as per relevant Indian Standard/ equivalent International standards. Rolling Steel shutter shall be provided for facilitating the installation and removal of D.G. set from D.G. Set Room building and its size shall be accordingly finalized. Main entrance door to the building shall be MS door frame with M.S. sheet single shutter of suitable size. Windows and ventilators shall be of powder coated aluminium and provided with 5.5 mm thick glazing.

16.2.15.9. Cable Trench inside D.G. Set Room Building: It shall be same as for control room building.

16.2.15.10. Plinth Protection: It shall be same as for control room building.

16.2.15.11. Parapet: 230 mm thick and 300 mm high brick wall parapet shall be provided. The both faces of parapet wall shall be plastered as specified for external faces of walls.

16.2.15.12. Building Storm Water Drainage: It shall be same as for control room building.

16.2.15.13. Details of Roof: It shall be same as for control room building.

16.2.15.14. Detailed Finishing Schedule: The detailed finish schedule for D.G. Room Building shall be as given below:

Table-16.3
DETAILED FINISHING SCHEDULE
(D.G. SET Room Building)

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL (INTERNAL)	CEILING	ROLLER SHUTTER, DOOR, WINDOWS & VENTILATOR

1.	D.G. Set Room Building	Cement Concrete flooring with 12 mm thick metallic hardener topping. Skirting shall be of cement sand mortar of proportion 1:3 (1 Part Cement :3 Part Sand).	Oil bound washable distemper	Oil bound washable distemper on smooth surface applied with plaster of Paris putty	Rolling shutter shall be of steel. Entry door shall be of steel single leaf door. Windows/ ventilators shall be of power coated aluminium sections with 5.5mm thick glazing.
----	------------------------	--	------------------------------	--	--

16.2.15.15. Electrification: It shall be same as for control room building.

16.2.16. Car Parking Shed

Aesthetically pleasant R.C.C. car parking shed shall be provided at suitable location near Control Room-cum- Administrative building to park 10 cars and 10 motorcycles/ scooters. The details shall be decided during detailed engineering stage.

16.2.17. Underground Water Storage Tank

16.2.17.1. A Reinforced Cement Concrete Underground Water Tank of 50 Cubic Meter Capacity shall be constructed for meeting the water requirement of substation. A sump of size 0.75 m x 0.75 m x 0.5 m deep shall be provided at one corner of tank. Top of water tank shall be about 300 mm above finished ground level of switch yard.

16.2.17.2. A steel hatch of size of not less than 600 mm X 600 mm shall be provided at top of tank at one corner for facilitating entry of maintenance staff inside the tank for its periodical cleaning and maintenance.

16.2.17.3. Suitable rubber coated MS rungs @ 300 mm centre to centre shall be provided on tank wall where steel hatch has been provided to act as ladder.

16.2.17.4. Integral water proofing compound of reputed brand shall be added to the concrete of water tank. Quantity of compound to be added in concrete shall be as per manufacturer's recommendation.

- 16.2.17.5.** Inside surfaces of water tank (i.e. floor and walls) shall be provided white glazed vitrified tiles of approved make.
- 16.2.17.6.** All inserts, nozzles, pipe sleeves etc shall be provided during concreting at suitable locations as per approved drawings.
- 16.2.17.7.** P.V.C. water stopper shall be provided at all construction joints of water tank.
- 16.2.17.8.** The design of water tank shall be carried out as an un-cracked section as per relevant Indian Standards/ equivalent International Standards.

16.2.18. Water Supply and Plumbing Works

- 16.2.18.1.** Water Source shall be identified by the Contractor. Employer/PMC may extent necessary assistance in this regard, if required by the contractor, but it shall remain the responsibility of the contractor. Contractor shall estimate the total water requirement both in terms of quantity and head and shall make necessary arrangement to bring water from source to substation site (i.e. to underground water storage tank). The whole arrangement shall be subject to the approval of Employer/PMC.
- 16.2.18.2.** The contractor shall carry out all the plumbing/erection works required for supply of water within substation to various buildings and facilities.
- 16.2.18.3.** A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall be got approved from Employer/PMC before actual start of work including all other incidental items not shown or specified but as may be required for complete performance of the works.
- 16.2.18.4.** The work shall, in general, shall be carried out as per C.P.W.D. specifications and relevant Indian Standards.

16.2.19. Sewerage Disposal System

- 16.2.19.1.** Sewerage system shall be provided for Control Room-cum-Administrative Building, D.G. Set Room Building and other facilities.
- 16.2.19.2.** The Contractor shall provide complete exterior sewerage disposal system including laying of soil pipes, necessary manholes, septic tank and soak pit suitable for 50 users. If septic

and soak pit system for sewerage disposal is not acceptable by local Nepalese Authorities, the contractor shall install sewerage system as per local statutory requirements.

16.2.19.3. The work shall, in general, shall be carried out as per C.P.W.D. specifications and relevant Indian Standards.

16.2.20. Miscellaneous General Requirements

16.2.20.1. All civil works, in general, shall be carried out as per C.P.W.D. specifications and relevant Indian Standards.

16.2.20.2. All Architectural designs & drawings of building including schedule of finishes shall be prepared by the contractor. These shall be as per local Nepalese practice. The landscaping of whole substation shall also be carried out and implemented by the contractor.

16.2.20.3. The materials and workmanship shall be of the best quality conforming to these specifications and relevant Indian Standard and shall be subject to the approval of the Employer/PMC. The word "to the approval of the Employer/PMC" shall be deemed to be included in the description of all materials incorporated in the Works, whether manufactured or natural, and also in the description of all operations for the due execution of the works.

16.2.20.4. All materials shall be of approved manufacturer and origin, matching with the samples and shall be delivered at the Site well in advance before they are to be used in the Works to enable the Contractor to take such samples as the Employer/PMC may require for testing before giving his approval. The Contractor shall provide any information required by the Employer/PMC regarding the quality, weight, strength, constituents, and description etc. of the materials.

16.2.20.5. No material of any description shall be used without prior approval by the Employer/PMC and any material rejected as unfit for use in the Works shall be removed immediately from the Site and without any compensation to the Contractor.

16.2.20.6. Dense concrete with controlled water cement ratio as per relevant Indian Standards/ equivalent International Standards shall be used for all foundations and concrete structures for achieving water tightness.

- 16.2.20.7.** All joints including construction and expansion joints for the water retaining structures shall be made water tight by providing PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be not less than 5 mm and minimum width shall be not less than 230 mm.
- 16.2.20.8.** All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti corrosive paint to take care of sea worthiness.
- 16.2.20.9.** All mild steel parts used in the water retaining structures shall be hot double dip galvanized. The minimum coating of the zinc shall be not less than 750gm/m² for galvanized structures and shall comply with relevant Indian Standards/equivalent International Standards. Galvanizing shall be checked and tested in accordance with relevant Indian Standards/equivalent International Standards. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with relevant Indian Standards or equivalent International Standards.
- 16.2.20.10.** A lean concrete layer of M-10 grade concrete of not less than 100 mm thickness conforming to relevant Indian Standards/equivalent International Standards shall be provided below all foundations, R.C.C. structures and floors at ground level.
- 16.2.20.11.** Bricks having minimum compressive strength of 75 kg/cm² shall only be used for masonry work. Contractor shall ascertain himself regarding the availability of bricks of minimum 75 kg/cm² compressive strength before submitting his offer. The contractor may use concrete blocks of equivalent compressive strength in place of brick work.
- 16.2.20.12.** Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with R.C.C. Sunshade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.
- 16.2.20.13.** The height of riser in stairs shall not be more than 150 mm and tread shall not be less than 300 mm wide. Minimum width of stairs shall be 1500 mm. Mid landing shall be provided after every 10 steps. Service ladder shall be provided for access to all roofs. Fire Escape

staircase, if required, as per local byelaws, shall be provided in control room building.

- 16.2.20.14.** Edge Protection Angles of size 45x45x5 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, supporting edges of manhole precast cover and any other place where breakage of edges/corners of concrete is expected.
- 16.2.20.15.** Anti termite chemical treatment for buildings shall be given to all column pits, wall trenches, foundations, filling below the floors etc. as per relevant Indian Standards / equivalent International Standards.
- 16.2.20.16.** Hand-railing of minimum 900mm height shall be provided around all floor/roof openings, projections/balconies, walk ways, platforms, stairs, underground tanks & sumps open to sky etc.
- 16.2.20.17.** For all civil works covered under this specification, design Mix concrete of minimum M-25 grade as per relevant Indian Standards / equivalent International Standards shall be used.
- 16.2.20.18.** Reinforcement steel shall be of grade Fe-415 or Fe-500 conforming to relevant Indian Standards/equivalent International Standards. The materials specification, workmanship and acceptance criteria shall be as per relevant clauses of applicable Indian Standards / equivalent International Standards
- 16.2.20.19.** Items/components of buildings not explicitly covered in the specification but required for completion of the project shall be deemed to be included in the scope.
- 16.2.20.20.** Requirement of Sulphate Resistant Cement (SRC) for sub structural works shall be decided based on sulphate/chloride contents in soil and subsoil water in accordance with relevant Indian Standards/equivalent International Standards based on the findings of the detailed soil investigation to be carried out by the contractor.
- 16.2.20.21.** Foundation system adopted by contractor shall ensure that total settlement, relative settlement and other criteria shall be as per provision in relevant Indian Standards / equivalent International Standards.
- 16.2.20.22.** All water retaining structures designed as un-cracked section shall also be tested for water

tightness at full water level in accordance with relevant Indian Standards/equivalent International Standards.

16.2.20.23. Construction joints shall be as per Indian Standards/equivalent International Standards.

16.2.20.24. All underground concrete structures like basements, pumps houses, water retaining structures etc. shall have plasticizer-cum-water proofing cement additive conforming to relevant Indian Standards/equivalent International Standards. The concrete surface of these structures in contact with earth shall also be provided with two coat of bituminous painting for water/damp proofing. In case of water leakage in the above structures, the rectification method shall be applied as per relevant Indian Standards/equivalent International Standards for repairing the leakage.

16.2.20.25. All building/construction materials shall conform to the best quality specified in relevant Indian Standards / equivalent International Standards.

16.2.21. Coordination & Interfacing

16.2.21.1. The proper coordination and all interfacing of civil works activities like fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedment, provision of cut outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to bare minimum.

16.2.22. Statutory Rules and Regulations

16.2.22.1. Contractor shall comply with all the applicable statutory rules and regulations pertaining to Factories Act, Fire Safety Rules & Regulations and Water and sewerage Act for pollution control etc. of Government of Nepal.

16.2.22.2. Provisions for fire proof doors, nos. of staircases, fire escape stairs, fire separation wall, plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Local Advisory Committee.

16.2.22.3. Statutory clearances and norms of Local Pollution Control Board shall be strictly followed

in design and construction of civil works and for effluent quality from plant.

16.2.23. Field Quality Plan

16.2.23.1. All tests as required in accordance to Indian Standards/ equivalent International standards shall be carried out. The contractor shall prepare field quality plan for civil works as per relevant Indian Standards/equivalent International Standards during detailed engineering stage and submit to Employer/PMC for approval within ONE month after award of work.

16.2.24. Trade Names

16.2.24.1. Trade Names and Catalogue References are given solely as a guide to the quality and alternative manufacturers of the materials or goods of equivalent quality may be approved by the Employer/PMC.

16.2.25. Samples of Materials

16.2.25.1. Samples of all materials shall be deposited with the Employer/PMC for approval prior to ordering or delivery to site. The Employer/PMC reserves his right to test any sample to destruction and retain samples until the maintenance period. No payment shall be made for supplying the samples to the Employer. All materials delivered at site shall be equal to or better in all respects than the samples approved by Employer/PMC.

16.2.26. Testing of Materials

16.2.26.1. For any material to be used in the Works, the Employer/PMC may direct contractor for carrying out any test which may be carried out at the place of manufacture or on the site or at an approved laboratory. The tests shall be required on soils, materials whether natural or manufactured and workmanship to verify their compliance with the Specifications. Samples of all such materials and manufactured articles together with all necessary labour, materials, plant and apparatus required for sampling and for carrying out tests shall be supplied by the Contractor at his own cost.

16.3. DOCUMENTS FOR APPROVAL

16.3.1. All documents including designs and drawings shall be submitted by the contractor for approval. A indicative but not exhaustive, list is given below for information and guidance:

- (a) Geotechnical/Soil Investigation Report;
- (b) Topographical Maps and related details;
- (c) Proposal for Site Levelling and Formation of Terraces
- (d) All Architectural drawings of buildings including schedule of finishes;
- (e) Structural design calculations, Structural drawings (including construction/fabrication), both in hard and editable soft copies, for all reinforced concrete and structural steel structures and foundations.
- (f) Fully dimensioned and detailed floor plans, elevations, cross-sections and longitudinal sections identifying the major building components for all buildings.
- (g) Product information of building components and materials, including walls, partitions, flooring, ceilings, roofing, doors, windows & ventilators, wall paneling and building finishes along with BOQ.
- (h) A detailed schedule of building finishes including colors schemes along with item description.
- (i) A door & window schedule showing door & window types and locations, lock sets and latch sets and other door hardware along with item details.
- (j) Cable Trench Layouts including cable trench details, road & storm water drains crossings and drainage of water from cable trenches;
- (k) Storm Water Drainage arrangement including drain layout, drain details, culverts for cable trench & road crossings and disposal of water to nearby natural drain;
- (l) Layout of Roads and Road-cum-Rail track in substation including all designs and drawings with full details;
- (m) Design/drawings of Fencings and Gates with their complete details.
- (n) Any other design and drawing as required or directed by Employer/PMC.

16.3.2. Approval of the above designs, drawings and other documents shall be obtained before ordering materials or starting construction/fabrication, as applicable. The approval of Employer/PMC shall not relieve the contractor of his responsibilities in regard to their correctness, safety and compliance to these specifications. Should anything happen to any structure/foundation/facility designed and constructed by the contractor, he alone shall be solely responsible for the same.

16.4. EXPATRIATE STAFF AND LABOUR

The Contractor's attention is drawn to the requirements for obtaining work permits from the Government of Nepal for his expatriate staff and labour and he shall follow all procedures laid down by the Government of Nepal with respect to the application for such work permits as well as for the recruitment, termination and repatriation of his expatriate staff and labour.

16.5. CONSTRUCTIONAL PLANT

16.5.1. The Contractor's attention is drawn to the various provisions of the Specification regarding the use of 'semi-mechanized' methods of construction including deployment of mechanical excavators & loaders, stone crushers, concrete batching plants and equipments for compaction of concrete. The Contractor shall submit the full list of Plant & Equipments he proposes to deploy at project Sites for the execution of the works.

16.6. PROGRAMS FOR THE EXECUTION OF WORKS

16.6.1. The Contractor shall, upon receiving the Letter of Award, within 15 days, submit to the Employer/PMC his Work Schedule for execution of works for approval.

16.6.2. The order in which works are proposed to be executed shall be subject to adjustment and approval by the Employer/PMC. The Contractor shall also carry out necessary adjustments in the work programme required by the Employer/PMC during the course of execution of works. The compliance by the Contractor of any such adjustment shall not relieve him of any of his obligations and responsibilities under the contract.

16.6.3. The Contractor shall execute the works in accordance with the Work Schedule approved by the Employer/PMC. However, the Employer's approval of Work Schedule does not relieve the contractor of his contractual obligations to complete the works in the prescribed order and by the prescribed completion date.

16.6.4. The Contractor shall, from time to time, review his progress and make such amendments in his programme of execution of the Works as may be necessary to ensure the completion of the works by the prescribed completion date.

16.7. ACCESS TO THE SITE AND LAND FOR TEMPORARY WORKS

- 16.7.1.** The Contractor shall be deemed to have satisfied himself as to the location of site, site conditions and access to various areas where works are to be executed.
- 16.7.2.** The Employer shall provide land, right-of-way and leeway for the Works. The Contractor shall be allotted the actual area necessary for the construction and execution of the works. Other areas which he may be required for storing, manufacturing, or other temporary works or for setting up site office or for what-so-ever use, shall be arranged by Contractor himself at his on cost. No separate payment shall be made to the Contractor on account of these items and the he must make due allowance for them in his quoted rates.
- 16.7.3.** The Contractor shall take necessary measures and precautions to prevent injury, damage and trespass of lands, fences and other properties near and adjacent to the his Works and shall, in this connection, make all necessary arrangements with adjoining landowners and in case of Government Property, with the concerned Department of Government of Nepal. The Contractor shall ensure that he and his personnel and workmen observe all rules and regulations of local self-Government and Government of Nepal in force.
- 16.7.4.** After completion of the works and before handing over to Employer, the Contractor shall make good, or pay compensation for any injury, damage or trespassing of land, fences and other properties caused by his operations and which in accordance with foregoing are not the responsibility of the Employer.
- 16.8. SAFETY OF EXISTING SERVICES**
- 16.8.1.** Drains, pipes, cables and similar other services encountered in the course of the works shall be guarded against damage by the Contractor for ensuring their continued and uninterrupted use by their users and to the full satisfaction of the owners of these services. The Contractor shall not store materials or otherwise occupy any part of the site in a manner likely to hinder the operation of such services.
- 16.8.2.** It is the responsibility of the Contractor to inform the Employer/PMC immediately whenever any existing service is encountered during execution of works.
- 16.8.3.** The Contractor shall be held liable for all damages to water supply mains & pipes, electric

lines & cables or any other line or installation of any kind either above or below ground caused by him or his subcontractors during the execution of the works, whether such services are shown on the bid drawings or not. The Contractor shall report to the Employer/PMC as well as concerned authorities of any such damage or interference without delay and he shall do all work to repair or reinstate as considered necessary by concerned authorities at his own cost and nothing extra shall be paid to him for such works.

- 16.8.4.** If the Contractor fails to repair or reinstate the damaged services within the time considered reasonable by the Employer/PMC, the Employer may get the damaged services repaired or reinstated by the other contractor and the cost thereof shall be paid by the Contractor to the employer.

16.9. PROTECTION OF MATERIALS FROM WEATHER

- 16.9.1.** All materials shall be stored on site in a manner specified in these specifications and approved by the Employer/PMC to protect them from the weather. The cost of all such protection shall be deemed to be included in the quoted rates of the contractor.

16.10. ARRANGEMENT OF WATER DURING CONSTRUCTION

- 16.10.1.** The Contractor shall make his own arrangement for water required by him for construction purposes as well as for drinking and other purposes during construction. He shall supply all hydrants, hoses, cocks, pumps, tanks, cart vessels and all necessary appliances for the distribution and transportation of water as per work requirements at his own cost.
- 16.10.2.** The possibility of obtaining water from local Public Water Supply shall also be explored by the contractor and if found possible, the contractor shall make all necessary arrangements and pay all the charges for connection to the mains and for water used.
- 16.11. CONSTRUCTION POWER**
- 16.11.1.** The Contractor shall make his own arrangements for electricity for meeting his requirements as well as requirements of his subcontractors for lighting and construction power at his own cost. All temporary wiring, connections, fittings etc. shall be removed after completion of work. The Contractor shall pay all fees and charges and obtain all

permits in connection therewith.

16.12. SANITATION AND PUBLIC HEALTH

16.12.1. The Contractor shall comply with all regulations and instructions issued by the Department of Health of Government of Nepal or by any officer appointed by any Public Health Authority with respect to the sanitation and Public Health of the laborers and the Contractor's Employees.

16.12.2. The Site shall be kept in a clean and proper sanitation condition. No nuisance shall be committed on or around the work site. Toilets for the workmen and staff shall be provided in accordance with the requirements of the Medical officer or Sanitary Authorities. Separate toilets shall be provided for women. The Contractor shall be responsible for the sanitary discipline of his personnel and laborers.

16.12.3. The Employer/PMC has a right to order any laborer, who in his opinion, does not have a satisfactory sanitary discipline, off the site with immediate effect.

16.13. STORAGE SPACES AND SHEDS

16.13.1. The Contractor shall be responsible for the erection of suitable temporary stores and workshops and their removal on completion of the works at his own cost. All stores shall be adequate for protection of materials and the equipment kept therein and shall be constructed and located to the satisfaction of the Employer/PM.

16.14. OFFICE FOR CONTRACTOR AND EMPLOYER/PMC

16.14.1. The Contractor shall erect an office of suitable construction near the Works Site for his requirements as well as for the requirements of Employer/PMC at his own cost. The contractor's office shall remain open at all hours during which the work is in progress at site.

16.14.2. Any notice to be given to or served upon the Contractor shall be deemed and taken to be effectually given or served upon by the delivery thereof at such office.

16.15. REMOVAL OF CAMPS

16.15.1. On the completion of the Contract, the Contractor, at his own cost, shall take down and remove all structures and materials connected with his temporary offices and camps and

backfill trenches, fill up all toilet pits, soak pits and other sewage disposal excavations, and shall restore the site as far as practicable to its original condition and leave it neat and tidy to the satisfaction of the Employer/PMC.

16.16. APPOINTMENT OF SAFETY SUPERVISOR

16.16.1. The Contractor shall designate one of his senior staff, who is qualified and experienced and having knowledge of safety matters and safety regulations as Safety Supervisor. The Safety Supervisor shall look after in all matters regarding safety, hygiene and welfare of the workmen. The Safety Supervisor may, in addition, carry out the other duties.

16.17. SETTING OUT OF WORKS

16.17.1. The Contractor shall be responsible for the setting out of the Works and shall employ all such qualified and experienced staff and equipments as may be necessary for this purpose.

16.17.2. The Contractor shall clear the site and set out the Works well in advance to enable the Employer/PMC to inspect and approve the same prior to commencement of the Works.

16.17.3. The Contractor shall provide a site plan showing the position of his site offices, storage sheds, accommodation, in relation to the Permanent Works for the approval of the Employer/PMC before commencing erection of his camp.

16.17.4. The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the Employer/PMC. The Contractor shall give all help in instruments, materials and personnel to the Employer/PMC for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

16.18. GEOTECHNICAL INVESTIGATIONS

16.18.1. Scope Of Work

This specification covers all the work required for detailed geotechnical investigation and preparation of a geotechnical investigation report. The work shall include mobilization of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc as required to carry out field investigation as

well as, laboratory investigation, analysis and interpretation of field data and test results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable/safe bearing capacity of soil for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the reduced level of these locations with respect to the benchmark established at substation site by the contractor for the work of topographical survey.

All the work shall be carried out as per relevant Indian Standards/ equivalent International Standards.

16.18.2. Bore Holes

Bore holes of Minimum 150 mm diameter in accordance with relevant Indian Standards/ equivalent International Standards at the rate of minimum one number of bore hole per hectare up to 12 meter depth (Minimum) or to refusal which ever occur earlier shall be drilled at each substation site. By refusal, it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration.

The number of boreholes shall not be less than as given below at each substation site:

- | | | |
|--|---|--------|
| ▪ Control Room-cum-Administrative building | : | 2 Nos. |
| ▪ D.G. Set Room Building | : | 1 No. |
| ▪ Transformer Area | : | 2 Nos. |
| ▪ 220kV Yard Area | : | 4 Nos. |
| ▪ 132kV Yard Area | : | 2 Nos. |
| ▪ 33kV Yard Area | : | 1 No. |

Number of boreholes may be increased in case soil strata are varying from borehole to borehole in order to have fair idea of soil profile. In case of deep pile foundations like pile, the borehole shall be taken up to 25 m depth from ground level or refusal whichever occurs earlier. In case rock is encountered, the rock coring in all the boreholes shall be carried out up to 3 meter in rock.

16.18.3. Back Filling of Bore Holes

On completion of each bore hole, the Contractor shall backfill all bore holes as directed by the Employer/PMC.

16.18.4. Standard Penetration Test (SPT):

Standard Penetration Tests shall be carried out at approximately 1.5 m interval in the borehole starting from 1.5 m below ground level onwards and at every change of stratum. Standard Penetration Tests shall be performed as per relevant Indian Standards/ equivalent International Standards.

16.18.5. Collection of Disturbed and Undisturbed Soil Samples from Boreholes

The disturbed soil samples from the standard penetrometer shall also be collected at every 1.0m or change of strata whichever occurs early for carrying out necessary laboratory tests on them.

Undisturbed soil samples shall be collected from borehole at every 1.50 m interval with first soil sample from a depth of 1.0 m below ground level and thereafter at an interval of 1.50 m or change of strata whichever occurs early in accordance with the recommendation of relevant Indian Standards/ equivalent International Standards for determining shear strength parameters and other engineering properties of soil..

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the information about depth of water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor's laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall also be handed over to the Employer/PMC.

16.18.6. Sub Soil Water Samples

Representative samples of sub soil/ground water shall be taken when ground water is first encountered in the boreholes before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

16.18.7. Trial Pits

The Contractor shall excavate trial pits of size 2.5 m x 2.5 m and 3.0 m depth. Disturbed & Undisturbed samples shall be taken from the trial pits at as per the direction of the Employer/PMC for carrying out necessary laboratory tests on them. Number of trial pits shall be as given below:

▪ Control Room cum Administrative Building	:	1 No.
▪ Transformer Area	:	1 No.
▪ 220kV yard area	:	2 Nos.
▪ 132kV yard area	:	1 No.
▪ 33kV Yard Area	:	1 No.

All Trial Pits shall be re-filled with approved material after collection of soil samples and logging of pits. Backfilling shall be done in layers of not more than 300mm and each layer compacted to 90% of Proctor Dry Density at optimum moisture content.

16.18.8. Plate load test

Plate load test shall be conducted at the location of Control Room-cum-Administrative Building and in Transformer Area to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant Indian Standards/ equivalent International Standards. Plate load test shall be performed at the proposed foundation depth below ground level.

Undisturbed soil samples shall also be collected from the pit at 1.0 m depth and bottom of pit for carrying out laboratory tests.

The size of the pit for plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall be observed.

Unless otherwise specified, the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs Settlement shall be kept as specified in relevant Indian Standards/ equivalent International Standards.

Backfilling of the pit shall be carried out as per the directions of the Employer/PMC. Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

16.18.9. Electrical Resistivity Test

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety grounding system/earthing mat for the entire substation area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall conform to relevant Indian Standards/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant Indian Standards/ equivalent International Standards. Unless otherwise specified, the test shall be conducted along two perpendicular lines parallel to the coordinate axis at each test location. On each line, a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.20 m upto a distance of 50.0 m.

16.18.10. Laboratory Tests

- (a) The laboratory tests shall be carried out progressively during the field work after sufficient numbers of soil samples have reached the laboratory so that the test

results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

- (b) All samples brought from field, whether disturbed or undisturbed, shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant Indian Standards/ equivalent International Standards.
- (c) The following laboratory tests shall be carried out on soil samples:
 - (i) Visual and Engineering Classification;
 - (ii) Tests for determining Atterberg's limits.
 - (iii) Natural moisture content;
 - (iv) In-situ Bulk density;
 - (v) Dry Density;
 - (vi) Specific Gravity;
 - (vii) Grain Size Distribution analysis by sieve analysis and hydrometer analysis;
 - (viii) California Bearing Ratio;
 - (ix) Appropriate Type Tri-axial Test as per type of soil;
 - (x) Direct Shear Test;
 - (xi) Chemical tests on soil and sub soil water samples for determining the carbonates, sulphates, nitrates, chlorides, organic matter and any other chemical harmful to the concrete foundations & reinforcement steel;
 - (xii) In case rock is encountered, the rock mechanics tests as required for rock as per relevant Indian Standards/ equivalent International Standards including following tests shall also be conducted.
 - (i) Unconfined Compression Test;
 - (ii) Point Load Index Test.

16.18.11. Test Results and Reports

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarized observations and test data, bore logs, and conclusions and recommendations on the type of foundations with all supporting calculations and details. The contractor shall also submit the bearing capacity calculation in editable soft copy to Employer/PMC. Initially the contractor shall submit two copies of draft report to Employer/PMC for examination and comments, if any. After receiving the comments/observations on draft report from Employer/PMC, the same shall be incorporated in the draft report and the final report in four (4) copies shall be submitted for approval. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and site representative of Employer/PMC.

The report shall include, but not limited to the following:-

- a) A plan showing the locations of the exploration work i.e. bore holes, trial pits. Plate load test, electrical resistivity test, CBR sample location etc.
- b) Bore Logs: Bore logs of each bore hole clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted and depths from which disturbed and undisturbed soil samples have been collected, soil classification etc as per relevant Indian Standard shall be clearly shown in bore logs.

Test results of field and laboratory tests shall be summarized strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed with the report.

16.18.12. Recommendations: The report shall contain specific recommendations for the type of foundation for the various structures in the scope of this specification. The Contractor shall acquaint himself about the type of structures and their functions from the Employer/PMC. The observations and recommendations shall include but not limited to the following:

- (a) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.
- (b) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.
- (c) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil if applicable shall be provided.
- (d) Recommendations regarding slope of excavations and dewatering schemes, if required.
- (e) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.
- (f) If expansive soil is met with, recommendations on removal or detainment of the same under the structure, road, drains, etc. and thickness of treatment shall be given. In the latter case detailed specification of any special treatment required including specification of materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.
- (g) Recommendations for additional investigations beyond the scope of the present work, if such investigation are found to be necessary.
- (h) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc shall also be given.
- (i) Recommendations regarding California Bearing Ratio required for the design of Road-cum-Rail Track and all internal roads;

16.19. TOPOGRAPHICAL SURVEY

16.19.1. Scope

The scope comprises carrying out topographical survey work, setting out and making profiles, preparation of plot plan, setting up Bench Marks and taking spot levels at a grid of not more than 3 m x 3 m size, preparation of contour maps on the 1 : 1000 scale with contour interval of 0.50 m. The whole work shall be carried out as per norms and guidelines of Survey Department of Government of Nepal.

16.19.2. The methodology of topographical survey work along with survey instruments proposed to be used, shall be submitted to Employer/PMC for approval.

16.19.3. Before starting the topographical survey work, a temporary bench mark shall be established by Contractor at each substation site and its level fixed from a known Permanent Bench Mark of Survey Department of Nepal by double levelling. The level shall also be linked with nearest bench mark established by transmission line contractor for the purpose of cross checking the levels.

16.19.4. The contractor shall carry out topographical survey work by taking spot levels at not bigger than 3 m x 3 m size grid as per topography of site and at all such points where there is sudden change in levels with respect to bench mark established at site by contractor.

16.19.5. Topographical survey shall be carried out by qualified surveyors using Total Station instrument.

16.19.6. The contractor shall submit the spot levels (in grid format) in editable soft copy in excel format and contour map on 1 : 1000 scale with contour interval of 0.5 m in editable autocad soft drawing.

16.20. SITE LEVELLING & FORMATION OF TERRACES

16.20.1. The land for construction of substations shall be handed over to the successful bidder as on where basis after award of work. Site shall be cleared, surveyed and leveled by the contractor as per approved general arrangement drawing of each substation. The Contractor shall develop the site area to meet the requirement of the intended purpose.

- 16.20.2.** Employer has carried out the preliminary topographical survey of substation sites and prepared preliminary contour maps and finalized the tentative nos. of benches to be formed and their levels. Substation layouts have been superimposed on contour map drawings which are attached in Section-6 of Part-II, Section-VI for information and guidance of bidders. The details given therein are tentative and in no way final.
- 16.20.3.** During detailed engineering stage, the contractor shall prepare the site grading and levelling proposal by optimizing the quantities of earth work in cutting and filling based on his topographical survey and contour maps and finalize the nos. of terraces and their levels and submit the same to Employer/PMC for approval. While finalizing the levels of terraces, it shall be ensured that no foundation of any major equipment is located on filled up soil as far as possible.
- 16.20.4.** Contractor shall submit the hard copy as well as editable soft copy of leveling proposal (Excavation and Filling Quantities calculation in Excel Sheet and levelling drawing in Auto CAD) to Employer/PMC for approval.
- 16.20.5.** Before taking of the work of site levelling and formation of terraces, the contractor shall remove all trees, plants, bushes and any other organic matter from the proposed area and stack the wood obtained from cutting of trees at a place as directed by Employer/PMC.
- 16.20.6.** The work shall involve excavation in all type of soils including soft rock and hard rock. The excavation shall be carried out by mechanical means using equipments of approved type and capacity. Soil obtained from excavation shall be used, if found suitable, for carrying out filling during site levelling operations.
- 16.20.7.** Excavation in Hard Rock shall be carried out by blasting. Explosives and necessary accessories including drilling equipments like jack hammer, compressors etc. required for excavation in hard rock shall be arranged by the contractor. The blasting shall be done by licensed blasters. All necessary precautions and safety measures as per relevant Indian standards/ International standards shall be taken while carrying out blasting. The rock obtained from blasting shall be suitably stacked at designated places and if found suitable, the same shall be utilized in the construction of Random Rubble Masonry Retaining and breast walls as well as in manufacturing of coarse aggregates required for concrete.

- 16.20.8.** The excavated soil to be used for filling during site levelling operation shall be suitable for the purpose and shall conform to the requirements specified under the clause of 'Filling' of this specification. Unsuitable excavated material, if any, shall be removed from site and disposed off at designated disposal areas. Any shortfall in the quantity of fill material shall be met from suitable borrow areas to be identified by the contractor and approved by the Employer/PMC. The works of leveling and filling shall be carried out as per relevant Indian Standards/ equivalent International Standards and as directed by Employer/PMC.
- 16.20.9.** The filling shall be carried out in layers of not more than 300mm thickness and each layer compacted by mechanical means (i.e. rollers of appropriate capacity and size) at optimum moisture content to achieve 95% of standard Proctor's dry density. Cohesion less material shall be compacted by vibratory rollers to achieve relative density of not less than 70%.
- 16.20.10.** Where formation of terraces requires the construction of retaining walls, these retaining walls shall be constructed before taking levelling operation in the said area.
- 16.21. SLOPE PROTECTION WORKS**
- 16.21.1.** While carrying out excavation during site levelling and terrace formation, stable slope on hill side shall be maintained. Wherever any instability or slide is observed in hill slope, suitable slope protection measures shall be taken which may involve construction of R.R. Masonry retaining walls, breast walls etc.
- 16.21.2.** Contractor shall prepare the designs and drawings of R.R. Masonry retaining walls, breast walls etc. as per site conditions and submit the same to Employer/PMC for approval. No construction work shall be undertaken without approval of Employer/ PMC.
- 16.21.3.** Construction of R.R. Masonry retaining/breast wall shall be carried out as per detailed specification of R.R. Masonry given under the clause of Masonry work of this specification.
- 16.21.4.** Weep Holes of suitable size and at appropriate spacing shall be provided in all retaining and breast walls. At the back of weep holes, properly designed filters shall be provided.
- 16.21.5.** 75 mm thick coping of 1:2:4 (1 Cement : 2 Fine Aggregates : 4 Coarse Aggregates of 20mm nominal size) concrete shall be provided at the top of retaining/ breast walls to protect the masonry.

16.22. CATCH DRAINS

- 16.22.1.** Stone Masonry Catch Drains shall be provided on uphill side of substation sites to arrest the surface runoff water from uphill slopes entering the substation.
- 16.22.2.** The size of catch drain shall be decided based on catchment area and one hour rain fall intensity of 25 years return period.
- 16.22.3.** The catch drains shall be constructed as per specifications and requirements for drains specified under the clause of 'General and Specific Design Requirements' of this specification.

16.23. EXCAVATION

- 16.23.1.** This clause covers excavation required for foundation works of Retaining/Breast Walls, Gantry Towers, Equipment support structures, Transformer foundations, Lighting poles, Cable trenches, Buildings, Car parking shed, Fire Protection Wall, Underground Water Storage tank etc.
- 16.23.2.** All excavation shall be carried out to such lengths, depths and inclinations as shown on the approved construction drawings or as may be ordered by the Employer/PMC.
- 16.23.3.** **No foundation shall be laid over filled-up area.** All excavation for Permanent Works shall be carried 0.9 meter into the virgin soil to the satisfaction of the Employer/PMC.
- 16.23.4.** Prior to the commencement of any excavation, the Contractor shall satisfy himself as to the circumstances at the Site and of all the various materials, obstructions, strata, water streams including the possibility of floods etc. likely to be encountered. The quoted rates in the Price Schedule shall provide for these circumstances.
- 16.23.5.** The Contractor shall carry out all excavations required for works in all types of materials whatsoever is encountered, including boulders, decomposed/fissured rock, or hard rock of any type. All excavation and blasting/drilling works shall be carried out as per IS: 1200(Part-I)-1992 and IS: 4081-1986 respectively.
- 16.23.6.** The Contractor shall take all precautions necessary to preserve the materials below and beyond any line of excavation in the soundest possible condition. Any damage to the

excavation or works due to the Contractor's operations, including shattering of the material beyond the excavation lines, shall be repaired at the expense of and by the Contractor. Any and all excess excavation carried out by Contractor for his convenience or for any purpose or reason, except as may be ordered in writing by the Employer/PMC, shall be at the expense of the Contractor.

- 16.23.7.** All excavations shall be carried out in the dry conditions. The Contractor shall take all necessary precautions including supplying and operation of all necessary pumping plant to remove all subsurface water and water from any source whatsoever which may enter the excavations whether these are in progress or completed. Every precaution shall be taken so as not to disturb the soil below foundation level.
- 16.23.8.** Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.
- 16.23.9.** If excavations are required to be carried out within 3.0 m of any building or other Constructions, the Contractor shall execute the work in such a way and manner that shall avoid damage and minimize disturbances.
- 16.23.10.** Excavation shall be finished to the lines and dimensions shown on the approved construction drawings or directed by the Employer/PMC. Final excavation & trimming of all excavations in the last 300 mm depth shall be carried out by the use of hand tools. In case, excavation is made below levels specified in construction drawings by mistake, the same shall be made up by contractor at his own cost by providing concrete of M-10 grade to bring the bottom of excavation to the required level.
- 16.23.11.** Where in the opinion of the Employer/PMC, the works are likely to cause disturbance to the public, the Contractor shall organize his operations in such a way as to reduce the interval between opening up and back-filling the excavations to a bare minimum. No further work shall commence until the Employer/PMC has inspected and approved the completed excavation.
- 16.23.12.** All excavation operation shall include excavation and disposal of the excess excavated

materials. The excavated material shall be disposed off at a place as directed by the Employer/PMC.

16.24. ANTIQUITIES

16.24.1. Any finds of Archeological interest such as relics of antiquity, coins, fossils or other articles of value shall be delivered to Employer/PMC and these shall be the property of the government.

16.25. REMOVAL OF SURPLUS EXCAVATED MATERIAL

16.25.1. Excavated material which is not required or suitable for filling/backfilling shall be removed and disposed off at designated dumping places approved by the Employer/PMC. All rubbish and waste material shall similarly be removed and disposed off by the Contractor.

16.25.2. If surplus earth generated from site levelling or foundation is disposed off within substation boundary, the same shall be spread in uniform layers of 300 mm thickness and compacted with rollers of appropriate capacity at optimum moisture content to achieve 95% of Protector's Dry Density

16.25.3. The contractor shall take every precaution against causing any nuisance, damage, injury or inconvenience in the handling, stacking, carting or disposal of excavated materials or any other operation, matter or thing in connection therewith.

16.25.4. No excavated material shall be placed in any position where it may be washed away or may be liable to fall or spread into any private property or across a road or footpath, and should this nevertheless occur, the Contractor shall forthwith remove such materials at no cost to the Employer.

16.25.5. Should the Employer/PMC direct the Contractor to tip certain surplus excavated materials in a particular place other than the tipping places obtained by the Contractor, the Contractor shall abide by such instructions and shall make no claim in consequence thereof unless the place specified entails a longer haul than what would be incurred by tipping at the place or places obtained by the Contractor and first approved by the Employer/PMC.

16.26. MATERIAL FOR FILLING/BACK FILLING

16.26.1. All materials used by the Contractor for the purpose of filling, backfilling and embankments shall be approved by the Employer/PMC.

16.26.2. Earth used for filling, backfilling and embankments shall be free from stone, shingle or boulders larger than 75mm in any direction, salts, organic or other foreign materials. Normally earth excavated from the same area shall be used for filling. However, if such earth contains deleterious material, saltpeter earth etc., the same shall not be used. All clots of earth shall be broken or removed.

16.27. BACK FILLING OF EXCAVATIONS

16.27.1. The backfilling of excavations shall commence as soon as practicable and only after the Permanent Works have been inspected and approved by the Employer/PMC. No backfilling shall commence without the approval of Employer/PMC.

16.27.2. Before back filling, the spaces around the foundations, pipes, drains etc. shall be cleared of all debris, brick bats etc. The filling shall be done in layers not exceeding 200 mm. Each layer shall be watered to optimum moisture content, rammed and compacted to achieve 95% of Proctor's dry density before the succeeding layer is laid, which shall also be watered and compacted in similar manner.

16.27.3. Earth shall be compacted with iron rammers or any other suitable means and with butt ends of crowbars where rammer cannot be used. Special care shall be taken so as to ensure that no damage is caused to foundations, pipes, drains, masonry, cables etc.

16.27.4. Reinstatement of Surfaces: Unless otherwise shown on the approved construction drawings, all trenches and backfilled excavations shall be reinstated to their original condition and appearance to the satisfaction of the Employer/PMC.

16.28. SAND FILLING

16.28.1. General

Sand filling shall be done similar to earth filling except that the compaction is done with vibratory compactors and by flooding with water. The surface of the compacted sand shall

be dressed to required level and slope. Any other operation on top of the sand fill shall not be started until the Employer/PMC has inspected and approved the sand filling.

16.28.2. Material

Local Sand conforming to the specifications of Department of Building and Department of Road, Government of Nepal and/or C.P.W.D. specifications shall be used.

16.28.3. Filling

The filling with sand in specified areas shall be done in layers in similar way as earth filling but compacted with vibratory rollers/compactors. After completion of filling, it shall be flooded with water for 24 hours.

16.29. COMPACTION

16.29.1. Backfilled earth shall be compacted to minimum 95% of Proctor's dry density at optimum moisture content (OMC). The sub grade for the roads and embankment filling shall also be compacted to minimum 95% of Proctor's dry density at OMC.

16.29.2. Cohesion less material shall be compacted to 70% of relative density (minimum). All compacted sand filling shall be confined as far as practicable.

16.29.3. Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the center of the road or towards the building as applicable. Rolling will also be required on rock fills. No compaction shall be carried out in rainy weather.

16.30. ANTI-TERMITE TREATMENT

16.30.1. General

Prevention of termites reaching the superstructure of the buildings shall be achieved by creating a chemical barrier. Therefore, the soil beneath the buildings and around the foundations shall be treated with chloropyrifos 20 EC (0.75%) or equivalent as per the

direction of Employer/PMC. This pre-constructional soil treatment shall be carried out in coordination with the building works and shall be executed in such a manner that the civil works are not hampered or delayed by the termite treatment.

16.30.2. Application

Treatment shall be carried out as detailed in IS: 6313(Part-II)-1981. The specified quantity of chemical emulsion shall be used for each specific area. Created barriers shall not be disturbed. If for any reason whatsoever, they have been disturbed, the continuity and completeness of treatment shall be restored.

16.30.3. Ten years guarantee shall be given by the Contractor for anti-termite treatment.

16.31. DAMP PROOFING COURSE

16.31.1. General

The Damp Proof Course over masonry walls at plinth level as shown in the approved construction drawings or as directed by the Employer/PMC shall be provided for damp proofing of all buildings.

16.31.2. Application

16.31.2.1. The surface of brick masonry shall be leveled and prepared before laying damp proof course.

16.31.2.2. Damp Proof Course shall consists of a 75 mm thick layer of cement concrete 1:1.5:3 (1 Cement : 1.5 Fine Aggregates : 3 Coarse Aggregates of 12.5 mm nominal size) and spreading a layer of bitumen over dried concrete surface as specified rate.

16.31.2.3. The concrete shall also be mixed with an approved water proofing compound as per the standard specification and cured for a minimum period of 7 days after laying or as directed by Employer/PMC.

16.31.2.4. After concrete surface has dried and has become free of any moisture, a coat of hot bitumen (asphalt 80/100 or equivalent) at the rate of 1.7 kg per square meter shall be applied over concrete surface. The pouring of bitumen shall be so regulated so that correct weight of material per unit area is spread uniformly over the concrete surface.

Edge of DPC shall be straight, even and vertical.

16.32. CONCRETE WORK

16.32.1. General

The contractor shall submit to the Employer/PMC the samples of all materials proposed for use in the production of concrete for the works, together with a list of suppliers. The Employer/PMC consent in writing shall be obtained for all such samples and sources of supply before any concreting work is taken up by the Contractor. No changes shall subsequently be made without the approval of Employer/PMC. The Employer/PMC shall have access to all sources of supply for the purpose of inspecting and taking samples.

16.32.2. Supervision

The contractor shall employ a competent supervisors approved by the Employer/PMC to supervise all stages of the concrete works, including the supervision of the making of tests cubes and all other site tests. The Contractor shall be responsible for keeping all records of testing and work progress as required by the Employer/PMC.

16.32.3. Responsibility

Approval of materials and workmanship by the Employer/PMC shall in no way relieve the Contractor of his responsibility of ensuring that materials and workmanship comply with these specifications and the quality and standards specified herein.

16.32.4. Materials

16.32.4.1. General

Materials used in the Works shall be of the qualities and kinds specified herein and equal to approved samples. The delivery of materials shall be made sufficiently in advance to enable further samples to be taken and tested if required. Materials not approved shall be immediately removed from the work's site by the contractor at his own cost.

All specified properties of the materials used in making concrete shall be tested with a frequency necessary to ensure continuous compliance to the specification. Whenever, any new material is to be used; testing frequencies shall be approved by the Employer/PMC.

The materials shall be transported, handled and stored at the site or elsewhere in such a manner as to prevent damage, deterioration or contamination.

16.32.4.2. Cement

Grade: Cement shall be procured from an approved source and shall be Ordinary Portland Cement of Grade 43 complying with IS: 269. Cement shall be delivered in sealed manufacturer's branded bags or barrels. Damaged bags or barrels and any cement, Employer/PMC considers unsatisfactory shall be rejected. Each bag shall be used on the day of opening and any bag/bags opened on the previous day shall be rejected. All rejected cement including that which has become affected by damp conditions is to be removed from site within 48 hours.

Storage: Cement shall be stored and stacked in bags in dry and water proof shed. The bags shall be stacked at least 200 mm clear above the floor. A space of about 600 mm all round shall be kept between the exterior walls and the stacks. Cement bags shall be placed close together in the stock to reduce circulation of air as much as possible. Cement bags shall not be stacked more than 10 bags high to avoid lumping under pressure. If the stack is more than 7 bags high, the bags shall be arranged in header and stretcher fashion, to lessen the danger of toppling over. For extra safety during the monsoon, the cement bags shall be properly covered with 700 gauge polythene sheet. Care shall be taken that the polythene sheet is not damaged any time during use.

When removing bags from storage some bags shall be removed from two or three tiers back rather than all from one tier. When removing cement bags for use, the "first in, first out" rule shall apply, that is the oldest cement shall be taken out first. Each consignment of cement shall be stacked separately therein to permit easy access for inspection and facilitate removal. Storage of cement at the site of work shall be at Contractor's expense and risk.

Expiry: Cement shall not be used after 6 months from its manufacture date or after it has been held in store for 3 months or more. All bags shall be dated upon arrival at the site.

Quality: In order to get a relatively quicker idea of the quality of cement, the compressive

strength test at 3 days shall be carried out in addition to 7-days test given in table below. In all cases, the 28 days compressive strength specified shall be the criterion for acceptance or rejection of the concrete. Notwithstanding the above requirements and tests the Employer/PMC may reject any cement which in his opinion is unsatisfactory for any reason whatsoever. Cement temperature shall not exceed 60 degree Celsius when used.

16.32.4.3. Water

Water for use in concrete mixing and curing shall be quality of portable water obtained from an approved source and shall not be of a quality that shall affect the setting time, strength and durability of the concrete or mortar. The water shall not affect the appearance of the hardened concrete or mortar by discoloration or efflorescence, nor shall it have any effect, whatsoever on the reinforcement at any stage. Water used for mixing concrete and mortars shall be clean and reasonably free from injurious quantities of deleterious materials such as oil, acids, alkalis, salts and vegetable growth. Generally potable water shall be used. Where water can be noticed to contain any sugar or an excess of acid, alkali or salt, the Employer/PMC may decide the maximum permissible limits of deleterious materials in water. Water for mixing and curing shall in general conform to IS: 456-2000.

Water shall be stored in approved, clean containers which are protected from wind, dust, organic contamination or from contamination by any other source.

16.32.4.4. Aggregates

General

Materials used as aggregates shall be obtained from a source known to produce aggregates of satisfactory quality for concrete and shall be chemically inert, strong, hard, durable, of limited porosity, and free from adhering coatings, clay lumps, coal and coal residues and organic or other impurities that may cause corrosion of the reinforcement or may impair the strength or durability of the concrete. Aggregates shall be natural gravel or crushed stone. The aggregates used in any concrete mix shall not cause damage or

weakening of the concrete.

Aggregates shall be stored and handled only on approved impervious free draining platforms. Aggregates shall be stacked separately according to the size in regular stacks of proper height. While stock-piling, the aggregates shall not form pyramids resulting in segregation of different sized materials. All aggregates which have become segregated shall be mixed mechanically before use for ensuing uniformity of gradation and quality. Aggregates which have become contaminated whilst stored on site shall be removed.

Fine Aggregates

Fine Aggregates/Sand shall be free from clay, silt and other harmful organic impurities. Sand shall satisfy all Mandatory Tests specified in IS: 383 and C.P.W.D. specifications and shall be of quality approved by Employer/PMC.

Coarse Aggregates

Coarse Aggregate for concrete shall be of specified nominal size and must have been manufactured from hard and durable stones and tested as per Mandatory Tests specified in IS: 383 and C.P.W.D. specifications and shall be of quality approved by Employer/PMC

16.32.4.5. Admixtures

Admixtures and additives shall comply with IS: 9103 and may only be used with the prior written approval of the Employer/PMC. Approved admixtures shall be used in accordance with the manufacturer's recommendations, shall be dispensed by approved equipment, which provides a visible means of checking each dose, and shall comply with the relevant Indian Standard. The proposed dosages, the manufacturer's technical information and the results of trial mixes shall be submitted to the Employer/PMC for approval.

When more than one admixture is to be used in a concrete, the compatibility of the various admixtures shall be ascertained and established by standard tests and certified by the manufacturer(s). No admixture containing chloride or nitrate shall be used.

16.32.5. Concrete Mix Proportions

The determination of the proportions of cement, aggregates and water to attain the

required strengths shall be made as per following two methods:

(i) By designing the concrete mix i.e. 'Design Mix Concrete'

or

(ii) By adopting nominal concrete mix i.e. 'Nominal Mix Concrete'.

In the bill of quantities, 'Nominal Mix Concrete' has been specified by specifying the proportions of concrete constituents i.e. cement, fine aggregates & coarse aggregates, by volume as is usual in Nepal. However, these proportions are given only for guidance and shall be altered as and when necessary in order to comply with the strength requirements of concrete.

'Design Mix Concrete' shall be allowed provided adequate (weight batching) equipment are available and it shall comply with IS: 456-2000.

16.32.6. Mixing

Mixing of concrete shall be done in a mechanical mixer of minimum size 7/10 (with hopper only). Mixing by hand shall be allowed only in special cases with the prior, written permission of the Employer/PMC. Coarse and Fine aggregates shall be washed with water to remove dirt, dust or any foreign materials, where necessary or directed by Employer/PMC.

The mixer drum shall be first cleaned of any foreign material, dust and any hardened concrete from previous use and then flushed clean with water. Measured quantity of dry coarse aggregates shall be first put into mixer drum followed by measured quantity of fine aggregates and then cement. The first batch of concrete at the start of work on any day shall have 10% extra quantity of cement. In case damp sand is used, only half of the quantity of coarse aggregate shall be added followed by cement and sand. Finally balance quantity of the coarse aggregate shall be added. The skip shall be raised and dry materials shall be lowered into the drum. The dry materials shall be mixed for at least 1 minute or ten turns of the drum, after which the correct quantity of water shall be added gradually while the drum is in motion for ensuring even distribution of the dry material. The total quantity of water for mixing shall be introduced before 25% of mixing time has elapsed

and the specified water cement ratio shall be strictly maintained. The complete contents of the mixed concrete shall be emptied before recharging. When the mixer is closed down for the day or at any time exceeding 20 minutes, the drum shall be flushed clean.

Mixing time: The materials shall be mixed for a period of not less than 2 minutes and until a uniform color and consistency are obtained. The time shall be counted from the moment all the materials have been put into the drum. Suitable admixtures may be added during mixing in case temperature is very low.

16.32.7. Trial Mixes

The Employer/PMC may require trial mixes for concrete of grades M20 and M15 prepared on site using the proposed plant, equipment and mixing methods. These mixes shall be made in presence of the Employer/PMC. From each mix, six cubes shall be prepared and cured as specified in relevant Indian Standard. The design of Concrete Mix shall be carried out and conform to IS: 10262-2009.

When concrete mix has been approved, no variations shall be made in the proportions, the source and type of materials i.e. cement and coarse & fine aggregates including the size and grading of aggregates without the consent and written approval of the Employer/PMC who may require further tests to be conducted before giving approval. Approval by the Employer/PMC of a concrete mix shall not relieve the Contractor of his responsibility of achieving and maintaining the specified strength of concrete.

16.32.8. Compliance and Quality Control

Samples from fresh concrete shall be taken as specified in these specifications and IS: 456-2000 to cast cubes of size 150 x 150 x 150 mm for testing for strength at 7 days and 28 days. All concrete of any given mix, poured between takings of two consecutive samples shall be represented by the former sample. The cost of casting cubes for testing the strength at 7 days and 28 days including the cost of concrete and all other incidental charges such as curing and carriage to the approved testing laboratory shall be borne by the Contractor within his quoted rates for concrete works. The testing fee for the cubes shall also be borne by the contractor.

The contractor shall keep a complete record of concreting including the date and time of placing the concrete in each portion of the work. The record shall be available for inspection at any time by the Employer/PMC. The following information for testing shall be recorded for each cube:

- (a) Concrete Mix and Grade
- (b) Slump
- (c) Maximum water-cement ratio
- (d) Date and time for casting cubes
- (e) Location of concrete in structure
- (f) Cube identification mark
- (g) Date of testing

All cubes shall be clearly marked prior to leaving the site and no cube shall leave the site unless documentation complying with the above has been supplied to the Employer/PMC. If instructed by the Employer/PMC, the temperature of concrete samples shall be determined.

Random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested, i.e. the sampling shall be spread over the entire period of concreting and cover all mixing units.

In order to get a relatively quicker idea of the quality of concrete, the compressive strength test on concrete cubes at 7 days shall be carried out in addition to compressive strength at 28-days. In all cases, 28 days compressive strength specified shall alone be the criterion for acceptance or rejection of concrete. 7 days and 28 days compressive strength of concrete shall be not less than as given in table below:

TABLE-16.4
(COMPRESSIVE STRENGTH OF CONCRETE)

Grade of Concrete	Compressive Strength of 150 mm Concrete Cubes at 7 days	Compressive Strength of 150 mm Concrete Cubes at 28 days
-------------------	---	--

M 15	10.0 N/mm ²	15.0 N/mm ²
M 20	13.5 N/mm ²	20.0 N/mm ²
M 25	16.7 N/mm ²	25.0 N/mm ²

The acceptance criteria for concrete shall be as prescribed in IS: 456-2000.

16.32.9. Concreting

The Contractor shall provide at least fifty percent of all concreting equipment as standby during any period of concreting.

Concreting shall commence only after the Employer/PMC has inspected the centering, shuttering and reinforcement and has approved the same.

Shuttering shall be clean and free from all shavings, saw dust, pieces of wood, or other foreign materials, and shall be treated as specified in these specifications and relevant standards. Construction plant and materials required during the concreting work and for curing shall be on site and fully prepared before concreting commences. All accessories shall be installed and formwork for holes, chases etc. shall be provided as specified. Only after all these preparations and other relevant requirements have been completed, shall the Employer/PMC's approval to place concrete be given.

In case of concreting of slabs and beams, wooden planks or catwalks supported directly on the centering by means of wooden locks or lugs shall be provided to convey the concrete to the place of disposal without to walk over the reinforcement. In case of columns and walls, the concreting shall be done without construction joints as far as possible. If construction joints are unavoidable, these shall be got approved from Employer/PMC well in advance of commencement of concreting. No construction joint shall be provided without the approval of Employer/PMC. The concreting in the vertical direction shall be restricted to one meter per hour. In deep trenches and footings, concrete shall be placed through chutes or as directed by the Employer/PMC. In case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete is not more than 1.5 meters at a time.

The concrete shall be deposited in its final position in a manner to preclude segregation of ingredients. During cold weather, the concreting shall not be done when the temperature falls below 4.5 degrees Celsius as a rule. If it is deemed necessary to perform concreting below 4.5 degrees Celsius, the approval from Employer/PMC shall be taken and appropriate procedure for concreting as per relevant standard shall be adopted. Concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone. During the hot weather, precaution shall be taken to ensure that the temperature of wet concrete does not exceed 38 degrees Celsius. No concreting shall be carried out in heavy rain. The time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with.

Concrete shall be compacted into a dense mass immediately after placing, by means of mechanical vibrators designed for continuous operation. Hand compaction, if permitted in very special circumstances, shall be done with the help of tamping rods so that concrete is thoroughly compacted and completely worked around the reinforcement, embedded fixtures and corners of the formwork. The layers of concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. The vibrators shall maintain the whole of concrete under treatment in an adequate stage of agitation, such that effective compaction is attained at a rate commensurate with the supply of concrete from the mixers. The vibration shall continue during the whole period occupied by placing of concrete, the vibrators being adjusted so that the center of vibrations approximates to the center of the mass being placed at the time of compacting.

Concrete shall be judged to be properly compacted when the mortar fills the spaces between the coarse aggregate and begins to cream up to form an even surface. When this condition has been attained, the vibrator shall be stopped. In case both internal and external vibrators are used, the internal vibrators shall first be withdrawn slowly after which the external vibrators shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions of the manufacturer of the particular type of vibrator used shall be strictly complied with.

Shaking of reinforcement for the purpose of compaction shall not be permitted. Compaction shall be completed before the initial setting starts, i.e. within 30 minutes of addition of water to the dry mixture. Vibrators shall not be used to move the concrete within the formwork. For items where the vibrators are not to be used, the Contractor shall obtain written permission of the Employer/PMC before the start of the work.

The Contractor shall provide openings, mortises, chases, sleeves etc. and fix bolts, anchors etc. in concrete as given in the approved construction drawings as work proceeds and shall support embedded items against displacement. Items cast shall have all voids filled with readily removable material to prevent concrete ingress.

The Employer/PMC shall have the right to reject any concrete which he considers to have been inadequately mixed or in which the ingredients have segregated or which is no longer capable of being effectively placed or compacted.

All receptacles used for the transport and placing of the concrete shall be kept clean and shall be thoroughly washed out after stopping work and at the end of each shift.

16.32.10. Construction Joints

Concreting shall be carried out continuously up to the construction joints, the position and details of which shall be as shown on the approved construction drawings or as directed by the Employer/PMC.

Construction Joints shall be kept to a minimum and shall not be located in valleys. They shall be kept at places where shear force is minimal and shall be straight and at right angles to the direction of the main reinforcement. In case of columns, the joints shall be horizontal and located at 100 to 150 mm below the bottom of the beam running into the column head. The portion of the column between the construction joint level and the top of the slab shall be concreted with the beams.

When concreting in slabs and beams is stopped on a vertical plane, an approved stop board shall be placed with necessary slots for reinforcement bars or any other obstruction to pass the bars freely without bending. The construction joint shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop board. Inclined or feather joints shall

not be permitted. Any concrete flowing through the joints of the stop board shall be removed soon after the initial set.

When stopping concrete on a horizontal plane, a key shall be provided by inserting a wedge. The surface shall be roughened and cleaned after the initial set.

When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean and thoroughly wetted for 24 hours. For vertical joints, neat cement slurry at the rate of 2.75 kg of cement per square meter shall be applied on the surface to make it dry. For horizontal joints, the surface shall be covered with a layer of mortar about 10 to 15 mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement mortar shall be freshly mixed and applied immediately before placing the concrete.

When the work has to be resumed on a surface which has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgment of coarse aggregates. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry at the rate of 2.75kg of cement per square meter. On this surface, a layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to comers and close spots; work thereafter shall proceed in the normal way.

16.32.11. Expansion Joints

Expansion joints shall be provided as shown on the approved construction drawings. Bitumen impregnated fiber board shall be provided at expansion Joints and sealed with bitumen.

16.32.12. Curing

After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected from quick drying by covering it with moist gunny bags, sand or any other material approved by the Employer/PMC. After 24 hours of laying of concrete, the surface shall be cured by flooding with water of minimum 25mm depth, or by covering with wet

absorbent materials. The curing shall be done for a minimum period of 10 days. In case of roof slabs, the top surface shall be finished even and smooth with wooden trowel, before the concrete begins to set.

Over the foundation concrete, the masonry work may be started after 48 hours of its laying but the curing of cement concrete shall be continued along with the masonry work for minimum period of 14days.

Where cement concrete is used as sub-grade for flooring, the flooring may be commenced before the curing period of sub-grade is over but the curing of Sub-grade shall be continued along with the top layer of flooring for a minimum period of 14 days.

The water used for curing shall not produce any objectionable strains or unsightly deposit on concrete surfaces. In special circumstances and locations, the curing by other means such as sealing materials, insulating blankets etc. may be adopted with the specific prior approval of the Employer/PMC.

16.33. CONSTRUCTION TOLERANCES

16.33.1. The tolerances within which concrete works shall be carried out are as summarized below:

TABLE-16.6
CONSTRUCTION TOLERANCES

Construction	Permissible Deviation (mm)
Size and shapes	
Thickness of walls and slab	± 6 mm
Sizes of Columns and beams	± 6 mm
Dimensions of foundations	+ 50 mm
Variation from plumb (vertically up to 5 m height)	± 12 mm
Levels to slabs and beams	± 10 mm

16.33.2. Unfinished floor slabs shall not show more than 6 .0 mm undulation when tested with 3 m

long true straight edge. The Contractor shall be responsible for keeping the deviations of the finished concrete structures within the limits given, and any rectification of work not constructed within the tolerances set out shall be entirely at the expense of the Contractor.

16.34. FORMWORK, SHUTTERING AND STAGING

16.34.1. Propping and Centering

Props used for centering shall be of steel, timber posts, ballies or any other material approved by the Employer/PMC. In no case bellies shall be of diameter less than 100 mm measured at mid length and 80 mm at thin end. Maximum permissible spacing of props shall be 1.2 meters center to center. Ballies shall rest squarely on wooden sole plates of 40mm thickness and minimum bearing area of 0.1 square meter laid either on ground or on 40x40 cm brick masonry pillars in mud mortar of height not exceeding 40 cm. Double wedges shall further be provided between the sole plates and the wooden props so as to facilitate tightening and easing of shuttering without jarring the concrete.

The details of form work stated above shall be applicable for spans upto 4.50 meters and height upto 3.50 meters. In case any of these limits is exceeded, the form work shall be properly designed for the self-weight, weight of reinforcement, weight of fresh concrete, various live loads imposed during the construction process (such as workmen and equipment) etc. Dumping of concrete, movement of construction equipment and action of the wind may produce lateral forces which must be resisted by the form work to prevent lateral failure for which suitable horizontal as well as diagonal bracing shall be provided.

The stresses in bending, buckling load of props, permissible deflection of shuttering shall not exceed the permissible stresses of the materials. In case height of centering exceeds 3.50 meters, the props may be provided in multi-stages.

Before the concreting is started, the props and wedges shall be thoroughly checked to ensure that these are intact and suitable action taken in case these are loose. While the concreting is in progress, at least one carpenter shall be readily available at the site. The carpenter shall keep a constant watch on the props and take immediate remedial

measures, as soon as any of these get loosened. Care shall be taken that props and wedges do not get loose till shuttering is removed and concrete gains required strength for supporting the self-load and imposed loads, if any.

16.34.2. Shuttering

The shuttering shall have a smooth and even surface and the joints shall not permit leakage of cement slurry. In general, only shuttering made of steel angles and steel plates or shuttering made of wooden frame and minimum 12mm thick laminated waterproof plywood shall be used. All bolts and nuts shall be countersunk and well ground to provide a smooth plane surface.

Where, on practical reasons of having a smooth surface finish, only wooden shuttering shall be used, approval for using the same shall be obtained from the Employer/PMC before starting the shuttering work. The timber used shall be well seasoned, free from loose knots, projecting nails, splits or other defects that may mar the surface of the concrete. It shall not be so dry as to absorb water from concrete and swell and bulge, nor so green or wet as to shrink after erection. Species of timbers which are not affected appreciably by its contact with water shall be used. Thickness of planks shall not be less than 25mm. For exposed concrete surfaces, timber for shuttering shall be dressed on all faces in contact with concrete. The chamfers, beveled edges and mouldings shall be made in the formwork itself. Opening for fan clamps and other fittings connected with services shall be provided in the shuttering as directed by the Employer/PMC.

As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable, minimum number of nails shall be used and these shall be left projecting so that they can be easily withdrawn. Use of double head nails shall be preferred. Shuttering shall also be provided for the sloping top faces of work and anchored to prevent floatation where the slope exceeds 1 (V) in 2.5 (H).

16.34.3. Surface Treatment for Shuttering

The surfaces of shuttering that shall come in contact with concrete shall be coated with soap solution or raw linseed oil of approved manufacture or any other approved material

(such as polythene sheets) to prevent adhesion of green concrete to form work. Soap solution, for the purpose shall be prepared by dissolving yellow soap in water to get the consistency of paint. Inside surfaces of forms shall be thoroughly cleaned before application of any of the materials mentioned above. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come in contact with any reinforcement. .

The Contractor shall give the Employer/PMC due notice before placing any concrete in the forms to permit him to inspect and accept the formwork as to its strength, alignment and general fitness, but such inspection shall not relieve the Contractor of his responsibility for safety of workmen, machinery, materials and results obtained.

16.34.4. Camber

Suitable camber shall be provided in horizontal members of structures, especially in long spans to counteract the effects of deflection. The form work shall be so assembled as to provide for such camber. The camber for beams and slabs shall be 4 mm per meter (1 in 250) or as directed by the Employer/PMC so as to offset the subsequent deflection. For cantilevers, the camber at free end shall be 1/50th of the projected length or as directed by the Employer/PMC.

16.34.5. Removal of Formwork

The form work shall be so removed as not to cause any damage to concrete due to shock or vibration. In a slab and beam construction, sides of beam shall be stripped first, then the underside of slab and lastly the underside of the beam. Form work must be so designed that it can be striped in the following order:

- (a) Shutters to vertical (non load bearing) vertical faces of column, beams etc.
- (b) Shutters forming soffits to slabs, horizontal and inclined which carry only light load such as bottom shutters of floor/roofs slabs, canopy etc.
- (c) Soffit shutters carrying heavy load such as bottom shuttering of beams and girders.

The whole of the formwork shall be accordingly planned and a definite scheme of

operation shall be worked out. In no circumstances shall forms be struck until the concrete reaches strength of at least twice the stress to which the concrete may be subjected at the time of striking. Where possible the formwork shall be left longer as it shall assist curing. Forms shall be eased carefully in order to prevent the load being suddenly transferred to concrete.

The minimum period that shall elapse after the concrete has been laid, before easing and removal of centering and shuttering is given in table below:

TABLE-16.5

STRIPPING PERIOD FOR FORMWORK

Sl.No.	Parts of Structure	Period for ordinary Portland cement
1	Sides of foundations, columns, beams	48 hours
2	Underside of slabs upto 4.5 meters span	07 days
3	Underside of slabs of more than 4.5 meters span and underside of beams and arches up to 6 meters span	14 days
4	Under sides of beams and arches over 6 meter span and up to 9 meters span	21 days

In case of cantilever slabs and beams, the centering shall remain till structures for counter action or bearing down have been erected and have attained sufficient strength. Proper precautions shall be taken to allow for the decrease in the rate of hardening and gaining of strength that occur with all cements in cold weather. Work damaged through or careless removal of forms shall be reconstructed.

The Contractor shall record the date upon which the concrete is placed in each part of the

work, and the date on which the formwork removed there from. The assessment of the period elapsing between placing the concrete and removing the form work and consequence arising there from shall be the Contractor's entire responsibility.

16.35. REINFORCEMENT

16.35.1. General

The Contractor shall furnish to the Employer/PMC the copies of the manufacturer's tests certificates for the steel reinforcement to be supplied. If required by the Employer/PMC, the Contractor shall submit samples to, and get the samples tested from a recognized testing laboratory approved by the Employer/PMC and obtain & furnish the test certificates.

All reinforcement steel bars shall be clean and free from corrosion, loose rust, mill scale, paint, oil, grease, adhering earth, or any other material that may impair the bond between the concrete and the reinforcement or that may cause corrosion of the reinforcement or may be detrimental to the quality of the concrete.

The Contractor shall ensure that cutting, bending and placing of reinforcement is checked by a competent person. The Contractor shall notify the Employer/PMC well in advance about portions of reinforcement work ready for inspection and shall keep a detailed record of the planning and control of the reinforcement work.

16.35.2. Storage of Reinforcement

Reinforcement shall be stored on properly constructed racks at least 200 mm above ground level. The storage, cutting and bending of steel reinforcement shall be carried out under cover on an approved, free draining platform. The method of storing shall be such as to prevent contamination or damage by weather or accident. Steel shall be protected from humidity when stored.

16.35.3. Cutting and Bending

Dirt, rust, concrete, scale, paint, oil, grease salt etc. shall be removed from the reinforcement by sand blasting or other approved methods. Reinforcement shall be subjected to a constant even load and not an impact load. Welding of reinforcement shall

not be allowed. Bars incorrectly bent shall be used only if the means used for straightening and re-bending be such as not to damage the steel. No reinforcement shall be bent when in position in the works without approval, whether or not is partially embedded in hardened concrete.

Bar types, sizes and placement shall be as shown on the approved construction Drawings and cutting and bending shall be carried out in accordance IS: 2502 - 1983.

16.35.4. Fixing Reinforcement

Reinforcement bars shall be placed in position as shown on the approved construction drawings. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.90 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during the placing of concrete. Overlapping of bars, where necessary, shall be done as per specification or as shown on the approved construction drawings. Overlapping bar shall not touch each other and they shall be kept apart by 25mm or 1.15 times the maximum size of the coarse aggregate, whichever is greater, with concrete between them. Otherwise the overlapping bars shall be bound together at intervals not exceeding twice the diameter of such bar, with two strands of annealed steel wire of 0.90 mm to 1.6mm thickness twisted tight. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum. Not more than 50% of bars shall be lapped at a section. The reinforcement shall be fixed accurately in position so that the reinforcement is in the correct position in relation to the formwork to give the specified concrete cover. The reinforcement shall be securely fixed in position so that it is not displaced at the time of placing of concrete due to movement of labourers for placing and compaction of concrete or any related operation.

Reinforcement shall be placed within the following tolerances:

- For effective depth 200 mm or less ± 10 mm
- For effective depth more than 200 mm ± 15 mm

The concrete cover to reinforcement shall in no case be reduced by more than one third

of specified cover or 5 mm whichever is less. Covers should be increased where water is predominant. The following procedure shall be followed for maintaining the correct cover to reinforcement:

- (a) In case of beam and slab construction, precast cover blocks made of cement mortar 1:2 (1 cement : 2 coarse sand) of about 40 x 40 cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering at sufficiently close spacing so as to secure and maintain the requisite concrete cover over reinforcement.
- (b) In case of cantilever beams and beams and slabs having reinforcement on two opposite faces i.e. bottom and top faces, the vertical distance between the horizontal bars shall be maintained by introducing chair spacers or support bars of steel at 1.0 meter or at shorter spacing to avoid sagging.
- (c) In case of beams, foundation footings or similar other structures which have been provided reinforcement in two layers in the same direction, the spacing between two layers of reinforcement shall be not less than the diameter of bigger bar or 5 mm more than the nominal size of coarse aggregates whichever is more. This spacing shall be maintained by providing spacer bar of required diameter as to meet the aforesaid requirements at spacing of not more than 1.0 meter.
- (d) In case of columns, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them, or with blocks of appropriate size made of cement mortar 1 : 2 (1 cement : 2 coarse sand) suitably tied to the vertical reinforcement of columns.

Site manufactured blocks shall be well compacted and water cured for a minimum of 14 days after casting and shall have a 10 minute absorption of less than 3.2% by weight. Concrete spacers shall be comparable in strength, durability and appearance to the surrounding concrete.

16.36. MASONRY WORK

16.36.1. Hollow Cement Concrete Block Masonry

16.36.1.1. General

- (i) Material: Hollow Concrete Blocks shall be made of concrete of grade M-20 with nominal size of coarse aggregates of 12.5mm. All materials of concrete and concrete mix requirements shall be same as for item of concrete specified in these specifications.
- (ii) In case of hand moulded blocks where compaction is done manually, concrete mix of damp earth consistency shall be used in order to enable de-moulding immediately after casting. The consistency of the mix shall be such that it may wither when compressed in the hand without free water being visible. Too little water causes the mix to be friable, whilst too much water causes difficulty in the immediate withdrawal of the mould.
- (iii) In case of machine moulded blocks, the web marking on the units as they come from the machine give a good indication as to whether the concrete of proper consistency has been used. If traces of moisture come on the outside of squared mass of concrete, it indicates unsuitable consistency.

16.36.1.2. Manufacture

In case of manual compaction, the mixture shall be placed into the mould in layers of about 50 to 75 mm and each layer thoroughly tamped with suitable tampers until the whole mould is filled up and stuck off level with a trowel. In the case of machine compaction, the mould shall be filled up to a certain height above the mould, vibrated or mechanically tamped and struck off level. After de-moulding, the blocks shall be protected until they are sufficiently hardened to permit handling without damage.

16.36.1.3. Curing

The blocks shall be cured in a curing water tank for at least 28 days. The water in the curing tank shall be changed at least every four days.

16.36.1.4. Drying

The blocks shall be dried in shade before being used on the work.

16.36.1.5. Physical requirement of blocks

The average crushing strength of blocks based on crushing strength of eight blocks shall be not less than 50 kg/sq.cm of gross area. The lowest strength of any individual block shall not be less than 80% .of the average strength of eight blocks.

The volume of cavity shall not exceed 50% of gross volume of block.The blocks shall be true to shape. The actual size of the blocks for different thickness of masonry shall be as given in table below:

TABLE-16.7

SIZE OF CONCRETE BLOCKS

Thickness of Masonry (mm)	Size of Block (mm)		
	Length	Breadth	Height
100	390	100	190
200	390	200	190

The permissible dimensional tolerance shall be 1.5 mm for breadth and height and 3.0 mm for length.

16.36.1.6. Laying of blocks

The blocks shall be laid by breaking joints in successive layers. Half or cut blocks shall not be used except where necessary for breaking the joints in successive layers. Blocks in such cases shall be cut to the required size and used near the ends of walls.

A layer of mortar of mix specified in the approved construction drawings shall be spread on full width of suitable length of lower course keeping the mortar droppings in the hollows of the blocks to the minimum possible. Each block shall be properly bedded and set home by gentle tapping with handle of shovel or wooden mallet. The side face shall be

buttered with mortar before the next block is laid and pressed against it. On completion of a course, the vertical joints shall be fully filled from the top with mortar.

All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The vertical joints in alternate layer shall come directly one over the other. The walls shall be truly plumb.

All the connected block work shall be carried up nearly at one level and no portion of the work shall be left more than one meter below the rest of the work.

All item fixtures, pipes, outlets of water, hold fasts of door and windows etc. which are required to be built in wall shall be embedded in cement mortar or cement concrete as specified in their correct position as the work proceeds.

A set of tools comprising of wooden straight edges, mason's spirit level, square half meter rule, line and pins string and plumb shall be kept on the site of work.

16.36.1.7. Joints

Blocks shall be so laid that all joints are fully filled with mortar. The thickness of joints shall not exceed 10 mm. The face joint shall be raked to minimum, depth of 10 mm by raking tool, daily during the process of work when the mortar is still green so as to provide proper key for plaster. Where plastering is not required to be done, the joints shall be struck flush and finished at the time of laying. The face of block work shall be cleaned the very day that block work is laid and all mortar dropping removed.

16.36.1.8. Curing

Green work shall be protected from rain by suitable covering. Masonry shall be kept constantly moist on all the faces for a minimum period of 10 (ten) days.

16.36.1.9. Scaffolding

Single scaffolding shall be allowed. The hole left in masonry work for supporting the scaffolding shall be filled and made good before plastering.

16.36.2. Random Rubble Masonry

16.36.2.1. General

The stones for masonry shall be hard, sound and durable of a quarry approved by the Employer/PMC before stones are used in the works. Stones shall be hammer dressed to seem closed joint so that the stones when laid shall come into closed proximately. Stones would be fairly equal and no stones shall be less than 150mm in size. Cement mortar shall be of proportion 1:6 (1 cement: 6 coarse sand). The materials of mortar i.e. cement and coarse sand shall be as specified for concrete work.

Through bond stones of one piece shall be provided, one for every 0.5 sq.m. of face and shall be extended to the full thickness of wall. All stones shall be thoroughly wetted before laying. The masonry shall be cured for a period of 10 days, and shall be protected from sun, rain, frost and other weather effects.

16.36.2.2. Scaffolding

Single scaffolding having one set of vertical supports shall be allowed. The supports shall be sound and strong, tied together by horizontal pieces. Over which the scaffolding planks shall be fixed. The inner end of the horizontal scaffolding member may rest in a hole provided in the masonry. Such holes, however, shall not be allowed in pillars less than one meter in width of near the skew pack of arches. The holes left in masonry work for supporting scaffolding shall be filled and made good with cement concrete 1:3:6 (1 cement:3 coarse sand: 6 coarse aggregates of 20 mm nominal size).

16.36.2.3. Curing

Masonry work shall be kept constantly moist on all faces for a minimum period of 10 days.

16.36.2.4. Protection

Green work shall be protected from rain by suitable covering and the work shall also be suitably protected from damage, mortar dropping and rain during construction.

16.36.3. Brick Masonry

16.36.3.1. Classification:

The brick masonry shall be classified according to the class designation of bricks used.

16.36.3.2. Mortar:

The proportion of mortar for brickwork of thickness 230 mm or more shall be 1 : 6 (1 Cement : 6 Coarse Sand) and for half brick walls, 1 : 3 (1 Cement : 3 Coarse Sand) and conforming to relevant Indian standards.

16.36.3.3. Soaking of Bricks:

Bricks shall be soaked in water before use for a period just sufficient to penetrate the whole depth of the brick. Alternatively, the bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period not less than six hours. The brick required for the masonry work using mud mortar shall not be soaked. When the bricks are soaked, they shall be removed from the tank sufficiently early so as to allow them to be skin dry. Such soaked bricks shall be stacked on a clean place where they are not again spoiled by dirt, earth etc.

16.36.4. Laying

Bricks shall be laid in English Bond unless specified otherwise. For brick work in half brick wall, the bricks shall be laid in stretcher bond. Half or cut bricks shall not be used except as a closer or where necessary to complete the bond. Closers in such cases, shall be cut to the required size and used near the ends of the wall. Header bond shall be used preferably in all courses in curved plan for ensuring better alignment.

All loose materials, dirt and set lumps of mortar which may be lying over the surface on which brick work is to be freshly started, shall be removed with a wire brush and surface wetted. Bricks shall be laid on full bed of mortar. Each brick shall be properly bedded and set home by gentle tapping with handle of shovel or wooden mallet. The side face shall be buttered with mortar before the next brick is laid and pressed against it. On completion of a course, joints shall be fully filled and packed with mortar such that no hollow space is left between the joints.

The walls shall be taken up truly in plumb or true to the required batter where specified. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in the alternate course shall come directly one over the other. Quonin, Jambs and other angles shall be properly aligned within following maximum permissible tolerances.

- (a) Deviation from vertical within a storey shall not exceed 6.0 mm per 3.0 m height.
- (b) Deviation in vertically in total height of any wall of building more than one storey in height shall not exceed 12.5mm.
- (c) Deviation from position shown on plan of any brick work shall not exceed 6.0 mm.
- (d) Relative displacements between loads bearing wall in adjacent storey intended to be vertical alignments shall not exceed 6.0 mm.

A set of tools comprising of wooden straight edge, Masonic spirit levels, square, 1.0meterrule line and plumb shall be kept on the site of work for every 2 masons for proper check during the progress of work.

All quoins shall be accurately constructed and the height of brick courses shall be kept uniform. This shall be checked using graduated wooden straight edge or storey rod indicating height of each course including thickness of joints. The position of damp proof course, window sills, bottom of lintels, top of the wall etc. along the height of the wall shall be marked on the graduated straight edge or Storey rod.

No part of the wall during its construction shall rise more than one meter above the general construction level. Parts of wall left at different levels shall be racked back at an angle of 45° or less with the horizontal. Tooting shall not be permitted as an alternative to racking back. For half brick partition to be keyed into main walls, indents shall be left in the main walls.

All pipes fittings and specials, spouts, hold fasts and other fixtures which are required to be built into the walls shall be embedded, as specified in the approved construction drawings, in their correct position as the work proceeds unless otherwise directed by the Employer/PMC.

Top courses of all plinths, parapets, steps and top of walls below floor and roof slabs shall be laid with brick on edge, unless specified otherwise. Brick on edge laid in the top courses at corner of walls shall be properly radiated and keyed into position to form cut (maru) corners. Where bricks cannot be cut to the required shape to form cut (maru) corners, cement concrete of proportion 1:2:4 (1 cement:2 coarse sand: 4 coarse aggregates of 20

mm normal size) equal to thickness of course shall be provided in lieu of cut bricks.

In case of walls of one brick thick and under, one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the faces shall be kept even and in proper plan.

To facilitate taking service lines later without excessive cutting of completed work, pipe sleeves shall be provided, where specified or directed by Employer/PMC, while raising the brick work. Such sleeves in external walls shall be sloped down outward so as to avoid passage of water inside.

Top of the brick work in coping and sills in external walls shall be slightly tilted. Where brick coping and sills are projecting beyond the face of the wall, drip course/throating shall be provided.

Care shall be taken during construction that edges of jambs, sills and projections are not damaged. In case of rain, new built works shall be covered with gunny bags or tarpaulin so as to prevent the mortar from being washed away. Damage, if any, shall be made good to the satisfaction of the Employer/PMC.

Vertical reinforcement in the form of bars (high strength deformed bars), considered necessary at the corners and junction of walls and jamb opening doors, windows etc, shall be encased with cement mortar not leaner than 1: 3 (1 cement : 3 coarse sand) or cement concrete of grade not leaner than M-15. The reinforcement shall be suitably tied, properly embedded in the foundation and at roof level. The diameter of bars shall not be less than 8mm and concrete proportion shall be not leaner than 1:2:4 (1 cement: 2 coarse sand: 4 coarse aggregates of 20mm nominal size).

In retaining walls and the like, where water is likely to accumulate, weep holes, 50 to 75mm square size, shall be provided at a spacing of 2.0 m vertically and horizontally unless otherwise specified. The lowest weep hole shall be at about 300 mm above the ground level. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly.

Work of cutting chases, wherever required to be made in the walls for housing G.I. pipe, CI

pipe or any other fixtures, shall be carried out in various locations as per following guidelines:

- (a) Cutting of chases in load bearing walls of one brick or more thick
 - (i) As far as possible services shall be planned with the help of vertical chases. Horizontal chases shall be avoided.
 - (ii) The depth of vertical chases and horizontal chases shall not exceed one third and one sixth of the thickness of the masonry respectively.
 - (iii) When narrow stretches of masonry such as between doors and windows, cannot be avoided, they shall not be pierced with openings for soil pipes or waste pipes or timber joints etc. Where there is a possibility of load concentration as narrow lengths of walls, they shall be checked for stresses and high strength bricks in richer mortar or concrete walls provided, if required.
 - (iv) Vertical chases shall not be closer than 2.0 m in any stretch of a wall. These shall be kept away from bearings of beams and lintels. If unavoidable, stresses in the affected area shall be checked and kept within permissible limits.
 - (v) Masonry directly above, if wider than 300 mm in horizontal dimension, shall be supported on lintel. Holes in masonry may be provided upto 300 mm in width and 300 mm in height without any lintel. In the case of circular holes in the masonry, no lintel needs to be provided for holes upto 400 mm diameter.
- (b) Cutting of chases in half brick load bearing walls
 - (i) No chase shall be permitted in half brick load bearing walls and as such no recessed conduits and concealed pipes shall be provided with half brick thick load bearing walls.
- (c) Cutting of chases in half brick non load bearing walls

- (i) Services shall be planned with the help of vertical chases. Horizontal chases shall be provided only when unavoidable.

16.36.5. Joints

The thickness of all types of joints including brick wall joints and cross joints shall be as specified in approved construction drawings or directed by Employer/PMC. However, the thickness of joints shall be not more than 10 mm. The deviation from the specified thickness of all joints shall not exceed one fifth of specified thickness.

16.36.6. Finishing of Joints

The face of brick work shall be finished flush or by pointing as specified in approved construction drawings or directed by Employer/PMC. In flush finishing, either the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick (in case no plaster on wall is required) or the joints shall be squarely raked out to a depth of about 10 mm while the mortar is still green for subsequent plastering (in case, plaster on wall is required to be provided). The faces of brick work shall be cleaned with wire brush so as to remove any splashes of mortar during the course of raising the brick work. In pointing, the joints shall be squarely raked out to a depth of 15 mm while the mortar is still green and raked joints shall be brushed to remove dust and loose particles and well wetted, and shall be later refilled with mortar to give ruled finish. Some such finishes are 'flush', 'weathered', ruled etc.

16.36.7. Curing:

The brick work shall be constantly kept moist on all faces for a minimum period of seven days. Brick work done during the day shall be suitably marked indicating the data on which the work is done so as to keep a watch on the curing period.

16.37. PLASTERING

16.37.1. General

Cement, water and sand to be used in plaster work shall be as per specifications of C.P.W.D. and conforming to relevant Indian Standards. Plastering shall be started from the

top and worked down towards the floor. All put log holes shall be properly filled in advance of the plastering as the scaffolding is taken down. To ensure even thickness and a true surface plaster about 15x15 cm patches shall be first applied, horizontally & vertically, at not more than 2 meters intervals over the entire surface to serve as gauges. The surface of these gauge areas shall be truly in the plane of the finished plaster surface. The mortar shall be applied to uniform surface which shall be brought to true surface by working a wooden straight edge reaching across the gauges with small upward and sideways movements at a time. Finally the surface shall be finished off true with trowel or wooden float as a smooth or a sandy granular texture as required. Excessive troweling or over working the float shall be avoided.

All corners, angles and junctions shall be truly vertical or horizontal as case may be and shall be carefully finished. Rounding or chamfering of corners, junction etc. wherever required shall be done without any extra payment. Such rounding or chamfering shall be carried out with proper templates to the size required.

While suspending work at the end of the day, the plaster shall be left out clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scraped, cleaned and wetted with cement slurry before plaster is applied to the adjacent areas to enable the two to properly joint together. Plastering work shall be closed at the end of the day on the body of the wall and not nearer than 15 cm to any corners or angles; it shall not be closed on the body of the features such as plasters, bands and copings, as these invariably lead to leakage. No portion of the surface shall be left out initially to be patched up later on.

The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

16.37.2. Finish

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the

work proceeds.

16.37.3. Precaution

Any cracks which appear in the surface, or any portion which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by Employer/PMC.

16.37.4. Thickness

The thickness of the plaster specified shall be measured exclusive of the thickness of key. The average thickness of the plaster shall not be less than the specified thickness and the minimum thickness over any portion of the surface shall not be less than specified thickness by more than 3 mm. Where the specified thickness of plaster is 20 mm or more, it shall be applied in two stages. In the cases of brick work the minimum thickness over the surface shall not be less than 12 mm on even face and 15 mm on rough face of wall.

16.37.5. Curing

Curing shall be started as soon as the plaster hardened sufficiently so as not to be damaged when watered. The plaster shall be kept wet for a period of at least 7 days and during this period, it shall be suitably protected from all damages by the contractor at his own expense by such means as the Employer/PMC may approve or direct. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

16.37.6. Scaffolding

For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong tied together with horizontal pieces over which scaffolding planks shall be fixed. For all other masonry in buildings, single scaffolding shall be permitted. In such cases, the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose. Only one header for each pole shall be left out. Such holes for scaffolding however, shall not be allowed in pillars/ Columns less than 1.0 m in width, or immediately near the skew backs of arches. The hole left in masonry works for scaffolding purpose shall

be filled and made good before plastering.

16.38. WATER PROOFING COMPOUND

16.38.1. General

The water proofing compound shall conform to relevant Indian Standards/equivalent International Standards and shall be mixed in concrete and cement mortar in the proportion and in the way as recommended by the manufacturer.

16.39. FLOORING, SKIRTING AND DADO WORKS

Unless otherwise shown on the approved construction drawings or specified, the materials, workmanship, etc shall be as per CPWD specifications.

16.39.1.1. Vitrified Tile Flooring And Dado/ Skirting

16.39.1.2. Materials

Vitrified Tiles: The tiles shall be vitrified, glazed and anti-skidding type conforming to IS:15622 and shall be of approved make, color and design. They shall be flat and true to shape and free from cracks, blisters, welts, crawling, crazing spots, chipped edges, corners or other imperfections detracting from their appearance. The glazing shall be of uniform shade.

The tiles shall be of square or rectangular of nominal sizes such as 300x300 mm, 300x600 mm, 600x600 mm or any other size as directed by the Employer/PMC.

The thickness of the tiles shall not be less than 10 mm for floor tiles and 6 mm for wall tiles.

Samples of tiles shall be got approved by the Employer/PMC before use in the work. Top surface of tile shall be glossy or matt as specified.

16.39.1.3. Preparation of Surface & Laying

Sub grade concrete or R.C.C slab or side brick wall/ or plastered surfaces on which tiles are to be laid shall be cleaned, wetted and mopped. Until and unless the surface is approved by the Employer/PMC, the flooring shall not be started. The bedding for the tile shall be of

Cement Mortar 1:3 (1 Cement : 3 Coarse Sand) and shall be applied and allowed to harden. The mortar shall be roughened with wire brushes or by scratching diagonal lines 1.5mm deep at 7.5mm centre both ways. The back of tiles shall be buttered with a coat of grey cement slurry paste and edges with white cement slurry and set in the bedding mortar. The tiles shall be tapped gently with wooden mallet and corrected to proper planes and lines. The tile shall be butt jointed in pattern and joints shall be as fine as possible. The top of skirting/ dado shall be truly horizontal and joints truly vertical. After a period of curing of 7 days minimum, the tiles shall be cleaned and shall not sound hollow when tapped. The surface during laying shall be checked with a straight edge 2 m long. Where full size tiles cannot be fixed, these shall be cut/sawn to the required size & their edges rubbed smooth to ensure straight and true joints. Tiles shall enter not less than 10mm under side skirting/dado. After the tiles have been laid, surplus cement grout shall be cleaned off.

Before laying the cement mortar bedding the concrete floor surface shall be thoroughly hacked, cleaned of all mortar scales, concrete lumps etc. brushed, washed with water to remove mud, dirt etc. from the surface and shall be thoroughly wetted. Until and unless the surface is approved by the Employer/PMC, the flooring shall not be started. A bedding of cement mortar (1:4 of specified thickness or more if required to make up the level or grade) shall be laid evenly and to the required slopes as directed. The terrazzo tiles shall then be laid immediately after laying the mortar. All tiles shall be truly and evenly set in a thick slurry of cement of honey like consistency applied to the sides and bottom and over the prepared base at the rate of 4.4 kg/sq.m. over such an area would accommodate about 20 tiles. The tiles shall then be tamped down with wooden mallet until they are properly bedded and exactly in true plane and line, with the adjacent tiles. Care shall be taken to ensure that the tiles are solidly bedded without voids and air pockets. All tiles shall be extended upto the un-plastered surfaces of masonry walls/ RCC columns/ RCC walls. Wherever full tiles / half tiles cannot be fixed, tiles shall be cut /sawn from full tile to the required size and their edges rubbed smooth to ensure a straight and true joint. The tiles shall be close jointed in matching cement slurry and the cement slurry oozing out through the thin joints shall be immediately wiped clean. The joints between the tiles shall

not be greater than 1.5 mm. and shall be kept in straight lines or to suit the required pattern. The junction between wall plaster and tile work shall be finished neatly and without any waviness. All tiles shall be laid as to have continuous lines from various rooms to the passage. No change of lines shall be permitted at junction between rooms and passage. The joints shall be fine and made neatly indistinguishable by grouting of the joints @ 2.20 kg/sq.m. of grey cement slurry mixed with suitable colouring pigments to match with the tiles. People should not be allowed to walk over the freshly laid tiles. Adjustment of levels in thickness of mortar bedding due to different type of flooring if any, shall be done by the contractor within a reasonable limit/distance as directed by the Engineer-in-Charge without any extra cost to the Department.

16.39.1.4. Mortar and Bedding:

Cement mortar for bedding shall be of proportion specified in items schedule and shall conform to the specification for materials, preparations etc. as specified under cement mortar. The amount of water added while preparing mortar shall be the minimum necessary to give sufficient plasticity for laying. Care shall be taken in preparation of the mortar to ensure that there are no hard lumps that would interfere with the evenness of bedding of the tiles. Before spreading the mortar bed the base shall be cleaned of all dirt, scum or laitance and loose materials and well wetted without forming any pools of water on the surface. The mortar of specified proportion and thickness shall then be even and smoothly spread over the base by use of screed battens to proper level or slope. Cement mortar of thickness and proportion as specified in the schedule for dado shall be applied to the wall after preparing the wall surface as specified under cement plaster 20mm. thick and brought to correct line and plumb and the surface left rough to receive the tiles.

16.39.1.5. Fixing of Tiles for Flooring:

The tiles before laying shall be soaked in water for atleast 2 hours. The tiles shall be laid on the bedding mortar when it is still plastic but has become sufficiently stiff to offer a fairly firm cushion for the tiles. Tiles which are fixed on the flooring adjoining the wall shall be so arranged that the surface on the round edge tiles shall correspond to the skirting or dado. Neat cement mortar grout 1:2, using fine sand (Table-III, Zone-IV and as per IS:383) of

honey like consistency shall be spread over the bedding mortar just to cover as much area as can be tiled within half an hour. The edges of the tiles shall be smeared with neat white cement slurry and fixed in this grout one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. There shall be no hollows in bed or joints. The joints shall be kept as close as possible and in straight line. The surface of the flooring during laying shall be frequently checked with a straight edge about 2 meter long to obtain a true surface with the required slope. in width. The joint shall be grouted with white/matching colour cement slurry. After fixing the tiles, finally in an even plane or slope, the flooring shall be covered with wet sand and allowed undisturbed for 14days.

16.39.1.6. Fixing Tiles for Dado & Skirting

The dado/skirting work shall be done only after fixing the tiles on the floor. The approved white glazed tiles before laying shall be soaked in water for atleast 2 hours. Tiles shall be fixed when the cushioning mortar is still plastic and before it gets very stiff. The back of the tile shall be covered with this layer of cement mortar 1:2 using fine sand (Table-III, Zone-IV, IS: 383) and the edge of the tile smeared with neat white cement slurry. The tile shall then be pressed in the mortar and gently tapped against the wall with a wooden mallet. The fixing shall be done from bottom of wall upwards without any hollows in the bed of joints. Each tile shall be as close as possible to one adjoining. The tiles shall be jointed with white cement slurry. Any thickness difference in the thickness of the tiles shall be arranged out in cushioning mortar so that all tiles faces are in one vertical plane. The joints between the tiles shall not exceed 1.00 mm in width and they shall be uniform.

While fixing tiles in dado work, care shall be taken to break the joints vertically. The top of the dado shall be touched up neatly with the rest of the plaster above. After fixing the dado/skirting etc., they shall be kept continuously wet for 7 days. If doors, windows or other openings are located within the dado area, the corners, sills, jambs etc. shall be provided with true right angles without any specials. The contractor will not be entitled to any extra claims on this account for cutting of tiles if required.

Cleaning: After the tiles have been laid in a room or the day's fixing work is completed, the

surplus cement grout that may have come out of the joints shall be cleaned off before it sets. After the complete curing, the dado or skirting over shall be washed thoroughly clean. In the case of flooring, once the floor has set, the floor shall be carefully washed clean and dried. When dry, the floor shall be covered with oil free dry saw dust. It shall be removed only after completion of the construction work and just before the floor is used.

16.39.2. Terrazzo (Marble Chips) Flooring

16.39.2.1. General

50 mm thick marble chips flooring grinded and polished to granolithic finish shall be provided in buildings wherever specified in the approved construction drawings. It shall consists of a 35 mm thick cement concrete 1:2:4 (1 Cement: 2 sand: 4 Coarse aggregates of 12.5 mm nominal size) under layer and a 15 mm thick top layer with 6 mm thick white, black or approved colour marble chips of nominal size 1.5 mm laid in white cement in proportion 1:2 (1 White Cement: 2 marbles chips). The thickness of the top layer shall not be less than that specified.

16.39.2.2. Under Layer

Cement concrete of specified mix shall be used and the concrete shall conform to the specification given under the 'Concreting'. The panels shall be of uniform size not exceeding 2.0sq.m.area and 2.0 m in length in inside situation. In exposed situations, the length of any side of the panel shall not be more than 1.25 meters.

Cement slurry @ 2.75 kg. per sq. m. shall be applied before laying of layer over the cement concrete / R.C.C. surface.

16.39.2.3. Glass and PVC Strips:

Glass or PVC strips of 4.0 mm thickness and 40 mm wide shall be provided in joints of terrazzo floors. The strips shall be fixed over under layer in a pattern shown in the construction drawings or as directed by Employer/PMC with their top at proper level.

16.39.2.4. Top Layer

Marbles: The mix for terrazzo topping shall consist of white cement with or without

pigment, marble powder, marble chips and water. The white cement and marble powder shall be mixed in the proportion of 3 part marble powder by weight. For every part of cement marble powder mix, the proportion of marble chips by volume shall be as follows:

TABLE-16.8
PROPORTION OF MARBLE CHIPS

Size of Marble Chips	Proportion of aggregates to binder mix
For grade 0 and 1	1.75 parts
For grade 2 and 3	1.50 parts
For grade 4 and 5	1.25 parts
Mixed size aggregate	1.50 parts

The marbles chips shall be hard, sound, dense and homogeneous in structure with crystalline and coarse grains. They shall be uniform in colour and free from stains, cracks decay and weathering.

Before starting the work, the contractor shall get the samples of marble chips approved by the Employer/PMC. The cement to be used shall be white cement with pigment of approved colour and quality in the specified ratio or in the ratio to get the required shade ordered by the Employer/PMC. Pigment where specified, shall be mixed dry thoroughly with the cement and marble powder and marble chips added and mixed as specified above. The full quantity of dry mixture of mortar required for a room shall be prepared in a lot in order to ensure a uniform colour. The mixture shall be stored in a dry place and well covered and protected from moisture. The dry mortar shall be mixed with water in the usual way as and when required. The mixed mortar shall be homogeneous and stiff and contain just sufficient water to make it workable.

The terrazzo topping shall be laid while the under layer is still plastic, but has hardened sufficiently to prevent cement from rising to the surface. This is normally achieved between 18 to 24 hours after the under layer has been laid. A cement slurry preferably of the same colour as the topping shall be applied on the surface immediately before laying of terrazzo topping is commenced. The terrazzo topping shall be laid to a uniform

thickness slightly more than that specified in order to get the specified finished thickness after rubbing. The surface of the top layer shall be troweled over, pressed and brought true to required level by a straight edge and steel floats in such a manner that the maximum amount of marble chips come up and are spread uniformly over the surface.

16.39.2.5. Curing, Polishing and Finishing

Curing shall be done by suitable means, such as laying moist jute bags or pounding water.

Polishing shall be done by machine. About 36 hours after laying the top layer, it shall be watered and ground evenly with machine fitted with special rapid cutting grit block (Carborandum stone) of coarse grade (No.60) till the marble chips are evenly exposed and the floor is smooth. After the first grinding, the surface shall be thoroughly washed to remove all grinding mud and covered with a grout of white cement in same mix and proportion as the topping in order to fill any pin holes that appear. The surface shall be allowed to cure for 5 to 7 days and then ground with machine fitted with fine grit blocks (No. 120). The surface is cleaned and repaired as before and allowed to cure again for 3 to 5 days. Finally the third grinding shall be done with machine fitted with fine grade grit blocks (No. 320) to get even and smooth surface without pin holes. The finished surface should show the marble chips evenly exposed.

Where use of machine for polishing is not feasible or possible, the rubbing and polishing shall be done by hand held machine or by hand, in the same manner as specified for machine polishing except that carborundun stone of coarse grade (No. 60) shall be used for the 1st rubbing, stone of medium grade (No. 80) for second rubbing and stone of fine grade (No. 120) for final rubbing and polishing.

After the final polish either by machine or by hand, the oxalic acid shall be dusted over the surface @ 33 gm per square meter sprinkled with water and rubbed, hard with a namdah block (pad of woolen rugs). The following day the floor shall be wiped with a moist rug and dried with a soft cloth and finished clean.

16.39.2.6. Precautions

Terrazzo flooring in lavatories and bathrooms, if specified in approved construction

drawings, shall be laid after fixing of water closet and squatting pans and floor traps. Traps shall be plugged, while laying the floor and opened after the floors are cured and cleaned. Any damage done to W.Cs, Squatting pans and floor traps during the execution of work shall be made good. The floor shall be protected from damage during the execution of work.

16.39.3. Marble Chips Skirting

16.39.3.1. General

Marble chips skirting of 150 mm height shall be provided in areas where terrazzo flooring has been provided, which shall be rubbed and polished to granolithic finish. The under layer shall be 12 mm thick plaster in cement mortar 1:3 (1 Cement: 3 Sand) and top layer 15 mm thick with marble chips of approved colours and of 4 mm nominal size laid in white cement with matching pigment (to floor) in proportion 1:2 (1 White Cement:2 marble chips).

16.39.3.2. Preparation of surface

The joints shall be raked to a depth of at least 15 mm in masonry walls, while the masonry is being laid. In case of concrete walls, the surface shall be roughened by hacking. The surface shall be cleaned thoroughly washed with water and kept wet for 12 hours before skirting work is commenced. The cement slurry shall be applied on cleaned surface just before laying the undercoat for skirting.

16.39.3.3. Application

Skirting with specified mortar and to specified thickness shall be laid immediately after the surface is prepared. The joints in skirting shall be finished smooth and true, with top truly horizontal and joints truly vertical except where otherwise indicated.

16.39.3.4. Curing

Curing shall be commenced on the next day of plastering when the plaster has hardened sufficiently. It shall be continued for a minimum period of 7 days except that the under coats shall be finished rough with a scratching tool to form base for the top coat.

16.39.4. Acid and Alkali Resistant Tiles Flooring

16.39.4.1. Manufacture and Finish

The tiles shall be of vitreous ware and free from deleterious substances. The iron oxide content allowable in the raw material shall not exceed two percent. The tiles shall be vitrified at the temperature of 1100⁰ C and above and shall be kept unglazed. The finished, tile, when fractured shall appear fine grained in texture, dense and homogenous. The tiles shall be sound, true to shape, flat and free from flows and manufacturing defects affecting their utility. The tiles shall be of required color.

The tiles shall be conforming to IS:4457. The tiles shall be tested for water absorption, compressive strength, acid resistance etc. as per IS:4457. Sampling procedure for acceptance tests and criteria for conformity shall be as per IS:4457.

16.39.4.2. Dimensions and Tolerances

Ceramic unglazed vitreous acid-resistant tiles shall be of sizes 100x100 mm (or 98.5 X 98.5 mm), 150x150 mm (or 148.5 X 148.5 mm) and 200x200 mm (or 198.5 X 198.5 mm) as per approval of Employer/PMC. The thickness of tiles to be used for flooring shall not be less than 15 mm and that for Dado, not less than 10 mm. The depth of the grooves on the underside of the tile shall not exceed 3 mm. Tolerance on length, breadth and thickness of tiles shall be as specified in IS:4457.

16.39.4.3. Shape

The tiles shall be square shape. Half tiles, rectangular in shape, shall also be available. Half tiles for use with full tiles shall have dimensions which shall be such as to make two half tiles, when joined together, match with the dimension of full tile. The shape of tiles other than square shall be used only after approval of Employer/PMC. Tiles shall be checked for squareness and warp as per IS: 4457.

16.39.4.4. Loss in Abrasion

The maximum percentage of loss in abrasion of the ceramic unglazed vitreous acid resistant tiles determined in accordance with the procedure laid down in IS:1237 shall be as mentioned in IS:4457.

16.39.4.5. Performance Requirements

The tiles when tested in accordance with method given in IS:4457 shall conform to be requirement specified therein.

16.39.4.6. Marking

Tiles shall be legibly marked on the back with the name of the manufacturer or his trade mark, batch number and year of manufacture. Each tile may also be marked with the ISI certification mark.

16.39.5. Ironite Flooring

16.39.5.1. General

To withstand heavy wear and tear, concrete flooring with metallic concrete hardening compound such as Ironite/ hardonate shall be laid as wearing layer in specified areas. It shall consist of 50 mm thick cement concrete (M-15 grade) under layer and 15 mm thick topping layer with metal hardener.

16.39.5.2. Metallic Concrete Hardening Compound

The metallic compound shall be Ironite/ Hardonate of approved quality consisting of uniformly graded iron particles, free from non-ferrous metal particles, oil, grease and soluble alkaline compound.

16.39.5.3. Cement Concrete Under Layer

Materials: The specifications for materials, grading, mixing shall generally conform to their relevant specifications described under the item of 'Concrete'. The nominal size of coarse aggregate shall be 10 mm. The fine aggregate shall consist of properly graded sand. Concrete shall be mixed by machine and hand mixing shall not be allowed.

Preparation of Base: The base concrete surface shall be thoroughly chipped to remove laitance, caked mortar, loose sand, dirt etc, cleaned with wire brush and washed clean and

watered until no more water is absorbed. Where the base concrete has hardened so much that roughening the surface by wire brushes is not possible, the same shall be roughened by chipping or hacking at close intervals. The surface shall be soaked with water for at least 12 hours and surface water removed and dried before laying the concrete under layer. Before laying the concrete, cement slurry at 2.75 kg/ sq.m. of surface shall be applied for better bond.

The joints in the floor finish shall extend through the borders and skirting/dado. The border shall have mitred joints at the corners of the room.

Mixing: The concrete of under layer shall be of mix of one part of cement, two parts of fine aggregates and 4 parts of well graded coarse aggregates of 10 mm nominal size. The ingredients shall be thoroughly mixed with just sufficient water to the required plasticity, having water cement ratio of not more than 0.4.

Laying: The free water on the surface of the base shall be removed and a coat of cement slurry to the consistency of thick cream shall be applied on the concrete surface. On this fresh grouted base, the prepared cement concrete shall be spread evenly and laid immediately after mixing and levelled carefully. Immediately after laying the concrete, the surface shall be inspected for high or low spots and any needed correction made up by adding or removing the concrete and whole surface is again levelled. The concrete shall be compacted and brought to the specified levels by means of a heavy straight edge resting on the side forms and down ahead with a sawing motion in combination with a series of lifts and drops alternatively with small lateral shifts, either mechanically or manually as directed by the Employer/PMC. When the layer is made even, the surface shall be completed by ramming or beating and then screed to a uniform line and level. Before the initial set commences, the surface shall be trowelled to smooth and even surface free from defects and blemishes and tested with straight edges.

Finishing the Surface: After the concrete has been thoroughly compacted and when most of the surface water has disappeared, the surface shall be given broom finish with an approved type of brass or M.S. fiber broom. The broom shall be pulled gently over the surface from edge to edge in such a manner that corrugation shall be uniform in width and

depth, the depth shall be not more than 1.5 mm. Brooming shall be done when the concrete is in such a condition that the surface shall not be torn or unduly roughened by the operation. Coarse or long bristles which cause irregularities or deep corrugation shall be trimmed out. Brooms which are worn or otherwise unsatisfactory shall be discarded.

The top surface shall be roughened with brushes while the concrete is still green and the form shall be kept projecting up 12 mm over the concrete surfaces to receive the metallic hardening compound topping.

16.39.5.4. Metallic Concrete Hardener Topping

This shall consist of 15 mm thick layer of mix 1:2 (1 part of cement mixed with hardener: 2 parts of stone aggregate of 6 mm nominal size by volume). The metallic concrete hardener compound being mixed with cement in the ratio of 1:4 (1 metallic concrete hardener: 4 cement used by weight) or as specified by the manufacturer.

Concrete hardener shall be dry mixed thoroughly with cement on a clean dry concrete/metal platform. This dry mixture shall then mixed with stone aggregate of 6mm nominal size or as otherwise specified in the ratio of 1:2 (1 cement mixed with hardener: 2 stone aggregate) by volume, and well turned over. Just enough water shall then be added to this dry mix as required for floor concrete, water cement ratio not exceeding 0.4. The mixture so obtained shall be laid in 12 mm thickness on cement concrete floor within 1 to 4 hours of its laying. The topping shall be laid true to provide a uniform and even surface. It shall be firmly pressed into the bottom concrete so as to have good bond with it. The concrete shall be mechanically well compacted. Manual compaction will not be permitted unless approved by the Employer/PMC. After the initial set has started, the surface shall be finished smooth and true to slope with steel floats.

16.39.5.5. Curing and Precautions

The completed flooring shall be protected from sun, wind and rain for the first two days and movement of persons over the floor is prohibited during this period. The finished surface shall be cured continuously from the next day after finishing, at least for a period of 7 days. Curing shall be done by spreading sand and kept damp throughout the curing

period of seven days minimum. The surface shall be protected from any damage to it whatsoever. The surface shall then be allowed to dry slowly. All corners, junctions of floor with plastered wall surface shall be rounded off.

16.39.6. Fine Grained Stone Slab Flooring

16.39.6.1. Marble Stone and Similar Fine Grained Stones:

These shall include natural stone slabs of regular shape and dimensions and capable of taking a good polish and lay over a under bed on a concrete or masonry surface.

16.39.6.2. Thickness

The under bed shall have a minimum thickness of 12mm and an average thickness of 20mm. The stone slabs shall be of 25 mm or 30 mm or 40 mm thickness as specified or directed by Employer/PMC. The total thickness shall however be as shown on the drawings.

16.39.6.3. Stone Slab

The stone slabs shall be made from selected stock and shall be hard, sound, homogeneous and dense in texture and free from flaws. Angles and edges shall be true, square, free from chipping and surfaces shall be plane. The slab shall be machine cut to the required dimensions. Tolerances of ± 5 mm in dimensions and ± 2 mm in thickness shall be allowed. Unless otherwise specified the slabs shall not be smaller than 300mm x 300mm.

Stone slabs shall come from specific regions and in specified quality with the top surface fine chisel dressed. All Sides shall also be fine chisel dressed to the full depth to allow for the finest possible joints. Slabs shall be delivered to the site well protected against damage and stored in a dry place under cover.

16.39.6.4. Mix for Under Bed

As specified for terrazzo tile finish.

16.39.6.5. Laying

The sides and top surface of the slabs shall be machine rubbed or table rubbed with coarse sandstone and washed clean before laying.

The under bed mortar shall be evenly spread and slab shall be laid over the under bed, pressed and tapped down with a wooden mallet to the proper level. The slab shall then be lifted and the under bed corrected if necessary and allowed to stiffen a little. Thick cement slurry shall then be mixed with a pigment matching the colour of stone. The slab shall be gently laid and tapped with a wooden mallet to bed properly to a very fine joint and to the required level. All surplus cement slurry shall be removed and the surface mopped clean with a wet soft cloth. The laid finish shall be cured for 7 days by keeping it wet.

16.39.6.6. Polishing and Finishing

Fine chiseling shall be done to remove slight undulations at the Joints. Polishing and finishing shall be done as specified for terrazzo tile finish. However, the joints shall be so fine in the case of stone slabs that grouting shall not be called for.

16.39.7. Glazed Tiles

The walls in toilets, bathrooms, pantries etc shall be finished with glazed tiles of approved size, quality, colour, texture and make upto ceiling height. Complete work shall be carried out as per C.P.W.D. Specification.

16.39.7.1. Glazed Tiles in Skirting and Dado

The tiles shall be of approved make and shall generally conform to IS:15622. The tiles shall be earthenware covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility. The top surface of the tiles shall be glazed. The underside of the tiles shall not have glaze in order that the tile may adhere properly to the base. The edges of the tiles shall be free from glaze;

The glaze shall be free from welts; chips craze specks, crawlings or other imperfections detracting from the appearance when viewed from a distance of one meter. The glaze shall be either glossy or matt as specified in approved construction drawings or directed by Employer/PMC.

16.39.7.2. Dimensions

Glazed earthenware tiles shall be of rectangular sizes such as 450 mm x 300 mm or as specified in approved construction drawings or directed by Employer/PMC and shall be straight or cushion edge type. Half tiles for use as full tiles shall have dimensions which shall be such as to make the half tiles when joined together (with 1 mm joint) match with dimensions of full tiles. The thickness of the tiles shall be not less than 6 mm.

The dimensions of fittings associated with the glazed tiles namely covered edges, round edge tile, angles corner cups, ridge and legs , cornices and capping beads shall be of the shape and dimensions as required and the thickness of fittings shall be same as the thickness of tiles given above.

16.39.7.3. Tolerances

Facial Dimensions: The dimensions of all the four sides of the tiles shall be measured to the nearest 0.1 mm .The average value of lengths /breadth shall not vary more than ± 0.8 mm from the specified dimensions of tiles. The variation of individual dimensions from average value of length and breadth shall not exceed ± 0.5 mm. Tolerance on thickness shall be ± 0.4 mm. Tiles shall be checked for squareness and warpage as specified herein under.

16.39.7.4. Trueness of Shape (Squareness)

Any variation from a right angle in the angle contained by any two adjoining sides shall be limited so that a builder's steel square is placed against the angle, the distance between the inner edge of the square and the adjacent side of the tile or fitting shall not be more than 0.5 mm per 100 mm run.

16.39.7.5. Warpage

The tiles when tested for warpage on the edge and on diagonal shall not have warpage exceeding the values as specified below:

TABLE-16.9

WARPAGE TOLERANCE

Size of Tile (mm)	Warpage (mm)
-------------------	--------------

100 mm x 100 mm	± 0.3
200 mm x 200 mm	± 0.4
152 mm x 152 mm	± 0.7

16.39.7.6. Performance Requirement

Water Absorption: The average water absorption of the tiles when tested and evaluated in accordance with IS:15622 shall not exceed 20 per cent.

Crazing: Tiles subjected to two cycles of crazing test as per IS:15622 shall not show any sign of crazing.

Impact Resistance: Tiles when tested for impact resistance as per IS:15622 shall remain intact, apart from surface marking.

Chemical Resistance: When tested as per IS:15622, the glazed surface of tiles and for the fittings having a white glossy glaze shall show no modification.

Preparation of surfaces: The joints shall be raked out to a depth of at least 15 mm in masonry walls. In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface shall be cleaned thoroughly, washed with water and kept wet for 24 hours before skirting is commenced

16.39.7.7. Laying

12 mm thick plaster of cement mortar 1:3 (1 Cement: 3 Coarse sand) mix shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonally at closed intervals.

The tiles shall be soaked in water, washed clean, and coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and corrected to proper place and lines. The tiles shall be set in the required pattern and jointed. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated. Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed, these shall be cut (sawn) to the required size and their edge

rubbed smooth.

16.39.7.8. Curing and Finishing

The joints shall be cleaned off the grey cement grout with wire/ coir brush or trowel to a depth of 2mm to 3mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigments if required to match the colour of tiles. The work shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

16.40. STRUCTURAL STEEL TRUSS ROOF

16.40.1. General

Unless or otherwise shown on the drawings or otherwise specified, the materials, workmanship, measurement and rate shall be as per Central Public Works Department (C.P.W.D.), Ministry of Urban Development, Government of India's Specifications and as per relevant Indian Standards for structural steel works

16.40.2. Material

All materials supplied or used in the manufacture of items of steelwork shall be the best of the respective kinds and free from defects and shall conform to applicable Indian Standards.

All finished steel shall be well and cleanly rolled to the dimensions and weight specified by applicable Indian Standard subject to permissible tolerances as per IS: 1852 (Rolling and cutting tolerances for hot rolled steel products). The finished material shall be free from cracks, surface flaws, laminations, rough and imperfect edges and all other harmful defects.

Steel sections shall be free from rust, scaling and pitting and shall be well protected. The decision of the Employer/PMC regarding rejecting steel section on account of any of the above defects shall be final and binding on the Contractor.

The mechanical and chemical properties of steel shall be as per as per relevant Indian

Standards.

- (a) All circular steel tubes shall conform to IS: 1161-1968 and manufactured from Steel of Grade Y_{st} 240, hot finished grade with carbon and sulphur contents of less than 0.3% & 0.06% respectively. The steel shall be of tested quality.
- (b) All rectangular and square hollow section shall conform to IS: 1387-1967, IS: 4293—1985 manufactured from steel of Grade Y_{st} 240, hot finished grade with carbon content of less than 0.3%. The steel shall have no more than 0.06% sulphur or more than 0.06% Phosphorus and shall be of tested quality.
- (c) All other steel shall conform to IS: 2062-2011 defined as ST 42-S (standard quality) unless mentioned in item below.
- (d) Steel conforming to IS: 1977 defined as ST 32-00 (ordinary quality) shall only be used for:
 - Anchors or brackets in concrete or brickwork
 - Holding down bolts for fixing trusses etc.
 - Wind bracing rods and rings
 - Bolts, nuts washers

If no relevant India Standard exists, the materials shall be of an approved manufacturer entirely adequate for their purpose in the Works as approved by Employer/PMC.

16.40.3. Fabrication

The fabrication of structural steel work shall be carried out in accordance with approved construction/ fabrication drawings and in accordance with relevant Indian Standards.

The contractor shall ensure that all materials and workmanship are free from defects and the contractor shall replace any defective material and workmanship found during fabrication or erection at no cost to the Employer.

16.40.4. Workmanship

The contractor shall observe the greatest accuracy and ensure that all parts fit together

properly on assembly and erection. When sealing hollow sections, the contractor shall ensure that insides of sections are dry and clear of debris before sealing ends and openings.

16.40.5. Welding

All welding of steel shall be carried out in the workshop of the contractor or of an approved manufacturer. No welding on the site shall be carried out without the prior written approval of the Employer/PMC. Welding shall be carried out as per following Indian Standards:

- (a) IS:806 - Code of Practice for use of steel tubes in General Building Construction;
- (b) IS:816 - Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel;
- (c) IS: 823 - Code of Procedure for Manual Metal Arc Welding of Mild Steel;
- (d) IS: 819 -Code of Practice for Resistance Spot Welding for light assemblies in Mild Steel.

In general, the size of Fillet welds shall not be less than 6 mm and the welds shall be continuous unless otherwise specified or approved by the Employer/PMC.

The Contractor shall not commence any fabrication of steel work before he has obtained the approval of the Employer/PMC of his proposed welding processes, techniques and weld procedures.

The Contractor shall select the type of electrode that he considers suitable for the Works. All electrodes shall comply with IS:814 (Part-1&2) and shall be baked and stored in accordance with the manufacturer's recommendations. All welds shall be cleaned off slag and ground smooth. The Employer/PMC may require tests on welds as per relevant Indian Standards.

16.40.6. Bolting

Only bolts, nuts and washers to be used in works shall be new and conform to relevant Indian Standards. All bolted connections shall fit closely together and bolt holes shall

match and be parallel. During erection, the holes shall not be distorted or enlarged. If the contractor wishes to enlarge any hole, this shall be carried out only after approval of Employer/PMC and shall be done by reaming. Bolts shall be tightened to the torque specified or as may be ordered or approved by the Employer/PMC. Taper washers shall be used wherever bolt heads or nuts are bearing on sloping surfaces of members.

16.40.7. Protective Coating

All surfaces of steelwork (with the exception of galvanized surfaces) shall receive one coat of approved zinc chromate primer conforming to IS: 104 before leaving the workshop.

16.40.8. Shop Assembly

Trusses, prior to their packing and transportation to the site, shall be assembled in the Contractor's fabricating workshop to determine the correctness of the fabrication. Each assembled unit shall be closely checked to ensure that the specified alignment has been provided. Assembly and disassembly work shall be carried out in the presence of the Employer/PMC (or his Representative). The Contractor shall rectify at his own expense any error or defect observed during the trial assembly.

Before the trusses are dismantled for delivery, each item shall be matched, marked to facilitate erection at the site. The markings on members shall be punched with the help of steel letters and figure punches and shall remain clearly visible. After the application of the protective coating, the location of the match marks shall be indicated by a ring of white paint.

Prior to the dispatch of the steelwork from the fabrication yard, the contractor shall prepare a plan showing the arrangement of the trusses and their appropriate match marks and shall forward one copy to the Employer/PMC.

16.40.9. Transportation

The contractor shall be responsible for all handling and transportation of the steelwork from its place of manufacture to the site. Prior to the transportation, the Contractor shall prepare the items of steelwork for transport so as to effectively protect all coatings against damage of any kind. Should any damage nevertheless occur, the same shall be

made good by the contractor at no cost to the Employer? All repairs of protective coatings shall be carried out in accordance with the paint manufacturer's recommendations and to the satisfaction of the Employer/PMC.

16.40.10. Erection of Steel Work

Holding down bolts shall be cast into first stage concrete. Before commencing any erection of structural steelwork, the contractor shall submit to the Employer/PMC for his approval, a written description of his proposed method and sequence of work including full details of his proposals for temporary supports, bracing and steadying. Such temporary supports etc shall be sufficient to ensure the stability of all members of steelwork during the erection. The Employer/PMC's approval of the Contractor's measures shall in no way relieve the Contractor of any of his responsibilities under the Contract. During the erection, the steelwork shall not be subjected to stresses in excess of the maximum permissible stresses specified in IS: 806-1968 or other applicable Indian Standards. The Contractor shall not carry out any modifications to fabricated steelwork without the written approval of the Employer/PMC. On completion of erection, the steelwork shall be plumb, true to line and level in accordance with the approved drawings to the satisfaction of the Employer/PMC.

16.40.11. G.I. Sheet Roofing

Roofing shall consist of steel roof trusses and set of purlins over which G.I. Corrugated Sheet of 1.0 mm thick shall be provided. All structural steel for roofing shall be mild steel of grade G24 having Young Modulus of 21,000 da N/mm² and yield strength of a minimum 24 da N/mm². All fillet welds shall be full penetration and be of structural purpose. Size of weld shall not be less than 0.7 times the thickness of the smallest member.

Purlins of mild steel rolled sections of requisite size shall be fixed over the principal rafters of trusses. The top surfaces of the purlins shall be uniform and plane. They shall be painted before fixing on top.

Gutters shall be fabricated from plain G.I. sheets 1.25mm thick or other size as specified in the approved construction drawings. Eaves gutters shall be of the shape and section as

specified in approved construction drawings. The overall width of the sheet referred to therein shall mean the peripheral width of the gutter including the rounded edges. The longitudinal edges shall be turned back to the extent of 12 mm and beaten to form a rounded edge. The ends of the sheets at junctions of pieces shall be hooked into each other and beaten flush to avoid leakage. Gutter shall be laid with a minimum slope of 1 in 100. Gutter shall be supported on and fixed to M. S. flat iron brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1.20 meter.

16.40.12. Ridges and Hips

Ridges and hips of roof shall be covered with ridge and hip sections of G.I. Sheet of 22 Gauge with a minimum lap of 200 mm on either side over the G.I. Corrugated sheets. The end laps of the ridges and hips and between ridges and hips shall also be not less than 200 mm. The ridges and hips shall be of 600mm overall width and shall be properly bent to shape.

16.40.12.1. Fixing

Ridges shall be fixed to the purlins below with the same 8.0 mm diameter G.I. hook, bolts and nuts and bitumen and G.I. limpet washers which fix sheets to the purlins. Similarly hips shall be fixed to the roof members below such as purlins, hip and valley rafters with the same 8.0 mm dia. G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to these roof members. At least one of the fixing bolts shall pass through the end laps of ridges and hips, on either side. If this is not possible, extra hook bolts shall be provided. The end laps of ridges and hips shall be joined together by galvanized iron seam bolts 25 mm x6mm size each with bitumen and G.I. washer white lead as directed by the Employer/PMC.

16.40.12.2. Finish

The edges of the ridges and hips shall be straight from end to end and their surface shall be plane and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets.

16.40.13. Wind Ties

These shall be fixed at the eave end of the sheets. The fixing shall be done with same hook bolts which secure the sheets to the purlin.

16.40.14. Holding Down Bolts

The holding down/foundation bolts shall be placed in the 1st stage concrete and these shall be held in position with a wooden/metal template. The bolt shall be provided with suitable timber mould or pipe sleeve to allow for adjustment. The timber mould or pipe shall be removed after initial set of concrete. The spaces left around holding down bolts shall have sloping channel leading to the side of pedestal and on the underside of the base plate to allow the spaces being grouted after the base plate is fixed in the position along with the column.

16.40.15. Mild Steel Bolts, Nuts and Washer

All bolts heads and nuts shall be hexagonal unless specified otherwise. The screwed threads shall conform to IS: 1363 and the thread surface shall not be tapered. The bolts shall be of such length as to project at least two clear threads beyond the nuts when fixed in position, and these shall fit in the holes without any slake. The nuts shall fit in 'the threaded ends of bolts properly. In all cases where full bearing area of the bolts is to be developed, the bolts shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. Where there is the risk of the nuts being removed or becoming loose due to vibration or reversal of stresses, these shall be secured from slackening by the use of lock-nuts, spring washers or cross cutting as directed by the Employer/PMC.

16.41. FALSE CELING

16.41.1. It shall involve providing and fixing tiled false ceiling of approved material of size 595x595 mm in true horizontal level, suspended on interlocking grid of hot dip galvanized steel sections (galvanized @120 gram per square meter both side inclusive).

16.41.2. The interlocking grid shall consist of main 'T' runners with suitably spaced joints to get required length and of size 24x38mm made from 0.8 mm thick (minimum) steel sheet, spaced @ 1200 mm centre to centre and cross 'T' of size 24x25mm made of 0.3 mm thick

(minimum) sheet, 1200 long paced between main 'T' at 600 mm centre to centre to form the grid of 1200x600 mm and secondary cross 'T' of length 600 mm and of size 24x25 mm, made from 0.8 mm thick (minimum) steel sheet to be interlocked at middle of the 1200x600 mm panel to form the grid of 600x600mm and wall angle of size 24x24x0.3 mm and laying false ceiling titles of approved texture in the grid including, required cutting/making opening for services like diffusers, grills, light fittings & fixtures, smoke detectors etc.

16.41.3. The main 'T' runners shall be suspended from ceiling using GI slotted cleats of size 27x37x25x1.6 mm fixed to ceiling with 12.5 mm diameter and 50 mm long dash fasteners, 4 mm diameter GI adjustable rods with galvanized butterfly level clips of size 85x30x0.8 mm spaced at 1200 mm centre to centre along main 'T'. The bottom exposed width of 24 mm of all 'T' sections shall be pre-painted with polyester paint.

16.41.4. The false ceiling panel/titles shall be either of the following material as approved by Employer/PMC:

- (a) 12.5 mm thick square edge PVC laminated Gypsum tiles made of Gypsum Plaster board manufactured from natural Gypsum as per IS:2095 and laminated with white 0.16 mm thick fire retardant PVC film on the face side on the back side with all edges sealed with the face side PVC film which shall go around and wraps the edges and is bonded to the edges and the back side polyester film so as to make the tile a completely sealed unit.
- (b) 12.5 mm thick fully perforated Gypsum Board tile made from plasterboard having glass fibers conforming to IS:2095 of size 595x595 mm, having 9.7x9.7 mm at 19.4 mm centre to centre with center of borders of 48 mm and the side borders of 30 mm, backed with non woven tissue on back side, having NRC (Noise Reduction Coefficient) of 0.79, with 50 mm resin bonded glass wool backing.
- (c) 15 mm thick densified regular edges eco friendly light weight calcium silicate false ceiling titles of approved texture spintone/cosmos/Hexa or equivalent of size 595x595 mm

(d) 15.0 mm thick approximately 600 X 600mm size mineral fiber board tiles.

16.41.5. The work shall be carried out at all heights as per approved drawings and direction of Employer/PMC.

16.42. POWER COATED ALUMINIUM DOORS AND WINDOWS

16.42.1. General

Power coated aluminum doors, windows and ventilators shall, in general, conform to C.P.W.D. specifications.

16.42.2. Extruded aluminum sections shall have a minimum 3 mm wall thickness. All sections shall be approved by the Employer/PMC before fabrication is taken up. Door frames, mullions, transoms, etc., shall be anodized in bath of sulphuric acid to provide a clear coating of minimum 6.0 mm thickness. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections before shipment from the factory.

16.42.3. All work shall be fitted and shop assembled to a first class job, and ready for erection. Shop joints shall be made to hair lines and then welded or braced by such method as shall produce a uniform colour throughout the work. Work on the above, other than described, shall be carefully fitted and assembled with concealed fasteners. Wherever possible, joints shall be made in concealed locations and on edges of doors. Field connections of all work shall be made with concealed screws or other approved type of fasteners. Glazing beads shall be snap fit type without visible screws and shall be of sizes to accommodate glazing. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

16.42.4. Doors, Windows, and Ventilators Fittings

16.42.4.1. General

The make and quality of the fitting shall be approved by Employer/PMC. The screws used for fittings shall be of same metal and finished as the fittings. Number of screws used for

the fittings shall be as specified in the approved drawings or specification of the fittings.

16.42.5. Hold Fast

16.42.5.1. General

The suitable Hold Fast shall be provided for fixing doors, windows and ventilator frames into masonry or concrete. 50 mm length at one end of the hold fast shall be bent at right angles and one hole of 11 mm diameter shall be made in it for fixing to the frame with 10 mm diameter bolt. The bolt head shall be sunk into the frame and covered with with suitable plugs matching with the frame. At the other end, the hold fast shall be forked and bent at right angles in opposite directions and fixed in cement concrete block/masonry wall of specified size.

16.43. PAINTING

16.43.1. Cement Paint

16.43.1.1. Materials

The cement paint shall be conforming to IS: 5410 and shall be of approved brand and manufacture. The cement paint shall be brought to the site of work in the containers in sealed condition. The materials shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the Contractor and the Employer/PMC. The empties shall not be removed from the site of work till the relevant item of the work has been completed and permission obtained from the Employer/PMC.

16.43.1.2. Preparation of mix

Cement paint shall be mixed in such quantities that the same can be used within an hour of its mixing as otherwise the mixture shall set affecting flow and finish. Cement paint shall be mixed with water in two stages. The first stage shall comprise of 2 parts of cement paint and one part of water stirred thoroughly as allowed to stand for 5 minutes. Care shall be taken to add the cement paint gradually to the water and not vice versa. The second stage shall comprise of adding further one part of water to the mix and stirring

thoroughly to obtain a liquid of workable and uniform consistency. In all cases the manufacturer's instructions shall be followed meticulously.

Cement paint drums shall be kept tightly closed when not in use as by exposure to atmosphere; the cement paint rapidly becomes air set due to its hygroscopic qualities. In case of cement paint brought in gunny bags, once the bag is opened, the contents should be consumed in full on the day of its opening. If the same is not likely to be consumed in full, the balance quantity should be transferred and preserved in an airtight container to avoid its exposure to atmosphere.

16.43.1.3. Application

The solution shall be applied on the clean wetted surface with brushes or spraying machine. The solution shall be kept well stirred during the period of application. It shall be applied on the surface which is on the dry side of the building so that the direct heat of the sun on the surface is avoided. The method of application for cement paint shall be as per manufacturer's specification. The completed surface shall be watered after the day's work.

The second coat shall be applied after the first coat has been set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted.

For new work, the surface shall be treated with three or more coat of water proof cement paint or as found necessary to get a uniform shade as per directions of Employer/PMC.

16.43.2. Red Oxide Ready Mixed Painting over C.G.I. Sheet

16.43.2.1. General

Ready mixed paint, suitable for painting over G.I. sheets, of approved brand and manufacturer and of the required shade shall be used. New or weathered G.I. sheet shall be painted with a priming coat of one coat of red oxide zinc chromate paint. Primer shall be applied before fixing sheets in place.

Application: - The crowns shall be painted first and when these get dried, the general coat

shall be given to ensure uniform finish over the entire surface without the crowns showing signs of thinning. The second or additional coats shall be applied when the previous coat has dried.

16.43.3. Distempering

16.43.3.1. General

Distempering shall be done with acrylic distemper of approved brand and manufacture (one or more coats) and of required shade on new work to give an even shade.

16.43.3.2. Materials

The acrylic distemper of required colour conforming to IS:427 and of approved brand and manufacturer shall be used. The shade shall be got approved from the Employer/PMC before application of the distemper. The acrylic distemper shall be stirred slowly in clean water using 0.6 liter of water per kg of distemper or as specified by the manufacturer. Warm water shall preferably be used. The mixture shall be allowed to stand for at least 30 minutes (or if practicable overnight) before use. The mixture shall be well stirred before and during use to maintain an even consistency. Distemper shall not be mixed in larger quantity than is actually required for one day's work.

16.43.3.3. Preparation of Surface

Before new work is distempered, the surface shall be thoroughly brushed free from mortar droppings and other foreign matter and sand prepared smooth. New plaster surfaces shall be allowed to dry for at least two months before applying distemper. In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc.

Plaster shall be made good with Plaster of Paris mixed with the color to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

16.43.3.4. Priming coat

A priming coat of whiting shall be applied over the prepared surface in case of new work. No white washing coat shall be used as a priming coat for distemper. The treated surface shall be allowed to dry before distemper coat is given.

16.43.3.5. Application

In the case of new work, the treatment shall consist of a priming coat of whiting followed by the application of three or more coats of distemper till the surface shows an even color. For old work, the surface prepared shall be applied two or more coats of distemper till the surface attains an even color. The application of each coat shall be carried out as follows:

The entire surface shall be coated with approved make and color distemper by proper distemper brushes (ordinary white wash brushes shall not be allowed) in horizontal strokes followed immediately by vertical ones which together shall constitute one coat. The subsequent coats shall be applied only after the previous coat has dried. The finished surface shall be even and uniform and shall show no brush marks.

Enough distemper shall be mixed to finish one room at a time. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which cannot be completed the same day. After each day's work, the brushes shall be washed in hot water and hung down to dry. Old brushes which are dirty or caked with distemper shall not be used.

16.43.4. Plastic Emulsion Paint

16.43.4.1. General

Plastic emulsion paint shall be conforming to IS: 5411 and shall be of approved make and manufacture and of required shade.

Preparation of Surface: The plaster surface shall be allowed to dry thoroughly. A thin layer of plaster of Paris shall be applied to make the wall/ceiling surface perfectly plane and wall junction lines perfectly straight and neat. The surface shall be finished smooth. Care must be taken to keep this layer as thin as possible. This shall be got inspected by the Employer/PMC before the application of the plastic emulsion paint. Turpentine shall not

be used for thinning purpose. The surface on finishing shall present a flat velvety smooth finish. If necessary more coats shall be applied till the surface present a uniform appearance.

No oil based putties shall be used in preparation of wall. Splashes of paint shall be cleaned out without delay as they shall be difficult to remove after hardening. Washing of surface treated with plastic emulsion paint shall not be done within 3 to 4 weeks of application.

16.44. PLINTH PROTECTION

Plinth Protection shall be provided as specified in the approved drawings to required width. It shall consists of 7.5 cm thick cement concrete of M15 Grade (1Cement: 2 Fine Aggregates: 4Coarse Aggregates of 20mm nominal size) over 7.5 cm thick bed of gravel or shingle 40mm nominal size grouted with fine sand. The outer edge shall be lined with bricks/stone blocks laid on edge and joints laid in cement mortar 1:4 (1 Cement : 4 Coarse sand). Plinth protection shall be laid with a minimum outward slope of 1 in 50.

16.44.1. Preparing the Ground Surface

The ground, where plinth protection is to be laid, shall first be prepared to the required slope. The high portions of ground shall be excavated; hollows and depressions filled up to the required level with the excavated/borrowed earth and watered and well compacted by iron rammers to give a firm base and uniform outward slope. Surplus earth, if any, obtained shall be disposed as directed by the Employer/PMC.

16.45. BITUMINIOUS ROAD WORK

16.45.1. General

All internal roads shall be designed for the load of heaviest transformer with the load of all HV/LV bushes and oil contained in it and considering the California Bearing Ratio (CBR) of soil strata determined during geotechnical investigation at each substation site.

16.45.2. The internal roads shall meet all the requirements specified under clause 'General and Specific Technical Requirements' of this specification.

16.45.3. Construction of Roads including shoulders shall be carried out conforming to specifications

for road work of C.P.W.D., Ministry of Urban Development, Government of India and Department of Roads, Government of Nepal.

16.46. OPEN SURFACE DRAIN

16.46.1. General

Constructing random rubble or brick masonry open surface drains in cement mortar 1:6 (1 Cement : 6 Coarse Sand) including earth work in excavation, 75 mm thick bed concrete 1: 3 : 6 (1 Cement : 3 Fine Aggregates : 6 Coarse Aggregate of 20 mm and down gauge) and 100 mm thick cement concrete 1:2:4 (1 Cement : 2 Fine Aggregates : 4 Coarse Aggregates of 12.5 mm nominal size) and plastering its inner and exposed surfaces above ground level with cement plaster 1:4 (1 Cement : 4 sand) with a floating coat of neat cement slurry inside the drain including disposal of surplus earth complete as per relevant Indian Standard and C.P.W.D. specifications.

The size of open surface drains shall be as per design requirement. However, it shall not be less than 300 mm wide and 450 mm deep including 150 mm free board. Drains shall be laid to such gradients and in such locations as may be shown in the relevant construction drawing or as directed by the Employer/PMC. A free board of not less than 150 mm shall be provided in all drains. The drain shall be given, as far as possible, uniform slope from the starting point to the discharge point.

16.47. CHEQUERED STEEL PLATE COVERS

16.47.1. General

Chequered Steel Plate covers over trenches and other openings inside buildings shall be installed as specified in approved drawings or as directed by the Employer/PMC.

In order to facilitate easy removal and placing, all covers shall be tapered along the perimeter towards the bottom. The maximum clearance between cover and outer frame shall be not more than 5.0 mm at finished floor level. The corrosion protection shall be generally achieved by painting.

16.48. CHAIN LINK FENCING

16.48.1. General

Fencing shall be designed for the most critical loading combination taking care of wind forces, stability, tension on wires, minimum requirements as per this clause and relevant recommendations. Fencing shall be of galvanized steel and it shall be at least 2.5 m high with diamond shapes. A concrete base shall be provided below fencing.

16.48.2. Material

The minimum requirements are as follows:

- (a) Chain Link Fence fabric shall be in accordance with IS:2721 with specifications in table 16.10 below:

TABLE-16.10

SPECIFICATIONS OF CHAIN LINK FENCE FABRIC

1.	Size of mesh	75 mm
2.	Size of coated wire	3.15 mm
3.	Width of chain link	2400 mm
4.	Class of Zinc Coating	Mecum

- (b) Posts: The size of Intermediate, straining and stay posts shall be not less than the sizes given in table 16.11 below:

TABLE-16.11

SIZE OF POSTS FOR FENCING

Angle Section	Size and Spacing in mm
Intermediate posts	L 65 x 65 x 5 2500
Straining posts	L 65 x 65 x 6 - 2500
Stay posts	L 45 x 45 x 6,2500

All structural steel shall conform to IS: 2062 and shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint after cleaning the surface by sand paper to remove all loose scale, rust, dust, oil etc.

The Chain Link fabric shall be fixed to the posts at the top and bottom of the fence by fixing 50 mm (wide) x 5 mm (thick) MS flat all through its length.

The barbed wire shall consist of two splices per reel. The barbed wire shall be formed by twisting two line wires, one containing the barbs. The barbed wire shall be 12 SWG galvanized steel barbed wire with its weight 155-136 gm/m length. Distance between two barbs shall be 75 mm. Above chain link fencing, 3-rows (6 nos.) of barbed tape/wire shall be provided in each arm of the Y shaped barbed arm at top.

16.48.3. Installation

Fence shall be installed along lines shown on approved drawings. Holes in ground for posts shall be excavated by approved methods. Intermediate posts shall be spaced at 2.5 m apart measured parallel to ground surface. Straining posts shall be installed at equal intervals not exceeding 25.0 m. Straining posts shall be installed at sharp changes in grade, at corners, at change of direction and where directed by the Employer/PMC. All corner posts shall have two stay posts and every tenth post shall have a transverse stay post. Post shall be set in concrete. Concrete shall be of M15 grade of nominal mix 1 : 2 : 4 (1 Cement : 2 Fine Aggregates : 4 Coarse Aggregates of 20 mm nominal size) and work shall conform to relevant Indian Standard. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.

Fence fabric shall not be installed until concrete has cured a minimum of 21 days. Bottom and top of the fence fabric shall be fixed with MS flats of size 50 mm x 5 mm. Fence fabric shall be laid out with barbed edge on top, stretched tightly and shall be fastened to intermediate, gate and straining posts with 50 x 5mm flats. Fabric shall be secured to tension wires with tie wires at 400 mm intervals. Tie wires shall be given no less than two twists. Gates shall be installed in locations shown on drawings.

16.49. GATES

16.49.1. General

The Gate frame shall be made of heavy duty MS pipe and grills of steel angle/flats conforming to relevant Indian Standard. The gates shall be fabricated with welded joints as per approved drawing/ specification to achieve rigid connections. The gate frame shall be painted with one coat of approved steel primer & two coats of approved synthetic enamel paint of approved color. Gates shall be fitted with approved quality iron hinges, latch and latch catch. Latch and latch catch shall be suitable for attachment and operation of padlock from either side of gates. Hinges shall permit gates to swing through 180 degree back against fence. Gates shall be fitted with galvanized chain hook or gate hold back to hold gates open. Double gates shall be fitted with center rest and drop bolt to secure gates in closed position.

16.50. WATER SUPPLY, PLUMBING AND SANITARY WORKS

16.50.1. General

All works shall be carried out, in general, in accordance with C.P.W.D. Specifications, relevant Indian & Nepalese Standards and as directed by Employer/PMC.

16.50.2. Materials

16.50.2.1. G.I. Pipes and Socket

The pipe shall be galvanized mild steel hot finished seamless (HFS) screwed and socket conforming to the requirements of IS: 1239 (Part-1) for medium grade. They shall be of the diameter (nominal bore) specified in the approved drawings or as directed by Employer/PMC. However, the diameter shall not be less than 15 mm. Galvanizing shall conform to IS: 4736. The zinc coating shall be adherent, smooth and free from imperfections such as flux, ash and dress inclusions, bare patches, black spots, pin holes, lumping, runs, rust strains, dull white deposits and blisters. The pipes and sockets shall be cleanly finished, well galvanized and free from cracks, surface flaw laminations and other defects. All screw threads shall be clean and well out. The ends shall be cut cleanly and square with the axis of the tube. All screwed tubes and sockets shall have pipe threads

conforming to the requirements of IS: 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

All tubes shall withstand a test pressure of 50 kg/cm^2 without showing any defect. The fittings shall be of mild steel tubular or wrought steel conforming to IS: 1239 (Part-II). The fittings and sockets shall be designated by the respective nominal bores of the pipe for which they are intended.

16.50.2.2. Bib Cocks and Stopcock

A bib cock (bib tap) is a draw off tap with horizontal inlet and free outlet. A stop cock (stop tap) is a valve for insertion in a pipe line for controlling or stopping the flow.

They shall be of size specified in the approved drawings and shall be of screw down type conforming to IS: 781. The closing device shall work by means of a disc carrying a renewable non-metallic washer which shuts against water pressure on a seating at right angles to the axis of the threaded spindle which operates it. The handle shall be either crutch or butterfly type securely fixed to the spindle. They shall be of the loose leather seated pattern. They shall open in anti-clock wise direction. They shall be made of brass polished bright or of Chromium Plated brass as specified in approved drawings. They shall be of approved brand. The free outlet of the bib taps shall have an outside thread to make connection with a threaded hose pipe connection possible whenever required.

16.50.2.3. Chromium Plated Brass Pillar Taps

These shall be of chromium plated brass and shall conform to IS: 1795. The nominal size of the tap shall be 15mm. The nominal size shall be designated by the nominal bore of the pipe outlet to which the tap is to be fitted. Every pillar tap complete with component parts shall withstand an internally applied hydraulic pressure of 20 kg/cm^2 maintained for a period of 2 minutes during which period it shall neither leak nor sweat. These shall be of approved brand.

16.50.2.4. European/ Indian Type W.C. Pan

Water closet shall be of white/vitreous china, **European/ Indian Type**, as specified in approved drawings or as directed by Employer/PMC confirming to IS: 2556 (Part-I, Part-II)

& Part-III). It shall be of the Wash down Type attached with S-trap. It shall be as specified in C.P.W.D. Specifications and shall be of approved make/brand. All vitreous sanitary appliances shall confirm to IS: 2556.

16.50.2.5. Low Level Flushing Cistern

Cistern shall be of 12.5 liters capacity, white vitreous china with complete fittings. Low level flushing cistern manually operated shall be installed in office toilet and shall conform to IS: 774. The body thickness shall not be less than 10mm at any place. The cistern shall be free from manufacturing defects and other defects affecting its utility. All working parts shall be designed to operate smoothly and efficiently. Cistern shall be mosquito proof. The breadth from front to back shall be such that the cover and seat of the water closet pan shall come to rest in stable position when raised. The cistern shall have removable cover which shall fit closely on it and be secured against displacement. The outlet fitting shall be securely connected to the cistern and shall be 40 mm in diameter and shall conform to IS: 1703.

The float shall be made of polythene. The flush handle shall be of chromium plated brass. The siphoned function of the flushing cistern shall be capable of being rapidly brought into action by the operating handle but shall not self-siphon or leak. The discharge rate of cistern shall be about 5 liters in 3 seconds and there shall be no appreciable change in the force of flush during the period of discharge. A tolerance of ± 0.5 liters shall be allowed over the rated discharge capacity of the cistern. The cistern shall be of approved brand and manufacturer.

16.50.2.6. White Vitreous Flat Back Wash Basin

Wash Basin shall conform to IS: 2556 (Part-I to Part-IV). Wash basin shall be of one piece construction of the sizes as specified in the approved drawings or directed by the Employer/PMC. All internal angles shall be designed to facilitate cleaning. Each washbasin shall have a skirting at the back and shall be provided with single or double tap holes as specified. The tap holes shall be 28mm square or 30 mm round. Each washbasin shall have a circular waste hold to which the interior of the basin shall drain. The waste hold shall be either rebated or beveled internally with diameter of 65mm at top. Stud slots to receive to

C.I. bracket on the underside of the wash basin shall be suitable for bracket, with stud not exceeding 13 mm, 5 mm high and 305 mm from the back of the basin to the centre of the stud. The stud slot shall be of depth sufficient to take 5mm stud.

C.I. brackets shall conform to IS: 775. They shall be protected by suitable paint of approved quality. Wash basins and C.I. brackets shall be of approved brand and manufacturer.

16.50.2.7. C.P. Brass Towel Rail

The rail shall be of Chromium Plated brass with two Chromium Plated brass brackets, to be fixed with 25mm C.P. screws. The size of the rail shall be 750 mm x 20 mm diameter and 1.25 mm thick. It shall be of approved brand and manufacturer.

16.50.2.8. C.P. Brass Waste

Waste shall be chromium plated brass conforming to IS: 2963 and shall be sound, free from laps, blow holes and pitting and other manufacturing defects. External and internal surfaces shall be clean and smooth. The body and nut shall be truly machined so that the nut smoothly moves on the body. It shall be of approved brand and manufacturer.

16.50.2.9. C.P. Brass Trap

Wash basins shall be provided with Chromium Plated brass trap of U type or bottle type, of required size. It shall be of approved brand and manufacturer.

16.50.2.10. C.P. Beveled Edge Mirror

Mirror shall be of superior sheet glass with edges beveled. It shall be free from flaws, specks, or bubbles. The size of the mirror shall be 90 x 45 cm and its thickness shall not be less than 5.5 mm. It shall be uniformly silver plated at the back and shall be free from silvering defects. Silvering shall have a protective uniform covering of red lead paint. Mirror shall be of approved brand and manufacturer.

16.50.2.11. C.P. Toilet Paper Holder

Holder shall be of Chromium plated brass of standard size. It shall be of approved brand and manufacturer.

16.50.2.12. Telescopic Flush Pipe for W.C

Pipe shall be of 40 mm diameter for low level cistern made of medium quality galvanized iron. The flushing pipe shall be of suitable length with bends etc. as required for fixing it with front or back inlet of W.C. pan.

16.50.2.13. Plastic Toilet Seat Cover/Lid

Seat Cover shall have Chromium Plated brass hinges and rubber buffers and shall conform to IS: 2548. It shall be made of molded synthetic materials, which shall be tough and hard with high resistance to solvents and shall be free from blisters and other surface defects. Seat cover shall be finished smooth, and lacquer shall not be used for surface finishing. It shall be of approved quality and manufacturer.

16.50.2.14. Sand Cast Iron Floor Trap

The floor trap shall be P type with a minimum of 50 mm water seal and shall be of self-cleaning design. Inlet shall be of size 100 mm and exit shall be the same as the size of waste pipe. It shall have a sand cast iron grating (screwed down or hinged) without vent arm. Coating, internally and externally shall be as approved by Employer/PMC. It shall be of approved manufacturer.

16.50.2.15. Sand Cast Iron Pipe and Fittings

Pipes and fittings shall conform to IS: 1729. The pipe shall have spigot and socket ends with bead on spigot end. The pipes and fittings shall be true to shape, smooth and cylindrical, their inner and outer surface being as nearly as practicable concentric. They shall be sound and nicely cast, free from cracks, laps, pinholes and other imperfections and shall be neatly dressed and carefully fitted.

The ends of pipes and fittings shall be reasonably square to their axis. The length of pipes shall be 1.5/1.8/2.0m including socket ends. The pipes and fittings shall be supplied without ears. All pipes and fittings shall ring clearly when struck over with a light hand hammer and shall be capable of being easily worked with a drill or file.

All pipes and fittings shall be coated internally and externally with the same material at

the factory, the fittings being preheated prior to total immersion in a batch containing a uniformly heated composition having a tar or other suitable base. The coating material shall be smooth good adherence and shall not scale off. The coating shall be smooth and tenacious and hard enough not to flow when exposed to a temperature of 77 degree Celsius, but not so brittle at a temperature of 0 degrees Celsius as to chip off when scraped lightly with a pen knife. The thickness and dimension specified for the corresponding sizes of straight pipes. The access door fittings shall be designed so as to avoid dead spaces in which filth may accumulate. Doors shall be provided with 3mm rubber insertion packing and when closed and bolted, these shall be water tight. They shall be submitted to the Employer/PMC for approval.

16.50.2.16. Glazed Stoneware Pipe

All pipes shall have spigot and socket ends conforming to IS: 651. They shall be sound, free from visible defects such as fire cracks or hair cracks or any other manufacturing defects. The glaze of pipes shall be free from crazing. The pipe shall give sharp clear note when struck with a light hammer. There shall be no broken blisters. The length of the pipes shall be 50, 75 or 90 cm exclusive of the internal depth of the socket.

16.50.2.17. C.I. Frame and Cover for Manholes.

Cast Iron Frame and Manhole covers shall be of heavy duty type conforming to IS:458.

16.50.2.18. Spun Yarn

Spun yarn shall be of clean hemp and of good quality. It shall be soaked in hot coal tar of bitumen and cooled before use.

16.51. CAST IRON SOIL, WASTE AND VENT PIPES AND FITTINGS

16.51.1. General

Pipe, fittings shall be as specified in this Specification and of size as specified in the approved drawings. Where pipes are running along walls, they shall be fixed at all joints with Galvanized M.S. holder bat clamps 1.6 mm thick. This shall be done by embedding

the hooks of the clamps in cement concrete blocks 10 x 10 x 10 cm 1:2:4 mix (1 cement :2 Fine Aggregates : 4 Coarse aggregates 20 mm nominal size) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 50 mm clear of finished face of wall, so as to facilitate cleaning and painting of pipes. The pipes shall be fixed perfectly vertical or to the lines and slopes as directed. The spigot of the upper pipe shall be properly fitted in the socket of the lower pipes such that there is a uniform annular space for filling with the jointing material.

The joint shall be caulked in with lead as soon as the next length of pipe is placed in position. The open end (socket end) of the pipe shall be kept closed till the next length of pipe is fitted and jointed, to prevent any foreign material falling in and choking the pipe. The spigot end shall butt the shoulder of the socket and leave no gap in between. The annular space between the socket and the spigot shall first be well packed in with spun yarn leaving 25mm from the lip of the socket for the lead. The joint shall then be lead caulked. All cast iron pipes shall be carried up above the roof and shall have a sand cast iron terminal guard.

The waste from wash basin shall be connected to the outside drains, without gully trap. The waste of toilet floor shall be connected to the outside drains through cast iron trap of self-cleansing design as specified in this Specification. The soil pipe of lavatories shall be connected directly to the inspection chamber.

16.51.2. Preparing the Joint

The interior of the socket and exterior of the spigot shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right up to the back of the socket and carefully centered by two or three laps of treated spun yarn, twisted into ropes of uniform thickness, well caulked into the back of the socket. No piece of yarn shall be shorter than the circumference of the pipe. The jointed pipe line shall be required levels and direction.

16.51.3. Leading

The leading of pipes shall be made by means of ropes covered with clay or by using special leading rings. The lead shall be melted so as to be thoroughly fluid and each joint shall be

filled in one pour. The following precautions shall be taken for melting lead:

- (a) The pot and the ladle, in which lead shall be put, shall be clean and dry.
- (b) Sufficient quantity of lead shall be melted.
- (c) Any scum or dross which may appear on the surface of the lead during melting shall be removed.
- (d) Lead shall not be overheated. The minimum quantity of lead for each joint shall be as under.

- 50 mm = 0.52 kg.
- 75 mm = 0.88 kg.
- 100 mm = 0.98 kg.
- 150 mm = 1.20 kg.

16.51.4. Caulking

After the lead has been run into the joint, the lead shall be thoroughly caulked. Caulking of joints shall be done after a convenient length of pipes has been laid and leaded. The leading ring shall first be removed and any lead outside the socket shall be removed with a flat chisel and then the joint caulked round three times with caulking tools of increasing thickness and hammer 2 to 3 kg weight. The joints shall not be covered until the pipe line has been tested.

16.51.5. Testing

All sand cast iron pipes and fittings including joints shall be tested by a smoke test to the satisfaction of the Employer/PMC and left in working order after completion.

16.51.6. Lead Caulked Joints

Lead caulked joints shall be enumerated for measurement. Rate shall include the cost of all materials and labour involved in the operations described above.

16.51.7. Painting

Cast iron pipes, fittings, holder bat clamps shall be painted with (a) one coat of primer followed by a finishing coat both of approved quality, where exposed. (b) Two coats of bituminous paint of approved quality, where buried under ground.

The paint shall be laid evenly and smoothly. The crossing and 'laying off' process given under this Specification shall be used. The painted surface shall present a uniform appearance and glossy finish free from streaks, blisters etc.

16.51.8. Glazed Stoneware Soil Pipes

Glazed stoneware soil pipes shall be as specified and of size as specified in the approved drawings. They shall be laid in concrete upto their haunches. Laying, jointing, measurement shall be as per C.P.W.D specification. The Concrete bed shall be 15 cm thick and 50 cm wide. Concreting shall be done upto haunches of the pipe. The concrete shall be of M15 grade of nominal mix 1 : 2 : 4 (1 cement : 2 Fine Aggregates : 4 Coarse aggregates 20 mm nominal size).

16.52. BRICK/RANDOM RUBBLE MASONRY MANHOLES

16.52.1. General

They shall be made of either brick masonry or Random Rubble stone masonry. without foot rests. For Construction of manholes, general specification and C.P.W.D., as far as applicable, shall be followed.

16.53. SEPTIC TANK

16.53.1. General

R.C.C. septic tank shall be of size suitable for specified number of users. These shall conform to relevant Indian Standards C.P.W.D. specifications and as per direction of Employer/PMC.

16.54. SOAK PIT

16.54.1. General

The construction of Soak pit shall be carried out as shown in approved drawings and as per C.P.W.D. specification and as per direction of Employer/PMC.

16.55. ANTIWEED TREATMENT & STONE SPREADING

16.55.1. Scope of Work

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work within fenced area. However the stone spreading along with cement concrete layer in future areas within fenced area shall also be provided in case step potential without stone layer is not well within safe limits.

16.55.2. General Requirement

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Employer/PMC.

The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40mm nominal size (ungraded single size) conforming to relevant Indian Standard. Hardness, flakiness shall be as required for wearing courses shall be as are per relevant Indian Standard.

(a) **Hardness**

- Abrasion value as per relevant Indian Standard;
- Impact value as per relevant Indian Standard.

(b) **Flakiness Index**

- One test shall be conducted as per relevant Indian Standards/ equivalent International Standards.

16.55.3. Application of Anti Weed Treatment

After all the structures/equipments are erected, anti weed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots.

The recommendation of local agriculture or horticulture department may be sought

where ever feasible while choosing the type of chemical to be used.

The anti weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation.

Nevertheless the effectiveness of the chemical shall be demonstrated by the contractor in a test area of about 10.0 m X10.0 m and shall be sprinkled with water at least once in the afternoon every day after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the Employer/PMC. The final approval shall be given by Employer/PMC based on the results.

Employer/PMC shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

16.55.4. Preparation of Sub Grade for Stone Spreading

After anti weed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by Employer/PMC. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.

In areas that are considered by the Employer/PMC to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

The sub grade shall be in moist condition at the time the cement concrete is placed. If necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the surface.

Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:5:10 (1

cement :5 Fine Aggregates : 10 Coarse Aggregates of 20 mm nominal size) shall be provided in the area excluding roads, drains, cable trenches as per approved drawing. For easy drainage of water, the slope of 1:1000 shall be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains. The above slope shall be provided at the top of base layer of cement concrete (1:5:10). A layer of cement slurry of mix 1:6 (1 cement: 6 sand) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg per 100 sq.m.

16.55.5. Stone Spreading

A final layer of 100mm thickness of natural /crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

16.56. SUPPLY AND LAYING OF R.C.C. NON-PRESSURE PIPES

16.56.1. Non Pressure R.C.C. pipes shall be of Class NP-3 or NP-4 conforming to IS:458 as specified in approved drawings.

16.56.2. The pipes shall be laid as per C.P.W.D. specifications and relevant Indian Standards.

16.57. QUALITY ASSURANCE, FIELD TESTING AND CHECKING PLAN

16.57.1. General

The contractor shall prepare a 'Quality Assurance and Field Testing and Checking Plan' within 30 days after award of work to Employer for approval. No field work shall be undertaken without having the approval of the same.

16.57.2. 'Quality Assurance and Field Testing and Checking Plan' to be prepared by the contractor shall include the following specific requirements:

16.57.2.1. Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards at his own cost in his Field Lab or lab approved by Employer/PMC and he shall submit the results in triplicate within 5 days after completion of test.

16.57.2.2. Sampling requirement for concrete shall be as given in table 16.8 below:

TABLE-16.8

SAMPLING REQUIREMENT OF CONCRETE

Qty. of Concrete in work	No. of Samples
Upto 5 Cum	One
6 – 15 Cum	Two
Above 16 Cum	Three to Four

Sampling shall be undertaken as described below:

- (a) At least 6 specimens per sample shall be taken. Three shall be tested at 7 days and remaining three at 28 days.
- (b) To control the consistency of the concrete from every mixer or mixing plant, slump tests shall be carried every 2 hours or as directed by Employer/PMC in accordance with IS:1199. The Employer/PMC may waive any test for small & unimportant concreting at his discretion.

16.57.2.3. Minimum cement content in different grades of concrete shall be as given in table 16.9 below:

TABLE-16.9

MINIMUM CEMENT CONTENT IN CONCRETE

Grades of Concrete	Minimum cement content per cum of finished concrete
M-10	240 kg
M-15	310 kg
M-20	360 kg

16.57.3. Standard Field Quality Plan

The field quality plan shall include the items as given in Table – 16.10 and all other relevant items of work:

TABLE-16.10

FIELD QUALITY PLAN

Sl. No.	Section	Sampling	Code reference	Review
1.	Foundation Material			
a)	Cement			
	Fineness, compressive strength, initial& final setting time, soundness etc.	One sample per 100 MT	IS: 456, IS: 269, IS: 8112, IS: 12269, IS: 1489	Manufacturer's test Certificates
b)	Coarse Aggregates			
	Grading, Specific Gravity, Crushing Value, Bulk density, absorption value etc.	One sample per 100 Cum	IS: 383, IS: 2386	Source to be approved by Employer/PMC
c)	Fine Aggregates			
	Grading, Specific Gravity, Crushing value, Bulk density, absorption value etc.	One sample per 100 cum	IS: 383, IS: 2386	Source to be approved by Employer/PMC
d)	Water	Random	IS: 456, IS: 3025	Source to be approved by Employer/PMC
2.	Reinforcement Steel			
a)	Dimensional check	Random	-	Employer/PMC
b)	Chemical analysis, Tensile Test, Yield Stress/Proof stress, percentage elongation, Bend &re-bend tests	One sample of 40 MT	IS: 432, IS: 1139, IS: 1786	Manufacturer test Certificate/ one lab test
c)	Placement of reinforcement including cutting,	100% check as per bar	IS: 456, IS: 2502	Employer/PMC

Sl. No.	Section	Sampling	Code reference	Review
	bending, lap length, joints, chairs, spacer bars, tying etc	bending schedule at each location		
3.	Structural Steel			
a)	Dimensional Check & Visual check for rust, pitting etc.	Random	-	Employer/PMC
b)	Physical properties of steel	One sample per 40 MT	IS: 2062	Manufacturer test certificate
4.	Gantry / Equipment Foundation & Trenches			
a)	Excavation for Dimensional conformity, location, slope, etc.	Each Location	-	Employer/PMC
b)	Foundation Bolts & Inserts, stubs sizes, location, levels, c/c distance alignment	100% at each location	-	Employer/PMC
5.	Shuttering/Formwork			
	Alignment, plumb, level, height, rigidity, strutting, shoring, cleaning, oiling bracing	-do-	As per specification	Employer/PMC
6.	Hallow Cement Concrete Block Masonry			
a)	Casting stage mix, strength, Water Cement ratio, grit size, finishing	Random but periodic checking	As per specification	Employer/PMC
b)	Laying			
	Alignment, plumb, line and level finishing	Regular Supervision		Employer/PMC
6.	Plastering			

Sl. No.	Section	Sampling	Code reference	Review
a)	Thickness, evenness mortar mix, gauges at 2 m intervals	Random	As per specification	Employer/PMC
b)	Curing	100% check	As per specification	Employer/PMC

16.58. MODE OF MEASUREMENT AND PAYMENT

16.58.1. Geotechnical investigation

The work of geotechnical investigation shall be measured on lump sum basis for each substation and shall include the whole of scope as given in this specification. This shall include carrying out all specified field tests, collection of disturbed and undisturbed soil samples, conducting all necessary laboratory tests on soil samples for determining the physical and engineering properties of soil, compilation of results and preparation of soil/geotechnical investigation report with recommendations for type of foundations i.e. shallow type or pile type to be provided for various structures and buildings etc.

16.58.2. Topographical Survey

The work of topographical survey shall be measured on lump sum basis for each substation and shall cover the whole plot area of substation including area 100 m beyond substation boundaries as well as adjoining existing roads and other important physical features like streams, rivers, buildings/hutments etc.

16.58.3. Site Leveling and Formation of Terraces

Measurement of earth work in cutting and filling required in site leveling work and formation of terraces for all leads and lifts including filling with suitable excavated earth shall be made in Cubic meters. The excavation in all kind of soils including soft/fissured rock and hard rock shall be measured separately. The quantities shall be calculated with reference to existing ground level and levels specified in approved site leveling drawings. The disposal of excess excavated earth to designated disposal areas shall be made in Cubic Meters.

16.58.4. Random Rubble Stone Masonry Breast & Retaining Walls

The payment for construction of Random Rubble Masonry Breast and Retaining Walls shall be made as per the unit rate of items involved in their construction i.e. Excavation, P.C.C., Stone Masonry Work and Concrete and their unit rate quoted in the price schedule. No separate payment for making weep holes, providing filter behind weep holes and providing flush or raised pointing shall be made and rates for these are deemed to be included in the quoted rate for stone masonry.

16.58.5. R.C.C. Retaining Walls

The payment for construction of R.C.C. Retaining Walls shall be made as per the unit rate of items involved in their construction i.e. Excavation, P.C.C., Concrete Work, Reinforcement Work and their unit rate quoted in the price schedule. No separate payment for making weep holes and providing filter behind weep holes shall be made and rates for these are deemed to be included in the quoted rates.

16.58.6. Excavation

The payment for Excavation required for foundations, cable trenches etc shall be made on cubic meter basis as per unit rates quoted in the price schedule. The quantity of excavation shall be calculated as per approved construction drawings and allowing 150mm margin beyond foundation dimensions irrespective of actual size of excavation made by the contractor. The rate for excavation in ordinary soil quoted in price schedule shall include excavation in all kinds of soil including excavation in soft rock not requiring blasting for all leads and lifts. Excavation in hard rock requiring blasting shall be measured separately and payment shall be made as per unit rate quoted in the price schedule. In case water table is encountered, the extra for excavation below water table shall be paid separately as per rate quoted in the price schedule.

The rate of excavation shall include disposal of surplus earth or rock to a suitable location within a lead up to 2 km. The surplus earth, if disposed off within substation boundary, shall be spread in uniform layers not exceeding 200 mm in thickness, each layer compacted with compacting equipment at optimum moisture content to achieve

Protector's Dry Density of not less than 95% and no separate payment for the same shall be made.

The quantity of excavation for foundations of towers, equipment support structures, all transformers/Reactors, firewall, cable trenches, firefighting water tank, buildings and underground water tanks, covered car parking, external lighting poles, control cubicles, marshaling box shall only be measured. The measurement of excavation of all aforesaid works shall be made considering dimension of the pit leaving 150 mm gap around the base pad (lean concrete) or actually excavated pit, whichever is less. The quantity shall be measured in cubic meters.

16.58.7. Backfilling

The payment for Backfilling around foundations, cable trenches etc shall be made on cubic meter basis as per unit rates quoted in the price schedule. The quantity of backfilling shall be calculated as per approved construction drawings and allowing 150mm margin beyond foundation dimensions irrespective of actual size of excavation made by the contractor. The backfilling shall be done in layers at optimum moisture content as per specification.

16.58.8. Plain Cement Concrete (P.C.C.)

Providing and laying Plain Cement Concrete of all types and at all locations including all leads and lifts shall be measured in cubic meters as per lines and levels indicated in the approved drawings. The payment for P.C.C. shall be made as per unit rate quoted in the price schedule.

The payment for P.C.C. required for works such as hold fasts of doors/windows/rolling shutters, fixing of plumbing pipes, bedding concrete for sewer lines, embedment of electrical conduits etc. shall not be made separately and deemed included in the composite rates quoted by the bidder for respective works.

16.58.9. Form & Shuttering Work

No separate payment for formwork, shuttering and staging work shall be made and its rate deemed to be included in the unit rate of concrete.

16.58.10. Reinforced Cement Concrete (R.C.C.)

Measurement of reinforced cement concrete at all locations shall be made and shall include all leads, lifts, formwork, grouting of pockets and underpinning (but shall exclude reinforcement & miscellaneous structural steel items like embedment, inserts, edge protection angles etc.) of specified grade/design mix. This shall also include pre-cast R.C.C. work and addition of water proofing compound wherever required for which no additional payment shall be made. The quantity shall be measured in cubic meters as per lines and levels indicated in the approved construction drawings. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings having cross-sectional area upto 0.10 sq.m.

16.58.11. Steel Reinforcement

The payment for reinforcement steel shall be made on per ton basis as per unit rate quoted in the price schedule. Reinforcement steel shall be measured in length (as per approved construction and bar bending schedule) including hooks, if any, separately for different diameters as actually used in R.C.C. work excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in metric ton on the basis of sectional weights as adopted by Indian Standards/equivalent International standards. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the unit rates quoted for reinforcement in price schedule.

16.58.12. Miscellaneous Structural Steel

- (a) The payment for Supply, fabrication, transportation and erection of all miscellaneous structural steel work required for rail fixing, gratings and supports for stone filling in transformers foundations, chequered plate covers, cable supports, earthing cleats and edge protection angles and all other steel fittings and fixtures, inserts and embedment in concrete shall be made on per metric ton basis and quantities calculated as per approved drawings and actually provided at site. The unit rate for this item shall be inclusive of cutting, grinding, drilling, bolting, welding, pre-heating

of the welded joints, applying a priming coat of steel primer and anti-corrosive bitumastic paint/ synthetic enamel paint and setting of all types of embedment in concrete etc.

- (b) The payment of galvanized steel embedded parts and structural members shall be made on per kg basis based on actual quantity supplied and installed at site.

16.58.13. Stone filling over Grating in Transformer Foundation and Oil Drainage Arrangement

- (a) Measurement of stone filling over gratings in transformer foundations shall be made as per theoretical volume of the space to be filled in the transformer foundation as per approved drawings. This shall be measured in cubic meters and payment made as per unit rate quoted in the price schedule.
- (b) The payment for laying R.C.C. pipes for oil drainage shall be measured in running meters and shall include the cost of all materials and operations required for laying the pipes as per relevant Indian standards.
- (c) The construction of masonry manholes required for oil drainage from transformer soak pit to central oil collecting pit shall be measured in numbers and payment made on per manhole basis.

16.58.14. Road-cum-Rail Track, Jacking Pads and Pulling Blocks

- (a) The quantities of excavation, P.C.C., structural concrete and reinforcement shall be calculated based on approved drawings and payment made at the unit rate of respective item quoted in price schedule.
- (b) The payment for rail shall be made in running meter as per approved drawings and actual quantity provided at site.
- (c) The payment for embedded steel parts like steel plate, angles etc required for fixing the rail shall be made as per the unit rate for miscellaneous structural steel and quantity calculated as per approved drawings

16.58.15. Internal Bituminous Roads

- (i) The measurement of bituminous road shall be made in running meter for different width of roads (the width specified is the width of black top of road excluding shoulders) and shall include all items such as excavation, compaction, rolling,

watering, sub base course, WBM, shoulder, premix carpet etc complete as per specification and approved drawings.

- (ii) The measurement of strengthening of existing road (bituminous road) shall be made on the basis of area in square meter (M^2) of the top bituminous completed surface of the road including premix carpet etc, completed as per specification.

16.58.16. Anti-weed Treatment and Stone Spreading

The payment shall be made for the actual area in square meters of stone spreading provided in the switchyard. It shall include providing all works as specified in the specification of this item.

16.58.17. Chain Link Fencing and Gate

The Payment shall be made in running meters of the fence provided as per approved drawing. The rate shall be including the all types of posts, chain link fabric, MS Flat, painting, brick work and plaster of toe wall etc complete including the excavation and concrete required for fixing the fencing posts in ground. The switchyard gate shall be measured in Kg the actual weight provided as per the approved drawings.

16.58.18. Cable Trenches

- (a) The payment earthwork, P.C.C., R.C.C., reinforcement steel, R.C.C. Hume pipes and miscellaneous steel required for construction of Cable Trenches, Sum Pits and cable trench crossings shall be measured under respective items of price schedule. No separate payment for brick work, plaster and PVC pipes used for cable trench crossings and sealing of trench mouth shall be made.
- (b) The lump sum payment for pumping arrangement per sump pit shall be made including the cost of pump, necessary piping and safe installation of pump.

16.58.19. External Drainage of Substation

The payment for the work of external drainage system shall be made on lump sum basis for each substation. The work shall include construction of all brick/stone masonry drains as per specification including construction of both pipe and box culverts at road & cable trench crossing and disposal of whole surface runoff water from substation site to natural

stream/river outside the substation boundary.

16.58.20. Control Room-cum-Administrative Buildings and D.G Set Room Building

The payment for each building shall be made on plinth/floor area basis, area measured in square meter correct upto third place of decimal. The rate shall be inclusive of all civil works, internal & external finishing works, internal water supply and sanitary works including all specified fitting and fixtures, internal electrification and all electrical fitting and fixtures, all civil works required for fire detection & alarm system, air conditioning etc. The entire work required for completing the buildings in all respects as per this specification and approved drawings shall be deemed to be included in this unit rate.

16.58.21. External water supply from Source to underground water tank and from underground water tank to all faculties in Substation

The work of external water supply shall include making arrangement for potable water from source to underground R.C.C. water tank of 50 cubic meter capacity and from underground water tank to all facilities including Control Room Building, D.G. Set Room Building etc and making and providing all pumping facilities complete as per specifications and approved scheme. The payment shall be made on lump sum basis. The contractor shall be required to complete the work in all respect as per specifications and direction of Employer/PMC.

16.58.22. External Sewage System for Substation

The work of External Sewage System for substation shall include laying of all soil pipes, construction of manholes with heavy duty cast iron manhole covers, and construction of Septic Tank and Soak Pit suitable for 50 users and carrying out all works as per this specification, related Indian standards and C.P.W.D. Specifications. The payment for this work shall be made on lump sum basis. The contractor shall be required to complete the work in all respect as per approved drawings and direction of Employer/PMC.

16.58.23. Landscaping

The landscaping of whole substation area shall be carried out by the Contractor through an Architect specialized in the above work. The payment for landscaping work shall be

made on lump sum basis.

16.58.24. Rate for Items of work not covered in the Specification

If any item of work is not covered in this specification but required to be executed, its rate for payment shall be considered as per District Rate of concerned district of Nepal. If the same is not available in the concerned District rates, the rate as per neighbouring District of Nepal shall be considered. In the absence of availability of rate as per above, the detailed analysis of rate as per norms of Nepal or C.P.W.D. as approved by Employer/PMC shall be carried out by Contractor and submitted to Employer/PMC for approval. The rate as approved by Employer/PMC shall form the basis for the payment for all such items of work. The decision of Employer/PMC in all the above matters shall be final and binding on contractor.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-17 **Substation**

Galvanized Steel Structures

SECTION-4**CHAPTER – 17****SUBSTATION GALVANIZED STEEL STRUCTURES****CONTENTS**

Sl. No.	DESCRIPTION	PAGE NO
1.1	SCOPE	1
1.2	SUBSTATION LAYOUT AND SECTIONS DRAWINGS	4
1.3	SUBLET ORDERS	4
1.4	CODES AND STANDARDS	5
1.5	DESIGN AND DRAWINGS	8
1.6	MATERIALS & WORKMANSHIP	10
1.7	STORAGE OF MATERIAL	12
1.8	GENERAL DESIGN REQUIREMENTS	12
1.9	STATUARY REQUIREMENTS	15
1.10	DESIGN LOADS AND LOAD COMBINATIONS	16
1.11	DESIGN OF STRUCTURES	27
1.12	FASTENERS: BOLTS, NUTS AND WASHERS	33
1.13	STEP BOLTS AND LADDERS	34
1.14	FOUNDATION BOLTS	35
1.15	GROUTING	36
1.16	FABRICATION	36
1.17	GALVANIZING	45
1.18	ERECTION	48
1.19	SAFTEY PRECAUTIONS	49
1.20	QUALITY CONTROL AND QUALITY ASSURANCE PLAN	49
1.21	BILL OF MATERIALS	50
1.22	GUARANTEED QUANTITIES OF STRUCTURES AND PAYMENT	51
1.23	INSPECTION, TESTING & ACCEPTANCE CRITERIA	52

Sl. No.	DESCRIPTION	PAGE NO
1.24	PACKING	54
1.25	SCHEDULE OF DEVIATIONS / VARIATIONS	55

SECTION 4

CHAPTER - 17

SUB-STATION STRUCTURES

1.0. SCOPE

- 1.0.1.** These specifications are intended to cover the design, fabrication, trial assembly, galvanizing, testing at manufacturer's works, inspection before dispatch, packing, transportation, storage and handling at site, erection etc. of substation galvanized steel structures comprising gantry towers/columns, lightening/lighting masts, beams, equipment supporting structures etc and any other structure which may be required for incoming and/or outgoing lines with all necessary accessories as required for successful commissioning of 220/132/33kV substations at Basantapur and Tumlingtar and 220/33 kV Substation at Baneshwar in Nepal. The tentative layout drawings of these substations appended with these specifications. All materials and works shall, in general, conform to these specifications and relevant Indian Standards/ equivalent International Standards.
- 1.0.2.** The scope shall also include supply and erection of all types of galvanized structures including supply of gusset plates, bolts, nuts, plain/tapered/spring washers, step bolts, ladders, base plates, foundation bolts, all necessary inserts in concrete, equipment mounting bolts, structure earthing bolts, fixing plates, necessary angles & bolts for structure/ground mounted marshaling kiosks/boxes (AC/DC Marshalling box & equipment control cabinets) and any other item as required for successful completion of job and commissioning of substations.
- 1.0.3.** It is the intent of the Employer/PMC to provide equipment supporting structures which allow interchangeability of equipment at a later stage. Accordingly, Contractor is expected to design the equipment supporting structures with the provision of stool. Stool shall be provided by the Contractor between the equipment and its supporting structure to match the bus bar height. The top of stool shall be connected to the equipment and the bottom of the stool shall be connected to the base of equipment supporting structure.

- 1.0.4.** Contractor shall provide suitable arrangement on the equipment supporting structures, wherever required, to suit the fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter etc and incorporate the details in the fabrication drawings of equipment supporting structures.
- 1.0.5.** The connection of all structures to their foundations shall be with base plates and anchor/foundation bolts.
- 1.0.6.** All steel structures and anchor/foundation bolts, fasteners (Nuts, bolts & washers) shall be fully galvanized as per relevant Indian Standards / equivalent International Standards. The weight of the zinc coating shall be at least 610 gram/m² for structural members and 450 gram/m² for all bolts, nuts & washers including anchor/foundation bolts.
- 1.0.7.** The lightening/lighting mast shall be designed suitably so as to have illumination platforms at required heights for installing the luminaries to obtain prescribed illumination intensity.
- 1.0.8.** The line diagrams of all structures of 220 kV, 132kV and 33 kV substations shall be prepared by the contractor based on their design during detailed engineering stage. The fabrication drawings, proto corrected drawings along with Bill of Material (BOM) for all the structures including equipment supporting structures shall be prepared by the contractor during detailed engineering for submission to Employer/PMC for their approval. Supporting structure for circuit breaker shall also be designed and supplied by the Equipment Manufacturer or Contractor.
- 1.0.9.** The Contractor shall be fully responsible for designing, detailing, fabrication, galvanizing and erection of the steel structures as per these specifications, testing as per relevant Indian Standards/ equivalent International Standards and for their satisfactory performance. All designs/drawings and details shall be subject to the approval of the Employer/PMC who shall have the right to instruct the contractor to make changes in designs/drawings and details necessary to make them conform to these specifications and relevant Indian Standards/ equivalent International Standards. The contractor shall be required:

- (a) To submit the detailed design calculations for all steel structures comprising gantry towers/columns, beams, lightening/lighting masts, equipment supporting structures for each substation as per their approved layout & section drawings (to be developed by the Contractor and approved by the Employer/PMC). The structures shall be designed for specified loads and loading combinations and meet all specified requirements.
- (b) To submit design and fabrication drawings of all substation structures including equipment supporting structures required for each substation for the approval of Employer/PMC.
- (c) To carry out testing of structures as per relevant codes and standards.
- (d) To suitably mark and transport all steel structures and accessories safely to the site and their proper and safe storage at site.
- (e) To carry out erection of all structures and accessories at site for the purpose for which structures have been designed, fabricated and supplied.

1.0.10. The approval of designs and drawings by the Employer/PMC shall not relieve the Contractor of his responsibility of ensuring correct designs, fabrication, galvanizing, supply and erection of all structures and their satisfactory performance. Should any deficiency or defect is noticed at any stage or performance was not found to be satisfactory or meeting the requirements of these specifications, the Contractor shall be responsible to rectify all such defects & deficiencies to the full satisfaction of Employer.

1.0.11. The contractor shall furnish all materials, labour, tools & plants, erection equipment etc, whether specified or not, required for the completion of job and successful commissioning of substations.

1.0.12. The bidders shall quote lump sum price for design, supply, galvanizing, packing, transportation, storage at site and erection of substation structures for each substation including supply of all necessary hardware, fittings & fixtures etc required for successful erection, testing & commissioning of substations. The rates to be quoted shall also

include the fee for the preparation of designs, design/fabrication drawings, furnishing the required number of hard & soft copies of all design & drawings, manuals, supply of all materials, hardware, fittings & fixtures, packing, transportation charges, octopi & tolls, labour, freight insurance, storage at site including arranging all erection plant and equipment etc and all temporary and permanent works necessary for satisfactory completion of job in all respects.

1.1. SUBSTATION LAYOUT AND SECTIONS DRAWINGS

1.1.1. The following preliminary layout plan and sectional elevations drawings of each substation are appended to these specifications for the information and guidance of bidders.

- (i) Drg. No. WAP/POWER/NEPAL/KOSHI/KC-2/04: Plot & Layout Plan of 220/132/33 kV Substation at Tumlingtar;
- (ii) Drg. No. WAP/POWER/NEPAL/KOSHI/KC-2/05: Plot & Layout Plan of 220/33 kV Substation at Baneshwar;
- (iii) Drg. No. WAP/POWER/NEPAL/KOSHI/KC-2/06: Plot & Layout Plan of 220/132/33 kV Substation at Basantpur.

The above drawings are purely tentative and for tender purpose only and in no way final drawings. The contractor shall be required to prepare layout and sectional elevation drawings of each substation to meet the requirements of these specifications and get them approved from Employer/PMC.

1.2. SUBLET ORDERS

1.2.1. No sublet order shall be placed by the Contractor on any manufacturer or supplier without prior written approval of the Employer and when such approval is given, the copies of all drawings/specifications referred to in the sublet order shall be furnished to the Employer/PMC for information.

1.3. CODES AND STANDARDS

- 1.3.1.** All works shall be carried out strictly in accordance with these specifications and relevant Indian/Nepalese Standards or equivalent International Standard and Codes of Practices whether mentioned in the specification or not.
- 1.3.2.** Except where otherwise specified or implied, the design, manufacturing, fabrication and galvanization of switchyard steel structures shall conform to the provisions of IS:802 (Part-I/Sec-1)-1992, IS:802 (Part-I/Sec-2)-1995 and IS:802 (Part-II)-1978.
- 1.3.3.** Unless otherwise stated, the latest version (i.e. as existing one month prior to date of submission of bids) of standards & codes as given in Table 1.1 below shall be applicable for steel structures and other allied works in the scope of this specification:

Table - 1.1

Indian Standards & Codes

S. No.	Standard No.	Title
1	IS:800	Code of practice for use of structural Steel in general building construction.
2	IS:802 (Part-I/Sec-2)-1992	Use of structural steel in Overhead Transmission Line Towers – Code of Practice: Part-1 Material, Loads and Permissible Stresses
3	IS:802 (Part-II)-1992	Code of Practice for Use of structural Steel in Overhead Transmission Line Towers: Part-II Fabrication, Galvanizing, Inspection and Packing
4	IS:808	Specification for Rolled Steel Beams, Channels and Angle Sections.
5	IS:813	Scheme of symbols for welding
6	IS:814	Covered electrodes for metal arc welding of structural steel
7	IS:815	Classification coding of covered electrodes for metal arc welding of structural steels
8	IS:816	Code of Practice for use of material arc welding for general construction in mild steel
9	IS:817	Code of practice for training and testing metal arc welders
10	IS:822	Code of practice for inspection of welds

S. No.	Standard No.	Title
11	IS:823	Code of practice for manual metal arc welding of mild steel
12	IS:875	Code of practice for structural safety of buildings: loading standards
13	IS:919	ISO System of Limits and Fits
14	IS:1364	Specification for hexagonal bolts, screws, nuts and lock nuts
15	IS:1367	Technical supply conditions for threaded steel fasteners
16	IS:1573	Specification for electroplated coatings of zinc on iron and steel
17	IS:1730	Dimensions for steel plate, sheet and strip for structural and general engineering purposes.
18	IS:1731	Dimensions for steel flats for structural and general engineering purposes
19	IS:1893	Criterion for earthquake resistant design of structures
20	IS:2016	Specification for plain washers
21	IS:2062	Specification for structural steel fusion welding quality
22	IS:2633	Method of testing uniformity of coating of zinc coated articles
23	IS:4759	Specification for hot-dip zinc coatings on structural steel and other allied products
24	IS:6639	Specification for hexagonal bolts for steel structures.
25	IS:7215	Tolerance for fabrication of steel structures
26	IS:7318	Approved tests for welders when welding procedure approval is not required
27	IS:2363	Black hexagonal bolts, nuts and lock nuts and hexagonal screws
28	IS:2629	Recommended practice for hot dip galvanizing of iron and steel
29	IS:1978	Specification for line pipe
30	IS:3063	Specification for spring washers
31	IS:806	Code of practice for use of steel tubes in general building construction
32	IS:1161	Specification for steel tubes for structural purposes
33	IS:209	Specification for zinc

S. No.	Standard No.	Title
35	IS:6610	Specification for heavy washer for steel structures
36	IS:5358	Specification for hot dip galvanized coatings on fasteners
37	IS:6745	Specification for methods of determination of weight of zinc coating on zinc coated iron and steel articles
38	IS:228	Method of chemical analysis of pig iron, cast iron, plain carbon & low alloy steel
39	IS:406	Specification for Method of CHEMICAL Analysis for slab zinc
40	IS:1083	Precision hexagonal bolts, screws and nuts (BSW & BHF threads).
41	IS:1181	Qualifying tests for metal arc welders (engaged in welding structures other than pipes).
42	IS:1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates
43	IS:1363	Specification for block hexagonal bolts, nuts and lock nuts and block hexagonal screws
44	IS:1477	Code of practice for finishing of ferrous metal in buildings – painting and allied finishers – Part-I (Operation and workmanship).
45	IS:1599	Method of bend tests for steel products other than sheet, wire & tubes
46	IS:1608	Method of tensile testing of steel products other than sheet strip wire & tube
47	IS:1852	Specification for rolling and cutting tolerance for hot rolled steel products
48	IS:2074	Ready mix paint, red oxide zinc chromate primer
49	IS:2551	Danger notice plates
50	IS:2595	Code of practice for radiographic testing
51	IS:3502	Steel for checked plates
52	IS:3613	Acceptance tests for wire flux combination for metal arc welding for mild steel
53	IS:3658	Code for practice for liquid penetrant flow detection
54	IS:3664	Code of practice for ultrasonic testing by pulse echo method
55	IS:4000	Code of practice for assembly of structural joints using high tensile friction grip fasteners
56	IS:5334	Code of practice for magnetic practice flow detection of

S. No.	Standard No.	Title
		welds
57	IS:5613	Code of practice for design, installation and maintenance of overhead power lines
58	IS:5624	Foundation bolts
59	SP:6(4)	Use of high strength friction grip bolts (IS Publication)
60	IS:10238	Step bolts for steel structures
61	IS:12427	Transmission tower bolts

0

1.3.4. The list of Standards & Codes as given in Table 1.1 above is not exhaustive but indicative only. All other relevant Indian/Nepalese Standard not mentioned in the list shall also be applicable.

1.3.5. The equipment/materials meeting the requirement of any other International standard which ensure a quality equal or better than the standard mentioned above shall also be acceptable.

1.3.6. Where any equipment/material conforming to any other standard other than mentioned above is offered by the bidder, then the salient points of difference between the standards adopted and those prescribed in these specifications shall be clearly brought out in the bid and a copy of the applicable standards shall also be enclosed with his bid. It shall, however, be subject to the acceptance and the approval of Employer/PMC.

1.4. DESIGNS & DRAWINGS

1.4.1. After the award of contract, the contractor shall submit to the Employer, for his approval, the detailed design calculations, drawings for each type of gantry tower, beams, lightening/lighting masts and equipment supporting structures etc. The design of structures shall be accompanied with the following drawings:

- (a) Loading diagrams of structures; and
- (b) Single line diagram of structures.

1.4.2. The contractor shall submit the following designs and drawings as well as any other design & drawing required in connection with substation steel structures for approval of Employer/PMC:

- (a) Design of all substation steel structures comprising gantry towers, beams, lighting/lightening masts, equipment supporting structures etc.
- (b) Design drawings of all structures including base plates, foundation bolts etc with the size of the various members and location of joints, etc.
- (c) Detailed fabrication drawings of all structures indicating the fabrication details of all members including gusset plates, base plates, foundation bolts etc; erection mark assigned to various members; sizes of the members; details of joints; details of stringing points etc. The details of joints, stringing points, base plates, foundation bolts and similar other items shall be furnished separately in the drawing on a larger scale.
- (d) One hard copy and one editable soft copy of all designs to both Employer and PMC.
- (e) Three hard copies and one editable soft copy of all drawings and bill of materials to both Employer and PMC.
- (f) Results of any test as & when conducted or required by the employer and report thereof.
- (g) Any other design or drawing or document required for successful completion of job as desired by Employer.

1.4.3. The fabrication drawings shall be prepared by the Contractor based on approved line diagram of structures and submitted to Employer/PMC for approval. The fabrication drawings shall indicate complete details of fabrication and erection including all erection/fabrication splicing details, joint details, weld sizes & lengths, bolt details and all customary details in accordance with standard structural engineering practice.

- 1.4.4.** The approval of designs & drawings by Employer/PMC shall, however, not relieve the Contractor of his responsibility for safety and durability of structures and good connections and any loss occurring due to defective design, fabrication or workmanship shall be borne by the contractor.
- 1.4.5.** The Contractor shall submit hard copy and editable soft copy of all designs preferably in STAAD PRO and drawings in AUTOCAD to Employer/PMC. The Contractor shall submit the copy of relevant Indian/International Standards & Codes referred to by him in design of structures to Employer/PMC for reference if necessary during detailed engineering stage.
- 1.4.6.** In case, the Employer/PMC feels that any design or drawing is required to be modified even after its approval, the Contractor shall modify the said design/drawing and resubmit the same for approval.
- 1.5. MATERIALS & WORKMANSHIP**
- 1.5.1. General Requirements**
- 1.5.1.1.** All materials used in the manufacture of the substation steel structures shall be of tested and best quality conforming to relevant Indian/Nepalese standards. The materials, for which no Indian/ Nepalese Standards exist, shall be in accordance with any other mutually acceptable International Standard.
- 1.5.1.2.** The workmanship shall be of the high order in accordance with relevant Indian standards and best engineering practices.
- 1.5.2. Structural Steel Sections and Plates**
- 1.5.2.1.** Structural steel of tested quality conforming to IS: 2062-2011 shall be used for the fabrication of steel structures, base plates, foundation bolts etc. The structural steel sections and plates shall be hot rolled manufactured either using mild steel of Grade E250 (Designated Yield Strength 250 MPa) or high tensile strength steel of Grade 350 (Designated Yield Strength 350 MPa).
- 1.5.2.2.** Structural Steel Sections used for the fabrication of structures shall, in general, conform to IS: 808-1989.

- 1.5.2.3. Structural Steel plates used in the fabrication of steel structures shall be of Grade E250 (Designated Yield Strength 250 MPa) or Grade E350 (Designated Yield Strength 350 MPa) of tested quality conforming to IS: 2062-2011. Flats of equivalent grade meeting mechanical strength and metallurgical properties may also be used in place of plates for packing plates and packing washers.
- 1.5.2.4. Other equivalent grade of structural steel angle sections and plates conforming to any other equivalent International Standards can also be used if approved by the Employer. The steel sections and plates conforming to any other International standards, if used, shall be of equal or superior quality with corresponding Indian Standards. However, the use of steel of grade having designated yield strength of more than 350 MPa shall not be permitted.
- 1.5.2.5. All steel sections and plates supplied shall be free from all imperfections, mill scales, slag intrusion, laminations, pitting, rusts etc that may impair their strength, durability and appearance. All materials shall be of tested quality and the test certificates from Manufacturer in respect of each consignment shall be submitted by the contractor to employer for acceptance. If any clarification on test certificates sought by the Employer/PMC shall be promptly furnished by the contractor. Till test certificates are accepted by the Employer/PMC, the steel of that particular consignment shall not be used in works.
- 1.5.2.6. Samples of all materials procured by the Contractor and workmanship proposed to be employed in the execution of the works may be inspected, at any time, by the Employer/PMC. In case either sample of any material or workmanship is found to be of substandard/unacceptable quality, the Contractor shall immediately discontinue use of such material and workmanship and get fresh samples approved from the Employer/PMC. Nothing shall affect the liberty of the employer to reject portions of the structures where defective materials and/or workmanship have already been used before detection.
- 1.5.3. Bolts, Nuts and Washers**
- 1.5.3.1. The bolts conforming to IS: 12427 and of property class 5.6 as per IS: 1367(Part-III) and matching nut of property class 5.0 as per IS: 1367(Part-VI) shall be provided.

1.5.3.2. Flat and tapered washers shall be of mild steel conforming to relevant Indian Standard.

1.5.3.3. Spring washers conforming to IS: 3063 shall be provided.

1.5.3.4. Foundation bolts shall be of mild steel of Grade E250 (Designated Yield Strength 250 MPa) conforming to IS: 2062.

1.5.4. Test Certificates

1.5.4.1. Copies of all test certificates relating to material procured by the Contractor for the works shall be submitted to Employer/PMC.

1.6. STORAGE OF MATERIAL

1.6.1. All materials shall be stored in such a manner so as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged shall be removed from Contractor's yard or site stores immediately.

1.6.2. Steel sections for fabrication of structures shall be stored in separate stacks above ground, section wise and length wise so that they can be easily inspected at any time.

1.6.3. Bolts, nuts and washers and other fastening materials shall be stored on racks off the ground with a coating of suitable protective oil. These shall be stored in separate gunny bags or compartments in accordance to diameter, length and quality.

1.7. GENERAL DESIGN REQUIREMENTS

1.7.1. Structural steel of tested quality conforming to IS:2062-2011 shall be used for the fabrication of substation steel structures. The steel shall be either Mild steel of grade Fe250 or high tensile steel of grade Fe350.

1.7.2. Except where otherwise specified or implied, the design, manufacturing, fabrication, galvanizing etc of steel structures shall conform to the provisions of IS:802 (Part-I/Sec-1)-1992, IS:802 (Part-I/Sec-2)-1995 and IS:802(Part-II)-1978 and other relevant Indian Standards.

- 1.7.3.** The Contractor shall furnish the most economical design for substation steel structures conforming to these specifications, relevant Indian Standards/ equivalent International Standards.
- 1.7.4.** The structures shall be self supporting lattice type steel structures with bolted connections and fully galvanized. No welding shall be allowed in lattice structures except for connecting the base plates & stiffeners to the legs of structures.
- 1.7.5.** The structures shall be so designed that only the rationalized ISI metric hot rolled sections of tested quality conforming to IS: 808 and IS: 2062 are used in fabrication of substation steel structures. Further, the Contractor, while designing substation structures, shall use only such sizes of steel sections which are easily available and procurable. Substitution, if any, of steel sections in the structures by higher sizes, due to non-availability or any other reasons, shall be at the cost of Contractor and the Employer shall not accept any liability on this account.
- 1.7.6.** The bidders shall take into account any fabrication wastages while quoting rates and the Employer shall not accept any liability in connection with wastage of steel during fabrication or otherwise.
- 1.7.7.** While designing gantry towers/columns, beams, lightening/lighting masts, equipment supporting structures etc, the base width of structures and size of beams shall be so chosen so that there is no hindrance to various electrical clearances and adequate electrical clearances as specified in these specifications, relevant Indian Standards/ equivalent International Standards and statutory rules and regulations of the country of Employer, whichever is more stringent shall be ensured.
- 1.7.8.** Grounding of all steel structures shall be done as specified in these specifications.
- 1.7.9.** The structures shall be designed for dead loads, live loads, wind loads, seismic loads, short circuit forces, operational loads, conductor/shielding wire/ground wire tensions & deviation loads and the load of conductors, insulators, shielding/ground wire, hardware and all fittings & fixtures, as applicable under specified loading conditions.

- 1.7.10.** The equipment supporting structures shall be either pipe type or lattice type as per the support requirement of equipment and fully galvanized and shall be designed to carry the weight of equipments, conductors, hardware, all fittings & fixtures, wind loads, earthquake loads, short circuit forces, operational loads etc.
- 1.7.11.** Lightening masts, if provided, shall also cater to the station lighting purposes. The height of lightening/lighting mast shall be as per approved structural layout and designed for diagonal wind also. The platforms shall be provided at heights required for mounting of lighting fixtures. Size of platforms shall be adequate for mounting a minimum of four lighting fixtures on each side. Provision shall be made for tilting the lighting fixtures to suitable angle. The platforms shall also have protection railing. The lightening masts shall be provided with structural steel ladder within its base upto the highest platform. The ladder shall be provided with safety cage.
- 1.7.12.** If luminaries are proposed to be fixed on gantries/towers, then the loading for the same shall be considered in the design. The holes in the relevant members of structures for fixing the brackets for luminaries shall be provided wherever required.
- 1.7.13.** All gantry towers and beams shall be designed as dead end structures i.e. all the balancing conductors/wires on one side of gantry shall be assumed broken. The structures shall be designed for normal condition and under short circuit condition as well as for earthquake loads. The Contractor can rationalize the designs and reduce the varieties if it is economical. All gantry towers and beams of same designation shall be interchangeable.
- 1.7.14.** The sequence of applying tension during stringing shall also be taken care of in the design of structures and specified by the contractor on the drawings.
- 1.7.15.** The beams shall be connected with gantry towers/columns by bolted joints.
- 1.7.16.** Foundation bolts shall be designed for the loads for which structures are designed.
- 1.7.17.** The analysis of structures shall be done with well established modern computer software programme like STAAD PRO. The computer software programme to be employed should have been prepared or approved by a recognized institution. The

contractor shall submit the particulars and name of the computer programme as well as names of the customers to whom the substation steel structures have been supplied based on the said computer programme and also the structures test results providing the efficacy of the programme to the Employer/PMC for approval before taking up the design.

1.7.18. The contractor shall also submit manual calculations, if required by the Employer/PMC, for verifying the analysis and design results of the structures obtained using software.

1.7.19. Hard copy of all designs along with soft copy of input files of the computer software used for analysis of various structures (i.e. gantry towers & beams, lightening/lighting masts, equipment supporting structures etc) shall be submitted by the contractor to Employer/PMC for approval. The Employer shall check the design of structures submitted by the Contractor and if any modifications/ changes are necessitated consequent to the checking, the same shall be incorporated by the contractor without any additional cost to the Employer.

1.7.20. Design Criteria to be prepared by Contractor: The Contractor shall be required to prepare a detailed design criteria and basis for the design of substation steel structures bringing out the standards proposed to be used, the details of materials & loads, analysis & design methods and computer software proposed to be used and all other relevant details in conformity with this specification and submit the same to Employer/PMC for approval. The design of substation structures shall be taken up only after the approval of aforesaid design criteria & basis by Employer/PMC.

1.8. STATUTORY REQUIREMENTS

1.8.1. Statutory requirements as laid down in the Safety and Electricity Supply Regulations of the country of Employer or by any other statutory body applicable to such structures shall be met and satisfied.

1.9. DESIGN LOADS AND LOAD COMBINATIONS

1.9.1. The substation steel structures shall be designed to withstand the following loads as applicable to respective structure:

- (a) Dead loads;
- (b) Tension in conductors/wires under various climatic conditions;
- (c) Live Loads;
- (d) Wind loads;
- (e) Earthquake/Seismic loads;
- (f) Short Circuit Forces;
- (g) Erection loads;
- (h) Service loads;
- (i) Operational loads;
- (j) All secondary effects due to temperature, shrinkage etc; and
- (k) Any other special load during erection or the service period of structures.

1.9.2. All structures shall be designed for the worst combination of dead loads, live loads, conductor/shield wire/ground wire tensions, wind loads, seismic forces, short circuit forces, etc as per relevant Indian Standards / equivalent International Standards. The loads due to deviation of conductor/shield wire/ground wire, unbalanced tension in conductor/shield wire/ground wire, torsional load due to unbalanced vertical and horizontal forces, erection loads, service loads, operational loads including 'snatch' in the case of bundled conductors etc shall also be considered in the design.

1.9.3. Wind and Seismic Loads shall not be considered acting simultaneously on structures i.e. only one load out of two shall be considered at a time in the design of structures in combination of other loads.

1.9.4. Short Circuit Forces: Short circuit forces shall be estimated as specified in IEC 865 or relevant Indian Standard/ equivalent International Standard and shall be subject to

the approval of Employer. Short circuit forces shall be calculated considering a fault level of 40.0 kA for 220kV, 31.5KA for 132kV and 25KA for 33kV or as directed by the Employer/PMC.

1.9.5. Wind Loads: Wind pressure on steel structures, rigid bus bar tubes, conductors, ground/shield wires, insulator strings, hardware, other fittings & fixtures and equipment shall be considered as per IS:802(Part-I/Sec-1)-1995 for specified wind zone.

1.9.6. Earthquake/Seismic Forces: Earthquake/Seismic Forces shall be considered and worked out in accordance with IS:1893 for seismic Zone – V. The appropriate inertia loadings on various structures shall be assessed depending upon individual responses of the structures and as stipulated in IS:1893. The vertical seismic co-efficient, where applicable, shall be taken as half of the horizontal seismic co-efficient. In important structures wherever there is a possibility of amplification of vertical seismic co-efficient, the stipulations of IS:1893 shall be followed.

1.9.7. Vertical Loads

1.9.7.1. The vertical loads shall comprise the following loads:

- (i) Weight of rigid bus bar, conductor, ground/shield wire, jumpers etc;
- (ii) Weight of insulators, hardware and other fittings & fixtures;
- (iii) Self-weight of structure and respective equipment;
- (iv) Weight of under hung connectors where applicable; and
- (v) Weight of man with tools at each conductor point or any location of structure critical for a particular member.

1.9.7.2. The vertical loads due to the weight of bus bars, approach span conductors, shield/ground wires, insulator strings, equipment etc if supported on the gantry, shall be considered in the design of beams & gantry towers.

1.9.7.3. A provision of a load of 1500 N shall be made for a lineman with tools in the design of substation structures. The weight of man with tools shall also be assumed to act anywhere on the horizontal members and members with inclination up to 15° .

1.9.7.4. The self-weight of the beam shall be considered in the design of beams. In case of the design of gantry towers, lightening/lighting mast, equipment supporting structures, the weight of superincumbent portion of the structure shall be considered in the design.

1.9.8. Conductor/ Wire Tension Loads

1.9.8.1. The maximum working tension for bus bars, conductors and shield wires shall be considered as per Sag Tension calculations or specified, whichever is more critical.

1.9.8.2. The loads due to wire tensions shall be calculated along and transverse to the beam axis at the points of attachment of conductor/wires. In case of gantry towers and lightening masts, the wire tensions shall be resolved in the direction of its adjacent faces.

1.9.8.3. The worst condition of unbalanced conductors and shield wire loads, with all balancing conductor/wire on the opposite side of the structure shall be assumed to be broken for the design of structures.

1.9.9. Terminal/ Line Take off Gentries

1.9.9.1. Terminal/line take off gentries shall be designed for a minimum conductor tension of 2.0 ton per phase for 220 kV, 1.0 ton per phase for 132 kV and 0.50 ton for 33 kV or as per actual requirement whichever is higher.

1.9.9.2. The distance between terminal gantry and dead end tower shall be taken as 200 meters for 220kV, 150 meters for 132kV and 80 meters for 33 kV switch yard or as actual whichever is more. The design of these terminal gentries shall also be checked considering $\pm 30^{\circ}$ deviation of conductor in both vertical and horizontal planes. For other gentries, the structural layout requirements shall be adopted in the design.

1.9.9.3. The maximum stringing tensions in the approach spans shall be taken as per design of dead end towers and actual site conditions.

1.9.10. COMBINATION OF LOADS

1.9.10.1. The structures shall be designed for the two loading conditions i.e. normal condition and abnormal condition. In abnormal condition, short circuit forces or earthquake loads whichever is more critical shall be combined with loads under normal condition. The earthquake loads and wind loads shall not be considered together i.e. one load shall be considered at a time. In both conditions, the design of all structures shall be based on the assumption that all the balancing conductors/wires on one side are broken. In addition, all structures shall also be checked under Safety & Maintenance Condition.

1.9.10.2. The combination of loads shall be made under the normal and abnormal conditions for wind blowing either normal to beam (longitudinal direction) or parallel to beam (transverse direction). In case of equipment supporting structures and stand alone structures like lighting masts etc, wind shall be assumed acting normal to two adjacent faces of structure, one at a time as well as in diagonal direction. Loads shall be resolved into transverse, longitudinal and vertical directions for the purpose of design. All balancing conductors/wires on one side of gantry shall be considered broken in Normal Condition as well as in Abnormal Condition.

1.9.10.3. Normal Condition

- (i) Wind loads on bus bars, conductors, shield/ground wires, insulator string, jumpers, other hardware, fitting & fixtures, equipments, members of structure etc.
- (ii) Winds on approach span conductors and ground wire.
- (iii) Unbalanced loads due to conductor/wire tensions considering all the balancing conductors/wires on one side being broken;
- (iv) Deviation loads due to conductor/wire tensions;
- (v) Dead loads of wires, insulators, hardware, fitting & fixtures, equipment, structural members, weight of lineman with tools etc.

The above loads shall be resolved in transverse, longitudinal and vertical directions as under:

- (a) **Wind Loads:** Wind load on gantry towers, Lightening/Lighting Mast, beams, bus bar, conductors, shield/ground wires, jumpers, connectors, insulators, equipment, other hardware, fittings & fixtures etc with wind blowing either in Transverse or Longitudinal direction;
- (b) **Transverse Loads:** Component of Mechanical Tension due to conductor and shield/ground wire deviation in Transverse direction;
- (c) **Longitudinal Loads:** Component of Mechanical Tension due to conductor and shield/ground wire deviation in Longitudinal direction;
- (d) **Vertical Loads:** Load due to weight of conductor, shielding wire, insulator strings, jumpers, hardware, other fittings & fittings, connectors, accessories, self-weight of structure, component of Mechanical Tension of conductor and shielding/ground wire in vertical direction.

1.9.10.4. **Abnormal Condition**

Either of the two conditions viz. short circuit condition or earthquake condition, whichever is more stringent, shall be considered for the design of substation steel structures as described below:

- (a) **Short Circuit Condition:** Where short circuit loads are specified, these shall be considered in addition to the combination of loads as stipulated in Normal Condition.
- (b) **Earthquake Condition:** Earthquake/Seismic forces as specified shall be considered in addition to the combination of loads as stipulated in Normal Condition excluding the wind loads.

1.9.10.5. **Safety & Maintenance Condition:** All bracing and redundant members of the gantry towers, beams, lightening/lighting masts and equipment supporting structures which are horizontal or inclined up to 15° from horizontal shall be designed to withstand an ultimate vertical load of 1500 N considered acting at the center or any other point of

the member independent of all other loads but including self weight of member. All gantry towers, beams and masts shall also be designed to withstand, independent of all other loads but considering self weight of structure, an ultimate vertical load of 1500 N as a weight of Lineman with tools and an additional load of 3500 N acting at each conductor attachment point of beam and shield/ground wire peak.

1.9.10.6. The Substation steel structures shall be designed for the most stringent combinations of loadings as specified above in Normal and Abnormal conditions and checked under safety & maintenance condition and shall be able to withstand these loads without exceeding the minimum guaranteed yield stress of material as per IS:802(Part-1/Sec-1)-1995 without any injury or permanent deflection.

1.9.10.7. **Sag Tension Calculations**

1.9.10.8. Sag tension calculations for conductor and shield/ground wire shall be made for the following conditions:

- (i) Full wind pressure on conductor and shield/ground wire at every day temperature;
- (ii) 36 % of full design wind pressure on conductor and shield/ground wire at minimum temperature;
- (iii) Every day temperature and nil wind (Initial condition);
- (iv) 85⁰ C temperature for ACSR conductor (95⁰ C temperature in case of AAAC or AA conductor) and nil wind; and
- (v) Minimum temperature and nil wind.

1.9.10.9. The sag of shield/ground wire shall be maintained within 90% of the conductor sag. The effect of insulator string on calculation of conductor sag shall also be considered.

1.9.10.10. Initial tension under every day temperature and 'nil' wind as applicable for conductor and shield/ground wire shall be such that maximum sag at maximum temperature is within permissible limits keeping in view the electrical clearances required from ground/ equipments / structures. Final sag shall be maintained considering the effect of insulator string.

1.9.11. Computation of Wind Loads

1.9.11.1. The wind pressure shall be assumed as acting horizontally.

1.9.11.2. Wind Load shall be corresponding to Wind Zone 4 of IS:802 (Part-1/Section-1)-1995.

The relevant design parameters for Wind Zone 4 shall be as under:

(a) Basic wind speed ' V_b ' = 47 m/s [which is peak gust velocity averaged over a short time interval of about 3 seconds at mean height of 10 meter above ground level in an open terrain (Terrain Category 2) and has been worked out for a return period of 50 years]

(b) Reliability Level : 1

(c) Terrain Category: 2

(d) Reference Wind Speed ' V_R ' = V_b/K_0 [V_R is extreme value of wind speed over an averaging period of 10 minutes duration and K_0 is factor to convert 3 seconds peak gust speed into average speed of wind during 10 minutes period at a level of 10 meters above ground. The value of K_0 is 1.375.

$$'V_R' = 47/1.375 = 34.18 \text{ m/s}$$

(e) Design Wind Speed ' V_d ' = $V_R \times K_1 \times K_2$

Where K_1 is Risk Coefficient & K_2 is Terrain Roughness Coefficient;

$$K_1 = 1.0 \text{ (For Reliability Level 1)}$$

$$K_2 = 1.0 \text{ (For Terrain Category 2)}$$

$$\text{Thus Design Wind Speed } V_d = 1.0 \times 1.0 \times 34.18 = 34.18 \text{ m/s}$$

(f) Design Wind Pressure $P_d = 0.6 \times V_d^2$

$$= 0.6 \times 34.18 \times 34.18 = 701 \text{ N/m}^2$$

1.9.11.3. Gantry towers/columns, beams, Lightening/Lighting Masts and equipment supporting structures etc shall be designed for Design Wind Pressure of 701 N/m².

1.9.11.4. The wind load on structures shall be determined assuming the specified wind pressure to be acting on the projected area of the members on the windward face in

accordance with IS:802 (Part-I/Sec-1)-1995 considering applicable Drag Coefficient, Gust Response Factor etc.

1.9.11.5. The wind load on bus bars, approach span conductors and shield wires shall be determined in accordance with IS:802 (Part-I/Sec-1)-1995 assuming the specified wind pressure to be acting on full projected area. In case of bundle conductors (more than one conductor per phase), the wind pressure shall be assumed as acting on full projected area of each sub-conductor in the bundle.

1.9.11.6. The wind load on insulator string shall be calculated in accordance with IS:802 (Part-I/Sec-1)-1995 by taking the effective projected area of the cylinder with diameter equal to that of the insulator skirt and length based on the number of discs and hardware in the insulator string.

1.9.11.7. The wind load on equipment shall be calculated based on the design wind pressure in accordance with IS:802(Part-I/Sec-1)-1995 considering projected area of equipment perpendicular to wind direction.

1.9.11.8. The direction of the wind shall be assumed so as to produce the maximum stress in any member for the combination of wind loads and other loads. For this condition, wind shall be assumed acting in two directions at right angles to each other and critical wind load shall be considered for the design of structures. The diagonal wind shall also be considered for standalone structures like equipment supporting structures, lighting masts etc.

1.9.11.9. Substation Steel Structures shall be designed for the maximum tension in conductor and shield/ground wire corresponding to any of the following conditions whichever is more critical:

- (i) Full design wind pressure and every day temperature;
- (ii) 36% of full design wind pressure and minimum temperature.

Provided that the tension in wires under any of the above conditions does not exceed 70% of ultimate tensile strength of conductor/ ground wire.

1.9.11.10. Wind Load on Structure: In order to determine the wind load on Gantry Towers, Beams, Lightening/Lighting Masts, Equipment Supporting Structures, it shall be divided into different panels having a height/length 'h'. These panels are normally taken between the intersections of the legs and bracings. For a lattice structures of square cross section, the resultant wind load F_{wt} in Newton, for wind normal to the panel, on a panel of height/length 'h' applied at the center of gravity of this panel shall be as under:

$$F_{wt} = P_d \times C_{dt} \times A_e \times G_t$$

Where

P_d = Design wind pressure in N/m^2 ;

C_{dt} = Drag coefficient for panel under consideration against which the wind is blowing. Values of C_{dt} for the different solidity ratio shall be as per Table-5 of IS:802(Part-1/Sec-1)-1995.

A_e = Total net surface area of members in the panel under consideration projected normal to the face in sq m.

G_t = Gust response factor, peculiar to the ground roughness and depends on the height above ground. Values of G_t shall be as per Table-6 of IS:802(Part-1/Sec-1)-1995.

1.9.11.11. Wind Load on Conductor, Shield/Ground Wire and Jumpers etc: The load due to wind on each conductor and shield/ground wire, F_{wc} in Newton applied at supporting point normal to the conductor or shield/ground wire shall be determined by the following expression:

$$F_{wc} = P_d \times C_{dc} \times L \times d \times G_c$$

Where:

P_d = Design wind pressure in N/m^2 ;

C_{dc} = Drag coefficient, taken as 1.0 for conductor and 1.2 for earth wire;

L = Wind span, being sum of half the spans on either side of supporting

Structures, in meters;

d = Diameter of conductor/earth wire, in meters

G_c = Gust response factor, takes into account the turbulence of the wind and the dynamic response of the conductor. Values of G_c shall as per Table-7 of IS:802 (Part-1/Sec-1)-1995 for the average height of conductor / ground wire above ground.

The average height of conductor shall be taken up to clamping point of conductor less two-third sag at minimum temperature and no wind. The average height of the shield/ground wire shall be taken up to clamping point less two-third sag at minimum temperature and 'nil' wind.

1.9.11.12. Wind Load on Insulator Strings: Wind load on insulator strings ' F_{wi} ' shall be determined on insulator length from the attachment point to the center line of the conductor in case of suspension insulators string and up to the end of clamp in case of tension insulators string, in the direction of the wind as follows:

$$F_{wi} = C_{di} \times P_d \times A_i \times G_i$$

Where,

C_{di} = Drag coefficient of insulators taken as 1.2;

P_d = Design wind pressure in N/m^2 ;

A_i = Area of insulator string projected horizontally on a vertical plane parallel to the axis of the string. In the absence of actual value, it may be taken as 50% of the gross projected area of the cylinder with diameter equal to that of the insulator skirt; and

G_i = Gust response factor, peculiar to the ground roughness and depends on the height of insulator attachment point above ground. Values of G_i shall be as per Table-6 of IS:802 (Part-1/Sec-1)-1995.

1.9.12. Snow Loads

- 1.9.12.1. Substation at Basantpur is located at an altitude of more than 2500 m and experiences snow fall during winter. Accordingly, snow load shall be duly considered in the design of steel structures, buildings and all other facilities at Basantpur substation.
- 1.9.12.2. At nil wind and minimum temperature of -5°C , 10 mm radial thickness of ice shall be considered on conductors, shielding/earth wire/OPGW.
- 1.9.12.3. At 28% of design wind pressure and minimum temperature of -5°C , 5 mm radial thickness of ice shall be considered on conductors, shielding/earth wire/OPGW.
- 1.9.12.4. The ice unit weight is to be considered as 916.80 kg/m^2 .
- 1.9.12.5. Snow load on structures and buildings etc shall be considered in accordance with IS:875 (Part-4).
- 1.9.12.6. Other substations are located on lesser altitudes and don't experience snow fall during winter. No snow load shall be considered in the design of these substations.

1.9.13. Computation of Conductor/Wire Tension Loads

- 1.9.13.1. The maximum tension for conductors and shield/ground wires shall be based on Sag Tension Calculations as per following conditions whichever is more stringent:
- (i) Full design wind pressure on conductor and shield/ground wire at every day temperature; and
 - (ii) 36% of full design wind pressure on conductor and shield/ground wire at minimum temperature.
- 1.9.13.2. The maximum tension to be considered for the design of structures shall be subject to the approval of the Employer.
- 1.9.13.3. The loads due to conductor/wire tensions shall be resolved along three perpendicular directions to the beams and gantry towers and considered accordingly in the design.

- 1.9.13.4. The worst condition of unbalanced conductors and shield/ground wire loads, with all balancing conductor/wire on the opposite side of the structure assumed broken shall be considered for the design of structures.(It is repetition)

1.9.14. Strength Factors Related to Quality

- 1.9.14.1. The design of substation steel structures shall be carried out in accordance with the provisions covered in IS:802(Part-1/Sec-2)-1992. However, to account for the reduction in strength due to dimensional tolerances of the structural sections, the following strength factors shall be considered depending upon the yield strength of steel:

- (i) If steel with minimum guaranteed yield strength is used for fabrication of substation structures, the estimated loads shall be increased by a factor of 1.02 to account for dimensional tolerances.
- (ii) If steel of minimum guaranteed yield strength is not used for fabrication of substation structures, the estimated loads shall be increased by a factor of 1.05, in addition to that mentioned in (i) above.

1.10. DESIGN OF STRUCTURES

- 1.10.1. The design of lattice type of steel structures for gantries, masts and equipment supporting structures shall be carried out in accordance with procedure and guidelines specified in IS:802(Part-1/Sec-1)-1995, IS:802(Part-1/Sec-2)-1992 and IS:802(Part-II)-1978 and as given herein under. Indian Standard IS:800 shall be referred to and used for any aspect of design not covered in IS:802.

- 1.10.2. The structural design of pipe type equipment supporting structures shall be carried out in accordance with IS: 806 entitled 'Code of Practice for Steel Tubes in General Building Construction.'

1.10.3. Minimum Thickness and Size of Members

- 1.10.3.1. The minimum thickness of angle section used in the design of substation steel structures, unless otherwise specified elsewhere in this specification, shall be kept not less than the following values:

- (a) Main leg members of gantry towers, Beams, lightening/lighting masts, and equipment supporting structures : 5 mm
- (b) For all other members : 4 mm
- (c) The thickness for gusset plate shall not be less than 6.0 mm. Where a gusset plate is required to transmit stress, it shall not be less than thickness of the thickest bracing member connected plus 2.0 mm.
- (d) Only Equal Angles shall be used and size of angle shall not be less than 45 x 45 mm

1.10.4. Allowable Stresses

1.10.4.1. Axial Stress in Tension

The estimated tensile stress on the net effective sectional area in various members shall not exceed 250 N/mm^2 for mild steel sections or the specified yield stress of steel for high tensile steel sections (if proposed to be used in the fabrication of substation steel structures and agreed to by Employer) as per IS: 2062-2011 or any other equivalent to International Standards.

1.10.4.2. Axial Stress in Compression

- (A) The estimated compressive stress in various members shall not exceed the value given by the formulae in clause 5.2 of IS: 802 (Part-I/Sec-2). As per said formula, the allowable unit stress F_a , in M_{pa} on the gross cross sectional area of the axially loaded compression members shall be calculated as under:

$$(a) F_a = \left[1 - \frac{1}{2} \left(\frac{Kl/r}{C_c} \right)^2 \right] \times F_y$$

$$\text{Where } Kl/r \leq C_c$$

and,

$$(b) F_a = \frac{\pi^2 \times E}{(Kl/r)^2}$$

$$\text{When } Kl/r > C_c$$

Where,

$$C_c = \pi \sqrt{\frac{2E}{F_y}}$$

F_y = minimum guaranteed yield stress of the material, Mpa

E = modulus of elasticity of steel that is 2×10^5 Mpa,

Kl/r = largest effective slenderness ratio of any unbraced segment of the member,

L = un-braced length of the compression member in cm, and

r = appropriate radius of gyration in cm.

(B) The formulae given in **(A)** above are applicable provided the largest width to thickness ratio 'b/t' is not more than the limiting value given by:

$$\left(\frac{b}{t}\right)_{\text{Lim}} = \left(210 / \sqrt{F_y}\right)$$

Where

B = distance from edge of fillet to the extreme fibre in mm, and

t = thickness of flange in mm.

(C) Where the width to thickness ratio exceeds the limit given in **(B)**, the formulae given in **(A)** shall be used substituting for F_y the value F_{cr} given by:

$$(a) \quad F_{cr} = 1.677 - \frac{6.77 \times b/t \times F_y}{b/t_{\text{lim}}}$$

$$\text{When} \quad b/t_{\text{lim}} \leq b/t \leq 378/\sqrt{F_y}$$

And,

$$(b) \quad F_{cr} = 65550/(b/t)^2$$

$$\text{When} \quad b/t > 378/\sqrt{F_y}$$

Note:- The maximum permissible value of b/t for any type of steel section shall not exceed 25.

1.10.5. Redundant Members

1.10.5.1. The redundant members shall be checked individually for 2.5 percent of axial load carried by the member to whom it supports. In addition, the members shall also satisfy the requirements specified under 'Safety & Maintenance Condition' in clause 1.9.11.4

1.10.6. Stresses in Bolts

1.10.6.1. The estimated stresses in bolts shall not exceed the values given in IS:802 (Part-1/ Sec-2) which are reproduced in Table – 1.2 below.

TABLE – 1.2

ULTIMATE STRESSES IN BOLTS in MPa

Nature of stress	Permissible Stress For Bolts of Property Class 5.6	Remarks
Shear Stress on Gross Area of bolts	310	For bolts in double shear, the area to be assumed shall be twice the area defined. For gross area of bolts, refer item (a) in clause 1.10.6.2 below.
Bearing Stress on Gross Diameter of Bolts	620	For the bolt area in bearing, see item (b) in clause 1.10.6.2 below.
Axial Tensile Stress	250	

1.10.6.2. Gross area and Bearing area of bolts shall be considered as under:

- Gross area of Bolt: For the purpose of calculating the shear stress, the gross area of bolts shall be taken as the nominal area of the bolt i.e. $(\pi \times d^2)/4$ where 'd' is the nominal diameter of bolt.
- Bearing Area of Bolt: It shall be taken as 'd x t' where 'd' is the nominal diameter of the bolt and 't' is the thickness of the thinner of the parts jointed.

- (c) Where the material of bolt and the structural members are of different grades, the bearing strength of the joint shall be governed by the lower of two.

1.10.7. Slenderness Ratio

- 1.10.7.1. Slenderness ratio of compression and redundant members shall be computed in accordance with clause 6 of IS:802 (Part-1/sec-2) which is reproduced in Table – 1.3 below:

Table – 1.3

Permissible Slenderness Ratio

Sl. No.	Type of Members	Value of KL/r
1.	Compression Members	
(i)	Leg sections or joint members bolted in both faces at connections for $0 < L/r \leq 120$	L/r
(ii)	Members with concentric loading at both ends of the unsupported panel for $0 < L/r \leq 120$	L/r
(iii)	Member with concentric loading at one end and normal framing eccentricity at the other end of the unsupported panel for $0 < L/r \leq 120$	$30 + 0.75 L/r$
(iv)	Member with normal framing eccentricities at both ends of the un-supported panel for $0 < L/r \leq 120$	$60 + 0.50 L/r$
(v)	Member unrestrained against rotation at both ends of the unsupported panel for $120 \leq L/r \leq 200$	L/r
(vi)	Member partially restrained against rotation at one end of the unsupported panel for $120 < L/r < 225$	$28.6 + 0.762 L/r$
(vii)	Member partially restrained against rotation at both ends of the unsupported panel for $120 < L/r < 250$	$46.2 + 0.615 L/r$
2.	Redundant Members	
(i)	For $0 < L/r < 250$	L/r

- 1.10.7.2. For the values of ' KL/r ' corresponding to 1(vi) and 1(vii) in above table, the following procedure of evaluation shall be adopted:

- (a) The restrained member must be connected to the restraining member with at least two bolts.

(b) The restraining member must have a stiffness factor ' I/L ' in the stress plane (I =Moment of inertia and L =Length) that equals or exceeds the sum of the stiffness factors in the stress plane of the restrained members that are connected to it.

(c) Angle members connected by one leg should have the holes located as close to the outstanding leg as feasible. Normal framing eccentricities at load transfer connection imply that connection holes are located between the heel of the angle and the center line of the framing leg.

1.10.7.3. In calculating the slenderness ratio of the members, the Length ' L ' shall be the distance between the intersections of the center of gravity lines at each end of the member.

1.10.7.4. The following maximum limit of the effective slenderness ratio i.e. the ratio of unsupported length of the section in any plane to the appropriate radius of gyration shall not exceed value specified herein under:-

- | | | |
|---|---|-----|
| (b) For main leg members of gantry towers, beams, lightening/lighting masts, and equipment supporting structures in compression | : | 120 |
| (c) For the members having computed stresses | : | 200 |
| (d) For redundant members | : | 250 |
| (e) For members having axial tensile stress only | : | 400 |

1.10.8. Erection Stresses

1.10.8.1. Where erection stresses combined with other possible co-existent stresses could produce a working stress in any member above the permissible stress, the additional strengthening of such members shall be affected or such other provisions made as are necessary to bring the stresses within the permissible limit.

1.11. FASTENERS - BOLTS, NUTS AND WASHERS

- 1.11.1.** All substation steel structure members shall have bolted connections. All bolts and nuts shall conform to IS: 12427. Bolts shall have hexagonal head, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight. All bolts and nuts shall be galvanized in accordance with IS:367 (Part-13)/IS: 2629.
- 1.11.2.** All bolts shall be of 16 mm in diameter or higher as per design requirement and shall be of property class 5.6 as specified in IS: 1367(Part-III) and matching nut shall be of property class 5.0 as specified in IS: 1367 (Part-VI).
- 1.11.3.** Bolts up to 16 mm diameter and having length up to 10 times the diameter of the bolt shall be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control.
- 1.11.4.** The shear strength of bolts for property class 5.6 shall be not less than 310 MPa as specified in Indian Standard IS:12427. Bolts shall be provided with washer face in accordance with IS: 1363 (Part-I) to ensure proper bearing.
- 1.11.5.** Nuts for hexagonal bolts shall be double chamfered as specified in IS: 1363 (Part-III). It shall be ensured by the manufacturer that nuts shall not be over tapped beyond 0.40 mm on effective diameter for size up to 16 mm. Nuts for anti-theft bolts shall be round tapered with hexagonal shear nuts. The hexagonal portion of shear nuts shall break away at specified torque recommended by the supplier to ensure proper tightening of members so that fasteners are not opened subsequently with tools. The tightening torque and shearing of anti-theft nuts shall be verified during proto-assembly.
- 1.11.6.** Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion shall not extend into the place of contact of the members.
- 1.11.7.** All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further. It shall be ensured that the

threaded portion of each bolt protrudes not less than 3.0 mm and not more than 8.0 mm when fully tightened.

1.11.8. Flat and tapered washers shall be provided wherever necessary.

1.11.9. Spring washers shall be provided for insertion under all nuts. These washers shall be electro-galvanized, positive lock type and 3.5mm in thickness for 16mm diameter bolts.

1.11.10. To avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of members more than three times its diameter.

1.11.11. The bolt positions in assembled structures shall be as per approved fabrication drawings. Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.

1.12. STEP BOLTS & LADDERS

1.12.1. In order to facilitate inspection and maintenance, each gantry tower, lightening/lighting mast and equipment supporting structure shall be provided with climbing devices at two diagonally opposite legs in the form of step bolts of not less than 16.0 mm diameter and 175 mm long, spaced not more than 450 mm apart, staggered on faces on diagonally opposite legs and extending from about 0.5 meter above the ground level to the top of the structure. The step bolts shall conform to IS: 5613 (Part-2/Sec-1)-1985 and other relevant Indian Standards.

1.12.2. Each step bolts shall be provided with two nuts on one end to fasten the bolt securely to the structure and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1500 N.

1.12.3. Lightening/Lighting Masts shall be provided with structural steel ladder with safety guard extending from about 0.5 meter above the ground level to the top most platform provided for installing lighting fittings & fixtures.

1.13. FOUNDATION BOLTS

- 1.13.1.** All foundation bolts for lattice and pipe structures shall be supplied by the Contractor as an essential part and parcel of structures.
- 1.13.2.** All foundation bolts shall be of mild steel of grade Fe250 conforming to relevant Indian Standards/equivalent International Standards.
- 1.13.3.** Diameter of foundation bolts shall not be less than 20 mm. All foundation bolts shall develop their full strength by bond between bolt and concrete i.e. the length of foundation bolt to be embedded in concrete shall be not less than the development length of bolt corresponding to the grade of foundation concrete.
- 1.13.4.** Each foundation bolt shall be provided with a plain/spring washer of appropriate thickness, one normal nut and one lock nut. In addition, one additional nut shall be provided in each foundation bolt below the base plate which may be used for the purpose of leveling. All nuts and washers shall conform to relevant Indian Standards/equivalent International Standards.
- 1.13.5.** All foundation bolts shall be provided with two numbers of standard nuts, one check nut, one plain washer and a mild steel plate of suitable size but not less than 75 x 75 x 6mm welded/bolted at the bottom of foundation bolt for ensuring mechanical anchorage of bolts in foundation.
- 1.13.6.** The foundation bolts shall be galvanized from the top to a point at least 300 mm below the proposed elevation of the concrete foundation. Utmost care shall be taken in not galvanizing the portion to be embedded in concrete below this stipulated level as it may affect the bond stress between bolt and concrete.
- 1.13.7.** Foundation bolts for gantry towers/columns, lightening/lighting masts and equipment supporting structures and elsewhere shall be embedded in first stage concrete while foundation is cast. The contractor shall ensure proper alignment of these bolts to match the holes in the base plate.
- 1.13.8.** The Contractor shall be responsible for the correct alignment and levelling of all steel structures at site to ensure that the towers/structures are plumb.

1.14. GROUTING

- 1.14.1.** The space between top of concrete foundations and bottom of base plates shall be grouted so as to ensure complete (i.e. 100%) contact between base plates and foundations for transfer of load from structures to foundations. The method of grouting shall be subject to the approval of Employer/PMC.
- 1.14.2.** The strength of grout mix shall not be less than that of foundation concrete. The mix proportion for grouting shall be subject to the approval of Employer/PMC.
- 1.14.3.** Anti shrinkage compound/admixture conforming to relevant Indian Standard shall be mixed in all grout mixes as per recommendation of Manufacturer.
- 1.14.4. Payment for Grouting:** The payment for grouting of bases of structures shall be deemed to be included in the erection charges of structures and no separate payment for the same shall be made.

1.15. FABRICATION

Except where here-in-after modified, the details of fabrication shall, in general, conform to IS: 802(Part-II), other relevant Indian Standards or equivalent International Standards.

1.15.1. General Requirements

- 1.15.1.1.** All materials shall be completely shop fabricated and finished with proper connections and erection marks for ready assembly in the field.
- 1.15.1.2.** Members of the structures shall be fabricated as per the approved fabrication drawings and in accordance with relevant Indian Standards/equivalent International Standards and the best engineering practice.
- 1.15.1.3.** No individual members shall be longer than 6000 mm.
- 1.15.1.4.** Normally bolted butt joint shall be used to connect the parts of structures. The thickness of inside angle cleat shall not be less than that of the heavier member connected. The lap splices may be used for connecting members of unequal thickness and the inside angle of lap splices shall be rounded at the heel to fit the

fillet of the outside angle. All splice joints shall be designed to develop full strength of connected members.

- 1.15.1.5. Joints shall be so designed so as to avoid eccentricity, as far as possible.
- 1.15.1.6. The use of gusset plates at joints shall be avoided as far as possible. However where the connections are such that the elimination of the guest plates and spacer plates are not possible, the gusset/spacer plates may be used in conformity with modern engineering practice.
- 1.15.1.7. The use of fillers in the connections shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate where necessary to avoid the use of fillers. Each diagonal shall be in one piece without splices or centre gusset and it shall be connected at the point of intersection by one or more bolts.
- 1.15.1.8. Members of the structures shall be accurately fabricated, so that the same can be assembled at site without any strain in members or in bolts.
- 1.15.1.9. The Contractor, during fabrication of structure members, shall ensure that mild steel and high tensile steel sections don't get mixed up and as such identification mark shall be embossed on each and every H.T. Steel section at the time of cutting/shearing of members.
- 1.15.1.10. All members of the structures shall be cut to correct lengths and fabricated in accordance with the fabrication drawings approved by the Employer. Welding of two or more pieces to obtain the specified length of member shall not be allowed. Members shall be straight to the permissible tolerances or better when required to ensure proper fit before being laid off or worked and after galvanizing.
- 1.15.1.11. No angle member shall have its two leg flanges brought together by closing the angle.
- 1.15.1.12. All parts of the structures shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets or depressions are likely to hold water.

1.15.1.13. All similar parts of structures shall be made strictly interchangeable. No rough edges shall be permitted anywhere throughout the work.

1.15.1.14. Structural members shall be so fabricated as to be bolted together easily at site. Preference shall be given to the design with least number of parts and the one which offers best facilities for transport, erection and maintenance. In designing the structures for minimum number of parts, the Contractor shall not, however, employ parts of such dimensions as shall prove difficult to handle.

1.15.1.15. Workmanship and finish shall correspond to the best engineering practices. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true by a method which shall not injure the material so that, when assembled, the adjacent surfaces are in close contact.

1.15.2. Straightening

1.15.2.1. All steel sections, before any cutting is done, shall be carefully straightened and made true by straightening machine or pressure. Hammering shall not be permitted for straightening or flattening of members. All sheared edges shall be free from burrs and no rough edges from shearing shall be left. Straightening shall be so done that it does not injure the material. Sharp bends shall be a cause for rejection.

1.15.3. Cutting

1.15.3.1. Cutting may be affected by shearing, cropping, sawing or by gas cutting by mechanically controlled torch. Shearing, cropping and gas cutting shall be clean, square and free from distortions and burns, and should the Employer/PMC find it necessary, the edges shall be ground by the Contractor after cutting without any additional cost. The cut surfaces shall be clean, smooth, reasonably square and free from any distortion. The cut edges of all plates shall be perfectly straight and uniform throughout.

1.15.4. Bending

1.15.4.1. Mild steel angle sections of size upto 75x75mm (thickness up to and including 6.0 mm) shall be bent cold up to and including bend angles of 10°. Mild steel angle

sections of size above 75x75mm (thickness upto and including 6.0 mm) and upto and including 100x100mm (thickness upto 8.0 mm) may also be bent cold upto bend angles of 5° . All other angle sections and bend angles not covered above shall be bent hot.

1.15.4.2. All plates upto 12.0 mm thickness shall be bent cold upto a maximum bend angle of 15° . Hot bending shall be employed for greater bend angles and thicker plates.

1.15.4.3. Bends on all high tensile steel sections/plates shall be done hot.

1.15.4.4. The bends shall be of even profile and free from any surface damages. All hot bent material shall be air-cooled.

1.15.5. **Holing**

1.15.5.1. Holes for bolts in the members shall be either punched or drilled to jig but drilled holes are preferred. Holes shall not be formed by flame cutting process. All burrs left by punching or drilling shall be completely removed.

1.15.5.2. Members shall be straightened again after punching or drilling of holes.

1.15.5.3. Punching may be adopted for mild steel sections with thickness upto 16.0 mm. For thicker sections, drilling shall be used.

1.15.5.4. The holes near the bend line of a bent member on both sides of bend line shall be punched/drilled after bending and relative positions of those holes shall be maintained with the use of proper templates/jigs and fixtures.

1.15.5.5. The limit of punching for high tensile Steel sections shall be intimated by the contractor, which shall be in accordance with relevant Indian Standard/ equivalent International Standard and subject to approval of Employer/PMC.

1.15.5.6. Punched/drilled holes shall be at right angle to the surface and the walls of holes shall be parallel. Holes shall be perfectly circular unless specified otherwise in the approved fabrication drawings.

1.15.6. Spacing of Bolts and Edge Distance

- 1.15.6.1. The minimum spacing and minimum edge distances of bolts shall be as given Table – 1.4 below:

Table – 1.4

Spacing of Bolts and Edge Distance

Bolt Diameter (mm)	Hole Diameter (mm)	Minimum Bolt Spacing (mm)	Minimum Edge Distance of Hole Centre to Rolled or Sawn cut edge (mm)	Minimum Edge Distance of Hole centre to sheared or flame cut Edge (mm)
16	17.5	40	20	23
20	21.5	48	25	28
24	25.5	60	33	38

- 1.15.6.2. As a general rule, the minimum distance from hole centre to edge shall be 1.5 x bolt diameter and minimum distance between centre to centre of holes shall be 2.5 x bolt diameter.

1.15.7. Locking Devices

- 1.15.7.1. Electro-galvanized spring washers of type 'B' of thickness indicated in the Table – 1.5 below corresponding to respective bolt diameter shall be provided for insertion under all nuts.

Table – 1.5

Diameter of Bolt and Thickness of Spring Washer

Bolt Diameter (mm)	Thickness of spring washer (mm)
16	3.5
20	4.0
24	4.5

1.15.8. Welding

- 1.15.8.1. The work shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, size & length of weld, weather shop weld or site weld etc. Symbols for welding on fabrication drawings shall be according to IS:813.
- 1.15.8.2. Welding shall be done before galvanizing. No welding shall be allowed after galvanizing.
- 1.15.8.3. Welding shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be used and testing and inspection procedures to be applied shall be subject to the approval and the satisfaction of the Employer/PMC and shall, in general, conform to relevant Indian standards viz. IS: 816, IS: 823, IS: 814 and Indian Standards Hand Book for metal arc welding etc.
- 1.15.8.4. All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS: 1811 and IS: 817.
- 1.15.8.5. **Edge Preparation for Welding:** Proper edge preparation shall be made for jointing of materials before welding except for square butt welds. Type of edge preparation shall depend on the thickness of parent materials that are to be joined. The edge forms shall be chosen to suit the design technology and production conditions and shall be subject to the approval of the Employer/PMC. The edge form shall be prepared either by machine or by automatic gas cutting with surface roughness of the welding area not exceeding $Ra = 50$. All edges cut by flame shall be ground before they are welded.
- 1.15.8.6. **Electrodes**
- (i) The electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired e.g. normal penetration welds or deep penetration welds.

- (ii) Where coated electrode are used they shall meet the requirements of IS:814 and relevant ASME-SEC IX. Covering shall be heavy to withstand normal conditions of handling and storage. They shall be free from all defects which interfere with performance of electrodes.
- (iii) Only those electrodes which give radiographic quality of welds shall be used.
- (iv) Where bare electrodes are used, these shall correspond to specification of the parent material. The electrodes shall be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements.

1.15.8.7. Sequence of Welding

- (i) The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion shall be effectively controlled either by a counter effect or by a counter distortion. The direction of welding should be away from point of restraint and towards the point of maximum freedom.
- (ii) All welds shall be finished full and made with correct number of runs. The welds being kept free from slag and other inclusions, all adhering slag being removed from exposed surfaces immediately after such run.
- (iii) Non uniform heating and cooling shall be avoided to ensure that excessive stresses are not locked up resulting ultimately in cracks.
- (iv) Intermittent welds shall not be permitted without the approval of the Employer/PMC. These shall be permitted only when specifically approved in the fabrication drawings.

1.15.8.8. Inspection of Welds

- (i) 100 per cent welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The length and size of weld shall be as per approved fabrication drawings. It may be slightly over sized but shall not be under sized. The profile of weld is affected by the position of the joint but it

shall be uniform. In case of butt and corner welds, the profile shall be convex and in case of submerged arc fillet weld, it shall be slightly concave.

- (ii) The welds shall have regular height and width of beads. The height and spacing of ripples shall be uniform. The joints in the weld run where welding has been recommended shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from unfilled craters on the surface, under cuts, slag on the surface and visible cracks. Such inspection shall be done after cleaning the weld surface with steel wire brushes and chisel to remove sputter metal, scale, slag etc. If external defects mentioned above are noticed, the work shall be dismantled and redone.

1.15.8.9. Rectification of Defective Welding Work: Whenever defects like improper penetration, extensive presence of blow holes, undercuts, cracking, slag inclusion etc. are noticed by visual inspection/other tests, the welds in such locations shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding if necessary and re-welded. The gouging shall as far as possible be done by gouging electrodes. Flame gouging shall be resorted to only in special cases with the specific permission of the Employer/PMC.

1.15.8.10. Acceptance of Welded Structures

- (i) The acceptance of the welded work shall depend upon correct dimensions, alignment and absence of distortion in the structure, satisfactory results from the examination of welds, the soundness of the welds and upon general workmanship being good.
- (ii) Random Dye Penetration (D.P.) test shall be conducted on welds after completing the welding.
- (iii) The radiographic/ultrasonic testing of welds shall be undertaken if found necessary and directed by the Employer.

1.15.9. ERECTION MARK

1.15.9.1. Each member of the structure shall have a unique erection mark conforming to component number given to it in the fabrication drawings. This mark shall be punched with marking dies of 16 mm size before galvanizing and shall be legible after galvanizing.

1.15.9.2. Erection Mark shall be in format A-BB-CC-DDD where:

A	=	Employer's Code assigned by the Contractor – Alphabet;
BB	=	Contractor's Mark – Numerical;
CC	=	Structure Type – Alphabet; and
DDD	=	Member Number assigned by the Contractor – Numerical

1.15.9.3. The proposal of Erection Mark shall be prepared by the Contractor and got approved from Employer/PMC before starting any fabrication work.

1.15.10. FABRICATION TOLERANCES

1.15.10.1. The fabrication tolerances shall, in general, conform to IS:802(Part-II)-1978 and as given herein under. The tolerances not specified IS:802(Part-II)-1978 shall, in general, conform to IS:7215-1974 unless otherwise specified here-in-under.

1.15.10.2. Tolerance on the overall length of a member shall be within ± 2 mm.

1.15.10.3. Tolerance on gauge distance shall be within ± 1 mm so that structure could be assembled at site without any undue strain on structure members or in bolts.

1.15.10.4. No bolt hole shall be more than 1.5 mm larger than the corresponding bolt diameter.

1.15.10.5. The maximum allowable difference in diameter of the holes on the two sides of the plate or angle shall be 0.8 mm, that is, the allowable taper in a punched hole shall not exceed 0.8 mm on diameter.

1.15.10.6. Tolerance cumulative and between consecutive holes shall be within ± 2 mm and ± 1 mm respectively.

1.15.10.7. The threaded portion of each bolt shall project out through the nut at least one thread.

1.15.10.8. The gap between the ends of two connected members in a butt splice shall not be more than 6.0 mm and less than 4.0 mm.

1.15.11. PROTO TYPE ASSEMBLY

1.15.11.1. The Contractor, after the approval of designs & fabrication drawings, offer the proto type of the each structure for Employer/PMC's inspection at his works or works of manufacturer so as to ensure fitment of various members and to avoid problems during erection..

1.15.11.2. Before proceeding with the bulk fabrication of any of structure i.e. gantry towers, beams, lightening/lighting masts and equipment supporting structures etc, the Contractor shall fabricate and assemble in his works for inspection by the Employer or his authorized representative, one structure of each type as finally approved by the Employer for checking the fabrication accuracy and workmanship. The check assembly shall be in a horizontal position. Proto assembly made on ground in horizontal position shall be adequately supported to prevent distortion and overstressing of members to ensure proper fit and shall be accomplished without extraordinary effort to align bolt holes or to force pieces into position. For the check assembly, bolts and nuts shall be not more than finger tight.

1.15.11.3. Any changes pointed out by Employer or his representative during inspection shall be incorporated by the contractor.

1.15.11.4. The mass manufacture of structures shall be taken up without the approval of prototype structure and its bill of materials.

1.16. GALVANIZING

1.16.1. All members of substation steel structures and fasteners including foundation bolts shall be hot dip galvanized. Spring Washers shall be Electro galvanized.

- 1.16.2.** Galvanizing of the members of the structures shall conform to IS: 2629-1966 and IS: 4759-1968 and that of fasteners to IS: 5358-1969. Spring washers shall be electro-galvanized as per Grade 4 of IS: 1573-1986.
- 1.16.3.** Zinc required for galvanizing shall be arranged by the Contractor. Purity of Zinc shall be not less than 99.95% as per relevant Indian Standards/equivalent International Standards.
- 1.16.4.** All galvanized members shall withstand tests as per IS: 2633-1986.
- 1.16.5.** The Galvanizing of steel members shall be done after all fabrication works have been completed except that the nuts may be tapped or re-run after galvanizing. Threads of bolts and nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of the bolts.
- 1.16.6.** Pickling shall be carried out by immersing the steel members in an acid bath containing either sulfuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and temperature of the bath can be varied, provided, the pickling time is adjusted accordingly. The pickling process shall be completed by thoroughly rinsing with water, which should be warm, so as to remove the residual acid completely.
- 1.16.7.** Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements, when tested in accordance with IS: 2633 – ‘Methods of Testing Weight, Thickness and Uniformity of Coating on Hot Dipped Galvanized Articles’. The zinc coating shall be uniform, clean and of a standard thickness on the entire surface of the material galvanized.
- 1.16.8.** Galvanizing of each member shall be carried out in one complete immersion. Double dipping shall not be permitted. When the steel member is removed from the galvanizing kettle, excess spelter shall be removed by ‘bumping’. The process known as ‘wiping’ or ‘scrapping’ shall not be used for this purpose.

- 1.16.9.** All bolts, nuts, locknuts, washers etc shall also be hot dip galvanized. Excess spelter from bolts, nuts etc. shall be removed by centrifugal spinning of bolts or nuts. Threading after galvanizing, shall not be permitted. Nuts, however, may be tapped, but not to cause appreciable racking of the nut on the bolts.
- 1.16.10.** The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized.
- 1.16.11.** Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after having under gone re-galvanization once, the same shall be rejected.
- 1.16.12.** All steel structures and accessories after galvanizing shall be treated by dipping them in Sodium Dichromate solution or treated with approved inhibitor (the details of which shall be provided by the contractor to the Employer/PMC before starting the galvanizing) for protection against white rust formation during transportation.
- 1.16.13.** Special care shall be taken not to injure the galvanized surfaces during transport, handling and erection. Damages, if any, shall be made good in accordance with the provisions of this specification or as directed by the Employer/PMC.
- 1.16.14. Adverse Atmospheric Conditions:** Low temperature coupled with high humidity (RH approaching 80%) causes fast rusting to steel parts. The Contractor, therefore, shall be required to give special attention to galvanizing for ensuring that it is of superior quality and not less than specified. Items not properly galvanized or getting rusted shall be rejected at the cost and risk of Contractor.
- 1.16.15.** The acceptable values of the coating of zinc on the steel members, bolts, nuts and washers shall be not less than specified in Table – 17.6 below:

TABLE - 1.6

Sl. No.	Item	Minimum Zinc Coating
1.	Structural steel members except bolts, nuts and washers	610 gm/m ²
2.	Bolts, nuts and washers	450 gm/m ²

- 1.16.16.** Members embedded in concrete shall be galvanized from the top to a point at least 300 mm below the proposed elevation of the concrete foundation. Utmost care shall be taken in not galvanizing the portion to be embedded in concrete below this stipulated level.
- 1.16.17.** The Contractor shall furnish sufficient quantity of zinc paint of approved quality, free of cost, for repairing damages of minor nature in galvanized surfaces in transit or during handling.
- 1.16.18.** Employer's approval shall be obtained if galvanizing is done outside the Contractor's fabrication plant.
- 1.16.19.** The Contractor shall be required to make arrangement for frequent inspection by the Employer/PMC as well as continuous inspection by a resident representative of the Employer/PMC, if so desired, for fabrication and galvanization work.

1.17. ERECTION

- 1.17.1.** The Contractor shall arrange at his own cost all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipments and all other accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage. Minor modification if any, required during erection shall be done at site with the approval of Employer/PMC.
- 1.17.2.** The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered, the drifts shall be used to align the part so that the bolts can be accurately positioned.

1.17.3. Touch-up Painting: Minor defects and damages in hot dip galvanized members shall be repaired at site by applying zinc rich primer and two coats of enamel paint in accordance with relevant Indian Standards and this specification to the satisfaction of Employer/PMC.

1.17.4. Stability of Structures: The Contractor shall be responsible for the stability of the structures at all stages of its erection at site and shall take all necessary measures by providing temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

1.18. SAFETY PRECAUTIONS

1.18.1. The Contractor shall strictly follow all precautions at all stages of fabrication, trial assembly, packing, transportation and erection of steel structures. The stipulations contained in relevant Indian Standards/ equivalent International Standards for safety during erection of structural steel work shall also be adhered to.

1.19. QUALITY ASSURANCE PLAN AND QUALITY CONTROL

1.19.1. The Contractor shall prepare a Quality Assurance Plan as per relevant Indian Standards/ equivalent International Standards to accept/check the materials, fabrication, welding, manufacturing, galvanizing etc within one month after award of work and submit the same to Employer/ PMC for approval. The Quality Assurance Plan shall include customer's hold points and shall cover all stages of work right from design till successful erection of structures. The Quality Assurance Plan shall be examined by the Employer/PMC and if found to be acceptable, the same shall be approved by the Employer subject to compliance to observations, if any. The Contractor shall follow the approved Quality Assurance Plan in true spirit. If desired by the Employer, the contractor shall give access to all the documents and materials to satisfy the Employer that the Quality Assurance Plan is being strictly followed.

1.19.2. To ensure effective quality control during manufacturing process, the manufacturer shall have in house testing facility for all tests like weight of zinc coating, shear strength and other tests etc. The manufacturer should also have proper Quality

Assurance System which should be in line with the requirement of this specification and ISO: 9000 & 14000 series Quality System Standard.

1.19.3. The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent deems necessary and as directed by Employer/PMC to ensure that all works are performed in accordance with this specification. In addition to the Contractor's quality control procedure, the materials and workmanship shall be subject to inspection by the Employer or his authorized representative.

1.19.4. The quality control procedure shall cover but not be limited to the following items of work:

- (i) **Steel:** Manufacturer's Test Certificates and Test Reports of representative samples of materials.
- (ii) **Bolts, Nuts & Washers:** Manufacturer's certificates, dimensional check for bolts, nuts & washers.
- (iii) **Fabrication:** Specifications, IS:802(Part-II) & other relevant Standards & Codes and approved fabrication drawings.
- (iv) **Galvanizing:** Tests for weight, thickness and uniformity of zinc coating in accordance with IS: 2633.
- (v) **Paints:** Manufacturer's test certificates, test physical inspection reports.

1.20. BILL OF MATERIALS

1.20.1. The bill of materials shall be prepared based on approved fabrication drawings. The bill of materials for each type of structure shall be prepared separately and submitted to the Employer/PMC for approval.

1.20.2. The bill of materials shall contain the erection mark of each member, dimensions, weight and total weight. Weight of bolts, nuts & washers shall be indicated separately. Total weight of the structure shall be indicated in the last page of bill of materials.

1.20.3. The weight of structures shall be calculated by using the standard sectional weights of steel structures of the sizes indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weight due to drilling of bolt holes, skew cuts, chamfering, etc. or increase in weight due to galvanization but taking into consideration the weight of bolts, nuts, washers, hangers, D-Shackles, 'U' bolts, strain plates etc.

1.20.4. The Contractor, while designing substation structures, shall use only such sizes of steel sections which are easily procurable. If for any reason, the sections approved are not easily procurable, it is the Contractor's responsibility to procure the alternative sizes which are satisfactory from the point of view of design, fabrication, and galvanization and supply the same at no additional cost to the Employer.

1.21. GUARANTEED QUANTITIES OF STRUCTURES AND PAYMENT

1.21.1. The Bidders are required to quote guaranteed weights for various structures in the Schedule of 'Guaranteed Technical Particulars for Substation Structures' in Section-5 of Part-II, Section-VI.

1.21.2. The payment for structures shall be made as per weight in approved drawings of respective structure or guaranteed weight quoted by Bidders in Schedule of 'Guaranteed Technical Particulars for Substation Structures', whichever is minimum and unit rate per metric ton for galvanized steel structures quoted by bidders in Price Schedule in Section-IV(A) of Part-I. The weight of each structure shall include the weight of all its members, nuts, bolts, washers, spring washers, gusset plates, foundation bolts etc. Bidders shall ensure that they quote for full scope of work on fit for purpose basis.

1.21.3. In case any new type of structure is required which is not covered under guaranteed weight, the payment for such structure shall be made as per its weight in approved drawing and unit rate per metric ton for galvanized steel structures quoted by bidders in Price Schedule in Section-IV(A) of Part-I.

1.22. INSPECTION, TESTING & ACCEPTANCE CRITERIA

- 1.22.1.** Each part of the fabricated steel work shall be inspected as per approved Quality Plans and certified by Employer/PMC as satisfactory before it is dispatched to the erection site. Such certification shall not relieve the Contractor of his responsibility regarding adequacy, correctness and completeness of fabrication and galvanization.
- 1.22.2.** Employer/PMC or his representative shall have free access to manufacturer's works to satisfy that the fabrication is being done in accordance with the provisions of this specification and approved fabrication drawings.
- 1.22.3.** The tests as specified in this specification and/or in the relevant Indian Standard shall be conducted on the material before dispatch.
- 1.22.4.** The Contractor shall provide all materials, stores, labour, tools and plant, apparatus and instruments, electricity, fuel, water, transport, accommodation etc as may be required by the Employer/PMC to carry out inspection and/or tests as specified in these specifications and relevant Indian Standards.
- 1.22.5.** The Contractor shall ensure compliance with the provisions of this specification and he shall carry out sampling and necessary tests in accordance with the relevant Indian Standards and as supplemented herein at his own cost, unless otherwise specified in the contract. The Contractor shall get the specimens tested in a laboratory approved by the Employer and submit to the Employer three copies of the test results within five days after completion of the test.
- 1.22.6.** Only tested quality steel conforming to IS: 2062 having mill test reports shall be used in fabrication of structures. However, to ascertain the quality of the steel used, the Employer reserves the right to get the material tested at an approved laboratory, the cost of which shall be borne by the contractor.
- 1.22.7.** All bolts, nuts and washers shall be procured from reputed manufacturers and shall conform to the relevant Indian Standards.
- 1.22.8.** The weight, thickness and uniformity of zinc coating on hot dipped galvanized members shall be tested in accordance with IS: 2633 for ensuring the compliance

with the requirements specified in specification. The galvanized steel member shall withstand minimum four, one minute dips in copper sulfate solution as per IS: 2633.

- 1.22.9.** The finished surfaces of steel structures shall be visually examined for defects like discolored patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky deposits, blistered surface, flaking or peeling off etc. There shall be no flaking or loosening when struck squarely with a chisel faced hammer. The presence of any of these defects noticed on visual microscopic inspection shall render the material liable to rejection.
- 1.22.10.** Defects in galvanizing in certain members indicating presence of impurities in the galvanizing bath in quantities larger than that permitted by the specifications, or lack of quality control in any manner in the galvanizing plant shall render the entire production in the relevant shift liable to rejection.
- 1.22.11.** Should any structure or part of a structure be found not to comply with any of the provisions of this specification, the same shall be liable for rejection. No structure or part of the structure, once rejected, shall be offered again, except in cases where the employer considers the defects rectifiable. The employer may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved laboratory and should the items, so tested, be found to be unsatisfactory, the same shall be rejected. The cost of tests shall be borne by the Contractor.
- 1.22.12.** When all tests to be performed in the Contractor's shop under the terms of this contract have been successfully carried out, the steel work shall be accepted forthwith and the Employer shall issue an acceptance certificate, upon receipt of which, the items shall be dispatched. No item shall be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of prescribed tests or the issue of the dispatch certificates shall not bind the Employer to accept the work, should it, on further tests before or after erection be found not in compliance with the specification.

1.23. PACKING

1.23.1. The material shall be boxed or bundled for transport in the following manner:-

1.23.2. All Angles members shall be packed in bundles securely wrapped four times around at each end and in the middle and at every meter with No.9 gauge galvanized steel wire with ends twisted tightly. Gross weight of any bundle shall not exceed approximately 450 kg.

1.23.3. Cleat angles, brackets, fillet plates and similar small loose pieces shall be nested and bolted together in multiples and securely wired together through holes, wrapped round at least four times with No.9 gauge galvanized steel wire and ends twisted tightly. Gross weight of each bundle shall not exceed approximately 70kg.

1.23.4. The correct quantity of bolts, nuts and washers plus 2.50 percent extra for each type of gantry tower, beam, lighting/lightening mast, equipment supporting structure etc. shall be packed in gunny bags, accurately & securely tagged in accordance with the contents and a number of bags packed in wooden box tightly wrapped with 25 mm wide x 18 gauge iron band stretched entirely around the box with end overlapping at least 150 mm. Gross weight of each box shall not exceed approximately 70 kg.

1.23.5. All packing shall be subject to the approval of the Employer, or his appointed representative. The packing shall be carried out with caution to protect the material against any damage during transportation as well as from moisture, salt or any impurities which may cause rusting or harmful effects. The packages shall be new and sufficiently sturdy in construction to withstand stresses during transportation from contractor's works to site as well as stress during handling at site without causing any damage to the material.

1.23.6. MARKING OF PACKING

The packing shall be marked in the following manner:

1.23.6.1. The bundles and the packages shall be clearly marked with the consignee and destination by indelible ink.

- 1.23.6.2.** Erection mark of the members of gantry towers, beams, lighting/lightening masts and equipment supporting structures etc shall be indicated on the bundles or packages of gusset plates, bolts & nuts, cleats etc.

1.24. SCHEDULE OF DEVIATIONS / VARIATIONS

- 1.24.1.** If the bidder has any exceptions to any of the clauses laid down in this specification, those shall be clearly stated in the schedule of deviations/variations (Technical or Commercial). Otherwise, it shall be presumed that the bidder agrees to the provisions of this specification and same shall be included in the award letter.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-18

Miscellaneous Items For Sub-Stations

SECTION 4**CHAPTER – 18****MISCELLANEOUS ITEMS FOR SUB-STATIONS****CONTENTS**

S NO	DESCRIPTION	PAGE NO
18.0	SCOPE	1
18.1	STANDARDS	1
18.2	CONTROL CABINETS AND MARSHALLING KIOSK	3
18.3	BUSBAR CONDUCTOR AND CONNECTORS	4
18.4	POWER CONNECTORS & CLAMPS	6
18.5	SUSPENSION AND TENSION INSULATORS AND HARDWARE	8
18.6	BUS POST INSULATORS	10
18.7	EARTHWIRE	13
18.8	FIRE FIGHTING SYSTEM OF THE SUB-STATION	15
18.9	AIR CONDITIONING AND VENTILATION EQUIPMENT	21
18.10	TESTS	24
18.11	DRAWINGS AND BILL OF MATERIALS	24

SECTION 4**CHAPTER - 18****MISCELLANEOUS ITEMS FOR SUB-STATIONS****18.0. SCOPE**

18.0.1. These specifications are intended to cover the design, engineering, manufacturing, inspection and testing at manufacturer's works, packing, supply & delivery, transportation to site, storage, , Testing & commissioning of miscellaneous items such as control cabinets, marshalling kiosks, bus bar conductors and connectors, power connectors, clamps, suspension and tension insulators and their hardware fittings, post insulators, earth wire and accessories, fire fighting system of the substation, air-conditioning and ventilation equipments etc. required for successful commissioning of 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. The design and workmanship shall be in accordance with relevant Indian/International standards and the best engineering practices to ensure satisfactory performance throughout the service life. Any material and equipments not specifically stated in this specification but necessary for satisfactory completion and commissioning of substations shall be deemed to be included in the scope of the contractor unless specifically excluded and shall be supplied without any extra cost. Items/Components having identical rating shall be interchangeable. The contractor shall furnish the testing facilities available at the manufacturer's works or any other testing facility.

18.1. STANDARDS

18.1.1. The equipments covered by this specification shall confirm to the requirements of the latest edition of the following Indian/International standards:-

TABLE-18.1

IS: 1646	Code of Practice for Fire Safety in Buildings.
IS: 2878	Portable CO ₂ Type Fire Extinguishers
IS: 398-1979	Hard Drawn Stranded Aluminium and Steel Core Aluminium Conductor for Overhead Power Transmission Line Purpose.

IS: 1778-1980	Reels and Drums for Bare Conductors
IS: 2486 (Part-I)	Insulator Fittings for Overhead Power Lines With Nominal Voltage Greater than 1000 Volts.
IS: 1521-1991	Methods for Tensile Testing of Steel Wire.
IS: 2544-1693	Porcelain Post Insulator (3.3 Kv And Above).
IS: 2121-1981	Specification for Earth Wire and Earth Wire Accessories
IS: 2633-1992	Methods for Testing Uniformity of Coating of Zinc Coated Articles.
IS: 5561	Power Connectors
IS: 731-1991	Porcelain Insulator for Overhead Power Lines with a Nominal Voltage Greater than 1000 V.
IEC : 120-1984	Dimensional of Ball And Socket Coupling of String Insulator Units.
IEC: 168-1994	Tests on Indoor And Outdoor Post Insulators of Ceramic Material or Glass of Systems with Nominal Voltage Greater than 1000 V.
IEC: 273-1990	Characteristics of Indoor And Outdoor Post Insulators for Systems with Nominal Voltages Greater than 1000 V.
IEC: 372-1984	Locking Devices For Ball and Socket Couplings of String Insulator Units – Dimensions and Tests.
IEC: 471-1977	Dimensions of Clevis and Tongue Couplings of String Insulator Units.
ANSI – C29	Wet Process Porcelain Insulators.
ANSI – C29.1	Test Methods for Electrical Power Insulators.
ANSI – C29.8	For Wet Process Porcelain Insulators Apparatus, Post Type.
ANSI – G8	Iron & Steel Based Ware.
ANSI – C119.4(AA)	Extra Heavy Duty Class – Tested Cartridge Fired ‘C’ Wedge Connectors.
	Electrical Power Technical Standards Of Nepal.

18.1.2. The Equipment and material meeting the requirement of any other equivalent internationally recognized standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable. Where the equipment/material confirms to any other standards, the salient points of difference between the standards adopted and those prescribed in these specifications shall be clearly brought out in the

bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

18.2. CONTROL CABINETS AND MARSHALLING KIOSK

- 18.2.1.** The control cabinets/junction boxes/marshalling kiosk shall generally confirm to IS-5039. Control cabinets & marshalling Kiosk shall be made of steel sheet of specified thickness enclosed and shall be dust, water and vermin proof. Sheet steel used shall be at least 2.0 mm thick cold rolled, 2.5 mm hot rolled and properly braced to prevent wobbling.
- 18.2.2.** The enclosures of the control cabinets & marshalling kiosk shall provide a degree of protection of not less than IP 55 (as per IS:2147).
- 18.2.3.** Control cabinets shall be of free standing floor mounting type or wall mounting type or pedestal mounting type as per requirement.
- 18.2.4.** Control cabinets and Marshalling kiosk shall be provided with double hinged doors with padlocking arrangement. The distance between two hinges shall not exceed 350 mm to ensure uniform sealing pressure against atmosphere.
- 18.2.5.** All doors, removable covers and plates shall be gasketed all around with neoprene gaskets. The marshalling kiosks shall have these removable covers on both the sides front as well as rear.
- 18.2.6.** The cable entries to the marshalling kiosk shall be from the bottom. Suitable cable gland plate of thickness of not less than 3 mm projecting at least 150 mm above the base of the marshalling kiosk shall be provided for this purpose. Necessary numbers of cables glands shall be supplied and fitted on this gland plate. The glands shall be dust free, tight, screw on compression type and made of brass. The glands shall have provision for securing armour of the cable separately and shall be provided with earthing tag, the gland shall be cadmium plated.
- 18.2.7.** All sheet steel sheet work shall be degreased, pickled, phosphated and then applied with two Coats of zinc chromate primer and two Coats of finishing synthetic enamel paint, both inside and outside. The colour of the outer finishing paint shall be light grey in accordance with shade No. 631 of IS-5 and inside shall be of glossy white.

18.2.8. Suitable heaters shall be mounted in the cabinet to prevent condensation. MCB and lamp control thermostat shall be provided. Heater shall be suitable for 220 V AC supply voltage.

18.2.9. The terminals shall be so staggered that the connection of external cable to any terminal block should be possible without disturbing the rest of the connections. The terminal block arrangements shall be such as to provide maximum accessibility to all conductor terminations and any arrangement preventing access to other terminal screws shall not be accepted.

18.2.10. The terminal blocks to be provided shall be fully enclosed with removable covers and made of moulded, non inflammable plastic material with boxes and barriers moulded integrally. Such blocks shall have washer and binding screws for external circuit wire connections, a white marking strip for circuit identification and moulded plastic cover. All terminals shall be clearly marked with identification, number of letters to facilitate connection to external wiring. These terminals shall be of stud type. All internal wiring in central cabinet & marshalling box shall be with FRLS, tinned, stranded (48 or more) PVC control cables.

18.2.11. The arrangements shall be made in such a manner that it is possible to safely connect or disconnect terminals on live circuits and replace fuse (MCB's shall be used wherever possible) links when the cabinet is live. Cabinet Wiring Control accessories shall be suitable for 60 Degrees C to take care of temperatures due to space heaters.

18.2.12. Tests

Control cabinets shall confirm to type and routine tests in accordance with IS: 5039. In addition to the type tests, verification of the degree of protection as per IS: 2147 for IS: 55 shall be conducted. After degree of protection tests on control cabinet, 2.5 kV rms for 1 minute, insulation resistance & functional tests shall be conducted.

18.3. BUSBAR CONDUCTOR AND CONNECTORS

18.3.1. General Requirement

18.3.1.1. Tubular aluminum bus bars with suitable size shall be made of alloy E91E confirming to BS2898 & IS: 5082 and stranded conductors to IEC 61089. The thickness of the tubes, size, numbers and type shall be finalized during detailed engineering. The dropper

connections shall be of Quad/Twin ACSR "Moose" conductor as per equipment. Equipment to equipment connections shall be made with Quad/Twin ACSR "Moose" as well as suitable size of aluminum tube may also be used.

- 18.3.1.2. The General construction of the connectors and their insulator supports shall be mechanically strong and shall withstand all stresses which may be imposed on them during normal working conditions due to fixing, vibrations, climatic conditions, short-circuit or other causes.
- 18.3.1.3. All connectors shall be kept as short and as straight as possible. Provisions shall be made to allow expansion and contraction of all connections due to changes in temperature, and under all loading and short-circuit conditions while keeping the whole system in perfect operating conditions, also without exerting of stress on any part of the system or supporting structure. The design of all conductor/insulator hardware and accessories shall avoid sharp corners of projections which produce high electrical stress in normal working conditions.
- 18.3.1.4. Aluminium strands of conductor shall be hard drawn confirming to IS: 398 and the conductivity shall not be less than 99.5%. The surface of the conductor shall be clean, dry and free from any grease that may be used in manufacturing. The strands shall be smooth and free from burrs, projections and imperfections. The steel wires shall be hot dip galvanized. Zinc chemical composition in the slab and the method of zinc coating shall be as per the applicable standards. The mass of the zinc coating over wires shall correspond to relevant Indian Standard.
- 18.3.1.5. Joints between buses and Tee-Off connection between individual lengths of buses and between connectors and equipments/apparatus shall securely clamp the conductor and at the same time provide ample contact surface for carrying the full rated current of the equipment. All necessary connections clamps etc. shall be supplied by the contractor.
- 18.3.1.6. Special care shall be taken to avoid the possibility of any electrolyte action between the conductors, clamps and the terminals of the apparatus.

18.3.2. Aluminium Tubular Bus Bar:

- 18.3.2.1. The aluminium tubes as per details given in table below shall be supplied and installed for 220/132/33kV substations at Tumlingtar, Basantapur and 220/33 kV substation at Baneshwar in Nepal.

TABLE-18.2

Sl. No.	Item	220 kV Bus Bar	132 kV Bus Bar	33 kV Bus Bar
a.	Material	Aluminium	Aluminium	Aluminium
b.	Diameter	120 mm	100 mm	100 mm
c.	Maximum Span	8500 mm	7500 mm	6000 mm

- 18.3.2.2. Post insulators, supporting structures and suitable connectors for tubular bus bars shall also be supplied and installed. The contractor shall also design, supply and install the anti-vibration facilities for aluminium tubular bus bars.

- 18.3.2.3. The conductor shall have the physical properties or equivalent:

TABLE-18.3

a.	Type	ACSR "Moose"
b.	Overall Diameter	31.77 mm
c.	Cross Sectional Area	597 mm ²
d.	Stranding (nos./mm)	54+7/3.53mm
e.	Mass	1998 kg/km
f.	Ultimate Tensile Strength	16275 kg (159.60 kN)
g.	Rated DC resistance at 20°C	0.05596 Ω/km

18.4. POWER CONNECTORS & CLAMPS

- 18.4.1. The suitable size of aluminium connectors/Bi-metallic connectors shall be used for making connection to the equipment terminals. These shall be bolted type. The clamps shall be made of aluminium alloy and shall be suitable for ACSR "Moose" (31.77 mm dia. Conductor) conductor. The surface of the clamp shall be smooth with all edges rounded off the clamps & connectors shall confirm to IS-5561.

18.4.2. The clamps & connectors shall be made of materials as given in the table below:

TABLE-18.4

a.	For connecting ACSR Moose conductor	Aluminium alloy casting confirming to designation A6 of IS: 617 and shall be tested for all tests as per IS-618.
b.	For connecting equipment terminals made of copper	Bimetallic connectors made from aluminum alloy casting confirming to designation A6 of IS:617 with 4 mm thick cast copper liner and shall be tested as per IS:618.
c.	For connecting shield wire	Malleable iron casting
d.	Bolts, nuts & plain washers	Hot dip galvanized mild steel confirming to relevant Indian standards
e.	Spring washers for item 'a' to 'c'	Electro galvanized in accordance with relevant Indian standards

18.4.3. All casting shall be free from blow boles, surfaces blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

18.4.4. No part of a clamp or connector shall be less than 10 mm thick.

18.4.5. All ferrous parts shall be hot dip galvanized in accordance to IS-2633.

18.4.6. For bimetallic clamps or connectors, copper alloy liner shall be cast integral with aluminium alloy body.

18.4.7. Flexible connectors, braids or laminated strap shall be made from tinned sheets or Aluminium Laminated clamps, depending on the clamp. The terminal clamps for bus posts shall be suitable for both expansion as well as fixed connections to "ACSR Moose" conductor.

18.4.8. Size of the terminal/conductor for which the clamp/connector is suitable shall be embossed/punched (i.e. indelibly marked) on each components of the clamp/connector, except on the hardware.

18.4.9. Clamps shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed

with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

18.4.10. All current carrying parts shall be designed and manufactured to have minimum contact resistance.

18.4.11. Clamps and connectors shall be designed corona controlled.

18.5. SUSPENSION, TENSION INSULATORS AND HARDWARES

18.5.1. All insulators shall be of porcelain and shall satisfactorily withstand the specific climatic and service conditions

18.5.2. The insulators shall be designed for fog conditions. Insulators for suspension & tensions strings shall confirm to IS-731. Insulator hardware shall confirm to IS-2486.

18.5.3. All the insulators shall be manufactured by the wet process. The porcelain shall be uniform brown colour, free from blisters, burrs and other similar defects. Insulators shall have a good luster. The glaze shall be un-affected by sudden changes in temperature and atmospheric pollutants such as ozone, acids, alkali, dust etc. Each insulator shall have marking as per applicable Indian standard.

18.5.4. The design of the insulator shall be such that stress due to expansion and contraction of any part of the insulators shall not lead to its deterioration. The porcelain shall not engage directly with hard metal.

18.5.5. Cement used in the construction of insulator shall not cause fracture by expansion and loosening by contraction. Proper care shall be taken to assemble and align the individual parts of the insulator correctly during cementing so that load distribution in discs takes place uniformly. The cement shall not cause chemical reaction with the metal fittings.

18.5.6. The tension and suspension insulator string shall be of ball and socket type. These shall be suitable to secure bus conductor to the structure. The number of discs, size and electro-mechanical strength are specified elsewhere in the specification. The support insulators shall be strong enough to withstand the electro-dynamics forces occurring during the short circuit conditions.

18.5.7. Each insulator string shall be supplied complete in every respect and shall include the following:

- a) Fittings for attachment to the U bolt or strain plate;
- b) Suspension and tension aluminum alloy clamps; and
- c) Fittings for attachment to the clamps to the string

18.5.8. The contractor shall be responsible for satisfying himself that the fittings are entirely suitable for the structures and the conductors and confirms to relevant standards.

18.5.9. The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to its deterioration. All ferrous parts shall be hot dip galvanized in accordance with the latest edition of IS-2629. The zinc coating used for galvanizing shall be grade Zn 99.5 confirming to IS: 209. The zinc coating shall be uniform, smooth, reasonably bright, continuous and free from intersection such as flux ash rust stains, bulky white deposits and blisters.

18.5.10. Contractor shall make available relevant data on all the essential features of design including the method of assembly of discs and metal parts, number of discs per insulator string etc;

18.5.11. Insulators hardware shall be of forged steel. Malleable cast iron shall not be accepted. All the surfaces must be clean, smooth, without cuts, abrasions or projection. No parts shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under the operating conditions.

18.5.12. Insulator hardware shall be of bolted type.

18.5.13. Contractor shall supply and install the following insulators sets with all necessary accessories.

TABLE-18.5

Sl. no	Item	220kV Level	132kV Level	33kV Level
i)	Type	Anti fog type, Outdoor Ball and Socket complying with IS 731 & IS 2486 (Part-II)	Anti fog type, Outdoor Ball and Socket complying with IS 731 & IS 2486 (Part-II)	Anti fog type, Outdoor Ball and Socket complying with IS 731 & IS 2486 (Part-II)

ii)	Size of Disc	254x145 mm ²	254x145 mm ²	254x145 mm ²
iii)	Rated Voltage	11 kV	11 kV	11 kV
iv)	No. of Disc. Unit per string			
	a. Suspension (S/S)	16	10	3
	b. Tension (S/T)	16	10	3
v)	Minimum failing load			
	a. Suspension	120 kN	120 kN	120 kN
	b. Tension	120 kN	120 kN	120 kN
vi)	Creepage Distance of insulator	320mm	320mm	320mm
vii)	Power Frequency (wet) withstand voltage	35 kV	35 kV	35 kV
viii)	Power Frequency (puncture) withstand voltage of single disk	1.3 times the dry flashover voltage of the unit	1.3 times the dry flashover voltage of the unit	1.3 times the dry flashover voltage of the unit
ix)	Impulse withstand voltage of the disk	75 kV	75 kV	75 kV

18.6. BUS POST INSULATORS

The post insulators shall conform in general to latest IEC-60168, IEC 60273 and IEC-60815.

18.6.1. Constructional Features

- Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they

may be subjected to by the operation of the associated equipment. Only solid core insulators shall be acceptable.

- b) Porcelain used shall be homogeneous, free from lamination, cavities and other flaws or imperfections that might affect the mechanical or dielectric properties and shall be thoroughly vitrified, tough and impervious to moisture.
- c) Glazing of the porcelain shall be of uniform brown in colour, free from blisters, burrs and other similar defects.
- d) The insulator shall have alternate long and short sheds with aerodynamic profile, the shed profile shall also meet the requirements of IEC-60815 for the specified pollution level.
- e) When operating at normal rated voltage, there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to Conductors or insulators by the formation of substance produced by chemical reaction.
- f) The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to its deterioration.
- g) All ferrous parts shall be hot dip galvanised. The zinc used for galvanising shall be of grade Zn 99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux ash, rust stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating corona under the operating conditions.
 - Every bolt shall be provided with a steel washer under the nut so that part of the threaded portion of the bolts is within the thickness of the parts bolted together.
 - Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.
 - All bolts and nuts shall be of steel with well formed hexagonal heads forged from the solid and shall be hot dip galvanised. The nuts shall be

good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

- Spring washers should be electro galvanized.

18.6.2. Tests

In accordance with the stipulations of the specification, the post insulators shall be subjected to type, acceptance, sample and routine tests as per IEC-60168.

18.6.2.1. In addition to acceptance/sample/routine tests as per IEC-60168, the following tests shall also be carried out.

- Ultrasonic test as an acceptance test
- Soundness test, metallurgical tests and magnetic test on MCI caps and pedestal tests as acceptance test.
- All hot dip galvanized components shall be subject to check the uniformity of thickness and weight of zinc coating on sample basis.
- The bending test shall be carried out at 50% minimum failing load in four directions as a routine test and at 100% minimum failing load in four directions as an acceptance test.
- Acceptance norms for visual defects allowed at site and also at works shall be agreed to, in the Quality plan.

18.6.3. Technical Parameters of Bus Post Insulators.

Table – 18.6

Sl. No	Description	220 kV	132 kV	33KV
a)	Type	Solid Core	Solid Core	Solid Core
b)	Voltage Class (kV)	245	145	36 kV
c)	Dry and wet one minute power frequency withstand voltage(kV rms)	552	330	90
d)	Dry lightning impulse withstand Voltage (kVp)	+ 1260	+780	204

e)	Radio interference voltage (Micro volt at 1 MHz) at a system voltage of 156 kV.	>500	>500	NA
g)	Corona extinction voltage (kV rms) (min.)	156	105	NA
h)	Cantilever Strength			
(i)	Total minimum cantilever strength (Kg)	800	600	450
(ii)	Total minimum breaking strength (Kg)	1000	720	-----
i)	Minimum torsional moment	As per IEC-273	As per IEC-273	As per IEC-273
k)	P.C.D Top (mm)	127	127	127
Sl. No	Description	220 kV	132 kV	33KV
	Bottom (mm)	254	254	254
l)	No. of bolts			
	Top	4	4	4
	Bottom	8	8	8
m)	Diameter of bolt/holes (mm)			
	Bolt dia	M16	M16	M16
	Hole dia	18	18	18
o)	Minimum total creepage distance for Heavy Pollution (mm)	6125+20%	3165+20%	900+20%

18.7. EARTHWIRE

18.7.1. The earth wire shall be Aluminum clad steel wire of size and mechanical characteristics as specified in the specification. The technical characteristics of the Earth wire shall be as specified in the table below.

TABLE-18.6

a.	Material	G.S. Wire
b.	Size	7/4.115 mm

c.	Ultimate Tensile Strength	10300 kg
d.	Overall diameter	12.35 mm
e.	Modulus of Elasticity	149000 MPA
f.	Co-efficient of linear expansion	12.9×10^{-6} per degree C
g.	Weight (kg/km)	619
h.	Cross sectional Area	77.89 mm ²

18.7.2. Earth wire Accessories

The earth wire accessories i.e. dead end assemblies, earthing clamps and P.G. clamps offered shall be suitable for earth wire. The material employed in the manufacture of accessories viz. Stainless steel, malleable cast iron and forged steel etc. depending on the type of application for which the accessories are required shall have requisite mechanical strength. The composition of materials to be used shall be made available to the Employer for verification if required.

18.7.3. Dead End Assemblies

Compression type dead end assemblies for G.S earth wire are required for use on the sub-station towers. The dead end assemblies shall be supplied complete with Jumper, terminals, nuts and bolts, suitable link pieces between steel clamps and tower strain plate so as to provide sufficient flexibility to the attachment. The portion to be compressed shall be clearly marked. Dead end assemblies shall have conductivity not less than that of equivalent length of ground wire and tensile strength not less than 90% of breaking strength of ground wire.

18.7.4. Earthing Clips

Earthing clips are required for establishing a good electrical contact between the earth wire Jumper connection of the two dead-end assemblies and the tension tower strain plate. Earthing shall be suitable for mounting directly on the strain plates without any other accessories.

18.8. FIRE FIGHTING SYSTEM OF THE SUB-STATION**18.8.1. Scope**

- 18.8.1.1. Portable fire extinguisher of CO₂ and Dry Chemical Powder type shall be provided for protection against fire in control room building for all 220/132/33kV substations. These equipments shall be located near all fire risk areas in such a manner that these shall be accessible at the time of fire. The quantity and location of extinguishers shall be as per requirements of Fire Protection Manual (Part I) issued by Tariff Advisory Committee of India (TAC) and IS: 2910 as well as applicable Nepal Standards and Practices.
- 18.8.1.2. A comprehensive fire protection system shall be designed, supplied, installed and commissioned which shall ensure fire protection where needed. The fire fighting installation shall be supplemented by fire detection and fire alarm system.
- 18.8.1.3. The buildings shall be of such design so as to minimize the possibility of fire spread internally and also with respect to their surroundings. This in particular pertains to exposure protection.
- 18.8.1.4. Escape routes and emergency exits shall be easily noticeable. Coloured signs and lights shall be selected and provided as per Employer's approval. Design features for all fire preventive measures shall be co-ordinate to suit the systems of the existing and new buildings and allow proper integration.
- 18.8.1.5. The fire fighting installation shall be ready for operation before commissioning of any building and/or equipment wherever applicable.
- 18.8.1.6. In addition, the system design shall be subject to the approval of concerned Nepal Authorities. The Contractor shall prepare all necessary documents and drawings to obtain the prior approval of the system design by the concerned Nepal Authorities, before the execution of procurement/manufacturing.
- 18.8.1.7. All parts of the system in contact with water shall be of corrosion resistant materials.

18.8.2. Portable Type Fire Extinguishers:

- 18.8.2.1. This Specification lays down the requirement regarding Portable Type fire extinguishers of following types:
 - a) Carbon Dioxide type
 - b) Dry Chemical powder type

- 18.8.2.2. All the portable extinguishers shall be capable of discharging freely and completely in upright position.
- 18.8.2.3. Each extinguisher shall have the instructions for operating the extinguishers on its body itself.
- 18.8.2.4. All extinguishers shall be supplied with initial charge and accessories as required.
- 18.8.2.5. Portable type extinguishers shall be provided with suitable clamps for mounting on walls/columns.
- 18.8.2.6. Capacities of Fire Extinguishers of each type shall be as indicated in the schedule of quantities.
- 18.8.2.7. Carbon Dioxide (CO₂ type) extinguishers shall conform to IS: 2878.
- 18.8.2.8. Dry chemical powder type extinguisher shall conform to IS: 2171.

18.8.2.9. Tests and Inspection

All tests required to ensure that the equipment conforms to the Specification requirements and relevant Indian standards and codes shall be conducted by the contractor. A performance demonstration test at site of five (5) percent or one (1) number whichever is higher, of the extinguishers shall be carried out by the Contractor. All consumable and replaceable items required for this test would be supplied by the Contractor without any extra cost to the Employer.

Performance Certificate of extinguishers shall be in line of applicable Indian Standards. In case, where no Indian Standard is available for a particular type of extinguishers, the method of testing shall be mutually agreed to before placement of order for the extinguishers.

18.8.2.10. PERFORMANCE GUARANTEE

The contractor shall guarantee all equipment supplied by him against any defect due to faulty design, materials and workmanship. The equipment shall be guaranteed to operate satisfactorily at the rated capacities at site.

18.8.3. Trolley Mounted Dry Chemical Powder Type Mobile Fire Extinguisher

The Specification lays down the requirements for Trolley mounted fire extinguishers of dry chemical powder type. Design, manufacture, material of construction and

performance of mobile type fire extinguishers shall comply with the requirements of latest Indian Standards & shall have BIS approval (ISI marked).

18.8.3.1. Performance Requirement

- i. The capacity of the mobile dry chemical powder type fire extinguisher shall be 22.5 kg, i.e. the total capacity of the container, when powder completely filled to the specified level shall be 22.5 kg.
- ii. The fire extinguishers shall be used for Class 'B', 'C', and 'E' fires. The extinguishers shall operate in the vertical position, mounted on solid rubber type trolley wheels. The effective throw during operation of the extinguishers shall not be less than 10 meter.
- iii. A carbon dioxide cartridge fitted with valved discharge head, shall provide sufficient carbon dioxide to expel the dry chemical powder.

18.8.3.2. Design and Construction

- i. The construction of trolley type fire extinguishers shall conform to relevant IS standard and not be limited to the requirements specified herein.
- ii. The body of the fire extinguisher shall be cylindrical. It shall have adequate supporting arrangement.
- iii. The balance of the fully equipped assembly shall be so arranged that it can be easily towed speedily behind a jeep or a car and also wheeled by a single operator.
- iv. Two solid rubber tyre trolley wheels shall be fitted to the body of the trolley type fire extinguisher. The rubber tyres shall have an effective life of less than three (3) years.
- v. The extinguisher shall be fitted with a discharge hose and nozzle connection. The hose shall be of rubber or composite construction having a minimum length of 4.5-meter. The bursting pressure of the hose shall not be less than 42 kgf/cm (g).
- vi. The design of discharge nozzle shall be such that when the extinguisher is operated in still air, the powder shall be thrown in the form of a jet having a range not less than 10m for a period of 50-60 seconds. The nozzle shall be fitted with a hand control device.
- vii. Provision shall be made for making a pressure test on the body.

- viii. To minimize corrosion, the various components shall be provided with suitable anti-corrosive treatment/paint as per the requirement of applicable codes.
- ix. Each mobile extinguisher shall be complete with initial charge, discharge fittings and accessories.

18.8.3.3. Tests and Inspection

Testing at manufacturer's works:

- i. The manufacturer shall conduct all tests required to ensure that the equipment furnished confirms to this Specification requirements, relevant Indian Standards and applicable codes. The body of Extinguisher shall be capable of withstanding an internal hydraulic pressure of 25 kgf/cm (g) without leakage or visible distortion, prior to painting, for a minimum period of 5 minutes.
- ii. In destruction tests, if called for, ultimate failure shall occur at a test pressure not less than 32 kgf/cm (g) and if it occurs below 32 kgf/cm (g), there shall not be damage in any joint, seam casting of fittings.
- iii. A performance demonstration test at site on five (5) percent or one (1) number, whichever is higher, shall be carried out by the CONTRACTOR. All consumable and replaceable items required for the test shall be supplied by the CONTRACTOR without any extra cost to Employer.

18.8.3.4. Performance Guarantee

The Contractor shall guarantee all equipment supplied by him against any defect due to faulty design, materials and workmanship. The equipment shall be guaranteed to operate satisfactorily at the rated capacity at site.

18.8.3.5. Painting

- i. Each mobile fire extinguisher shall be painted with durable enamel paint of red colour conforming to relevant Indian Standard. The mobile type fire extinguisher shall be of make approved by Tariff Advisory Committee/NFPA/FOC/UL. Appliances conforming to the relevant BS/NFPA Standards are also acceptable provided the construction generally conform to the IS Standards so that spares refills/cartridges of Indian make conforming to IS Specification can be used after the operation of the extinguisher.

- ii. Spare charge cartridges equivalent to requirements of 2 Nos. extinguishers shall also be supplied.

18.8.4. Trolley Mounted Carbon-Dioxide Type Mobile Fire Extinguisher

This Specification lays down the requirements regarding Trolley mounted fire extinguishers of carbon-dioxide. Design, manufacture, material of construction and performance of extinguisher as specified herein shall comply with the requirements of latest applicable Indian Standards IS: 2878 or equivalents and shall have BIS approval (ISI marked).

18.8.4.1. Performance Requirement

- i. The capacity of the extinguisher shall be 22.5 kg of carbon-dioxide when filled in the container.
- ii. The extinguisher shall be designed for use where larger high intensity fire hazards are involved requiring versatility of action. These shall be used for Class 'B' fire, i.e. fire in flammable liquid. Class 'C' fire i.e. fire in gaseous substances under pressure and Class 'E' fire, i.e. fires in live electrical equipment.
- iii. The extinguisher shall be operated in upright position, by releasing a suitable valve.
- iv. The range of effective operation of the extinguishers shall be about 4 meters.

18.8.4.2. Design and Construction

- i. The construction of Trolley mounted fire extinguisher of carbon-dioxide type, shall in general conform to IS:2828 subject to the requirements mentioned hereunder:
- ii. The carbon-dioxide gas shall conform to IS:307.
- iii. The body of the extinguisher shall be cylindrical in shape and made of steel. It shall have adequate supporting arrangement so that it can rest on the wheeled body in upright position and the operator be free to direct the stream.
- iv. The weight of the full equipped trolley unit shall be so arranged, that despite its considerable weight, it can be easily wheeled by one man. It shall be capable of being towed speedily behind a jeep or car.
- v. The cylinder shall be mounted on a trolley fitted with two cushion tyred wheels and fitted with suitable handle. The overall wheel diameter shall be about 280 mm.

- vi. The frame of the trolley shall be made of welded steel section.
- vii. The design shall permit easy maintenance and operation by one person.
- viii. The extinguisher shall be fitted with a high pressure flexible hose of about 9 m length and internal dia to hoses shall not be more than 12 mm.
- ix. A discharge horn made of fibre or any other material non-conducting to electricity shall be fitted with a handle made of thermal insulating material capable of protecting operators hand from freezing effects.
- x. Suitable provision for firmly securing the horn to the body, when it is not in use, shall be provided. The fixing device shall not interfere with the operation or mobility of the extinguisher.
- xi. The discharge valve or operating head shall be capable of being operated satisfactorily. It shall be made of material as specified in IS: 2878.
- xii. There shall be no leakage of CO₂ from valve or fitting during the use of extinguisher. Valve shall be provided with suitable safety device to prevent over pressure in cylinder.
- xiii. A seal or device shall be fitted on extinguisher to indicate that the extinguisher has not been used.
- xiv. Each extinguisher shall be complete with initial charge, discharge fittings and other accessories as required.

18.8.5. The minimum quantity of fire extinguishers to be supplied for each of 220/132/33 kV substation at Tumlingtar & Basantapur and 220/33 kV substation at Baneshwar in Nepal is as follows:

TABLE-18.7 Minimum Requirement of Fire Extinguishers for each Substation

S. No.	Type	Location	Quantity
a.	22.5 Kg Capacity fire extinguisher of CO ₂ type, Trolley Mounted	Switchyard	2 Nos.
b.	25 Kg Capacity fire extinguisher of Dry Chemical Powder type, Trolley Mounted	Switchyard	2 Nos.
c.	Fire Buckets (12 Nos. with stand in one set)	Switchyard	2 Nos.

d.	CO ₂ fire extinguisher of 6.5 kg capacity wall mounted	Control Room/Battery Room/Diesel Generator Room	6 Nos.
e.	CO ₂ fire extinguisher of 4.5 kg capacity wall mounted	Office Room/Conference Hall	2 Nos.

However, the contractor shall estimate the quantity of Fire extinguishers of various types required based on the substation and control room layout to meet the requirement of TAC and NEMA standards and in case the requirement so worked out is higher than that minimum requirement specified above, the higher quantity shall be provided. In no case, the quantity shall be less than minimum specified above.

18.9. AIR-CONDITIONING AND VENTILATION EQUIPMENT

18.9.1. General

- 18.9.1.1. This specification covers supply, installation, testing and commissioning of Air conditioning system in specified areas of the control room building. It is proposed to provide Air conditioners in the control room where very sophisticated electronic equipment & modules are installed for maintaining proper temperature.
- 18.9.1.2. Air conditioning shall be provided in the following areas of the Control room building:
- 18.9.1.3. Control and Relay panel Area, ACDB & DCDB/LT room, Engineer room, Conference Room, OPGW room etc. Proper Ventilation system shall be provided for work shop, Store, battery room etc.
- 18.9.1.4. Air conditioning units for control room building shall be set to maintain the inside DBT at $24^{\circ}\text{C} \pm 20^{\circ}\text{C}$.
- 18.9.1.5. Each Control panel room shall be provided with temperature transducer to monitor the temperature of the panel room. The Temperature transducer shall have the following specification:

Sensor	:	Air temperature sensor (indoor use)
Output	:	4 to 20mA

Temperature range	:	-50 ⁰ C to 60 ⁰ C
Resolution	:	0.1 ⁰ C
Accuracy	:	0.5 ⁰ C or better.

18.9.1.6. In the LT room where 3 phase, 4 wire AC LT panels & DC panels are installed, a lot of heat is generated and the temperature of the equipment goes up. To maintain proper temperature of LT panels, exhaust fans shall be provided to dissipate the heat generated inside the LT boards.

18.9.2. SCOPE

- The scope of the equipment to be furnished and services to be provided under the contract are outlined hereinafter and the same is to be read in conjunction with the provision contained in other sections/ clauses. The scope of the work under the contract shall be deemed to include all such items, which although not specifically mentioned in the bid documents and/or in Bidder's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation.
- Copper refrigerant piping complete with insulation between the indoor and remote outdoor condensers as required.
- PVC drain piping from the indoor units upto the nearest drain point.
- Power and control cabling between the indoor unit and outdoor unit and earthing and voltage stabilizer units for each AC unit.
- Supply and erection of Power and control cable and earthing.
- MS Brackets for outdoor condensing units, condensers as required.
- The minimum number of Air conditioners of High wall type split AC units of 1.5 TON and 2.0 TON capacity with high wall type indoor evaporator unit shall be installed in various rooms are listed below Table:

TABLE-18.8 Minimum Requirement of Split Type Air conditioners for each Substation

S. No.	Substation	Area of Installation	Capacity of Split AC (In TON)	Quantity (Nos.)
1	Basantapur	Control Room	2	4
		Conference Room	1.5	2

		Office Room	1.5	1
		OPGW Room	1.5	2
		Engineer Room	1.5	1
2	Tumlingtar	Control Room	2	4
		Conference Room	1.5	2
		Office Room	1.5	1
		OPGW Room	1.5	2
		Engineer Room	1.5	1
3	Baneshwar	Control Room	2	3
		Conference Room	1.5	2
		Office Room	1.5	1
		OPGW Room	1.5	2
		Engineer Room	1.5	1

18.9.3. Specification of Split AC units

- 18.9.3.1. The split AC units shall be complete with indoor evaporator and outdoor condensing units and cordless remote control units.
- 18.9.3.2. Outdoor unit shall comprise of hermetically sealed reciprocating/rotary compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminum finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.
- 18.9.3.3. The indoor units shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by special motors and copper tube aluminum finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi

function cordless remote control unit with special features like programmable timer, sleep mode and soft dry mode etc.

18.9.3.4. The split AC units shall be of reputed and approved make.

18.10. TESTS

18.10.1. Type Tests

All the equipments/miscellaneous items offered shall be fully type tested as per the relevant standards. In case the equipment of the type and design offered has already been type tested, the contractor shall furnish the type test reports for approval before placing the order. The employer reserves the right to demand repetition of some or all the type tests in the presence of employer's representative.

18.10.2. Routine and Acceptance Tests

All the routine tests as stipulated in the relevant standards shall be carried out by the contractor at the manufacturer's works. All acceptance tests as stipulated in the relevant standard shall be carried out by the Contractor/Manufacturer in the presence of the Employer's representative. No material shall be dispatched without the approval of test certificates.

18.11. DRAWINGS AND BILL OF MATERIALS

The contractor shall furnish the following drawings:

- 1) Sectional drawings showing the general constructional features of insulators (tension, suspension & post and hardware, conductors for equipment, bus conductors and earth wires).
- 2) General outline diagram showing all dimensions, net weight of each type of hardware fittings.
- 3) Drawing of Marshalling Kiosks/Control cabinets.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-19

Erection, Testing And Commissioning of **Electrical Equipment**

SECTION 4**CHAPTER – 19****ERECTION, TESTING AND COMMISSIONING OF
ELECTRICAL EQUIPMENT****CONTENTS**

S NO	DESCRIPTION	PAGE NO
19.0	GENERAL	1
19.1	DETAILED DESIGN AND DRAWING	3
19.2	ERECTION	7
19.3	TESTING AND COMMISSIONING	11

SECTION 4**CHAPTER - 19****ERECTION, TESTING AND COMMISSIONING OF
ELECTRICAL EQUIPMENT****19.0 GENERAL**

19.0.1 This covers tentative requirements for installation, testing and commissioning of all electrical equipment for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. The electrical and associated equipment shall be erected in conformity with the requirement of Indian Standards, Codes/International codes and practices, Indian & Nepal Safety rules and all other statutory regulations of Nepal that may be relevant to erection and testing/commissioning as per requirements of IS/IEC and other details given elsewhere in the Project Documents.

19.0.2 The contractor shall furnish all labour, skilled and un-skilled, supervisory and administrative personnel erection tool & tackles, transport vehicles, mobile cranes, digging/excavation equipment, testing and commissioning equipment, implements necessary for timely and effective execution of the contract. The installation work is inclusive of supply of erection material, hardwares, consumable and supply items to complete the installation under turnkey execution of the project.

19.0.3 Sub-Station Checks

Contractor shall carry out the following checks at the substation under the project, and submit the report to Employer.

- 1) The installation has been carried out in accordance with the approved drawings.
- 2) Phase-to-phase and phase-to-earth clearances are provided as required.
- 3) All equipments are effectively earthed and properly connected to the required number of earth electrodes.

- 4) The required ground clearance to live terminals is provided.
- 5) Suitable fencing is provided with gate with lockable arrangements
- 6) The required number of caution boards, fire-fighting equipments, operating rods, insulating mats, etc. is kept in the substation.
- 7) In case of indoor substation, sufficient ventilation and draining arrangements are made.
- 8) All cable trenches are provided with non-flammable covers.
- 9) Free accessibility is provided for all equipments for normal operation.
- 10) All name plates should be fixed and the equipments; fully painted.
- 11) All construction materials and temporary connections are removed.
- 12) Oil levels, bus bar tightness, transformer tap position, etc. are in order.
- 13) Earth pipe troughs and cover slabs are provided for earth electrodes earth pits. Neutral and lightning arrester earth pits are marked for easy identification.
- 14) Earth electrodes are of GI pipes or CI pipes of copper plates. For earth connections, brass bolts and nuts with lead washers are provided in the pipes/-plates.
- 15) Earth pipe troughs, oil sumps/pits are free from rubbish and dirt and stone jelly and the earth connections are visible and easily accessible.
- 16) Panels and equipments are all vermin and damp proof and all unused openings or holes are blocked properly.
- 17) The earth bus bars are checked for tightness and for corrosion free joint surface.
- 18) Control switch fuses are provided at an accessible height from ground.
- 19) Safety devices, horizontal and vertical barriers, bus bar covers/shrouds, automatic safety shutters/doors interlock; handle interlock for safe and reliable operation in all panels and cubicles.
- 20) Clearances in the front, rear and sides of the switchboards are adequate.

- 21) The gap in the horn gap fuse and the size of fuse adequate.
- 22) The switch operates freely; all the blades make contact at the same time. The arcing horns contact in advance, and the handles are provided with locking arrangements.
- 23) Insulators are free from cracks and are clean.
- 24) In the case of transformers, there is no oil leak.
- 25) Connections to bushings in transformers are tightened and have good contact.
- 26) Bushings are free from cracks and are clean.
- 27) Accessories of transformers like breathers, vent pipe, buchholz relay, etc. are in order.
- 28) Connections to gas relay in transformers are in order.
- 29) Oil and winding temperature are set for specific requirements in transformers.
- 30) In case of cable trenches, adequate arrangements to pump out water that has entered due to seepage or other reason is provided and
- 31) All incoming and outgoing circuits of panels are clearly and indelibly labeled for identifications both at the front and at the rear.

19.1 DETAILED DESIGN AND DRAWING

Detailed dimensional drawings and design calculation for the following shall be submitted by the contractor to the Employer and Consultant for scrutiny and approval.

TABLE-19.1.1

List of drawings	
S No	Drawing title
	Electrical Design and Drawings
1.	Single Line Diagram

2.	General Layout Plan
3.	General Layout Section
4.	Single line Protection Diagram
5.	Control and Protection Philosophy
6.	Sub Station Operation Philosophy
7.	Electrical clearances diagram
8.	Fault Level calculation
9.	Short Circuit Forces calculation on Bus Bars
10.	Short Circuit Forces calculation for equipments structures
11.	Gantry Loading Details
12.	Gantry Layout Plan
13.	Gantry Loading Diagram
14.	Gantry tower and girder design calculations
15.	Gantry tower and girder drawings
16.	Equipment structure design calculation design
17.	Equipment structure drawings
18.	Earthmat Design Calculations
19.	Calculations for step and touch potential
20.	Earthing Layout Diagram
21.	Gantry and Equipment Earthing Details
22.	BOQ for earthing system
23.	Erection Key Diagram
24.	BOQ for Hardware, Clamps & Connectors, ACSR conductor, Post Insulators, Disc Insulators, Equipment Bus bar
25.	Cable trench layout drawing
26.	Cable size calculations
27.	Wiring diagram and Cable schedule

28.	BOQ for control and power cables
29.	Illumination system design calculations outdoor and indoor
30.	Illumination system layout outdoor and indoor
31.	BOQ for illumination system
32.	Control Room Layout Plan, Elevation & Side View
33.	Control Room building Architecture Drawing
34.	Lightning system design calculations
35.	Lightning system design layout
36.	Fire Protection System Design Philosophy and calculations
37.	BOQ for Fire Protection System
38.	Drawings for Fire Protection System
39.	Station Auxiliary Supply System Load calculation
40.	Station Auxiliary Supply Single Line Diagram
41.	Protection Single Line diagram for station auxiliary system
42.	Relay setting details for Aux AC System
43.	Station Auxiliary Supply Yard Layout
44.	BOQ For Station Auxiliary Supply
45.	Battery sizing calculations and selection of battery bank for Aux DC Supply and OP Communication System
46.	Single Line diagram for Aux DC System and DC For Optical Fiber Communication System.
47.	BOQ for DC System
48.	Battery Charger rating calculations
49.	Control and Protection Philosophy, SCADA System
50.	Relevant drawings & documents for Substation Automation System
51.	System architecture for control and protection system
52.	BOQ for control and protection system

53.	Relay setting calculations for protection system
54.	Any other Relevant drawing required for the completion of the work
	Civil Design and Drawings
1.	Design of transformer foundation
2.	Drawing of transformer foundation
3.	Design of gantry tower foundation
4.	Drawing of gantry tower foundation
5.	Design of equipment foundations
6.	Drawing of equipment foundation
7.	Design of lightening mast foundation
8.	Drawing of lightening mast foundation
9.	Design of equipment foundations
10.	Drawings of equipment foundations
11.	Design of foundation for equipments in station auxiliary supply yard
12.	Drawing of foundation for equipments in station auxiliary supply yard
13.	Design for control room building
14.	Drawing for control room building
15.	Conduit layout for illumination and fire protection system concealed wiring for control room
16.	Design for cable trench sections
17.	Drawing for cable trench sections
18.	Design for drain and water harvesting system
19.	Drawing for drain and water harvesting system
20.	Drain and road layout drawing
21.	Design for drain/trench culvert at road crossing
22.	Drawing for drain/trench culvert at road crossing
23.	Design for road

24.	Drawing for Sub Station fencing
25.	Drawing for transformer pit grating
26.	Drawing for street light pole foundation
27.	Drawing for fire protection pump house building
28.	Drawing for vehicle parking shade
29.	Design for transmission line tower foundations
30.	Drawing for transmission line tower foundations
31.	Design for foundation of AC kiosk
32.	Drawing for foundation of AC kiosk
33.	Design , Drawing of RCC retaining wall, Stone masonry breast wall
34.	Any other Relevant drawing required for the completion of the work

19.2 ERECTION

19.2.1 Erection of Power Transformers

The bidder shall assemble and install the outdoor Power Transformers including the tap change gear as covered in the specification. The bidder shall be responsible for arranging the necessary equipment required for the erection of the transformers. Necessary commissioning tests shall be carried out before putting the transformers in commercial operation to the satisfaction of Employer.

19.2.2 Erection of the outdoor equipments

The bidder shall assemble, install and connect all the circuit breakers, current transformers and potential transformers, CTs, lightning arrestors, coupling capacitors, communications system etc. in the technical specifications. The equipment shall be placed and leveled carefully on their respective foundation or structures as the case may be. The operating mechanism and control circuits of the circuit breakers shall be tested for proper opening, closing and position indications. The opening and closing tests shall be made from the control points and also in service operation. The equipment will be subjected to normal

commissioning tests before putting the equipment in commercial operation. Main contact resistances of all the phases shall be recorded so as to ensure that the contacts are properly closed.

19.2.3 Erection of Isolator and Isolators cum Earthing Switches

The isolators and isolators cum earthing switches as covered in the document of the specification shall be mounted by the bidder on the steel structures. The poles of the switches shall be aligned accurately and leveled on the supporting steel structures. The switches shall be adjusted so as to permit operation with ease by one man. Each bearing of the operating mechanism shall be properly lubricated. The equipment shall be subjected to normal commissioning tests before putting it in commercial operation.

19.2.4 Erection of Indoor equipment

The bidder shall install various indoor equipment as indicated in the Document in the control room building which will consist of control and relay panels for HV & LV, SAS panels, Fiber Optical Telecommunication System, 400 V AC and 110 V DC distribution boards, Battery & Battery Chargers, RTCC etc., All the materials such as bolts, nuts, washers and screws for installing the equipment, insulating tape compound, solder, soldering paste and connectors for making the electrical connections and hard-wood blocks for supporting the cables shall be arranged by the contractor. Special care shall be exercised in the sub-station to avoid damage to the equipment. The bidder shall furnish the patching lacquer and shall repair any damage to the lacquered surface of the board. The cables entering at the bottom of the control board shall be adequately supported at the trench opening by means of aluminum clamps. Each block shall be drilled with holes to fit the cable longitudinally and the clamped together with two through bolts.

19.2.5 Erection of Control and Power cables

The bidder shall be responsible for laying the control and power cables covered under the project. The bidder shall furnish all insulating tape and compound,

solder, soldering paste and connectors. Power and control cables shall be run into cable trenches on supports of suitable dimension in the switchyard and in cable conduit near equipment for equipment connection. Conduits shall be cleaned and free from obstructions and sharp corners. A clean, dry, tight fitting rag shall be drawn through the conduit immediately before installing the cables. The cables shall be installed in such a manner that there will be no cuts or abrasion in the insulation or protective covering of the conductors. Splicing of conductors shall be made in boxes, panel boards and cabinets. Where a lubricant is required for pulling wire or cable only soapstone or a similar approved material not injurious to the wire or cable sheath shall be used. Any wire or cable damaged during installation shall be removed and replaced at the bidder expenses. After all cables are installed and all equipment wiring, devices and fixtures have been connected by the bidder, he shall conduct such insulation and operating tests as in his opinion are necessary to demonstrate the adequacy of the electrical installations and to ensure that no damage has occurred to the cables during the installation. All runs, connections, soldering and taping of conductors shall be made neatly.

19.2.6 Erection of Fiber Optic Telecommunication System

The bidder shall be responsible for the complete erection, testing and commissioning of the Fiber Optic Telecommunication System.

19.2.7 Erection of sub-station structures, insulators and hardwares, bus-bars, earthing and other sundry materials

- a) The bidder shall be responsible for erection of structures, insulators and hardware, bus-bars, earthing and other sundry materials etc. required for the project.
- b) No steel structure shall be erected on foundations until at least 14 days after placing of the concrete in foundations. Base plates where required shall be grounded. All base plates shall be set accurately to the grade and alignment designated on drawings duly approved by the Employer. All galvanized steel

shall be handled with care to avoid bending or damage to the galvanizing. Pieces bent in handling may be used only if they can be straightened without injury to the galvanizing. The method of erection of the structure is left to the contractor.

c) Insulators and bus bars' materials.

The bidder shall install all bus-bars, insulators and hardware, overhead ground wires over substation structures, as covered in the specification. The bidder shall also install the conductors, over head ground wires, OPGW, Optical Approach Cable, hardware and insulators in the span between the dead end tower and the sub-station structures. Conductors which are used in tension and overhead ground wires shall be free of joints or splices. The equipment used for stringing the conductor and overhead ground wires shall be such that the conductor will not be damaged or injured. All section of the conductors damaged by the application of gripping attachments shall be replaced before the conductors are strung. All data such as stringing tables, giving tension with temperature variations will be supplied by the contractor. The contractor shall also be responsible for installing the various conductors, required for connection of the various equipments in the sub-station.

19.2.8 Grounding system

The Contractor shall lay the ground mat, as per design and drawing approved for the substation. They shall make all the grounding connections to equipment and structures. Risers from the station ground mat for this purpose shall also be provided by the bidder as per drawings approved by Employer.

19.2.9 Erection of lighting fixtures, sockets outlets, fire-fighting equipment etc.

The Contractor shall install and connect all lighting fixtures in the switchyard and along fencing. Distribution pillars and socket outlets, detailed in specifications for lighting and fire protection system shall be provided for power supply to electrical instruments/equipment and oil filtration plant etc. All the materials such as tape

and compound, solder, soldering paste, required for wiring of the lighting fixtures shall be arranged by the contractor. Switchyard and control room lighting fixtures shall be installed as per the approved drawings of illumination design.

19.2.10 Electrical Conduits

The bidder shall furnish and install all embedded and exposed electrical conduits, conduits fittings, boxes and accessories. The conduits and the fittings shall be as per the relevant Indian/International Standard. The underground metal/PVC conduits as per project requirements shall be embedded in a concrete encasement. Conduits, conduit boxes and fittings shall be secured in positions while concrete is being placed. The threads of all embedded G.I. conduit joints shall be covered with red lead or applied with an insulating varnish. Joints between conduits and cabinets in outdoor installations shall be watertight. The route of all conduit in sub-station, steel structures for purpose of lighting in switchyard shall be determined by the bidder.

19.3 TESTING AND COMMISSIONING

19.3.1 Before the substation is energized, necessary commissioning tests may be conducted and any adjustments etc. required to be made in the equipment may be carried out. After all the pre-commissioning tests are successfully carried out, the substation shall be put into commercial operation and handed over to the Employer. The commissioning test reports shall be submitted to the Employer for his approval.

19.3.2 The contractor shall perform all tests as per IS/International standard and any additional tests based on specialties of the equipment without any extra cost to the Employer. The bidder shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of the instrument to the Engineer for his approval. The tentative description is given as below.

19.3.2.1 General checks

- a) Check for physical damage
- b) Check from name plate that all items are as per specification.
- c) Check tightness of all bolts, clamps and connecting terminals.
- d) For oil-filled equipment, check for oil leakage. Check oil level and top up wherever necessary.
- e) Check ground connections.
- f) Check cleanliness of insulators and bushings.

19.3.2.2 Transformers

- a) Testing of Transformer Oil as per ISS.
- b) Insulation resistance and checking of polarization index of winding.
- c) Voltage ratio test on all taps
- d) Vector group test
- e) Operation test of tap changer
- f) Buchholz relay operation test
- g) Operation test of all protective devices and interlocks.
- h) Insulation resistance of control wiring.
- i) Measurement of core loss.
- j) Measurement of winding resistance.
- k) Calibration of temperature indications and temperature relays.
- l) All checks on OLTC.

19.3.2.3 Circuit Breakers

- a) Insulation resistance of pole
- b) Check adjustment if any suggested by manufacturer
- c) Breaker closing and tripping operation
- d) Trip free and anti-pumping operation
- e) Minimum pick up voltage of coils
- f) Contact resistance

- g) Functional checking of SF₆ Gas system
- h) Functional checking of control circuits, interlocks, tripping through protective relays.
- i) Insulation resistance of control circuits, motor etc.
- j) Resistance of closing & tripping coils.
- k) Leakage testing of SF₆ (gas).

19.3.2.4 Isolators

- a) Insulation resistance of pole
- b) Manual & electrical operation and interlocks
- c) Insulation resistance of control circuits and motors
- d) Ground connections
- e) Contact resistance
- f) Proper alignment so as to minimize the vibration during operation.

19.3.2.5 Current Transformers

- a) Insulation resistance test
- b) Polarity test
- c) Ratio test
- d) Dielectric test of oil (wherever applicable)
- e) Magnetizing characteristic test.
- f) Winding resistance test

19.3.2.6 Voltage Transformer

- a) Insulation resistance test
- b) Polarity test
- c) Ratio test
- d) Dielectric test of oil (wherever applicable)

19.3.2.7 Lightning Arrester

- a) Leakage current

- b) Resistance of ground connection.

19.3.2.8 Motors

- a) Insulation resistance
- b) Phase sequence and proper direction of rotation

19.3.2.9 Station Earthing

- a) Check soil resistivity
- b) Check continuity of ground conductor
- c) Check earth resistance of the entire grid.
- d) Check for weld joint and application of zinc paint on galvanised surface.

19.3.2.10 ACSR Conductor, Power Connectors

- a) Physical check for finish
- b) Electrical clearance check
- c) Millivolt drop test on all power connectors
- d) Sag and tension check on conductors

19.3.2.11 Insulators

- a) Verification of dimension.
- b) Verification of displacement.
- c) Verification of the locking system.
- d) Temperature cycle test
- e) Porosity Test
- f) Galvanizing Test
- g) Visual Examination Test.
- h) Residual Strength Test.
- i) Metallurgical Test.
- j) Mechanical Performance Test.

19.3.2.12 Control & Relay Panels

- a) Operation of all type of relays, alarms and controls independently and through equipment

- b) Insulation testing of warning
- c) Operation of substation automation system
- d) Operation of Terminal Equipment Panel (OPGW)

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-20 **Station Transformers**

SECTION 4**CHAPTER – 20****STATION TRANSFORMERS****CONTENTS**

S.NO	DESCRIPTION	PAGE NO
20.0	SCOPE	1
20.1	INTRODUCTION	2
20.2	PERFORMANCE	4
20.3	TECHNICAL REQUIREMENTS	8
20.4	TERMINAL ARRANGEMENT	8
20.5	INSPECTION AND TESTING	9
20.6	FACTORY TEST	10
20.7	FITTINGS	12
20.8	PAINTING	13
20.9	SPARE PARTS	14

SECTION 4

CHAPTER - 20

STATION TRANSFORMERS

20.0 SCOPE

- 20.0.1** These specifications are intended to cover design, engineering, manufacture, inspection and testing at manufacturer's works before dispatch, supply, transportation, insurance, dispatch & delivery for project site in Nepal, handling, storage & preservation at site, complete work of site assembly, erection, dehydration, testing and commissioning & remedial action, if any, up to defect liability period of following type of oil immersed core type Transformers complete with all accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specifications for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar in Nepal.
- 20.0.2** The scope of supply shall include all parts, accessories, auxiliaries, mountings, etc. including insulating oil required for first filling plus 10 % extra, which are necessary for satisfactory operation of the Transformers even though not individually or specifically stated or enumerated.
- 20.0.3** Corresponding parts of the Transformers, accessories, spares, etc. shall be of the same materials, dimensions and workman-ship and shall be interchangeable.
- 20.0.4** The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life.
- 20.0.5** Power cables, control cables & special cables, supports, cable racks, cable glands, lugs, terminals, connectors, etc. for cabling between equipment & devices covered in this section and upto UCB, Protection Panels shall be under scope of Supply.
- 20.0.6** Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost.
- 20.0.7** Components having identical rating shall be interchangeable.

20.0.8 The performance of the equipment shall be guaranteed as per **Section 5 – “Guaranteed and Other Technical Particulars”**.

20.0.9 The bidder has to furnish the testing facilities available at the manufacturer's works.

20.0.10 The Technical Specification for oil filled transformer i.e. 400KVA, 11/0.4 kV are given below:

20.1 INTRODUCTION

- 1) The 400 KVA, 33/0.4KV 3-phase Transformer shall be of core type, oil immersed ONAN cooled.

20.1.1 SPECIFIC TECHNICAL REQUIREMENTS (STANDARD CONDITIONS)

Since the Switchyards are located at an Altitudes above 1000m i.e. Baneshwar (1330 Mtrs), Tumlingtar (1970 Mtrs) and Basantapur (2470 Mtrs), the equipment shall be suitable for increased insulation level with an Altitude correction factor of 1.2 times the normal values and shall be suitable for operation under prescribed conditions.

The values of Impulse withstand Voltage and Power frequency withstand voltage given in General technical particulars requirement below have been increased for the higher altitude taking a correction factor of 1.2

Further the equipment being supplied shall be suitable for operation under sub Zero Temp with ICE/Snow considerations. The equipment shall be suitable for working in the temperature variation between (-5 Deg) to (+40 Deg) without reporting any malfunction.

SPECIFIC TECHNICAL REQUIREMENTS FOR 400KVA TRANSFORMER

(i) Rated KVA of the Transformer	400 KVA ONAN
(ii) Type of installation	Outdoor
(iii) Frequency	50 Hz \pm 3%
(iv) Cooling medium	Mineral oil

(v) Rated Voltage		
a) High voltage side	33 kV	
b) Low voltage side	0.4 kV	
(vi) Highest Continuous System Voltage :		
a) High voltage (HV)	36 kV	
b) Low Voltage (LV)	0.45 kV	
(vii) Method of system earthing:		
a) High voltage (HV)	Solidly earthed	
b) Low Voltage (LV)	Solidly earthed	
(viii) Type of tap changer	Off load Tap changer	
(ix) Range of tapping	Plus 5% to minus 10% with six(6) equal steps of 2.5%	
(x) Impedance at rated MVA Base on Principal tap	10 %	
(xi) Type of insulation & insulation level for winding:	33 kV	0.4 kV
a) Type of insulation:	Uniform	Uniform
b) One minute power frequency withstand test voltage (kV RMS)	70	28
c) Lightning Impulse withstand test voltage (kVp):	170	75
(xii) Winding connection	Delta (HV)	Star (LV)
Material	Copper	Copper
(xiii) Vector group:	Dyn1	

(xiv) Type of cooling	ONAN
(xv) Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency	1.6 wb/m ²
(xvi) Short circuit level of the system to which Transformer is to be connected	25 kA for one sec.
(xvii) Maximum Temperature Rise for various types of cooling over an ambient of 40 deg C a) Temperature rise of top oil (Measured by Thermometer) b) Temperature rise of winding (Measured by resistance)	50 ⁰ C 55 ⁰ C
Note: The allowable temp rise during testing shall be reduced by 1 ⁰ K for every 250m above 1000m as per IS 2026 part II.	
(xviii) Noise Level at Rated Voltage & Frequency	Less than 75db for ONAN Less than 80db at full load
(xix) Transformer Oil	As per IS:335 (latest edition), with pouring temperature -10 ⁰ C

20.2 PERFORMANCE

- The Transformers shall be capable of operating at full load for at least ten (10) minutes during total failure of auxiliary power supply.
- The maximum flux density in any part of the core and yoke at normal voltage and Frequency shall be such that the flux density under 10% over voltage condition shall not exceed 1.63 Tesla with limiting value as (6.3.3) below.

- c) The maximum flux density in any part of the core and yoke at rated MVA, voltage and frequency shall not exceed 1.9 tesla at the lowest tap position under 10% continuous over voltage & frequency condition.
- d) The insulation of core to bolts and core to clamp plates shall withstand a voltage of 2kV (rms) for 1minute.
- e) The insulating oil shall be virgin high grade inhibited, conforming to IEC 60296.
- f) It shall withstand and give desired performance, without injurious heating for combined voltage and frequency fluctuations. It shall withstand over fluxing conditions of 110, 125 and 140% for continuous, 1 minute and 5 seconds respectively.
- g) It shall be capable of being loaded upto 150% of rated load as per IS 6600/ IEC 60076-7. There shall be no limitation for overloading imposed by bushing, tap changer etc or any other associated equipment.
- h) Transformer shall be capable of withstanding for two second without damage to any external short circuit, with the short circuit MVA available at the terminals.
- i) Transformer shall under exceptional circumstances due to sudden disconnection of the load, be capable of operating at the voltage approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal for a period of 5 seconds.
- j) The transformer may be operated continuously without danger on any particular tapping at the rated MVA $\pm 10\%$ of the voltage corresponding to the tapping.
- k) Transformers shall be suitable for continuous operation at rated output with a frequency variation of up to $\pm 3\%$ from normal frequency of 50 Hz without exceeding the specified temperature rise.
- l) The transformer shall be so designed that the current density of all the windings and the regulating winding at the lowest tap should not exceed 100 A/sq.cm.

20.2.1 AUXILIARY POWER SUPPLIES

The following Auxiliary power supplies shall be available at site:

- i) AC, 1 phase 230 volts 50 Hz. earthed
- ii) 110 volts DC ungrounded.

20.2.2 DRAWINGS INCORPORATING THE FOLLOWING PARTICULARS SHALL BE SUBMITTED WITH THE BID

- i. General outline drawing showing shipping dimensions and overall dimensions, net weights and shipping weights, quality of insulating oil, spacing of wheels in either direction of motion, location of coolers, marshalling box and tap changers etc.
- ii. Height of centre line of HV and LV connectors of transformers from the rail top level.
- iii. Dimensions of the largest part to be transported.
- iv. GA drawings/details of various types of bushing.
- v. Type test certificates of Identical design transformers.
- vi. Illustrative & descriptive literature of the Transformer.
- vii. Maintenance and Operating Instructions.

20.2.3 MISCELLANEOUS

- a) Padlocks along with duplicate keys as asked for various valves, marshalling box etc., shall be supplied by the contractor, wherever applicable.
- b) Foundation bolts for wheel locking devices of Transformer shall be supplied by the Contractor.

20.2.4 PARALLEL OPERATION

The transformers Banks shall be capable of satisfactory parallel operation with each other if connected between the high voltage and low voltage bus-bar.

20.2.5 SCHEDULES

All Schedules annexed to the specification, shall be duly filled by the bidder separately.

20.2.6 NAME/RATING PLATE

Transformer rating plate shall contain the information as given in clause 7 IS-2026 (Part-I). The details on rating plate shall be finalized during the detailed engineering.

20.2.7 STANDARDS & CODES

- 20.2.7.1 The equipment, materials and service covered by this specification shall conform to the latest applicable provision of the following Laos/ Indian/International standards:

TABLE 6.1.3: STANDARDS

IS:2026 (Part I to IV)	Power Transformer
IS:6600	Guide for loading of oil immersed transformers
IS:335	New insulating oil for transformers, Switchgears
IS:3639	Fittings and accessories for power Transformers
IS:2099	High voltage porcelain bushings
IS:2705	Current Transformers
IS:3347	Dimensions for porcelain Transformer/Bushings
IS:3202	Code of practice for climate proofing of electrical equipment
IS:2147	Degree of protection
IS:2071	Method of high voltage testing
IS:3637	Gas operated relays
IS:1271	Classification of insulating materials for electrical machinery and apparatus in relation to their stability in services
IS:5	Colour for ready mixed paints
IS:10028	Code of practice for selection, installation and maintenance of transformers, Part I, II and III
IS:5561	Electric Power Connectors
C.B.I.P. Publication	Manual on Transformers
IS 8478	OLTC

20.2.7.2 The Equipment and material meeting the requirement of any other Nepal Standards or internationally recognized standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable. Where the equipment conforms to any other standards then salient points of difference between the standards adopted and those prescribed in these specifications shall be clearly brought out in the bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

20.3 TECHNICAL REQUIREMENTS

20.3.1 Core

The core shall be constructed from high grade, non-aging, cold rolled grain-oriented silicon steel laminations. The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall be such that the flux density at any tap position with 10% voltage variation from the voltage corresponding to the tap shall not exceed 1.9 Wb/sq-m.

20.3.2 Windings

The conductor shall be of electrolytic copper, free from scales and burrs.

20.3.3 Insulating Oil

The oil supplied with transformer shall be unused and have the parameters for unused new oil conforming to IEC: 60296 while tested at oil Contractor's premises, No inhibitors shall be used in oil. Ten percent extra oil shall be supplied for topping up after commissioning in nonreturnable containers suitable for outdoor storage.

20.4 TERMINAL ARRANGEMENT

- a) Bushing terminals shall be provided with suitable terminal connectors of approved type and size for cable/overhead conductors termination of HV side and cable termination on LV side.
- b) The neutral terminals of 400V winding shall be brought out on a bushing along with the 433 volt phase terminals to form a 4 wire system for the 400 volt. Additional neutral bushing shall also be provided for earthing.

20.4.1 Off Circuit Tap Changing Equipment

The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating an external hand wheel.

20.4.2 Marshalling Box

A metal enclosed, weather, vermin & dust proof marshalling box shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. It shall have a degree of protection of IP 55 as per IEC: 60947 Part-1.

20.4.3 Cable boxes

Whenever cable connections are required, suitable cable boxes shall be provided and shall be air insulated. They shall be of sufficient size to accommodate Purchaser's cables and shall have suitable removable side/top cover to facilitate cable termination and inspection. Cable boxes shall be dust & vermin proof.

20.5 INSPECTION AND TESTING

- a) The Contractor shall draw up and carry out a comprehensive inspection and testing program during manufacture and commissioning of the transformer. The programme shall be duly approved by the Purchaser.
- b) The Contractor shall carryout all routine tests on all the transformers as per relevant standards. Type test report shall be submitted for approval during detail engineering.

20.5.1 INSPECTION

20.5.2 Tank and Accessories

- a) Physical and dimensional check of transformer tank and accessories.
- b) Crack detection of major strength weld seams by dye penetration test.

20.5.3 Core

- a) Physical inspection and check of quality of varnish, if used.
- b) Sample testing of core material for checking specific loss, bend properties, magnetisation, characteristics and thickness.
- c) Check on completed core for measurement of iron loss and check for any hot spot by exciting the core so as to induce the designed value of flux density in the core.
- d) HV Test

20.5.4 Insulating Material

- a) Sample checks for physical properties of the material
- b) Check for dielectric strength
- c) Check for the reaction of hot oil on insulating material

20.5.5 Winding

- a) Sample check on winding conductor for mechanical properties and electrical conductivity and on installation covering.
- b) Sample check on insulation paper for pH value, Bursting strength, Electric strength.

20.5.6 Assembled Transformer

- a) Check complete transformer against approved outline drawing provision for all fittings, finish etc.
- b) Jacking test on all the assembled transformers.

20.5.7 Oil

All Standard tests in accordance with relevant Standards shall be carried out on oil samples taken from the transformer before and after testing of the transformer.

The contractor shall also prepare a comprehensive inspection and testing programme for all bought out sub-contracted items and shall submit the same to the Purchaser for approval. Such programme shall include the following components:

- a) Buchholz Relay
- b) Winding temperature Indicator
- c) Bushings
- d) Marshaling Box
- e) Tap changer switch
- f) Oil temperature indicator

20.6 FACTORY TEST

20.6.1 All standard routine tests in accordance with latest issue of IEC: 60076 shall be carried out on each transformer.

20.6.2 The transformer shall conform to all the type tests in accordance with latest issues of IEC: 60076. The manufacturer shall submit type tests & additional test reports as listed above as already carried out on transformers of identical design for owner's acceptance. In such a case validity of type test reports shall be in line with clause 9.2 of Chapter 2-GTR of

technical specifications. Following parameters in general shall be ensured for establishment of identical design as per IEC 60076, Part-V.

- a) Same Voltage ratio, KVA rating, vector group & impedance.
- b) Same conceptual design of core and winding.
- c) Same arrangement and geometrical sequence of the main windings.
- d) Same type of winding conductors.
- e) Same type of main windings.
- f) Absorbed power at short circuit (ie rated power/per unit short circuit impedance) between 30% and 130% of that relating to the reference transformer.
- g) Axial forces and winding stresses occurring at short circuit not exceeding 120% of those relating to the reference transformer.
- h) Same manufacturing process.
- i) Same Clamping and winding support arrangement..

20.6.3 In addition to all type and routine tests, transformer shall also conform to following additional type tests as per IEC: 60076.

- a) Measurement of zero sequence impedance
- b) Short circuit test
- c) Measurement of acoustic noise level. This shall conform to NEMA standard publication TR-1.
- d) Measurement of capacitance and tan delta of transformer winding.
- e) Test on oil samples as per equivalent international standard.

20.6.4 All auxiliary equipment shall be tested as per the relevant Test Certificates shall be submitted for bought out items.

20.6.5 High voltage withstand test shall be performed on auxiliary equipment and wiring after complete assembly.

20.6.6 Tank Tests:

- i) Routine Tests: As per IEC: 60076 Part-1 including
- ii) Vacuum Tests: As per IEC: 60076 Part-1

iii) Pressure Test: As per IEC: 60076 Part-1

20.6.7 In addition to the above, the following checks should be carried out at manufacturer's works before despatch for all transformers:

- a) Check for interchangeability of components of similar transformers and for mounting dimensions.
- b) Check for proper packing and preservation of accessories like radiators, bushings explosion vent, dehydrating breather, Buchholz relay, conservator etc.
- c) Check for proper provision of bracings to arrest the movements of core and winding assembly inside the tank.
- d) Test for gas tightness and derivation of leakage rate. To ensure adequate reserve gas capacity during transit and storage.

20.6.8 The Contractor shall submit a detailed inspection and testing programme for field activities, covering areas right from the receipt of material stage upto commissioning stage as per equivalent international standard - Code of practice for installation and maintenance of transformers. The indicative checks and tests are given below.

- a) Physical checks on each transformer on receipt at site for any damage or short supply.
- b) Tests on oil samples
- c) Oil leakage test
- d) Physical checks for colour of silica in breather
- e) Check for oil level in breather housing, conservator tank, etc.
- f) Check for correct operation of all protections and alarms.
- g) Insulation Resistance Measurement for Main Winding, control wiring etc.
- h) Continuously observe the transformer operation at no load for 24 hours.

20.7 FITTINGS

The following fittings shall be provided with each transformer covered under this specification.

- i) Conservator with drain plug and oil filling hole with blanking plate
- ii) Plain oil Gauge
- iii) Silica gel Breather
- iv) Pressure Relief vent
- v) Pocket on tank cover for Thermometer
- vi) Valves
- vii) Earthing Terminals
- viii) Rating & Terminal Marking Plates
- ix) Lifting Lugs
- x) Rollers
- xi) Air Release Plug

The fittings listed above are only indicative and any other fittings which generally are required for satisfactory operation of transformer are deemed to be included.

20.8 PAINTING

20.8.1 The interior of all transformer tanks and other oil filled chambers and internal structural steel work shall be cleaned of all scale and rust by shot-blasting. These surfaces shall be painted with not less than two coats of heat resistant, oil insoluble and insulating varnish. Steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of a glossy oil and weather resisting non fading, paint of shade No. 631 as per IS:5.

20.8.2 Metal parts not accessible for painting shall be made of corrosion resistant material.

20.8.3 Interior surfaces of mechanism chambers and marshalling kiosks shall receive three coats of paint after proper cleaning. The final coat shall be of a light coloured anti-corrosion paint.

20.8.4 All paints shall be carefully selected to withstand heat, rain and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

20.8.5 In case finish paint chips off or crinkle during transit or installation, the contractor shall arrange for repainting transformer at site at his cost. The paint for repainting shall be supplied by the contractor.

20.9 SPARE PARTS

20.9.1 The list of spares for outdoor type transformers covered under this chapter shall be as specified in Chapter 1- PSR

20.9.2 In addition, the Bidder shall also recommend optional spare parts and maintenance equipment necessary for three (5) years of successful operation of the equipment. The prices of these shall be indicated in respective schedules and these shall not be considered for the purpose of evaluation.

Package-KC2

Koshi Corridor 220/132/33 kV Substations (Basantapur-Baneshwar-Tumlingtar- Inaruwa Substations)

Part II-Section VI: Employer's Requirements

Section-4

Chapter-21

100 KVA, 415 V Diesel Generator Sets

SECTION 4**CHAPTER – 21****100 KVA, 415 V DIESEL GENERATOR SETS****CONTENTS**

S NO.	DESCRIPTION	PAGE NO
21.0	SCOPE OF SUPPLY	1
21.1	STANDARDS	2
21.2	DIESEL ENGINE	3
21.3	LUBRICATING SYSTEM	4
21.4	FUEL OIL SYSTEM	5
21.5	AIR INTAKE SYSTEM	6
21.6	AIR EXHAUST SYSTEM	7
21.7	COOLING	7
21.8	ENGINE GOVERNOR	8
21.9	NOISE LEVEL	8
21.10	DC EQUIPMENT	9
21.11	PIPING, VALVES AND FITTINGS	10
21.12	ANCILLARY EQUIPMENT	11
21.13	ALTERNATOR	12
21.14	EXCITATION SYSTEM	15
21.15	VOLTAGE REGULATOR	15
21.16	CONTROL PANELS FOR DG SET	16
21.17	CONTROL OF DIESEL GENERATOR SETS	19
21.18	ANNUNCIATION SYSTEM & AUXILIARIES	20
21.19	CURRENT TRANSFORMERS	21
21.20	RELAYS	23
21.21	INDICATING INSTRUMENTS	25
21.22	CONTROL / SELECTOR SWITCHES	26

21.23	PUSH BUTTONS	26
21.24	INDICATING LAMPS	26
21.25	INSTRUMENTS FOR DIESEL ENGINE	27
21.26	FUEL CONSUMPTION	27
21.27	CONSTRUCTION FEATURES OF DG SET	27
21.28	INSPECTION & TESTING	28
21.29	CIVIL WORKS	31
21.30	DRAWINGS/ DOCUMENTS	32
21.31	RECOMMENDED SPARES PARTS	33

SECTION 4

CHAPTER - 22

100 KVA, 415 V DIESEL GENERATOR SETS

21.0 SCOPE OF SUPPLY

21.0.1 The specification covers the design, engineering, manufacture, testing at manufacturer's work, supply, transportation to project site, storage, transportation upto site, erection, testing and commissioning at site of 4 Nos of 3 Phase, 415 V Diesel Generator Sets of stationary type having a net electrical output of 100 kVA, silent type, with acoustic enclosure, capacity at specified site conditions complete with all materials, accessories and fittings, erection & maintenance tools & tackles, mandatory spares as detailed in this specification for 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar in Nepal. and each equipped with the following.

- a) Diesel Engine complete with all accessories
- b) An alternator directly coupled to the engine through flexible /rigid coupling complete with all accessories.
- c) A control panel for starting
- d) Complete starting arrangement like a starter battery & battery charger of suitable capacity and suitably mounted etc.
- e) Base frame, foundation bolts etc.
- f) Interconnection piping, cabling and accessories
- g) Power & Control Cables, glands, lugs etc.
- h) AMF panel and its accessories etc

21.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless

specifically excluded and shall be supplied without any extra cost. The performance of the equipment shall be guaranteed as per **Section-5 – “Guaranteed and Other Technical Particulars”**.

21.0.3 The bidder has to furnish the testing facilities available at the manufacturer's works.

21.1 STANDARDS

22.1.1 All materials and equipment shall comply with all the applicable provisions of the latest revision of IEC/ Indian Standards, Indian Electricity Rules and other applicable statutory provisions, rules and regulations. Where no Indian Standards are available, the material and equipment shall comply with all applicable provisions of the latest revisions of the relevant International Standards and regulations. The Standards applicable to the specification are given below:

TABLE-21.0

BS: 5522&BS: 64 9	Diesel Engines for general purposes.
IS: 4722 & BS: 2613	Three phase alternator
IS: 1651& IS: 4172	Stationary cells and batteries, lead acid type
IS: 8623	Low voltage switchgear and control gear assemblies
IS: 5002	Performance requirements for constant speed compression ignition (diesel) engine for general purposes (above 20 KW)
IS: 13947	Low voltage switchgear and control gear

21.1.2 The Equipment and material meeting the requirement of any other internationally recognized standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable. Where the equipment conforms to any other standards then salient points of difference between the standards adopted and those prescribed in this specification shall be clearly brought out in the bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

21.2 DIESEL ENGINE

21.2.1 Each Diesel set shall include but not limited to the following:

21.2.1.1 The diesel engine shall be of four stroke with vertical or 'V' type cylinder arrangement, turbo charged and water cooled with inter cooler and pre-combustion chamber capable of developing specified load at rated speed at the site conditions & altitude. The engine shall be capable of driving the alternator continuously at its rated full load and rated speed without getting over loaded under the prevailing operating conditions. The engine shall be of medium speed type and the rated speed shall not exceed 1500 RPM. The Engine shall be fitted with all standard accessories according to modern standard practices including cold starting.

- a. The engine shall be electrical self-starting type. The source of energy shall be 24 V maintenance free batteries along with float & boost chargers which are to supplied installed commissioned by the bidder. The cranking device shall be designed in such a way that the engine starts automatically and reaches rated speed within 30 seconds of starting impulse being received. The fuel oil system and the lubricating oil system shall also start operating simultaneously and automatically as soon as starting impulse is received to obviate the chance of seizure of the piston and bearing as well as air locking in fuel supply system.
- b. Starter Motor: The starting motor shall conform to IS: 4722.
- c. The engine starting system complete with starter motors, batteries etc. shall be suitable to start automatically.

21.2.1.2 The Contractor must furnish a detailed calculation justifying that the engine offered by him will meet the requirement of developing 100 kVA continuous net power output at alternator terminals under site conditions, without getting over loaded. Continuous BHP rating of the engine shall be such that the DG set can continuously deliver the specified net electrical output, while supplying power/driving all electrical

and mechanical auxiliaries connected to alternator terminals and engine shaft at the specified site conditions.

21.2.1.3 The power rating, quantity of fuel consumption, governor performance and torsional vibration shall be in accordance with BS: 5514 or equivalent standards.

21.2.1.4 Each engine shall be provided with exhaust gas turbocharger having an integral intake air filter. It shall be of a robust construction, suitable of being driven by engine exhaust, having a common shaft for the turbine and blower. It shall draw air from air filter of adequate capacity to suit the requirements of the engine.

21.3 LUBRICATING SYSTEM

21.3.1 The engine shall have a closed cycle integrated lubricating oil system with positive oil pressure and crank chamber for the collection/storage of the lubricating oil during circulation. The Engine lubricating oil system shall be suitable to lubricate the required working parts of the engine effectively under the specified climatic condition, with the recommended grades of reputed oil companies. The lube oil shall conform to IS: 466. A pump shall be provided with a regulator for controlling the oil pressure.

21.3.2 The engine shall include in its supply necessary lubricating oil filters and coolers. The system shall be complete in all respects. The filter elements shall be of replaceable type. The filters provided shall be for operation under normal conditions for a period of more than 250 hours without the necessity for its replacement for cleaning.

- a) Pressure switch shall be provided in the lubricating oil system to trip the engine in case of inadequate lube oil pressure. When the minimum safe pressure of the lube oil is reached the engine must get tripped.
- b) Necessary temperature and pressure gauges for lubricating oil system should be provided.

- 21.3.3 The Contractor should provide suitable heater to pre-heat the lube oil with provision for automatic switching off. In case the Contractor in his opinion feels, the heaters are not required, he will furnish all calculations to justify his opinion.
- 21.3.4 The oil cooler shall be either of Air or raw water-cooled preferably air-cooled. The coolers shall be an integral part of the DG set and shall be equipped with necessary accessories.
- 21.3.5 1 No. Semi-rotary hand-operated pump complete with rubber hosepipe of at least 5-meter length with suitable nozzles for transferring lube oil from barrels to service tank shall be provided.
- 21.3.6 All required piping, fittings valves, filters, strainers, lubricating oil heat exchangers, temperature and pressure gauges, bypass valves, pressure switches, alarm controls, thermostat, cooler accessories, hose pipes and other accessories, instruments, equipment needed for the above services are covered under the scope of the Contractor. Companion flanges, gaskets, and nuts & bolts at all the terminal points shall be provided by contractor/ supplier.

21.4 FUEL OIL SYSTEM

- 21.4.1 The engine shall be capable of running on all types of High Speed Diesel Fuel oil normally available in market.
- 21.4.2 The fuel consumption of the engine at full, three quarters and half of its rated power output are to be indicated by the Contractor. Also specific fuel consumption of the engine to be furnished.
- 21.4.3 A fuel oil service tank with capacity of 900 liters shall be provided on a suitably fabricated steel platform. The tank shall be complete with level indicator marked in liters, filling inlet with removable screen, an outlet, a drain plug, an air vent and necessary piping, low level oil sensing device with annunciation circuit and other instrumentation. The tank shall be painted with oil resistant paint and shall be erected in accordance with Indian explosive act 1932. Any license required to be

obtained from explosive department for the installation of fuel tank has to be obtained by the contractor. A mechanical type oil level indicator to indicate low/high level in the tank shall also be provided. In addition to this there should be fuel oil level sensing device, which will give an alarm in case oil level goes below a preset value.

21.4.4 A hand pump for pumping the fuel into the fuel service tank together with necessary pipes and tubing shall be provided. The inlet of the pump shall be provided with 5 meters long armoured hose with suitable filter. The Contractor shall provide suitable length of flexible hosepipe at the diesel oil fuel transfer pump outlet to enable transfer of diesel oil from barrels to the tank.

21.4.5 Complete interconnecting piping between the fuel tank and engine along with necessary fittings, valves, filters, strainers, instruments for monitoring cleanliness of filters/strainers and accessories for flow of fuel oil to the engine and also for return of excess fuel oil from the engine to the tank shall be provided.

21.4.6 The oil system should be self-priming type.

21.4.7 Fuel passage of proper size and type shall be provided

21.4.8 An engine driven booster pump shall be provided to deliver fuel oil from the supply line, filtered through filters, to the fuel oil injectors. The Contractor may offer any alternative method of fuel supply to the engine.

21.4.9 Injection shall be provided to receive low-pressure fuel from the fuel pump and deliver it into the individual combustion chamber at right time in exact quantity and in proper condition of combustion.

21.5 AIR INTAKE SYSTEM

21.5.1 The diesel engine shall be provided with special dry type air filters having low resistance to air passage, high dust retaining efficiency and provision for easy cleaning. Filters shall be suitable for achieving satisfactory engine operation and ensuring the engine life under tropical humid conditions with Sulphur dioxide and trioxide fumes, abrasive dust and particles of 5 to 50 microns present in the

atmosphere. The minimum efficiency of filters shall be 90% down to the 5-micron size. The face velocity across the filters shall be limited to 2.0 M/Sec.

21.6 AIR EXHAUST SYSTEM

21.6.1 The exhaust system shall consist of exhaust gas driven turbocharger with piping inter connection cylinder head outlets with the turbo charger inlet. Exhaust manifold shall be fabricated steel construction and suitably insulated. The exhaust gases after passing through turbo charger should be taken out through the wall of engine room through necessary piping, adopters etc. The exhaust piping shall be diverted to a point outside the DG-room and terminated at a height about 2.0 M above the roof of the DG room. The exhaust piping along with silencer shall be suitably thermally insulated with proper insulation and flexible connections shall be provided in the exhaust piping to avoid transmission of vibrations from the engine to the structures. The engine shall be provided with an exhaust manifold in sections suitably equipped with matching flanges, expansion joints with least possible bends and drain plug. Filters, silencers of residential type, ducts, exhaust pipes, and fittings accessories for support from the ground as well as from walls shall be provided.

21.7 COOLING

21.7.1 The cooling of the engine shall be with water filled radiator. The Jacket cooling water shall be circulated by the engine self driven pump for cooling of cylinder head, cylinder liners, cylinder blocks, injectors, intake and exhaust valve, charger air cooler and turbo charger. The Contractor shall indicate quantity of water required for cooling in a closed circuit. Jacket water in turn shall be cooled by air-cooled radiator. The radiator shall be cooled by Engine driven fans and shall be complete with screens, dampers, ducts and accessories etc. The temperature of the Jacket water shall be thermostatically controlled for initial run.

21.7.2 Provision for alarm on high Jacket water temperature shall be made. Jacket water system complete with necessary engine driven pumps, air cooled radiator type heat

exchangers, engine driven fans, expansion tank with wall bracket, alarm on high water jacket temperature, required pipes, fittings, valves, instruments and accessories shall be supplied by the Contractor.

21.8 ENGINE GOVERNOR

21.8.1 The governor for diesel engine shall be provided with hydro-mechanical/electronic governor of "Wood-Ward" or equivalent make conforming to "Class A 1. Precision grade governing" of BS: 5522 or approved equal standard and the governor shall have the following features:

- a. It shall be capable of operating with "Zero Droop" and the droop shall be adjustable at the engine from 0 to 5% of the rated full load speed upon gradual changes from no load to full load. It shall have necessary characteristics to maintain the speed of the Engine substantially constant even on sudden variation in the load. It shall take care of Heavy duty motor starting.
- b. The governor shall be suitable for operation without external source of power supply. Electronic governor shall be preferred.
- c. A mechanical over speed tripping mechanism shall be provided to shut off fuel automatically in case it reaches about 110% of rated speed. The value at which the mechanism trips the engine shall be adjustable. In no case, even under the worst conditions the speed shall increase more than 120% to save the alternator.
- d. An engine mounted emergency stop push button shall be provided.

21.9 NOISE LEVEL

21.9.1 The engine shall be designed to achieve maximum quietness of operation. Efficient Industrial silencer shall be provided for the exhaust as well as the air intake. Noise level shall not exceed 93 dB at 1 m. distance. Arrangement provided to reduce noise level may be indicated.

21.10 DC EQUIPMENT

21.10.1 For starting, protection and control circuit, 1 set of 24 V DC equipment comprising of heavy duty maintenance free battery and battery charger with all accessories instruments shall be supplied by the Contractor for each DG set. 24 V heavy-duty battery shall be of suitable rating on 10 hrs. basis conforming to the relevant BS/IS to cater to the no. of starting attempts of the engine and other DC equipment requirements. The battery for starting the engine shall be capable of performing at least six (6) normal starts without recharging. The batteries shall be of reputed make suitable for diesel engine starting duty.

21.10.2 A battery charger comprising of Float charger unit and Boost charger unit shall be supplied for each battery. Normally the float charger shall supply continuous DC requirements and trickle charge the battery floating on DC bus. The boost charger unit shall quick charge the battery as and when required. Battery charger using semi conductor rectifier shall be provided with all accessories mounted in an enclosed sheet steel cubicle. Battery charger, which shall normally be used as trickle charger, shall have built in automatic voltage control to maintain output DC voltage within one (1) percent of the voltage setting when input AC supply has voltage and frequency variation. When the battery has been substantially discharged, boost charger shall quick charge the battery. For quick charging, charger shall have a built in automatic constant current characteristic load-limiting feature. Battery charger shall be supplied complete with all devices including but not limited to following:

TABLE-21.1

S.No	Item	Quantity per DG Set
a.	ON/OFF MCB for 415 V AC (3 pole)	1 No.
b.	Suitably rated transformer with ± 2.5 percent and 5 percent. tapping on primary winding to compensate for AC supply voltage variations.	1 No.

c.	Suitably rated silicon rectifier Bridge complete with RC surge suppression net work, heat sink and semi-conductor fuse & trip indicating fuse.	1 No
d.	Ripple filtering devices.	1 Set
e.	Double pole ON/OFF rotary switch for DC	1 No.
f.	HRC fuses with fittings for above with trip indication	2 Nos.
g.	Red indicating light to indicate DC supply 'ON'.	1 No.
h.	Automatic voltage regulator.	1 Set
i.	Selector switch for selecting mode of charging, i.e., float charging/quick charging.	1 No.
j.	Suitably scaled square faced moving coil ammeter each for AC & DC current measurement.	1 No each
k.	Auto/Manual selector switch.	1 No.
l.	Potentiometer with knob for setting the quick charging current or current limit for load limiting feature and other potentiometers needed for auto and manual mode of operation.	1 No.
m.	Voltmeter each for indication of AC & DC output voltages	1 No.each
n.	Charger with necessary filters, instruments and suitable characteristics for charging the battery and keeping it in fully charged state complete with all auto control, protection monitoring, annunciation equipment and self supporting panels indicating lamps etc.	

21.11 PIPING, VALVES AND FITTINGS

21.11.1 The engine shall be supplied with all piping, valves and fittings for the fuel oil, lubricating oil, engine starting air inlet and engine exhaust system, along with expansion joints, drain plugs, flanges etc.

21.12 ANCILLARY EQUIPMENT

21.12.1 The following equipments shall be supplied as a part of the engine -

1. Exhaust gas driven turbo charger (s), flexible connection (s) and exhaust piping suitably designed for operation at high temperature associated with exhaust gases and with silencers.
2. Charge-air cooler, dry type air filters, corrosion resistors, dry paper elements, air cleaners, residential type silencers.
3. Hydraulic/electronic (Wood –Ward Model or equivalent) class A1 precision grade Governor with speed droop control.
4. Over speed trip mechanical
5. Crank case breather
6. DC motor starting device (s)
7. Torsional vibration dampers.
8. Fly wheel and guard
9. Pipe fittings and valves for the fuel oil, lubricating oil, engine starting air inlet and engine exhaust system, along with expansion joints, drain plugs, flanges etc.
10. Indicator cocks and adaptors, oil/jacket water heater, thermostats, temperature gauges.
11. Filters, strainers, lubricators and residential type silencers, crank case oil dip stick.
12. Set of common base frame for engine, alternator and exciter, foundation bolts, flexible couplings between engine and generator, necessary holding down bolts, nuts, shims, base frames for panels, batteries, battery chargers, day tanks etc.
13. Control panel for auto/manual startup, operation and shut down with all related instruments and controls.
14. Local instrument, gauge board (s) for oil pressure/temperature, jacket water temperature, running hour meter, RPM meter, exhaust gas thermometers.
15. Expansion joints for connection to exhaust piping.
16. Thermal insulation for exhaust gas silencers and piping to limit outside surface temperature to 70 Deg. C at an ambient temperature of 37⁰ deg. C.

17. Radiator
18. Tachometer.
19. Protective equipment, i.e. fuel cut off solenoid and suitable relays to protect the engine against excessive cylinder temperature, low lubrication oil pressure, low & high lubrication oil level etc.
20. Lifting attachment for lifting the complete set or the engine and alternator separately.
21. Instruction manuals and wall charts describing installation, operation, service and overhaul along with necessary details of equipment part list and spares.
22. Drain trays for placing under engine sump.
23. Hand pumps for pumping fuel oil in service tanks with hoses and filters.
24. Daily service fuel oil tanks, piping and drain cock or plug, make up water tank.
25. All other instruments and accessories etc., as specified.

21.13 ALTERNATOR

21.13.1 The alternator shall be brushless with horizontal shaft, revolving field, alternating current synchronous type and suitable to be driven by diesel engine specified in the specification and shall conform to requirement of IS: 4722 & BS: 5000 and other equivalent standards. All insulated winding conductor of the alternator shall be of copper. The overall alternating winding insulation shall be class 'H' Operation from temperature rise consideration and suitable to feed 3 phase, 4 wire system. Each alternator shall have the following technical particulars.

TABLE-21.2

S.No.	Item	Quantity
a.	Alternator net continuous output at site conditions, after deducting power requirement of auxiliaries	100 kVA
b.	Power factor	0.8 lagging
c.	Overload capacity for one (1) hour in twelve consecutive	10%

	hours of operation	
d.	Rated voltage	415 V
e.	Rated Frequency	50 Hz
f.	Number of phases	Three (3)
g.	Winding connections	Star (Y)
h.	Design max ambient temperature	40 Deg. C
i.	Type of insulation a. Armature winding b. Field winding c. Connections d. Core connections e. e) Type of enclosure	Class H Class H Class H Class H Screen protected IP 23
j.	Permissible voltage variation for satisfactory operation at rated KVA	±10%
k.	Permissible frequency variation	± 5%
l.	Permissible combined voltage and frequency variation (Absolute sum)	10%
m.	Method of Neutral grounding	Solidly earthed
n.	Efficiency	Better than 90%

21.13.2 The continuous rating of the alternator at 45⁰ C ambient shall at least be equal the net electrical output specified for DG set plus the power requirements of all auxiliaries connected to alternator terminal including excitation (it is taken from alternator terminals). The alternator shall be self excited & automatic regulated type.

- 21.13.3 The temperature rise limits shall be 77.60°C above maximum ambient temperature of 40°C when measured by resistance i.e. temperature rise to be limited to Class 'B' insulation for stator and rotor.
- 21.13.4 All parts of the generator and accessories shall be able to withstand all electrical, mechanical and other stresses which may be experienced during operation, including frequent over speed conditions. The generator unit shall be capable of withstanding three phase short circuit at the generator terminals when operating at rated KVA and power factor, 5 percent over voltage and with fixed excitation for three (3) seconds.
- 21.13.5 The stator shall be of rigid construction, built up of steel stampings of high permeability and low hysteresis loss. The design shall be such that the temperature of all parts of the windings and core is kept as uniform as possible throughout to avoid excessive local heating. The generator shall incorporate embedded temperature detectors mounted on control panel with adjustable alarm. Alternator bearings shall also be provided with RTDs. (Resistance Temperature Detectors).
- 21.13.6 Two Earthing terminals diametrically opposite to each other and with clamps shall be provided on the generator suitable for 50 mmx10 mm GS flat conductors.
- 21.13.7 The generator shall be of air-cooled type with air circulation through the machine by the blower fans mounted on the rotor. The Contractor will clearly indicate the type of cooling arrangement being provided with the generator. Air intake shall be from non-drive end of the alternator and outlet towards engine side.
- 21.13.8 The alternator rotor and bearings shall be so designed as to safely with-stand an over speed of 20% over normal speed. The type of the bearing provided shall be so designed and arranged that displacement between portions of the coil and between the coils and the cover due to centrifugal force is minimized.
- 21.13.9 The supply of cables, laying and termination is in the scope of the contractor. Cables of suitable size shall be XLPE insulated, aluminum wire, armoured, FRLS, PVC overall sheathed. The winding of the alternator shall be star connected. Neutral formation shall be done in the control panel after providing CTs before neutral formation.

Cables from alternator phase terminals shall be terminated in the control panels after providing CTs of suitable rating. Details of CTs shall be supplied by the Contractor. The cables on the control panels side shall be terminated and connected by the Contractor and shall provide cable glands, gland plate (s) and crimping type cable sockets of reputed make for these cables. Contractor shall take special care to provide sufficient space in the control panel for termination of all cables.

21.14 EXCITATION SYSTEM

21.14.1 The alternator shall have its own excitation system. If a rotating exciter is provided for this purpose, it shall be driven by the alternator shaft. Excitation power shall be driven from alternator terminals itself if exciter is not provided. The excitation system shall be of self excited, self regulated/static type. The response ratio of the excitation shall be not less than 0.5. The excitation system shall be designed and / or protected such that harmful over voltage cannot occur due to machine over speed. The exciter shall be provided with two (2) nos. diametrically opposite grounding terminals with suitable clamps.

21.15 VOLTAGE REGULATOR

21.15.1 Each generator shall be capable of operation over a range of $\pm 10\%$ of the rated voltage and shall keep the terminal voltage within $\pm 1\%$ of the set value. Voltage regulator shall be supplied complete with cross current compensation (preferably of the static type), voltage adjusting rheostat, all accessories and alarm contacts for successful operation including mounting and wiring. Current transformers for compensation shall be included in the scope of Contractor and shall be suitably mounted. Voltage regulator will be provided on the control panels for the voltage control of DG sets. The components used in the system shall be adequately designed for satisfactory operation under full load conditions, overload conditions as specified and also under short circuit condition. The allowable variation for the aforesaid system shall be within the range of ± 1 percent. It shall have a rapid

transient voltage response to suddenly applied loads together with the reliability of the system. The setting available on voltage regulator shall be $\pm 10\%$. The excitation system shall be complete with all necessary accessories.

21.15.2 Terminal Box and Connection:

The alternator output terminals shall be enclosed in a terminal box mounted in an accessible position on the alternator frame. Cable glands and lugs shall be provided for all power and control cables, which have to be terminated on the equipment supplied under this package. As far as possible, connections between the exciter and alternator shall be connected with the machine frame and connections carrying AC and DC shall be segregated from each other.

21.16 CONTROL PANELS FOR DG SET

21.16.1 A free standing control panel and/ or board mounted near DG Set, safely accessible while engine is running shall be provided. Control panels/board shall be made of 2.00 mm thick cold rolled sheet steel and have IP 52 degree of protection as per IS : 13947. It shall be vermin and dust proof. The paint shade shall conform to shade 692 of IS-5.

21.16.2 The control panel shall be of unit type construction, compact and neat, provided with hinged door, locking arrangement, keys and flush handles. It shall be provided with 2 nos. grounding terminals with suitable clamps.

21.16.3 All cables shall enter from bottom. Separate cable chamber shall be provided in the control panel with cable termination, complete with cable glands, lugs etc. Generator star point shall be formed in the control panels.

21.16.4 All the control switches, push buttons, indicating instruments, signal lamps shall be flush mounted on the front of the control panel.

21.16.5 All internal wiring shall be carried out by 1150 volts grade, FRLS, PVC insulated copper wires of cross section not less than 2.5 sq.mm. The wiring shall be identified at both ends by means of plastic ferrules. Suitable internal lights (panel illumination) and 3 pin, 15 A plug socket shall be provided alongwith control MCBs.

21.16.6 A tinned copper bar of adequate dimension shall be provided for each connection complete with nuts and bolts as required for external connections to the earth grid of the substation.

21.16.7 CT shorting links, test terminals, blocks etc. Shall be provided. All the equipment mounted inside the control panels shall be identified by Lamicoid Labels.

21.16.8 The panel shall have mounted on it the Automatic Voltage Regulator, field breaker and field discharge resistor with associated control switches and indicating lamps or this may be provided in the separate matching cubicle to be mounted along side the control panel.

21.16.9 Requirements in AMF panel

- Four pole Air break contactor for Mains and for Alternator of 630A capacity
- Three over current relay for generator protection (CDV61/62)
- Instantaneous earth fault Rely through Neutral CT (1A-4A)
- Field failure relay YCGF-11A
- HRC fuses for short circuit protection on both mains and for alternator.
- Mode selector switch (Auto / Manual / test / off
- f Voltmeter with selector switch 0 – 500V A.C. Analog type
- f Ammeter with selector switch 0 – 400A, A.C. Analog type
- f Line voltage monitor (3phase) with adjustment for presetting the voltage
- f Current transformers 400/5A 5P10 for protection and class1 for measuring

Note: The line voltage monitor (LVM) should monitor the voltage condition of the mains supply and bring the D-G set in to operation if the line voltage falls below $\pm 10\%$ from the rated voltage of 415V.

21.16.10 The control panel shall also be provided with the following accessories for each DG sets:-

TABLE-21.3

S.No.	Item	Quantity per DG set
1.	Single phase AC Ammeters	3 Nos
2.	Single phase CTs for metering (Cast resins)	3 Nos
3.	Single phase CTs for protection 15 VA CL 5P10 for o/c & E/F relay	3 Nos
4.	CTs for REF protection.	4 Nos.
5.	Reverse power relay	1 No.
6.	AC voltmeter with a selector switches (0-500 V).	1 No.
7.	Frequency meter of 45-50-55 Hz digital type	1 No.
8.	Watt meter to read 3 phase power (3 phase 4 wire)	1 No.
9.	Power Factor meter.	1 No.
10.	Counter to indicate no. of times set has operated and time totalize.	1 No.
11.	Red lamps for D.G. "ON" position	1 No.
12.	Green lamps for D.G. "OFF" position	1 No.
13.	24 V Battery charger	1 No.
14.	DC volt meter 0-30 V.	1 No.
15.	DC Ammeter 0-40A.	1 No.
16.	Energy meter – Electronic type	1 No.
17.	Mains supply voltage monitor.	1 No.
18.	Relays and timers for the control and protection	1 set
19.	Auto – Test - Manual – OFF switch	1 No.
20.	Silicon bridge rectifier of suitable capacity	1 No.
21.	Double compression type cable glands of suitable sizes	1 No.
22.	Mode selector switch off/manual/ Test / Auto.	1 No.
23.	Fluorescent lamp 40 W 240V complete with MCB for Internal illumination	1 set
24.	Contactor for generator neutral over voltage relay	1 No
25.	Door switches 240 V AC.	1 No

26.	Push button for starting/stopping of the DG set	1No. each
27.	Electronic hooter for the annunciation.	1 No
28.	Rotary switch of 2 position ON/OFF.	1 No
29.	3 Phase, 4 Poles contractor	1 No
30.	Mimic diagram of DG	1 No
31.	Annunciation for DG set	1 No
32.	5 A, 3/2 pin socket with MCB	1 No
33.	Speed raise, speed lower, test start and stop push buttons with 2 NO +2 NC contact element shrouded types	
34.	Selector switch for OFF/TRICKLE/BOOST charging	1 No
35.	Any other item essential for DG Set operation & maintenance will be provided	

21.17 CONTROL OF DIESEL GENERATOR SETS

21.17.1 The diesel generating sets shall be controlled from control panel. Diesel generator sets shall normally be at rest when AC supply of the station is available and start automatically upon failure of normal power supply and stop automatically after restoration of normal power supply. The DG Set shall also be able to start and stop manually by push button.

21.17.2 The protection scheme of the DG set shall include the following:

1. A triple pole thermal over load protection relay.
2. 2 Nos. O/C and 1 no. E/F protection with IDMT characteristic.
3. Restricted E/F protection for the alternator.
4. AUTO MAINS FAILURE : (AMF)

Protection and interlocks needed for the auto starting of the diesel generator set in case of main supply failure in future.

5. Over voltage and under voltage protections.

6. Reverse Power flow protection
7. Protection for
 - a. Low lube oil pressure
 - b. High jacket water temp
 - c. Over speed
8. Any other protection recommended by the manufacturer for the safe, efficient and trouble free running of the equipment and their accessories during the life time.

21.17.3 Failure to start:

21.17.3.1 A three attempt starting facility using two impulse timers and a summation timer for engine shall be provided and if voltage fails to develop within 30 seconds from receiving the first start impulse the set shall block automatically & a visual indication and audible alarm shall be provided.

21.18 ANNUNCIATION SYSTEM & AUXILIARIES

21.18.1 Annunciation System

The control panel shall be supplied with all necessary relays and other accessories suitable for operation on DC supply. The contractor shall provide 24 V DC supply exclusively meant for the purpose of starting of the DG sets. Window type annunciation complete with ACCEPT, RESET, TEST BUTTONS AND FLASHER RELAY etc. shall be provided on the diesel generator control panel to give visual and audible indication of any one or more the following troubles.

Trip Alarms:

- a. High Jacket water temperature
- b. Lubricating oil pressure low
- c. Engine over speed
- d. Generator fault – O/C, E/F, Reverse Power, Over Voltage

- e. Failure to start the engine
- f. Loss of 24 volts DC control supply

Non-Trip Alarms:

- a. Lubricating oil level low
- b. Sub-fuel oil tank low
- c. Fuel oil tank level low
- d. Excitation failure

21.18.2 In addition 4 Nos. spare windows shall be provided.

21.18.3 The annunciation system shall be window type having static circuitry. On initiation by protective relay contact, the relay actuates and flashing signal is turned to the corresponding channel. Simultaneously, the alarm circuit is also made operative. On operation of the accept push button, the audible signal is switched off and the flashing window changes its state to steady illumination. Operating sequence shall be as follows.

TABLE-21.4

Condition	Audible Alarm	Visual Condition
Normal Fault/Abnormal	OFF ON	OFF ON Flashing
Accept	OFF	ON (Steady)
Initiating Test	OFF	ON (Steady)
Reset	OFF	OFF

21.19 CURRENT TRANSFORMERS

21.19.1 The technical particulars of current transformers shall be as follows:

TABLE-21.5

a.	Type	Cast resin insulated bar or wound type
b.	Specification & standards	As specified herein and as per IS: 2705
c.	Number of phases	Single Phase
d.	Secondary CT	5 Amp.
e.	Rated Burden	15 VA for metering & 15 VA for Protection
f.	Accuracy Class	1 (Metering) 5P10 (Protection)
g.	Rated continuous thermal Current at specified ambient temperature	Same as rated primary current
h.	Rated short time thermal current	25 KA for (1) one second or the maximum let through current of the previous (upstream) protective device.
i.	Rated dynamic current	65 KA (peak) or the maximum current of the previous (upstream) protective device.
j.	Class of insulation	Class 'H'
k.	One (1) minute power frequency withstand voltage i) Between all terminals connected together and all parts to be earthed ii) Between contacts terminal	2 kV

	with contacts closed and all remaining terminals connected together	2 kV
--	---	------

21.20 RELAYS

21.20.1 The following type of relays shall be provided:

- Non-directional 3 over current & Inst. Earth Fault relay with setting range of 50-200% and relay 20-80% rated time 1.3 second shall be supplied. The relay shall have inverse time current characteristics on all taps and very low overshoot.
- REF relay.
- Under frequency relay. It shall have a continuously variable pick up setting range of 47 to 50 C/s and consistent accuracy of about 0.1 C/S.
- Hand/ electrically Reset Alternator trip relay (86).
- The relays shall be fast acting multi-contact, attracted armature type with high mechanical stability. It shall be suitable for tripping duties requiring simultaneous switching operation. The relay shall be suitable for 24 V DC supply.
- Fuse failure relay: 3 pole fuse failure relays shall be provided to block incorrect operation of protective relays associated with voltage circuits of generators and AVR due to failure of secondary fuses of PTs.
- One No. Voltage Sensing Relay to sense that voltage developed is correct so that breaker is permitted to close.
- Reverse Power relay.

21.20.2 The technical particulars of the relays shall be as follows:

TABLE-21.6

S.No.	Item	Specification
a.	Type	Flush mounted,tropicaliseddrawout.
b.	Specifications and standards	As specified herein and as per IS:3231
c.	Current coil rated current	5 A, AC
d.	Potential coil rated voltage	110 V AC/ 24 V DC
e.	Operating time class	As needed for instantaneous relay
f.	Control supply	24 V DC
g.	Class of insulation	'H'
h.	One (I) minute power frequency tests voltage	
	i) Between all terminals connected together and all parts to be earthed	2 kV
	ii) Between contacts terminal with contacts closed and all remaining terminals connected together	2 kV
	iii) Between circuits to be connected in use	2 kV
	iv) Between contacts in open position	1 kV

21.20.3 Rated continuous, short time thermal and dynamic currents for coils and contacts shall be suitable for service involved. Relay shall provide reliable, sensitive and selective circuit and equipment protection at all times while maintaining supply to healthy circuits. False tripping shall not take place. Relays shall be rectangular in shape and have dust tight covers. Relays shall be equipped with auxiliary reset, positive action operation indicator. No control relay tripping a circuit breaker on

being de-energized shall be used in control schemes. Auxiliary relays shall be designed for operation of DC and shall operate satisfactorily between eighty (80) per cent and hundred and ten (110) percent of the rated voltage.

21.21 INDICATING INSTRUMENTS

21.21.1 Technical particulars of the indicating instruments shall be as follows:

TABLE-21.7

S.No.	Item	Specification
a.	Type	Flush mounted,
b.	Specifications and standards	As specified herein and as per IS: 1248
c.	Accuracy	± 1 percent
d.	Size	96 mm x 96 mm
e.	Finish	Parallax free dull black with white dial and black markings
f.	1 (One) minute power frequency test voltage	2 kV

21.21.2 Instruments shall be mounted on the front of the cubicle. AC instruments shall be suitable for connection to 1 A CTs and 110 V VTs and series resistors wherever necessary. DC instruments shall be supplied with shunts, wherever necessary. The instruments shall be of accuracy class 1.0 and switch board types. Elements shall be shock resistant and shielded from external magnetic fields. Cases of the instruments shall be dust and moisture proof.

21.22 CONTROL / SELECTOR SWITCHES

21.22.1 Control and selector switches shall be rotary type and provided with properly designated escutcheon plates clearly marked to show operating positions.

21.22.2 Switch ratings shall be adequate for the purpose intended. Selector switch handles shall be either spade or pointer or oval shaped. These shall have required number of position and contacts. Voltmeter selector switch shall be four (4) position stay put type with pointer or oval shaped handle, and an engraved escutcheon plate.

21.23 PUSH BUTTONS

21.23.1 All push buttons shall have two at least 1 NO and 1 NC contacts. The contacts shall have adequate rating for their application. The push button knob colours shall be as per approval of the purchaser. All push buttons shall be of self reset type with standard push knobs. The contacts of push buttons shall be enclosed in a transparent cover. It shall be possible to add at least 1 NO & 1 NC contact to the push buttons, if so required at site. All push buttons shall have integral inscription plates duly inscribed to indicate their function.

21.24 INDICATING LAMPS

21.24.1 Indicating lamps shall be filament type and of low watt consumption. They shall be of double contact bayonet cap type. Each lamp shall be furnished with a suitably rated series resistor to avoid short circuiting of control supply in the event of filament fusing. Lamps shall be provided with translucent lamp covers which shall diffuse coloured light red, green, amber, or white as the case may be. Lamp covers shall be unbreakable, moulded from heat-resistant, translucent and fast colour material. Bulbs and caps shall be interchangeable and easily replaceable from the front and shall normally not require any special tools for replacement. If any special tool is required, the same shall be supplied with each switchgear and control panel.

21.25 INSTRUMENTS FOR DIESEL ENGINE

21.25.1 The following instruments shall be provided for each Diesel Engine on the Gauge Board.

- a. Thermometers for measurement of lube oil and jacket water temperatures.
- b. Hour meter and RPM indicator.
- c. Pressure gauges for lube oil, fuel oil system, jacket water inlet to engine, and for all aux. pumps provided with DG sets.
- d. Pressure and temperature switches for lube oil system shall be provided on the panel and to trip the unit if the pressure falls below safe limit or temperature rises above desired limit. Temperature switches for annunciation of high jacket water temperature should also be provided.
- e. A thermo switch shall be provided at the lube oil outlet from engine bearing for alarm on high oil temperature.
- f. Starting switch with key.
- g. Locally mounted pressure and temperature gauges on the concerned piping on inlet and outlet of cooling water for heat exchanger.

21.26 FUEL CONSUMPTION

21.26.1 The guaranteed fuel consumption based on net calorific value of 10,000 k cal./litre under full load, $\frac{3}{4}$ load, $\frac{1}{2}$ load conditions with tolerance $\pm 5\%$ shall be indicated. The Contractor shall intimate the consumption of lubrication oil/hour and the number of hours after which the replacement of the lubricating oil is recommended.

21.27 CONSTRUCTION FEATURES OF DG SET

21.27.1 General

- a. All materials used shall be new and of tested quality conforming to applicable National and International standards and Indian Electricity Rules.

- b. The whole equipment shall be transportable and capable of installation at site with ease and without any damage. It shall give continued reliable operation over long life at full load rating under worst specified site conditions.
- c. All renewable and similar parts shall be interchangeable.
- d. All components shall be designed to withstand the extremes of all magnetic, electrical, mechanical and thermal stresses and gas pressure which may be encountered during normal and abnormal operating conditions.
- e. All metal parts not accessible for painting shall be made of corrosion resisting material. All machined or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- f. Paints shall be carefully selected to withstand tropical heat and extremes of weather. It shall not scale off or crinkle or be removed by abrasion in handling.
- g. Adequate quantity of loose paints for retouching in field shall be furnished. Should the finish paint scale off or crinkle during transit or installation, the contractor shall arrange for repainting at site, at his cost.
- h. Equipment shall be completely assembled at the works to ascertain that all parts fit correctly. Maximum possible wiring and assembly or components like instruments transformers, relays instruments etc. shall also be carried out before dispatch to minimize erection time at site.

21.28 INSPECTION & TESTING

- 21.28.1 The DG set (Diesel Engine, alternator, exciter etc.) should have been successfully type tested as per relevant IS/IEC/BS and the contractor shall submit the type tests report of the type tests alongwith the tender for similar DG set.
- 21.28.2 After completion of the manufacture of equipment, routine tests shall be performed as per relevant IEC/IS and requisite copies of the test certificates shall be furnished.
- 21.28.3 Diesel engine, alternator, control and switchgear panels, AVR, battery and battery charger, cables, instruments, busbars, relays, CTs, contactors and all accessories etc.

shall be subject to routine, type and acceptance tests in accordance with the requirements of the latest issue of relevant India/IEC Standards in the presence of purchaser's representative. The bidder shall clearly state the testing facilities available at his works for testing the complete equipment with all fittings and accessories offered. Each completely wired control panel and board shall be tested to ensure that all its protective, control, interlock systems are satisfactorily functioning as per requirements. Test certificates for functional tests shall be furnished to the purchaser.

21.28.4 The tests to be carried out on diesel generator set shall include (but not limited to) the following:

21.28.4.1 Diesel Engine

- a. Power output at full throttle
- b. RPM, torque, fuel rate, fuel pressure, lubricating oil pressure, intake manifold pressure blow by exhaust temperature and smoke checks.
- c. Performance parameters measurements at full load, half load, $\frac{3}{4}$ load and $\frac{1}{4}$ load shall be noted.
 - i) RPM and lubricating oil pressure at high idle and low idle shall be noted.
 - ii) Engine washing for leakage check
 - iii) Performance parameters at 10% overload.
- d. Calculations for horsepower and efficiency at full load, $\frac{1}{2}$ load, $\frac{3}{4}$ load, and 10% overload shall be furnished.
- e. Time from initiation of start command to rated speed shall be noted.
- f. Chemical and physical characteristics shall be tested and certificate shall be submitted to the owner.
- g. Crack detection check and ultrasonic test on forgings and casting of critical parts, e.g. crank shaft, camshaft, connecting rod, cylinder head, piston and alternator shaft.
- h. Hydrostatic test shall be carried out on all pressure parts.

- i. Static balancing shall be carried out in all rotating parts and shafts shall be both statically and dynamically balanced.
- j. Performance test of fuel pump and injector.
- k. Bench test of all the safety control devices separately.

21.28.4.2 Type Test of Alternator

The alternator should have been type tested for the following tests as per IS: 4722 (latest edition, amended upto date). The test reports of these tests shall be submitted for Owner's review.

- a. Measurement resistance
- b. Phase sequence test.
- c. Regulation test (for alternator only)
- d. Measurement of leakage reactance and potier reactance (for alternator only)
- e. Measurement of open circuit characteristics
- f. Measurement of short-circuit characteristics (for alternator only)
- g. Efficiency test
- h. Temperature rise test
- i. Momentary overload test
- j. Over speed test
- k. High voltage test
- l. Insulation resistance test (both before and after high voltage test)
- m. Noise level and vibration
- n. Determination of deviation of voltage wave form from sinusoidal (for alternator only)

21.28.4.3 Routine Test of Alternator

- a. Phase sequence and polarity marking tests
- b. Check of direction of rotation
- c. Insulation resistance measurement both before and after high voltage tests
- d. Vibration test

- e. Measurement of resistance of field winding, main armature winding, space heaters etc. and leakage reactance measurement.
- f. Open circuit test.
- g. Short circuit test.
- h. Temperature rise test and 50% overload test for 15 seconds after temperature rise test.
- i. High voltage test
- j. Wave form test
- k. 120% over speed test
- l. Momentary overload test
- m. Regulation test

21.28.4.4 Exciter

Nominal exciter response test and other tests as per standard.

21.28.5 Tests on completely assembled DG set

- a. Functional checks for local, manual, auto start, speed and voltage control.
- b. Tests to check the starting time from completely cold conditions.
- c. Vibration and noise tests.
- d. One hour at full load, one hour at $\frac{3}{4}$ load running.
- e. Four hours at full load followed by one hour continuous load of 110%.
- f. Fuel consumption tests
- g. Automatic starting and interlocks checks
 - i. Governor response
 - ii. Over speed test and over speed trip test.

Note: The contractor submit the type test and routine test report of the bought out items at the time of inspection and testing of the DG set by the representatives of WAPCOS.

21.29 CIVIL WORKS

21.29.1 All the civil works for DG Set i.e. foundations, trenches etc. are to be carried out by the Contractor.

21.29.2 All the required drawings for the civil works shall be furnished by the Contractor for approval without any extra cost.

21.30 DRAWINGS/ DOCUMENTS

21.30.1 The following Drawings/ Document shall be submitted within 10 days after the award of contract.

- a. Dimensioned general arrangement drawings showing front and side elevations,
- b. Plan, sectional views of the equipment terminal blocks, terminals for external connections, cable end box and cable glands forming part of the contractor's supply.
- c. Schematic wiring diagram along with write ups for control, interlocks etc.
- d. Instrumentation, protection, space heating and panel illumination circuits.
- e. Terminal blocks and terminal arrangement drawing showing control and power cable connections.
- f. Net and shipping weights, crane lifts for assembly & dismantling and size of lifting lugs and eyes.
- g. Outline drawings indicating weights, dimensions, all forces and loads under normal and abnormal operating conditions for the design of foundations and associated equipment by the Contractor.
- h. Schedule of all base channels, sleeves, foundation bolts, inserts and other parts to be set in the foundation.
- i. List of nameplates with text.
- j. Leaflets and instruction for cards of control components, instruments, relays and other accessories, as applicable.
- k. Any other drawings or details not specifically mentioned herein but necessary for the satisfactory operation of the equipment.
- l. Instruction Manuals and wall charts:

Six (6) copies of installation, testing and commissioning, operation and maintenance manuals shall be furnished. These manuals shall be sturdily bound volumes and shall

contain every drawing and detailed by step information required for installation, testing, setting and adjustment of all components after installation, operation and maintenance, and spares of the equipment and all its components.

21.31 RECOMMENDED SPARES PARTS

21.31.1 The bidder shall furnish a list of spare parts for DG set with recommended quantities for 5 years of normal operation. The spare parts catalogue depicting various parts of the equipment along with part number shall be supplied. Unit prices must be quoted along with recommended spares.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4

Chapter-22 **CCTV System**

SECTION 4

CHAPTER – 22

CCTV SYSTEM

CONTENTS

S NO	DESCRIPTION	PAGE NO
22.0	SCOPE	1
22.1	CODES AND STANDARDS	2
22.2	SYSTEM DESIGN REQUIREMENTS	3
22.3	QUALITY ASSURANCE AND CONTROL	13
22.4	DOCUMENTATION	13
22.5	HANDLING	16
22.6	INSPECTION AND TESTING	17
22.7	INSTALLATION AND PRE-COMMISSIONING	18
22.8	SPARE PARTS AND CONSUMABLES	19

SECTION 4

CHAPTER – 24

CCTV SYSTEM

22.0 SCOPE

22.0.1 Introduction

This specification covers the minimum requirements for the design, materials, construction, fabrication, inspection, supply & delivery, storage, transportation upto site, testing and commissioning of integrated colored closed circuit television (CCTV) system giving complete visual coverage and remote monitoring of designated operation of Isolators of Each bay in a Substation. All camera views shall be available to the Main Control Room (MCR). Camera selection shall be via keypad control units connected to a video switching matrix for Construction of 2220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa in Nepal. All equipment supplied shall conform to that detailed within this specification. The system shall comprise:-

- a) Local control and monitor facilities in locations providing selective control and monitoring of up to cameras.
- b) All closed circuit camera should be capable for Zoom-in & Zoom –out facility & Turn around facility.
- c) Tentative Locations of camera as detailed below and finalized during detailed engineering and minimum no. of cameras 15 nos.
 - All incoming bays should cover all the isolators in the bay
 - All outing bays should cover all the isolators in the bay
 - All Transformer bays
 - Bus coupler bays
 - Covering Entrance gate of Substation
 - Any other locations as desired by the ED with in substation premises finalized during detailed engineering

d) Field installed camera equipment with Zoom-in & Zoom-out, turn around features

- Monitors
- Central Rack Equipment
- Optical fibre patch panels
- VCRs/HDD drive recording

22.0.2 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. Any material and equipments not specifically stated in this specification but which are necessary for satisfactory operation of the equipment shall be deemed to be included unless specifically excluded and shall be supplied without any extra cost. Components having identical rating shall be interchangeable.

22.0.3 The performance of the equipment shall be guaranteed as per **Section-5– “Guaranteed and Other Technical Particulars”**. The bidder has to furnish the testing facilities available at the manufacturer’s works.

22.1 CODES AND STANDARDS

22.1.1 It shall be the VENDOR’s responsibility to be, or to become, knowledgeable of the requirements of the referenced Codes and Standards. The following Nepal/Indian/International codes and standards, to the extent specified herein, form a part of this specification. When an edition date is not indicated for a code or standard, the latest edition in force at the time of VENDOR’s proposal submission shall apply.

- a) IEC 60028 International Standard of Resistance for Copper
- b) IEC 60248 Conductors of insulated cables
- c) IEC 60255 Electrical relays all or nothing
- d) IEC 60331 Fire resistance characteristics of electric cables
- e) IEC 60326 Printed circuit boards
- f) IEC 60529 Degrees for protection provided by enclosures (IP Code)

- g) IEC 60801 Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment
- h) IEC 60885 Electrical test methods for electric cables
- i) ITU-T Standards and Recommendations, including those previously published under the CCITT regulations
- j) AMERICAN NATIONAL STANDARDS INSTITUTE
- k) IEEE-472 Surge Withstand Capability
- l) MILITARY SPECIFICATIONS AND STANDARDS
- m) MIL HDBK 217 Reliability Prediction of Electronic Equipment
- n) Electrical Power technical standards of Nepal.

22.1.2 The Equipment and material meeting the requirement of any other internationally recognized standards which ensure a quality equal or better than the standard mentioned above shall also be acceptable. Where the equipment conforms to any other standards then salient points of difference between the standards adopted and those prescribed in this specification shall be clearly brought out in the bid and a copy of the applicable standards shall also be enclosed by the bidder with the bid.

22.2 SYSTEM DESIGN REQUIREMENTS

A) SYSTEM REQUIREMENTS

22.2.1 General

The system shall be based on state of the art reliable solid state technology. It shall use microprocessor software control based architecture. The central system shall have full redundancy to be fault tolerant. The system shall be modular in design and allow future expansion to double its capacity with no or minimal service interruption. However, the central system shall be equipped to cater for 25% system expansion. It shall include, but not limited to, the following equipment. A Central Control Rack providing the interface between the control and monitoring facilities and field installed camera equipment. Field installed colour cameras. A number of cameras shall be mounted on Mast/ Support structure in the substation. Control facilities and video display monitors providing a display of camera images

manually selected from the control keyboard or sequentially selected pictures arranged in a pre-determined sequence.

22.2.2 Equipment Location

- (i) A Central Equipment Rack - 19" type equipment racks, located in the Telecoms Rack Room (TRR).
- (ii) Operator Monitoring and Control:-

22.2.2.1 The Main Control Room (MCR) shall include at least a 29" colour video display monitor's flat square screen LCD/Desktop Computer and associated control keyboard units.

22.2.3 Transmission Equipment

22.2.3.1 Transmission equipment shall be of modular construction and shall utilize optical fibre cables. Multimode optical fibre cables shall be provided between the Central Equipment Rack and the field located optical fibre patch panels located in each IES. These optical fibre cables shall carry both video and telemetry data control information.

22.2.3.2 Each camera shall be connected via multimode fibre cable that has minimum capacity of four fibers.

22.2.4 CCTV Camera Multimode O.F. Transmitter Unit

The multimode optical fibre cable from each camera will be terminated via a SC connector to a optical fibre transmitter unit. The bi-phase telemetry data control information shall terminate on a RS-485 data module. One transmitter and data module is required for each camera unit. The O.F transmitter and the bi-phase telemetry data unit shall be contained within the camera housing. The optical fibre transmitter shall modulate the analogue video signal and convert it to light, suitable for optical fibre cable transmission. The video signal will then be routed via the optical fibre cable and patch panels to the video matrix within the CCTV Central equipment rack.

22.2.5 Central Rack Equipment

The Central Rack Equipment shall house the main electrical, electronic, optical fibre and processing equipment necessary for system distribution, video switching matrices, microprocessor control subsystem, power supplies, operator control keyboard, etc. The rack shall be provided with powered fans to enable adequate air flow. The system shall include extensive self-diagnostic routines to detect and report any system (hardware or software) malfunction including the connecting cables and outdoor equipment. The system shall be fully redundant and fault tolerant with no single point of failure. The system should be capable to be interfaced and integrated with similar CCTV system.

22.2.5.1 Central Rack Unit

The CCTV Central Rack Unit with its associated switching and fibre optic equipment, complete with rack mounted 9" colour monitor shall be provided. This shall enable the CCTV to operate as an independent stand-alone CCTV sub-system should the need arise, i.e. the event of a fault or a break in the optical fibre cable, and or a fault within the main CCTV control and switching system. Hence operation and control of the cameras can still be available directly from a control keyboard/display unit or portable PC.

22.2.5.2 Switching Matrix Unit

Video switching shall be carried out by a microprocessor-based cross point modular matrix switching units capable of automatically routing video signals from a requested camera position to a specified monitor. The switching unit shall present a number of output ports for interfacing to monitors and accommodate other integrated VCRs. An interface port shall be reserved for maintenance/administration purposes. A Laptop PC terminal shall be provided, it shall be loaded with the latest version of diagnostic software according to standard specs. An interface port shall be reserved for a Real Time Clock. GUI port required for the connectivity of central rack unit with LAN of control room required so that

to enable authorized workstations to monitor the whole plant from their remote locations.

The Switching matrix units shall have none blocking structure and support broadband video transmission with almost no signal degradation (i.e. attenuation, delay, etc.).

22.2.5.3 Video Quad Processor

Selectable quad/full screen coloured processors units shall be provided. The system shall be capable of presenting the selected video images to video monitors and recorders in quad, split or full screen viewing modes, and shall be independent of both record and real time viewing functions. The system shall allow any and all monitors to activate the quad split feature simultaneously.

22.2.5.4 Video Cassette Recorders

A number Video Cassette Recorders shall be required. The Vendor shall state within his tender documents the number of Video Recorders to be provided.

- a) The TV video to be recorded shall be Pal colour 625.
- b) Only S-VHS high grade professional tapes shall be provided.
- c) The recorders shall be capable of being fed from and played back through multiplexes.
- d) The equipment shall be suitable for 19" rack mounting and shall be located within the Central Equipment Rack.
- e) All video recorders shall have the facility to be switched on and off remotely.
- f) Time, date and title of cameras shall be recorded on all tapes.
- g) It shall be possible to replay both real time and lapse recordings through the same system, whether in quad, split or full screen mode.
- h) Recorders shall operate in the standard 3 hour mode for real time recording.
- i) A facility for external time synchronization shall be provided.
- j) As an option the CONTRACTOR shall study the feasibility of recording the video signals on the multichannel digital recorder. The final method of recording shall be finalized during detailed design engineering phase.

22.2.6 Operator Control Keyboard Units

Control functions of the CCTV cameras from the MCR and ECR keyboards i.e. camera selection, sequence programming, sequence hold commands shall be provided. Alpha numeric/display keyboards shall be provided, suitable for desk mounting. A busy indicator device shall be provided on each monitor to indicate, if a chosen camera is already under control by another operator. One Keyboard/display unit shall be installed (flush mounted) in each of the workstations in the MCR, and one keyboard/display unit shall be installed in and shall have the following functions:-

- a) Power on/off control of each camera.
- b) Zoom-in & Zoom-out of each camera.
- c) Turn round of each camera.
- d) Sequence Control - to program required automatic camera selection.
- e) Iris Control - to open/close camera iris.
- f) Wash/wipe Control - enable the wash/wipe facility to clean camera glass face.
- g) Camera selection enabling up to four camera outputs to be displayed on the monitors simultaneously.
- h) Access security programmed codes shall be provided, for use of keyboards by authorised operators.

22.2.7 Monitors

22.2.7.1 At least 21" diagonal size CCTV monitors shall be supplied they shall be of the indoor type with a minimum protection of IP 20, c/w with overhead brackets suitable for ceiling mounting. The exact size shall be finalized in the EPC phase and the model has to be the latest at time and to be reviewed and approved by the company. CCTV monitor control adjustments shall be via an infra-red or wireless remote control unit, and shall include the following control functions as a minimum:-

- a) Brightness control
- b) Contrast control

- c) Colour control
- d) On/Off and standby control

22.2.7.2 Picture Quality

- a) To be compatible with Pal 625 colour standard or better.
- b) The monitors shall be responsive to widely varying lighting conditions from 5 lux reflected light to 100,000 lux as may be associated with bright sunlight, Electric arc and welding arc lights.
- c) Under the worst case lighting conditions specified above the overall signal to-noise ratio shall be 45dB.
- d) Horizontal resolution of greater than 600 lines and 440,000 pixels.
- e) Accept a supply voltage of 240 Volts 50Hz.

22.2.7.3 Other Facilities

- a) Time, date and title ID information of cameras shall be displayed on all monitors.
- b) The monitors shall be capable of supporting 2 or 4-way split screen displays.

22.2.8 Cameras

Colour Charge Coupled Device (CCD) cameras shall be provided and installed at strategic locations within the plant area to enable efficient monitoring of the plant equipment for safe operation. The cameras shall be solid state microprocessor controlled intelligent type. The camera design shall ensure high definition and brilliant images of the covered areas under normal daylight, low visibility periods and at night under emergency light (i.e. 1.5 LUX). The main features of the cameras shall meet the following:

- a) The standard shall be Pal 625 line colour with 2:1 interlace.
- b) The cameras shall generate standard Pal 625 line colour video and provide a 1v Pk to Pk video signal at the video output.
- c) Cameras shall be designed to provide high picture quality under varying light conditions and fitted with automatic light correction facilities.
- d) Fitted with automatic iris control, zoom and gain control.

- e) Able to operate with a fixed focus lens and motorized zoom lens.
- f) All cameras shall be powered from the nearest plant UPS 240 Volts 50Hz local power source.
- g) All cameras shall be of identical model that shall be fully controlled & rotated from the system central maintenance terminal (PC).

22.2.9 Camera Housing

Depending on the location, the cameras as well as any other outdoor equipment shall be housed in an explosion-proof and/or weather-proof IP67 non-metallic (GRP) cases. The explosion proof requirements shall be in accordance with the area classification in which the equipment will be installed.

The Camera housing shall be:-

- a) Suitable for housing all equipment necessary for camera operation.
- b) Cameras shall be housed in a sealed unit.
- c) Equipped with sun hood, and window wipe facilities.

22.2.10 Equipment alarms

The Vendor shall state the alarm indications supplied as standard with the equipment. These alarms shall include but not limited to the following:-

- a) Equipment failure
- b) Mains fuse failure
- c) Common group or individual equipment failure. This shall take the form of an earth-free and volt-free contact rated nominally for 5 amps at 24V D.C. This alarm condition shall be interfaced to the SCS for annunciation.
- d) Provision in the SCS (Station Control System) to be considered by the Contractor and SCS (Substation Control System) Vendor for CCTV alarms.

22.2.11 Cables

All required cables including the multimode optical fiber cables between field cameras and optical fiber patch panels shall be provided by CONTRACTOR.

22.2.12 Electrical Protection

All field mounted electrical equipment shall be of the explosion-proof type EEx(d) or EEx(i) certified to CENELEC/IEC or equivalent for hazardous area classified Zone 1, IIC, T3 or Zone 2, IIC, T3 as required.

22.2.13 Power Supplies and Earthing

The control system, monitors and all critical components of the CCTV system shall be powered by the Telecom 240 Volt, 50 Hz Uninterruptible Power Supply (UPS). Power to all cameras and associated equipment will be supplied from the UPS 240 volt 50 Hz vital power distribution panels. All system components shall be capable of operating at a minimum of $\pm 10\%$ available voltage, $\pm 5\%$ frequency, and interruption time of 10 m Seconds and 5% harmonic content. VENDOR shall state the total load requirements for each system, in his offer to permit sizing of the UPS system. This shall include the power requirements for each cabinet and total power for each system. VENDOR will include inrush currents and crest factors in supplied information.

22.2.14 Mean Time to Repair (MTTR)

The design and construction of the CCTV system shall ensure high reliability and availability. The CCTV system shall employ modular constructional techniques in its design, allowing a first line maintenance philosophy of module replacement to be implemented. The average module replacement time for the system will be less than 1 hour as long as the correct spares holding are maintained as recommended by the supplier.

22.2.15 Environmental conditions

Cameras shall be located in the switch yard, in the control room and entrance gate.

- a) Maximum Temperature (shade) 37.2°C
- b) Minimum Temperature 14°C
- c) Maximum Relative humidity 80%
- d) Maximum Wind Velocity 32 m/s
- e) Altitude <1000 m AMSL.

22.2.16 System Software

A. Programming

All programming and configuration shall be performed by the manufacturer and will be developed on the basis of the approved software specifications. Approval of the software specifications shall be by NEA/WAPCOS. Software shall be protected from unauthorized changes by the use of multilevel passwords. Manufacturer shall state with proposal methods available and proposed in their system to implement such protection. The latest proven software version shall be loaded prior to the system testing. At the time of Final Acceptance the final software issue shall be offered to NEA . The manufacturer shall provide all information required to carry out editing and configuration of the system. A full description shall be provided in the techniques required to amend existing configuration and replace old versions in the system. A separate list of editing features shall be included, defining what can be done on line, and anything that must be developed off line.

B. Licenses and Installation

All software shall be supplied fully installed on the equipment and a master copy provided on suitable media, CD-ROM preferred. All manuals shall be included and manufacturer shall ensure that all applicable software licenses are transferred to NEA.

22.2.17 Noise Immunity (RFI/EMI)

The system shall be designed to prevent the emission of, and susceptibility to, RFI and EMI. The system shall not be unduly affected by the emissions of nearby equipment, nor shall it affect the nearby equipment. Emissions shall not initiate unpredictable or undesirable actions / responses, measurement errors, communications faults etc. If such instances become evident at site, the VENDOR shall be wholly responsible for the expeditious resolution of the problem to owner satisfaction. The application of RFI/EMI protection components or configurations such as filtering, screening, minimal physical discontinuities and bonding shall be employed. This includes unit construction and packaging design to ensure easy

serviceability and also that the integrity of RFI/EMI features, will not be degraded during normal maintenance conditions. RFI protection against hardware damage and system errors shall be provided for the equipment being furnished. Errors caused by RFI shall not exceed 0.1 percent of span for exposure to a field strength of 10 volts/meter over the frequency range of 10 Hz-1000 MHz with all covers in place. With covers removed errors shall not exceed 0.5 percent of span. A certified test report shall be required in the proposal to verify this performance. Vendor equipment shall meet all applicable RFI emissions standards. VENDOR's equipment shall not cause RFI interference to Owner hand held radios. VENDOR shall provide hand held radio to be used for factory test of RFI and susceptibility. The frequency is to be offered for review to the Owner operations personnel. The most probable source of radio frequency interference (RFI) at the site is the use of hand held radio transceivers with nominal transmitted power of 5 watts. VENDOR shall state any frequencies in the VHF and UHF bands for which they cannot comply. Other sources of RFI/EMI include fixed radio stations, vehicle radio transmitters, hand-held or mobile communications equipment, commutator type electrical devices, electrical storms, welding equipment, solenoids, relays and contactors carrying heavy currents. The control system shall be immune from these sources of RFI/EMI and shall comply with the requirements of IEC 60801. The system shall also be supplied with provisions for protecting against system errors and hardware damage resulting from electrical transients on power or signal wiring. These transients include those generated by switching large electrical loads, by power line faults, and due to lightning strikes which induce surges on power or signal cables. The IEEE Standard 472 shall apply to all system power inputs and signal inputs from field devices. The VENDOR shall detail in the proposal the method proposed to provide this protection.

22.3 QUALITY ASSURANCE AND CONTROL

22.3.1 The manufacturers shall have in effect at all times, a QA/QC program which clearly establishes the authority and responsibility of those responsible for the quality system. Persons performing quality functions shall have sufficient and well defined authority to enforce quality requirements that initiate, identify, recommend and provide solutions to quality problems and verify the effectiveness of the corrective action. Manufacturer's proposed quality system shall fully satisfy all the elements of ISO 9001, "Quality Systems - Model for Quality Assurance in Design/Development, Production, Installation, and servicing" and ISO 9004, "Quality Management and Quality System Elements- Guidelines". The quality system shall provide for the planned and systematic control of all quality-related activities performed during design. Implementation of the system shall be in accordance with the manufacturer's Quality Manual and Project Specific Quality plan, which shall both together with all related/referenced procedures, be submitted to NEA/WAPCOS for review, comment and approval. The manufacturers shall identify in purchase documents to its contractors all applicable QA/QC requirements imposed by the NEA/WAPCOS, and shall ensure compliance thereto. On request, manufacturers shall provide objective evidence of its QA/QC surveillance of its contractor's activities. If selected manufacturer have ISO 9001 or ISO 9002 certification, as required for contracted scope, then copies of these certifications are to be provided for NEA/WAPCOS review.

22.4 DOCUMENTATION

- 22.4.1** Manufacturers shall submit the type and quantity of drawings and documentation for NEA/WAPCOS.
- 22.4.2** Mutual agreement of scheduled submission of drawings and engineering data shall be an integral part of any formal Purchase Order.
- 22.4.3** Comments made by NEA/WAPCOS on drawing submissions shall not relieve EPC contractor of any responsibility in meeting the requirements of the specifications.

Such comments shall not be construed as permission to deviate from requirements of the Purchase Order unless specific and mutual agreement is reached and confirmed in writing.

22.4.4 Each drawing shall be provided with a title block in the bottom right-hand corner incorporating the following information:

- a. Official trade name and logo of COMPANY
- b. PO number together with item tag numbers
- c. Document number and revision
- d. Manufacturer drawing number and revision

Drawing title giving the description of contents whereby the drawing can be identified Revisions to drawing shall be identified with symbols (alpha or numeric) adjacent to the alterations, a brief description in tabular form of each revision shall be given, and if applicable, the authority and date of the revision shall be listed. The term "Latest Revision" shall not be used.

22.4.5 Additionally, all final system design documentation shall be provided in electronic format. All project specific system design drawings shall be provided in DXF file format. All project specific design specifications produced shall be provided in Microsoft Word format. All project database information shall be provided in .dbf format. Additionally, it is desired to have as much standard system documentation as possible available on CD-ROM with search and retrieval capabilities. Manufacturer shall advise the extent of provided hardware and operating software covered by documentation in this manner.

22.4.6 All suppliers' documents and drawings shall strictly follow revision marking (vertical line in right border) along with (strikethrough) for deletion and (underlined) for addition & modifications in hard copy as well as in electronic copy. All documents/drawings shall be submitted showing the last revision and changes/additions made along with a list of item-by- item vendor response to Company comments. When Company approves a document with "No Comments", suppliers shall issue such documents/drawings as "Company approved issue". In

this issue, the document shall be same as previous submission except that it will only show revised/added version without any revision marks.

22.4.7 CCTV system documentation to be supplied by VENDOR shall include, but not be limited to connection drawings, detailed descriptions of hardware equipment, fully dimensioned outline drawings of all panels and equipment, power requirements, earthing, site preparation, installation, operation, maintenance and fault finding manuals, and catalogue sheets of all furnished components. Wiring diagrams shall include customer tag numbers. The Vendor documentation shall include, but not be limited to, the listed documentation below related to project:

- a) Functional Design Specification (FDS) for CCTV system.
- b) Drawing cross reference.
- c) CCTV system FAT specification.
- d) CCTV system hardware configuration.
- e) CCTV system Software Design Specification.
- f) CCTV termination details.
- g) CCTV system panels general arrangement.
- h) CCTV system SAT specification.
- i) Communications Interface protocol specification(s).
- j) Recommended spare parts list with part numbers.

Any other documentation listed in the Document Requirement Schedule.

22.4.8 The CCTV system VENDOR shall provide an advance copy of wiring details and software floppy disks to NEA for follow-up prior to system installation at site. All engineering documents shall have the legend pages at the beginning (if applicable) to show the standard symbols, abbreviations, definitions and description of used logic/functional blocks. Software media (operating and application), all related manuals, all sub Vendors software media and manuals shall be part of supplied documentation.

22.4.9 As Built Drawings

Before completion of final Site Acceptance Test, the manufacturer shall issue a complete set of approved updated drawings incorporating all modifications, additions or other changes that have taken place during manufacture and site pre-commissioning. Each drawing shall be clearly marked "as-built" and dated. Prior to their issue, manufacturer shall maintain a NEA master set of working drawings at site detailing all changes made during installation and commissioning.

22.5 HANDLING

22.5.1 Packaging and Shipping

Preparation for shipment shall be in accordance with the manufacturer's standards and as noted herein. Manufacturers shall be solely responsible for the adequacy of preparation for shipment provisions with respect to materials and application, and to provide equipment at the destination in ex-works condition when handled by commercial carriers. Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the job site. Preparation for shipment and packing will be subject to inspection and rejection by NEA/WAPCOS inspectors. All costs occasioned by such rejection shall be to the account of the Contractor. All equipment shall be packed with moisture desiccant and moisture detection strips shall be installed in all packed equipment. These shall be inspected after installation and previously established testing / replacement policies will be implemented should internal exposure to moisture be evident. These procedures will be prepared by the manufacturer and approved by the NEA/WAPCOS. Equipment shall be packed, securely anchored, and skid mounted when required. Bracing, supports, and rigging connections shall be provided to prevent damage during transit, lifting, or unloading. Separate, loose, and spare parts shall be completely boxed. Pieces of equipment and spare parts shall be identified by item number and service and marked with Purchase Order number, equipment / tag number, and weight, both inside and outside of each individual package or

container. A bill of material shall be enclosed in each package or container of parts. One complete set of the installation, operation, and maintenance instructions shall be packed in the boxes or crates with equipment.

22.5.2 Preservation and Storage

Equipment and materials shall be protected to withstand ocean transit and extended period of storage at the job site for a minimum of 18 months. All supplied items shall be protected to safeguard against all adverse environments, such as: humidity, moisture, rain, dust, sand, mud, salt air, salt spray, and seawater. All equipment and materials shall be preserved and export packed in accordance with Preservation and Storage Specification.

22.6 INSPECTION AND TESTING

22.6.1 All tests and inspection shall be made at the manufacturer's works unless otherwise specifically agreed upon by the manufacturer and employer at the time of placement of purchase order. The manufacturer shall afford to the inspector representing the employer, all reasonable facilities, without charge to satisfy him that the material being furnished is in accordance with these specifications. The employer reserves the right to get any component/material being used by the manufacturer of the CCTV Camera tested from any recognized test house. No material shall be dispatched without prior approval of the all the test reports and certificates by the employer.

22.6.2 The testing shall be structured in a logical manner and shall cover, but not be limited to, the following:

- a) Earthing isolation and continuity measurements at sample locations
- b) Power up, power distribution verification plus Voltage and Current measurements
- c) Diagnostics
- d) Power supply test (momentary power loss, voltage fluctuations, etc.)
- e) RFI and EMI testing.

22.6.3 CCTV Functional Test

22.6.3.1 For each system this test after site installation shall repeat all the FAT tests related to system behaviour:

- a) system power-up
- b) power failure
- c) hardware diagnostics
- d) test of all other system basic functions
- e) Load and fault simulation

22.6.3.2 The test shall demonstrate that the system has been received in good condition, is installed correctly, is healthy and can successfully be used for further site activities.

22.6.4 Site Acceptance Test

The SAT acceptance date shall start after successful completion of all approved tests and after the system behavior and performances have been monitored for a period of thirty days. After thirty days if the system operates as per specification, Site Acceptance of the system shall be signed. Check of network load shall be done in the course of the Site Acceptance test. SAT procedures must be detailed and should be reviewed and accepted by the company.

22.7 INSTALLATION AND PRE-COMMISSIONING**22.7.1 Installation of Equipment**

Installation will be carried out by the EPC contractor. Any special tools required for installation will be provided by the contractor. One notebook PC shall be provided for remote access of the system to monitor, alter or correct the system configuration. The notebook shall be of latest proven model. The PC configuration shall be finalized during the EPC.

22.7.2 Pre-commissioning Procedure

Pre-commissioning shall include, but is not limited to, the following:

- a) An audit and inspection of equipment received. A deficiency report shall be written and appropriate action taken to rectify any problems.

- b) Each system shall be powered up and functionally tested, including communications, diagnostics functions and logic, with appropriate test equipment as defined by manufacturer.

22.8 SPARE PARTS AND CONSUMABLES

22.8.1 Start-Up and Commissioning Spares

The VENDOR shall supply start-up spares, as required in order to avoid using any of the recommended spares. The cost of start-up spares shall be quoted separately. The time scales and procedure for repair and/or replacement of parts shall be stated in the VENDOR's proposal.

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-4 **Chapter-23**

Mandatory Spares, Tools & Testing **Equipment**

CHAPTER – 23**MANDATORY SPARES, TOOLS & TESTING EQUIPMENT****CONTENTS**

S NO	DESCRIPTION	PAGE NO
23.0	SCOPE	1
23.1	TRANSFORMERS	1
23.2	220/132/33 kV SF6 (GAS) CIRCUIT BREAKERS	3
23.3	CURRENT TRANSFORMERS	4
23.4	POTENTIAL TRANSFORMERS	4
23.5	220/132/33 kV ISOLATORS	4
23.6	216/120/30 KV SURGE ARRESTORS	5
23.7	C & R PANELS (220/132/33 kV Substation)	5
23.8	OPGW COMMUNICATION PANEL	7
23.9	TOOLS & TESTING EQUIPMENT	7
23.10	MANDATORY SPARES FOR COMMUNICATION EQUIPMENT	8

CHAPTER - 23**MANDATORY SPARES, TOOLS & TESTING EQUIPMENT****23.0. SCOPE**

- 23.0.1. Mandatory spares, tools, testing and equipment are required for 33.3 MVA Single Phase, 220/132 kV power transformers, 25/30 MVA, 132/33 kV power transformers, 25/30 MVA, 220/33 kV power transformers 220/132/33 kV circuit breakers, 220/132/33 kV Isolators, CTs, PTs, C&R panel etc. of 220/132/33 kV substations at Tumlingtar, Basantapur, 220/33 kV substation at Baneshwar and extension of 2 No. of 220 kV line bays at Inaruwa for preventive maintenance & emergency maintenance during break down of the equipment. The bidders may quote their rates in the schedule of prices for mandatory spares. A list of mandatory spares for five years of normal operation is given below. Their cost shall be taken into account for the evaluation of financial bids. The bidder shall also submit their list of recommended spare parts for 5 years, for the equipments.
- 23.0.2. The maker of spares shall be as that of the main equipments and all the spares shall be interchangeable.
- 23.0.3. The testing equipment must be also of the original equipment manufacturer. If not in the range of manufacturer given for the Project, the same shall be mutually decided between Employer & Contractor, as Employer only would accept material of standard make and proven quality.

Note: Hydraulic Jacks are covered in the main supply as per specifications.

23.1. TRANSFORMERS

TRANSFORMERS at each Substation wherever applicable				
	Spares for Power Transformers	220/132 kV 33.3 MVA	220/33 kV 25MVA	132/33 kV 25 MVA
i)	HV bushing with metal parts and gaskets	1 No.	1 No.	1 No.
ii)	LV bushing with metal parts and gaskets	1 No.	1 No.	1 No.

iii)	LV Neutral bushing with metal part and gaskets	1 No.	1 No.	1 No.
iv)	Set of gaskets	1 set	1 set	1 set
v)	Buchholz Relay complete with contacts	1 set	1 set	1 set
vi)	Winding temperature indicator	1 No.	1 No.	1 No.
vii)	Oil Temperature indicator with local and remote sensing device and contact	1 No.	1 No.	1 No.
viii)	Magnetic Oil Level gauge	1 No.	1 No.	1 No.
ix)	Set of valves complete	1 set	1 set	1 set
x)	Tap change Diverter switch (complete for one phase)	1 set	1 set	1 set
xi)	Silica Gel	20 kG	20 kG	20 kG
xii)	Winding Temperature sensing element	1 No.	1 No.	1 No.
xiii)	Oil temperature sensing element	1 No..	1 No..	1 No..
xiv)	Diaphragm for explosion vent (if provided in the transformer)	2 set	2 set	2 set
xv)	Terminal Connectors	1 set	1 set	1 set
xvi)	Silicagel breather for main tank	1 No.	1 No.	1 No.
xvii)	Silicagel breather for OLTC	1 No.	1 No.	1 No.
	Remote Tap Position Indicator	1 No	1 No	1 No
	Oil Flow Indicator with Flow Switch	1 set	1 set	1 set
	Cooler fan with motor	1 No	1 No	1 No
	Oil Cooler Pump with motor	1 No	1 No	1 No

	Strarters, contactors, switches & Relays for Electrical control panels (One set of each type)	1 set	1 set	1 set
--	---	-------	-------	-------

23.2. 220 kV SF6 (GAS) CIRCUIT BREAKERS**220 kV SF6 (GAS) CIRCUIT BREAKERS AT EACH SUBSTATION WHEREVER****APPLICABLE**

	SF6 (GAS) CIRCUIT BREAKERS	220 kV	132 kV	33 kV
i)	One pole complete with column and Interrupter but without support structure	1 No.	1 No.	1 No.
ii)	Fixed & moving contacts complete for one pole	1 set.	1 set.	1 set.
iii)	Rubber gaskets, 'O' rings and seals for three phase pole	2 sets.	2 sets.	2 sets.
iv)	Density & Moisture meter with switch contact	1 No.	1 No.	1 No.
v)	Closing coil	2 No.	2 No.	2 No.
vi)	Trip coil	2 No.	2 No.	2 No.
vii)	Terminal connectors	3 Nos.	3 Nos.	3 Nos.
viii)	Pressure gauge for SF6 (Gas)	1 No.	1 No.	1 No.
ix)	Operation counter	1 No.	1 No.	1 No.
x)	SF ₆ gas	For two complete breaker (3 phases)	For two complete breaker (3 phases)	For two complete breaker (3 phases)

xi)	All types of coupling for SF ₆ gas	1 No.	1 No.	1 No.
xii)	Motor for spring charging	2 No.	2 No.	2 No.
xiii)	Support Insulators	2 No.	2 No.	2 No.

23.3. CURRENT TRANSFORMERS**CURRENT TRANSFORMERS AT EACH SUBSTATION WHEREVER APPLICABLE**

i)	220 kV , 2000-1000-500/1-1-1-1-1A, 5 Core, 1 Phase CT	3 No.
ii)	132 kV, 1200-600-300/1-1-1-1-1A, 5 Core	3 Nos

23.4. CAPACITIVE VOLTAGE TRANSFORMERS/POTENTIAL TRANSFORMERS**CAPACITIVE VOLTAGE TRANSFORMERS/POTENTIAL TRANSFORMERS AT EACH****SUBSTATION WHEREVER APPLICABLE**

i)	220kV, 132 kV and 33 kV	2 No. each
----	-------------------------	------------

23.5. 220/132/33 kV ISOLATORS**220/132/33 kV ISOLATORS AT EACH SUBSTATION WHEREVER APPLICABLE**

No.	Description	220 kV	132 kV	33 kV
i	Complete Insulator unit for one pole	3 No.	3 No.	3 No.
ii	Copper contact fingers for male & female contacts	1 set	1 set	1 set
iii	Terminal connectors	1 set	1 set	1 set
iv	Limit switch & Auxiliary contacts	1 set	1 set	1 set
v	Earthing blade & fixed contact assembly	1 set	1 set	1 set
vi	Motor Housing bearing assembly	1 set	1 set	1 set

vii	Motor with gear assembly	1 set	1 set	1 set
viii	Bearings	1 set	1 set	1 set
ix	Auxiliary Switch assembly complete	1 set	1 set	1 set
	Interlocking coils	1 set	1 set	1 set

23.6. 216/120/30 KV SURGE ARRESTORS**216/120/30 KV SURGE ARRESTORS AT EACH SUBSTATION WHEREVER APPLICABLE**

		216 kV	120 kV	30 kV
i)	216/120/30 kV,10kA Single Phase Surge Arrestor complete in all respects Including base and surge monitor	3 Nos.	3 Nos	3 Nos

23.7. C & R PANELS (220/132/33 Substation)**C & R PANELS (220/132/33 Substation) AT EACH SUBSTATION WHEREVER APPLICABLE**

i)	Tool Kit	1 No.
ii)	Set of Control switches used	1 set
iii)	Each type of Auxilary and trip relays used	1 set
iv)	Multifunction meter	1 No.
v)	Each type fuse links and MCB used	1 No. of each type
vi)	Terminal blocks -20% of used TB	1 No.
vii)	FO Cable 10 meters	2 No.
viii)	Indicating lamps	10 No.
ix)	Ilumination lamps	5 No.
x)	3 pin 15 A socket with ON/OFF switch	5No.
xi)	Energy meter	1 No.
9	Battery & Battery Charger	

i)	Intercell inter row connections	One set of each
ii)	Nuts, bolts & washers	5 sets
iii)	Insulators used as supports for connecting strips	5 No. of each type
iv)	Pad insulators to be placed below the batteries	25 No.
v)	Flexible copper end connector strips	6 No.
vi)	Petroleum jely	5 Kg
	Battery Charger	
vii)	Set of diods of each type & rating	1 No.
viii)	Set of silicon controlled rectifiers of each rating used	1 No.
ix)	Set of chokes of each type & rating used	1 No
x)	Set of capacitors of each type & rating	1 No
xi)	Set of resistors of each type & rating	1 No
xii)	Set of transistors of each type & rating	1 No
xiii)	Set of MCB of each type & rating	1 No
xiv)	Set of fuses of each type & rating	1 No
xv)	Set of fuse assembly unit of each type & rating	1 No
xvi)	Set of contactors of each type & rating	1 No
xvii)	Set of thermal over current relay of each type & rating	1 No
xviii)	Set of auxiliary contactors of each type & rating	1 No
ixx)	Set of control & selector switches of each type & rating	1 No
xx)	Indicating lamps	20 No.
xxi)	Panel / Cabinet space heater with thermostat	2 No.
xxii)	Transformer Protection Panel	
a)	Transformer Differential Protection	1 No
b)	REF Protection Relay with Non linear resistor	1 No
c)	Directional Over Current and E/F Protection	1 No
xxiii)	Line Protection Panel	
a)	Numerical Distance Relay (1 no of each type)	1 No
xxiv)	Breaker Relay panel	

a)	Breaker failure relay	1 No
b)	Trip circuit supervision relay	
c)	Auto Reclose relay with check synchronizing relay and dead line charging relay	1 No
d)	Self reset trip relay (relay of each type)	1 No
e)	Hand reset trip relay(relay of each type)	1 No
f)	Timer relay(relay of each type)	1 No
g)	DC supervision relay(relay of each type)	1 No
h)	Flag relays(relay of each type)	1 No
i)	Auxiliary relays(relay of each type)	1 No

23.8. OOPGW Communication Panel**OPGW Communication Panel AT EACH SUBSTATION WHEREVER APPLICABLE**

i	As recommended by the manufacturer	1 set
---	------------------------------------	-------

23.9. TOOLS & TESTING EQUIPMENT**TOOLS & TESTING EQUIPMENT AT EACH SUBSTATION WHEREVER APPLICABLE**

S.No	Item	Quantity
a.	Transformer oil testing (BDV) kit	1 No.
b.	Transformer oil sampling steel bottles of 1 liter capacity	2 Nos.
c.	2.5 kV Megger (Motorized)	1 No.
d.	1000 V Megger	1 No.
e.	Multimeter digital	1 Nos.
f.	4 Terminal Earth tests	1 No.
g.	Phase sequence meters	1 Nos.
h.	6000 LPH Oil filtration Unit	1 No

23.10. MANDATORY SPARES FOR COMMUNICATION EQUIPMENT

BOQ for Mandatory Spares of Communication Equipments			
S.No.	Item Description	Unit	Quantity
1.0	Transmission Equipment		
A	SDH Equipment (STM- 1 ADM, upto two directions)		
(I)	Common cards, Power supply cards, power cabling, other hardware & accessories (each)	Set ^{\$\$}	1
(II)	Optical Interface/SFP for		
(a)	L1.2	No.	1
(b)	Optical Line Interface card (to support minimum 150 kms)**	No.	1
(c)	Optical Line Interface card (to support minimum 150 kms)**	No.	1
(III)	Tributary Cards		
(a)	E1 Interface card (Minimum 16 interfaces per card)	No.	1
(b)	Ethernet interfaces 10/100 Mbps with Layer-2 switching (Minimum 4 interfaces per card.)	No.	1
2.0	Termination Equipment		
A1	Drop & Insert Multiplexer Common cards, Power supply cards, power cabling, other hardware & accessories (each)	Set ^{\$\$}	1
A2	Subscriber Line Interface Cards		
a)	2 wire (sub/sub) voice channel cards (min 8 channels per card)	No.	1
b)	4 wire (E&M) voice channel cards (min 8 channels per card)	No.	1
c)	Asynchronous Sub Channels data cards, minimum 4 channels per card	No.	1
d)	Synchronous data card (NX64kbps)	No.	1

BOQ for Mandatory Spares of Communication Equipments

S.No.	Item Description	Unit	Quantity
3.0	Pre Connectorized Optical Fiber Patch Cords (10 Mtrs) – Pack of Six Patch Cords	Set	1

Note \$\$: One Set means one of each type of module/unit card etc

Note** : Suitable Optical Interface Card(s) or any other solution such as SDH equipment with optical amplifier, wavelength translator or higher aggregate bit rate SDH equipment may be offered for the length to meet the link budget requirements without repeater

Package-KC2

Koshi Corridor 220/132/33 kV Substations **(Basantapur-Baneshwar-Tumlingtar- Inaruwa** **Substations)**

Part II-Section VI: Employer's Requirements

Section-5 **Guaranteed Technical Particulars**

SECTION-5

GUARANTEED TECHNICAL PARTICULARS

CONTENTS

Sl. No.	Chapter	Description
1.	Chapter-1	Surge Arrestors
2.	Chapter-2	Capacitive Voltage Transformers/Voltage Transformers
3.	Chapter-3	Current Transformer
4.	Chapter-4	245/145/36 kV Isolator And Isolator With Earth Switch
5.	Chapter-5	245/145/36kv SF6 (Gas) Circuit Breakers For Outdoor Application
6.	Chapter-6	Power Transformers
7.	Chapter-7	Earthing System
8.	Chapter-8	Lightning Protection
9.	Chapter-9	Substation Automation and Control System
10.	Chapter-10	Control and Relay Panels
11.	Chapter-11	Fibre Optics Terminal Equipment
12.	Chapter-12	A.C Distribution Board
13.	Chapter-13	D.C. Battery, Battery Charger & DC Distribution Board
14.	Chapter-14	Power and Control Cables
15.	Chapter-15	Illumination/Lighting System

16.	Chapter-16	Civil Works
17.	Chapter-17	Galvanized Steel Structures
18.	Chapter-18	Miscellaneous Items For Sub-Stations
19.	Chapter-19	Erection, Testing And Commissioning of Electrical Equipment
20.	Chapter-20	Station Transformers
21.	Chapter-21	100 KVA, 415 V Diesel Generator Sets
22.	Chapter-22	CCTV System
23.	Chapter-23	DIGITAL TELEPHONE EXCHANGE (PBX)

CHAPTER 1: SURGE ARRESTERS (220/132/33 kV)

Sr. no.	Description	Guaranteed Particulars		
		220kV	132kV	33kV
1.	Manufacturer's Name and Country			
2.	Manufacturer's type designation			
3.	Applicable technical standard			
4.	Rated frequency (Hz)			
5.	Arrestor rating (kV rms)			
6.	Maximum Continuous Operating voltage (kV rms)			
7.	Lightning Impulse withstand voltage (kV _p)			
8.	Power Frequency Withstand Voltage (kV _{rms})			
9.	Standard Nominal Discharge Current			
10.	Line discharge class			
11.	Degree of protection			
12.	Max. Steep current impulse residual voltage at 10 kA (kV _p)			
13.	Max. Lightning Impulse residual voltage at 10 kA (kV _p)			
14.	Max. switching surge residual voltage at 1 kA (kV _p)			
15.	Partial discharge at 1.05 COV not greater than			
16.	Low current long duration test value			
17.	High current short duration test value (4/10 μ second wave) (kA _{peak})			
18.	Minimum Corona Extinction Voltage (kV _{rms})			
19.	Maximum partial discharge at 1.05*Continuous Over Voltage(COV)			
20.	Prospective symmetrical fault current for pressure relief test for (0.2 sec) kA			
21.	Maximum energy dissipation capability (kJ/kV of rated voltage of arrester) (kJ/kV)			
22.	Whether pressure relief devices provided (Yes/No)			
23.	Metal oxide discs:			

	a). Country of manufacture			
	b). Size of discs (Diameter & Thickness) (mm, mm)			
	c). How the electrical contact is ensured between blocks			
	d). Medium of heat dissipation from the blocks to the surrounding			
24.	Whether following curves enclosed with offer			
	a). Volt time characteristic (Yes/No)			
	b). Voltage current characteristic of arrester (Yes/No)			

INSULATOR HOUSING

Sr. no.	Description	Guaranteed Particulars		
		220kV	132kV	33kV
1.	Manufacturer's Name and Country			
2.	Power frequency withstand test voltage (wet) (kV rms)			
3.	Lightning impulse withstand/tests voltage (kVp)			
4.	Creepage distance (mm)			
5.	Cantilever Strength (Kg)			

CHAPTER 2
CAPACITIVE VOLTAGE TRANSFORMER
(220/132 kV)
POTENTIAL TRANSFORMERS
(33 kV)

Sr.NO	DESCIPTION	Guaranteed Particulars		
		220 kV	132 kV	33 kV
1.	Manufacturer's Name and Country			
2.	Manufacturer's type designation			
3.	Mounting of tank			
4.	Rated voltage kV (rms)			
5.	Max System Voltage kV (rms)			
6.	Rated frequency			
7.	System Earthing			
8.	Short circuit level for one second kA (rms)			
9.	Rated primary operating voltage			
10.	No. of Secondary Windings			
11.	Rated secondary voltage			
	• Winding No.1			
	• Winding No. 2			
	• Winding No. 3			
12.	Class of accuracy of Each secondary winding			
	• Winding No.1			
	• Winding No.2			
	• Winding No.3			
13.	Temperature rise above ambient (Deg. C)			
14.	Voltage factor continuous / For 30 sec			
15.	Rated Insulation level			
	a) Rated voltage kV			
	b) 1.2 /50 micro sec. impulse withstand voltage (kV peak)			
	c) One minute dry power frequency Withstand voltage (kV peak)			
16.	Rated burden (VA)			

	<ul style="list-style-type: none"> • Wdg I 			
	<ul style="list-style-type: none"> • Wdg II 			
	<ul style="list-style-type: none"> • Wdg III 			
17.	Standards reference range of frequency for which the Accuracy's are valid for protection and measuring winding.			
18.	One minute power frequency Withstand test voltage for secondary winding (kV rms) (Hz)			
19.	Partial discharge level (Pico coulombs)			
20.	Rated Capacitance (picco-farad)			
21.	Minimum Corona extinction Voltage (kVrms)			
22.	Maximum Radio interference voltage for frequency between 0.5 to 2 MHz (at 156 kVrms)			
23.	Equivalent resistance over entire carrier frequency range (ohms) for CVT			
24.	Maximum ratio error (%) with rated burden and normal primary voltage (%)			
25.	Maximum phase error (%) with rated burden and normal primary voltage (%)			
26.	Quantity of insulating oil (Litres)			
27.	Total weight including oil (Kg)			
28.	Whether sealed (if so type of sealing) (Yes/No)			
29.	Over all dimensions			
	a). Height (mm)			
	b). Length (mm)			
	c). Breadth (mm)			
30.	High frequency capacitance for entire carrier frequency range			

Insulator Housing

Sr. No	DESCTIPTION	Guaranteed Particulars		
		220 kV	132 kV	33 kV
1.	Manufacturer's Name and Country			
2.	Power frequency withstand test voltage (kV rms)			
3.	Lightning impulse withstand/tests voltage (kVp)			
4.	Creepage distance (mm)			
5.	Cantilever Strength (Kg)			

CHAPTER 3 CURRENT TRANSFORMERS

Sr. no.	Description	Guaranteed Particulars		
		220kV	132kV	33kV
1.	Manufacturer's Name and Country			
2.	Rated Voltage (kV)			
3.	Max. Continuous rated voltage (kV)			
4.	Standard to which it conforms			
5.	Rated frequency (Hz)			
6.	Core Details			
	a) No. of cores			
	b) Rated primary current (Amp)			
	c) Rated secondary current (Amp)			
	d) Rated output (Burden) (VA)			
	e) Accuracy class of CT Cores i. core-1 ii. core-2 iii. core-3 iv. core-4 v. core-5			
	f) ISF for metering core			
	g) CT resistance of secondary winding (Ohms)			
	h) Ratios available at different taps			

7.	a).Rated short circuit withstand capacity for 1 second (kA)			
8.	Rated insulation level (Standard Values)			
	a) Lightning Impulse withstand voltage (Peak) kV			
	b)One minute power frequency withstand voltage (kV rms)			
	i). Primary Winding			
	ii). Secondary Winding			
9.	Type of insulation			
10.	Rated continuous thermal current			
11.	Maximum temperature rise over maximum ambient temperature			
12.	Max. Corona excitation voltage(kV)			NA
13.	Max.RIV for frequency between 0.5 to 2 MHz (μ Volt)			NA
14.	Cantilever Strength			
15.	Max. Partial discharge level (pC)			
16.	Total weight (Kg)			
17.	a) Quantity of oil (litres) b) Standard with which it complies			
18.	Overall dimensions (mm x mm x mm)			
19.	Type of primary winding			

20.	Flux density at knee point voltage (knee point defined at the point at which 10% increase in voltage produces a 50% increase in magnetization current) for PS accuracy class(Tesla)			
21.	Variation in ratio and phase angle error due to variation in			
	a.) Voltage by 1% (% , %)			
	b.) Frequency by 1 Hz (% , %)			
22.	Whether pressure relief device is provided (Yes/No)			
23.	Whether the following are enclosed with tender: (Yes/No)			
	a.) Drawings as per the specification (Yes/No)			
	b.) Technical literature for current transformer and marshalling box. (Yes/No)			
	c.)Magnetization curve (Yes/No)			
	d.) Ratio and phase angle characteristics at least up to accuracy limit factor (Yes/No)			

Insulator Housing

Sr. no.	Description	Guaranteed Particulars		
		220kV	132kV	33kV
1.	Voltage Level(kV)			
2.	Power frequency withstand test voltage (wet) (kV rms)			
3.	Lightning impulse withstand/tests voltage (kVp)			
4.	Creepage distance (mm)			
5.	Cantilever strength (Kg)			

CHAPTER 4

ISOLATOR AND ISOLATOR WITH EARTHING SWITCH

S.No.	Description	Parameter		
		220 kV	132 kV	33 kV
1.	Manufacturer's Name and Country			
2.	Type Designation			
3.	Applicable standard			
4.	Type - (Outdoor)			
5.	Rated voltage kV (r.ms)/Highest System Voltage kV			
6.	Rated frequency (Hz)			
7.	Number of poles			
8.	Whether all three poles are ganged together mechanically/electrically (Yes/No)			
9.	Rated current (Amp)			
10.	Rated dynamic short circuit current of			
	a). Isolator (kA peak)			
	b). Earthing switch (kA peak)			
11.	a) Rated lightning impulse withstand voltage between line terminals and ground [kV(peak)]			
	b) Between terminals with Isolator contacts open [kV(peak)]			

12.	One min. power frequency withstand voltage in kV (rms)			
	a) between line terminals kV (rms) and earth (Kv rms) b) Between terminals with isolator contacts open Across the isolating distance kV (rms)			
13.	Temperature rise above ambient temperature (Deg.C)			
14.	Rated mechanical loads for horizontal break isolator			
	a).Longitudinal (N)			
	b).Transverse (N)			
15.	Operating Mechanism			
a)	Type of operating mechanism			
b)	Name of manufacturer			
c)	Whether inter-pole cabling included in scope of supply (Yes/No)			
d)	Whether separate operating mechanism provided for operation of isolator pole and earthing switch. (Yes/No)			
e)	Electrical operation			
	i) Motor type (AC/DC)			
	ii) Applicable standard			
	iii) Rated voltage and current (V, A)			
	iv) Type of enclosure and method of cooling			
	v) Power required for closing and opening operation (Watts)			

	vi) Running time of motor for closing and opening operation (Sec)			
	vii) Control supply for motor control center (Volts)			
f)	Type of manual operating mechanism for isolator pole			
g)	Whether padlocking included as per the specification (Yes/No)			
h)	Type of manual device for Earthing Switch			
16.	Operating time			
	a).Opening time (sec)			
	b).Closing time (sec)			
17.	i) Number of auxiliary contact of each isolator			
	ii) Earth Switch			NA
18.	Phase to phase spacing			
19.	Main contacts (fixed and moving)			
	a. Type			
	b. Material			
	c. Whether contacts are silver plated (Yes/No)			
	d. Thickness of silver coating (mm)			
	e. Contact area (Sq. mm)			
	f. Contact pressure (kg/sq. cm)			
	g. Current density			
	h. Number of operations which the isolator can make without deterioration of contacts. (Nos.)			

20.	D.C. Supply voltage for Interlocks			
21.	No. of terminal in control cabinet(including inter pole cabinet)			
22.	Minimum Corona extinction voltage in open and close position (kV rms)			NA
23.	Maximum RIV for frequency between 0.5 to 2 MHz in close and open position (micro volt)			NA
24.	Mechanical Endurance Class			
25.	Auxiliary contacts			
a).	Isolator			
	i) Total number of spare contacts provided for purchaser's use			
	a) NO (Nos.)			
	b) NC (Nos.)			
	ii) Rated voltage (Volts)			
	iii) Rated continuous current (Amp)			
	iv) Rated breaking current (Amp)			
b).	Earth Switch			
	i) Total number of spare contacts provided for Purchaser's use			
	a) NO (Nos.)			
	b) NC (Nos.)			
	ii) Rated voltage (Volts)			
	iii) Rated continuous current (Amp)			
	iv) Rated breaking current (Amp)			
c).	Whether arcing contacts provided and if so give type and material used. (Yes/No)			

26.	Interlocking			
a)	Details of mechanical interlock between isolator and earth switch enclosed (Yes/No)			
b)	Details of electrical interlock for isolator and earth switch enclosed(Yes/No)			
c)	Details of electrical scheme to provide remote alarm for pole discrepancy. (Yes/No)			
d)	Details of electrical interlock to bring back all three poles to open position in case any pole fails to close within specified time (Yes/No)			
e)	Details of provisions to cut off supply to the motor during manual operation and provision for declutching the motor. (Yes/No)			
f)	Arrangement provided to prevent electrical or manual operation unless interlock conditions are satisfied. (Yes/No)			
27.	a) Minimum phase to ground clearance (mm)			
	b) Minimum distance between phases when isolator is open (mm)			
28.	Terminal Clamps & Connectors			
a).	Manufacturer's name			
b).	Applicable standard			
c).	Material			
	i) Clamp body			
	ii) Bolts and nuts			

	iii) Spring washer			
	iv) Liners if any			
d).	Rated current (Amp)			
e).	Rated terminal load (Kg)			
f).	Weight of clamp complete with hardware (Kg)			
g).	Radio Interference Voltage (mV)			
h).	Corona extinction voltage (kV rms)			
29.	Total creepage distance of insulator (mm)			
30.	Cantilever strength of insulator			
31.	Control Cabinets / Marshalling box			
a).	Manufacturer's name			
b).	Thickness of sheet (mm)			
c).	Degree of protection provided			
d).	Colour of finish paint			
	i) Outside			
	ii) Inside			
e).	Control wiring			
	i) Voltage rating (Volts)			
	ii) Size and material of conductor (Sq. mm / SWG)			
f).	Terminal block			
	i) Make			
	ii) Current rating (Amp)			
g).	Space heater rating at 240 volts (Watts)			

h).	Whether all cabling for wiring out contacts to control cabinet included in scope of supply (Yes/No)			
32.	Size and Weight			
a).	Weight of each pole (Kg)			
b).	Dimension of the isolators			
	i) without earthing switch (mm x mm x mm)			
	ii) with earth switch on one side (mm x mm x mm)			
	iii) with earth switch on both sides (mm x mm x mm)			
33.	Enclosures			
	Whether the following are enclosed			
	i) Type test report for main equipment and auxiliaries (Yes/No)			
	ii) Drawings as per specification (Yes/No)			
	iii) Technical literature for isolator, operating mechanism and support insulators. (Yes/No)			

CHAPTER 5

SF6 CIRCUIT BREAKERS

Sr.No	Parameters/Standards	Guaranteed Particulars		
		220 kV	132 kV	33 kV
1.	Manufacturer's Name and Country:			
2.	Manufacturer's type designation			
3.	Applicable Technical Standards			
4.	Rated Voltage (kV rms)			
5.	Rated frequency (Hz)			
6.	Type of arc quenching medium			
7.	Number of poles			
8.	Rated normal current (A)			
9.	First pole to clear factor			
10.	Rated short circuit current breaking capacity at rated voltage (kA rms)			
11.	Rated short circuit making current (kA rms)			
12.	Rated short circuit current duration (seconds)			
13.	a) Total break time for any current upto the rated breaking current with limiting conditions of operating & quenching media pressure (ms) b) Rated break time(ms)			
14.	Closing time (ms)			
15.	Standard value of rated transient recovery voltage for terminal fault			
16.	Rated operating duty cycle			
17.	Auto reclosing			
18.	Rated insulation level			
	a) 1.2/50 micro second lightning impulse withstand voltage between line terminals and ground between terminals with contact open			
	b) One minute power frequency withstand voltage between line terminals and			

Sr.No	Parameters/Standards	Guaranteed Particulars		
		220 kV	132 kV	33 kV
	ground and ground between terminals with contact open (kV rms)			
19.	Minimum corona extinction voltage in open and close position (kV rms)			
20.	Maximum radio interference voltage for frequency between 0.5 to 2 MHz in open and close position (micro volt)			
21.	Maximum line charging current (rms)			
22.	Rated cable charging breaking current capacity (rms)			
23.	Difference in instants of closing/opening of contacts a) Within a pole(ms) b) Between poles for opening(ms) c) Between poles for closing(ms)			
24.	Maximum noise level upto 50 m distance from the base of CB (dB)			
25.	Temperature rise above ambient temperature (Deg.C)			
26.	No. of trip coils			
	Operating mechanism			
	a) Type			
	b) Charging			
	c) Max. actuating force required for manual charging of spring			
	d) Supply voltage			
	e) Permissible supply voltage variation in case of motor charging			
	a) Auxiliary Contacts			
	b) No. of Auxiliary contacts			
	c) Number of auxiliary contacts (Over and above for Control/Supervision)			
	d) Auxiliary contacts continuous current rating			

Sr.No	Parameters/Standards	Guaranteed Particulars		
		220 kV	132 kV	33 kV
	e) Auxiliary contacts breaking capacity			
27.	Minimum Creepage distance (mm)			
28.	Control circuit voltage			
29.	Circuit breaker class			
30.	CLEARANCES			
a)	Phase to Phase spacing for breaker (mm)			
b)	Phase to earth clearance (mm)			
31.	Quantity of SF6 (gas) required for 1 st filling of all 3 poles of CB at rated pressure			
32.	Rated pressure of SF6 (gas) in CB			
33.	Quantity of SF6 gas & its pressure supplied in SF6 (gas) cylinder + 20% extra			
34.	Make and type of vacuum interrupter	—	—	
35.	Short circuit rating of vacuum interrupter	—	—	
36.	Whether vacuum interrupter are Type Tested (Yes/ No)	—	—	
37.	No. of operation with full short circuit	—	—	

CHAPTER – 6

POWER TRANSFORMERS

Sr. no.	Description	Guaranteed Particulars		
		220/132 kV 100MVA AUTO TRANSFORMER	220/33 kV 25/30 MVA TRANSFORMER	132/33 kV 25/30MVA TRANSFORMER
1.	Name of the Manufacturer and Country			
2.	Governing standard			
3.	Service			
4.	Rated MVA of the Transformer Bank			
5.	a) With ONAN cooling (MVA)			
	b) With ONAF cooling (MVA)			
6.	Rated MVA of the unit			
7.	Frequency (Hz)			
8.	Cooling medium			
9.	Rated Voltage			
	a) High voltage side (kV)			
	b) Low Voltage side (kV)			
10.	Highest Continuous System Voltage :			
	a) High voltage (HV)			
	b) Low Voltage (LV)			
11.	Method of system earthing:			
	a) High voltage (HV)			
	b) Low Voltage (LV)			
12.	Type of tap changer			
13.	Range of tapping			
14.	Positive sequence impedance on rated MVA base, at rated current and frequency and at HV-LV.			
	a) Principal Tap (Ohms, pu)			
	b) Lowest tap (Ohms, pu)			

	c) Highest tap (Ohms, pu)			
15.	Zero sequence impedance at principal tap (Ohms, pu)			
16.	Leakage reactance for HV and LV (Ohms, pu)			
17.	Capacitance to earth for HV and LV (pF, pu)			
18.	Type of insulation & insulation level for winding:			
	a) Type of insulation:			
	b) One minute power frequency withstand test voltage (kV RMS)			
	c) Impulse withstand test voltage (kVp):			
19.	Winding connection			
20.	Material			
21.	Vector group:			
22.	Type of cooling			
23.	Maximum Flux Density (B_m) in core & yoke at normal voltage & frequency			
24.	Short circuit withstand capacity			
25.	Terminal details			
	a) 220 kV Termination			
	b) 132 kV Termination			
	c) 33 kV Termination			
26.	Rail a. Shorter Axis: b. Longer Axis:			
27.	Ten delta of winding			
28.	Maximum Temperature Rise for various types of cooling over an ambient of 40 deg C a) Temperature rise of top oil (Measured by Thermometer) b) Temperature rise of winding (Measured by resistance)			

29.	Limit of hot spot temperature for which the transformer is designed (Deg. C)			
30.	Overload Capacity			
31.	i. Time in minutes for which the transformer can be run at full load without exceeding the maximum permissible temperature at reference ambient temperature when :			
	ii. The fans are not in operation (minutes)			
32.	Noise Level at Rated Voltage & Frequency			
Note: The arcing distance of the busing shall be increased by 15% at all the substations to account for the high altitude as per IEC 60137-2003.				
33.	Transformer Oil Grade and reference of standard			
34.	a) Guaranteed no load losses at rated voltage, normal ratio and rated frequency at 75 Degree Centigrade average winding temperature. (kW)			
	b) State whether the losses are firm or subject to tolerance. In a case it is subject to tolerance indicate the ceiling for tolerance. (%)			
35.	a) Guaranteed load losses at rated output, rated frequency, corrected for 75 degree centigrade winding temperature for the:			
	i)Principal Tap (kW)			
	ii)Lowest tap (kW)			
	iii)Highest tap (kW)			
	b) State whether the losses are firm or subject to tolerance. In a case it is subject to tolerance indicate the ceiling for tolerance. (%)			
36.	a) Guaranteed cooler losses at rated output, normal ratio, rated voltage,			

	rated frequency at ambient temperature of 40 degree centigrade. (kW)			
	b) State whether the losses are firm or subject to tolerance. In a case it is subject to tolerance indicate the ceiling for tolerance. (%)			
37.	Withstand time for three phase short circuit at terminals (sec)			
38.	Over Excitation withstand time			
	a)125% (sec)			
	b)140% (sec)			
	c)150% (sec)			
39.	Efficiency at Unity Power Factor (UPF) and 0.85 PF (lagging)			
	a)On 100% Load (%)			
	b)On 75% Load (%)			
	c)On 50% Load (%)			
40.	Regulation at full load at expressed as a percentage of normal voltage, at			
	a)Unity power factor			
	b)0.85 power factor (Lagging)			
41.	Core data			
	a)Material for core laminations.			
	b)Thickness of laminations (mm)			
	c)Insulation between core lamination			
	d)Insulation of core bolts, washers, end plates etc.			
	e)Number of limbs of the core.			
	f)Magnetizing inrush current (mA)			
	g)No-load current at normal ratio and frequency for			
	(i) 85 Percent of rated voltage (Amp)			

	(ii) 100 Percent of rated voltage (Amp)			
	(iii) 105 Percent of rated voltage (Amp)			
42.	Core bolt insulation withstand voltage for one minute (kV)			
43.	Data on windings			
	i)Maximum current density			
	a)HV winding (A/sq. mm)			
	b)LV winding (A/sq. mm)			
	ii)Conductor material			
	a)HV winding			
	b)LV winding			
	iii)Insulating material used for			
	a)HV winding/LV Winding			
	iv)Insulating material used between			
	a)HV winding			
	b)LV winding and core			
	vi)Whether HV winding interleaved (Yes/No)			
	vii)Position of tapping on the winding			
44.	Partial discharge level (pC)			
45.	Noise level when energized at normal voltage and frequency without load (dB)			
46.	Whether the offered transformer can be transported to destination (Yes/No)			
47.	Cooling System			
	a) Make and type			
	i) Radiators			
	ii) Fans			

	b) Number of cooler banks			
	c) Number of fan/oil pump per cooler bank			
	d) Number of standby fan/oil pump			
	e) Rated power input capacity (kW)			
	f) Rated voltage (Volts)			
	g) Efficiency of motor at full load (%)			
	h) Temperature rise of motor at full load (Deg. C)			
	i) BHP of driven equipment (BHP)			
	j) Temperature range over which cooler control is adjustable (Deg. C)			
	k) Whether fan is suitable for continuous operation at 85 percent of their rated voltage (Yes/No)			
	l) Calculated time constant			
	i) Natural cooling (hours)			
	ii) Forced air cooling (hours)			
48.	On-Load tap changing Gear			
	a) Make and type			
	b) Rated current (Amp)			
	c) Rated voltage (Volts)			
	d) Number of steps (Nos.)			
	e) Step voltage (Volts)			
	f) Whether control suitable for			
	i) Remote/local operation (Yes/No)			
	ii) Auto/manual operation (Yes/No)			
	iii) Parallel operation (Yes/No)			
	g) Rated voltage of drive motor (Volts)			
	h) Rated voltage of control devices provided (Volts)			

	i) Particulars of protective devices provided			
	j) Whether control panel complete with OLTC control equipment for installation in the control room included in the scope of supply at no extra cost. (Yes/No)			
	k) Time taken to change one step (sec)			
49.	Bushings			
	a) Make and type			
	b) Rated current (Amp)			
	c) Lightning impulse withstand voltage (kV peak)			
	d) Switching surge withstand voltage (kV peak)			
	e) Power frequency withstand voltage			
	i) Wet for one minute (kV rms)			
	ii) Dry for one minute (kV rms)			
	f) Visible corona discharge voltage (kV rms)			
	g) Partial discharge level (pC)			
	h) Creepage distance in air (mm)			
	i) Free space required above the transformer tank top for removal of tank (mm)			
	j) Whether terminal connector for all bushings included in the scope of supply (Yes/No)			
	k) Whether test tap provided or not (Yes/No)			
50.	Conservator			
	a) Total volume (cu. m)			
	b) Volume between the highest and lowest visible oil levels (cu. m)			

	c) Material of air cell			
	d) Continuous temperature withstand capacity of air cell (Deg. C)			
51.	Tank			
	a) Material and thickness of plate for tank construction			
	b) Tank cover conventional or Bell type			
	c) No. of Pressure relief devices provided			
	d) Operating pressure of relief device (kN/sq. m)			
52.	Bushing Type Current Transformers			
	a) Voltage class (kV)			
	b) Number of cores			
	c) Ratio			
	d) Accuracy class			
	e) Burden			
	f) Accuracy limit factor			
	g) Maximum resistance of secondary winding			
	h) Knee point voltage			
	i) Current rating of secondaries			
53.	Vacuum withstand capacity of			
	a) Main tank (mm Hg)			
	b) Radiators and accessories (mm Hg)			
54.	Pressure withstand capacity of			
	a) Main tank (kN/sq. m)			
	b) Radiators and accessories (kN/sq. m)			
55.	Transformer Oil			
	a) Quantity of oil (Before filling & Before commissioning) (litres)			

	b) Moisture content (%)			
	c) Tan delta at 90 Degrees centigrade			
	d) Resistivity (Ohm-cm)			
	e) Breakdown strength (kV)			
	f) Interfacial tension at 20 Degree centigrade (N/m)			
	g) Quantity supplied (litres)+10% Extra			
	h) Applicable standard			
56.	Temperature Indicators			
	a) OTI			
	i)Range			
	ii)Accuracy			
	b) WTI			
	i)Range			
	ii)Accuracy			
	c) RWTI			
	i)Range			
	ii)Accuracy			
57.	Minimum clearance			
	a) HV Terminal			
	i) In oil			
	Between phases (mm)			
	Phase to ground (mm)			
	ii) In air			
	Between phases (mm)			
	Phase to ground (mm)			
	c) LV Terminal			
	i) In oil			

	Between phases (mm)			
	Phase to ground (mm)			
	ii) In air			
	Between phases (mm)			
	Phase to ground (mm)			
58.	Weights and Dimensions			
	i) Weights			
	a) Core (Kg)			
	b) Windings (Kg)			
	c) Tank (Kg)			
	d) Fittings (Kg)			
	e) Oil (Kg)			
	f) Total weights of complete transformers with oil and fittings (Kg)			
	ii) Dimensions			
	a) Overall Height above track (mm)			
	b) Overall length (mm)			
	c) Overall breadth (mm)			
	d) Minimum bay width required for installation of the transformer (mm)			
	iii) Weight of the heaviest package of the transformer arranged for transportation (Kg)			
59.	Lifting Jacks			
	a) Number of jacks included			
	b) Type and Make			
	c) Capacity (tones)			
	d) Pitch			
	e) Lift (m)			

	f)Height in close position (m)			
60.	Rail Track gauges			
	a) 2 Rails or 4 rails			
	b) Distance between adjacent rails on shorter axis (mm)			
	c) Distance between adjacent rails on longer axis (mm)			

Sr.No.	Description	Guaranteed Particulars
61.	FIRE FIGHTING EQUIPMENT	
	NIFPES	
a.	Maximum fire extinction period as commencement	
b.	Maximum period from system activation to complete cooling	
c.	Fire detector heat sensing temperature	
d.	Heat sensing area	
e.	Pre stressed non return valve setting	
f.	Minimum capacity of Nitrogen cylinder (litre)	

CHAPTER – 7

EARTHING SYSTEM

Sr. no.	Description	Units	Guaranteed Particulars		
	EARTHING MAT		220 kV	132 kV	33 kV
1.	General				
a)	Specification / Standards followed				
2.	Earthing mat data				
a)	Area under which the mat will be laid (L x W)	(m x m)			
b)	Details of switchyard earthing mat conductor				
	i) Size material and shape	(mm)			
	ii) Allowance made for corrosion	(%)			
c)	Detail of risers				
	i) Size material and shape	(Sq.mm)			
	ii) Allowance made for corrosion	(%)			
	iii) Length of conductor	(m)			
	iv) Weight	(Kg)			
d)	Details of conductor for connections to earthing points of current carrying parts				
	i) Size material and shape	(Sq.mm)			
	ii) Allowance made for corrosion	(%)			
	iii) Length of conductor	(m)			
	iv) Weight	(Kg)			
e)	Details of conductors for connection to non-				

	current carrying parts				
	i) Size material and shape	(Sq.mm)			
	ii) Allowance made for corrosion	(%)			
	iii) Length of conductor	(m)			
	iv) Weight	(Kg)			
3.	Equipment earthing electrode systems				
a)	Details of earthing system for potential transformers				
	i) Number and material of earthing electrodes	(Nos.)			
	ii) Diameter and length of electrode	(mm, mm)			
	iii) Size and material of conductors	(mm)			
b)	Details of earthing system for capacitor voltage transformers				
	i) Number and material of earthing electrodes	(Nos.)			
	ii) Diameter and length of electrode	(mm, mm)			
	iii) Size and material of conductors	(mm)			
c)	Details of earthing system for lightning arrestors				
	i) Number and material of earthing electrodes	(Nos.)			
	ii) Diameter and length of electrode	(mm, mm)			
	iii) Size and material of conductors	(mm)			
4.	Fault current for which the earthing mat is designed	(kA)			

5.	Duration of fault assumed for design	(seconds)			
6.	Duration of shock	(seconds)			
7.	Resistivity of surface layer	(Ohm-m)			
8.	Size of crushed rock and thickness of layer	(mm)			
9.	Estimated value of earthing mat resistance	(Ohms)			
10.	Estimated values of				
a)	Touch potential	(Volts)			
b)	Step potential	(Volts)			
c)	Ground potential rise	(Volts)			
d)	Transferred potential	(Volts)			
11.	Measures envisaged to be taken to limit the various potentials within safe limits, if the estimated values are found to exceed the safe limits.				
12.	Size of weld for welded joints	(mm)			
13.	Number of diameter of bolts for bolted joints	(m)			
14.	Locations where bolted joints shall be provided				
15.	Protection measures against corrosion of				
e)	Welds				
f)	Earthing mat conductors				
g)	Bolted connections				
h)	Risers and other connectors				
16.	Drawings (Attach drawings showing details of earthing mat, arrangements for				

	connections to various system, equipment fence etc., details of welds, bolted joints etc., and bill of materials as per this specification)				
17.	Tests				
18.	List of tests that the bidder will carry out				

CHAPTER – 7

LIGHTNING SYSTEM

A.	DIRECT STROKE LIGHTNING PROTECTION SYSTEM	220 kV	132 kV	33 kV
1.	General			
a)	Type of protection system			
b)	Applicable specification and standards			
2.	Lightning Masts			
a)	Number of lightning masts required for shielding the entire switchyard and transformer yard (Nos.)			
b)	Height of lightning masts (m)			
c)	Does the total mast height consists of switchyard structure and pipe fixed on the top of masts (Yes/No)			
d)	If yes, give the breakup of heights			
	i) Switchyard structure (m)			
	ii) Pipe (m)			
e)	Diameter and material of pipe and weight / unit length (mm,Kg)			
f)	Size of shield wire (mm)			
3.	Drawings (Please enclose calculations, drawing, bill of materials etc., as stipulated in this specifications)			

CHAPTER – 8

SUBSTATION AUTOMATION AND CONTROL SYSTEM

Sr. no.	Description	Guaranteed Particulars
A.	Control Panels	
1.	Manufacturer's name	
2.	Place of manufacture	
3.	Type designation & model number	
4.	Degree of Protection	
B.	Distance Relays Phase and Earth	
1.	Manufacturer's name	
2.	Place of manufacture	
3.	Type designation & model number	
4.	Phase switches (Yes/No)	
5.	Zone switched (Yes/No)	
6.	Number of zones	
	- Zone 1	
	- Zone 2	
	- Zone 3	
	Particulars	
	- Reverse looking element (blocking signal initiation)	
7.	Sensitivity	
	i) Minimum operating current	
	- Earth fault (A)	
	- Phase fault (A)	
	ii) Minimum necessary voltage at Zone 1 reach point	
	- Earth fault (V)	
	- Phase fault (V)	
	iii) Minimum Zone 1 ohmic impedance to which relay can be set	
	iv) Maximum Zone 1 ohmic impedance to which relay can be set and maintain accuracy	

	v) Minimum Zone 2 ohmic impedance to which relay can be set (ohms)	
	vi) Maximum Zone 2 ohmic impedance to which relay can be set and maintain accuracy (ohms)	
	vii) Maximum zone 3 ohmic reach	
	- Forward reach (ohms)	
	- Reserve reach (ohms)	
8.	Are forward and reverse reach setting independent of each other? (Yes/No)	
9.	Can resistance and reactance reaches be set independent of each other (Yes/No)	
10.	Directional sensitivity (V)	
11.	Back up zone range	
	- Zone 1 (sec)	
	- Zone 2 (sec)	
12.	Method used to clear close-in faults	
	i) which occur when line is already energized in service	
	ii) which exist upon line energisation	
13.	Has distance protection been previously used in the type of scheme specified for this contract? (Yes/No)	
	i) If yes, year of going into service (Years)	
	Particulars	
	ii) Year of first going into service	
	iii) Approximate number of years in service (Years)	
	(A complete reference list should be submitted stating client, system voltage and year of going into service)	
C.	Directional/Non-Directional Over-current and Earth Fault Relays	

1.	Manufacturer's name	
2.	Place of manufacture	
3.	Type designation & model number	
4.	Inverse time element	
5.	Range of current settings:	
	i) over-current (A)	
	ii) earth fault (A)	
6.	Range of operating times at highest timing setting at ten times current setting (sec)	
7.	Range of operating times at highest timing setting at twice current setting (sec)	
8.	High set instantaneous element	
9.	Range of settings:	
	- over-current (A)	
10.	Transient over-reach (%)	
	- at twice setting	
	- at ten times setting	
11.	Directional element (where applicable)	
	i) 1 x rated current	
	ii) 10 x rated current	
	Particulars (Units)	
12.	Whether directional element control the over-current protection	
13.	Reset time after removal of ten times CT rated current for:	
	i) phase element (100%) (ms)	
	ii) EF element (40%) (ms)	
D.	CB Failure Relays	
1.	Manufacturer's name	
2.	Place of manufacture	
3.	Type designation & model number	
4.	Setting of current elements:	
	i) phase fault (A)	
	ii) earth fault (A)	

5.	Timer setting (sec)	
6.	Burden of relay at minimum current setting at 10 times CT secondary rated current during:	
	i) phase fault (VA)	
	ii) earth fault (VA)	
E.	Synchronizing Check Relay	
1.	Manufacturer's name	
2.	Place of manufacture	
3.	Type designation & model number	
4.	Setting ranges	
	i) phase angles (deg)	
	ii) Voltage difference (V)	
	iii) Frequency (Hz)	
5.	Any time delays (specify function and value)	
F.	Auto-reclosing Relays	
1.	Manufacturer's name	
2.	Place of manufacture	
3.	Type designation & model number	
	Particulars (Units)	
G.	Restricted Earth Fault Relays	
1.	Manufacturer's name	
2.	Place of manufacture	
3.	Type designation & model number	
4.	Operating principle, high impedance	
5.	Minimum relay setting (A)	
6.	Sensitivity of scheme (allowing for CT magnetizing current, etc.) (A)	

7.	Maximum through fault current at which protection is stable (A)	
8.	CT requirements	
9.	Operating time at twice relay minimum setting (ms)	
10.	Operating time at ten times relay minimum setting (ms)	

CHAPTER – 9
CONTROL AND RELAY PANELS

NOT APPLICABLE

CHAPTER- 11
DIGITAL MULTIPLEX AND OPTICAL LINE TERMINATION SYSTEM (SDH)

Sr. No.	Description	Guaranteed Particulars
A.	General	
1.	Manufacturer	
2.	Place of manufacture	
3.	Model	
4.	Type of multiplexer	
5.	Complying to ITU-T rec	
6.	Transmission Capacity (Mbits/s)	
7.	Access capacity on 64 kbit/s (channel)	
8.	Access capacity on 2 Mbit/s (channel)	
9.	Redundant central processor	
10.	PDH cross connect capacity	
11.	SDH cross connect capacity	
12.	Equipment used in substation environment	
13.	The equipment is KEMA type tested or by equivalent independent international test center	
B.	Protection functionality	
1.	Multiplex Section Protection MSP	
2.	Linear Trail Protection LTP	
3.	Sub Network Connection Protection SNCP	
C.	Teleprotection functionality:	
1.	Integrated distance teleprotection functionality	
2.	Integrated optical teleprotection functionality	
3.	Addressing system for commands	
4.	Loop test for delay time	
5.	Switch-over less than 10ms	
	Description	
1.	Optical SDH aggregates (ITU-T G.957)	

2.	Based on SFP technology	
3.	Electrical SDH aggregates	
4.	Available USER INTERFACES	
	a) Voice interfaces for trunk lines:	
	i. 1 + 1 com path protection, available for all	
	ii. Analogue, 4wire with E&M: Input level Output level (dBr)	
	iii. Analogue, 2wire with E&M: Input level Output level (dBr)	
	iv. Digital, 2Mbit/s CAS or PRI	
	b) Voice interfaces for remote subscriber:	
	i. 2wire, subscriber side (dBr)	
	ii. Minimal number of subscriber	
	iii. 2wire, PABX side (dBr)	
	iv. Minimal number of PABX	
5.	Integrated teleprotection	
	a) Interface for Commands:	
	i. Number of independent commands	
	ii. Transmission time max. (ms)	
	iii. Signal voltage (Vpeak)	
	iv. 1 + 1 com path protection	
6.	b) Interface(s) for Differential Protection:	
7.	i. Electrical interface: G.703 (kbits/sec)	
8.	ii. Optical Interface (k bits/sec)	
	Description	
1.	Data: channels per module	
	i. 1 + 1 com path protection, available for all	
	ii. V.24/V.28 (RS-232): up to 38.4kbit/s	
	iii. V.11/X.24 (RS-422): 64kbit/s	
	iv. V.35: 64kbit/s	
	v. G.703: 64kbit/s	
	vi. Ethernet: 10/100BaseT	
	vii. Ethernet: WAN capacity (Mbits/sec)	

	viii. Ethernet: Logical WAN ports	
	ix. Ethernet: GFP (acc. ITU-T G.7041)	
	x. Ethernet: VCAT (acc. ITU-T G.707)	
	xi. Ethernet: LCAS (acc. ITU-T G.7043)	
	xii. Ethernet: Routing protocols	
	xiii. Ethernet: WAN capacity	
	xiv. Integrated Ethernet Hub 10/100BaseT	
2.	Type/Name of configuration tool	
	i. For local / remote operation	
	ii. Data communication network (DCN)	
	iii. Integrated Management of Teleprotection Commands	
	Description	
1.	Network Management System	
2.	Type/Name of configuration tool	
	i. For fault / configuration management	
	ii. Data communication network (DCN)	
	iii. Integrated Management of Teleprotection Commands	
3.	Ambient Conditions:	
	i. Storage: ETS 300 019-1-1, class 1.2 (°C / % hum)	
	ii. Transport: ETS 300 019-1-2, class 2.2 (°C / % hum)	
	iii. Operation: ETS 300 019-1-3, class 3.1E For operational applications (°C / % hum)	
4.	Power Supply	
	i. Operation (V, DC)	
	ii. Fully redundant power supply	
	iii. Dual power feeder	
5.	Emission of the equipment (substation environment)	
	i. Test Name : Radiated radio frequency interference	
	ii. Description : 30 MHz to 1 GHz	

	iii. Basic standard: EN 55022	
	iv. Test Name : Conducted radio frequency interference AC/DC Power supply	
	v. Description : 150 kHz to 30 MHz	
	vi. Basic standard: EN 55022	
6.	Immunity of the equipment (substation environment)	
	i. Test Name : ESD test	
	Description : Contact/air discharge	
	Basic standard: IEC 61000-4-2	
	ii. Test Name : Radiated electromagnetic field	
	Description : 80 to 1000 MHz, 80% AM, 1 kHz modulated	
	Basic standard: IEC 61000-4-3	
	iii. Test Name : Radiated electromagnetic field	
	Description : 1.0 to 2.5 GHz, 80% AM, 1 kHz modulated	
	Basic standard: IEC 61000-4-3	
	iv. Test Name : Fast transient test	
	Description : AC/DC Power supply all other ports:	
	Basic standard: IEC 61000-4-4	
	v. Test Name : Surge test (1.2/50 ms)	
	Description :	
	<i>AC/DC Power supply:</i>	
	Common mode	
	Differential mode	
	<i>DC Power supply 48 V:</i>	
	Common mode	
	Differential mode	
	<i>Signal terminals:</i>	
	Common mode	
	Differential mode	
	<i>Telecommunication ports:</i>	
	Common mode	

	Basic standard: IEC 61000-4-5	
vi.	Test Name : Conducted radio frequency interference	
	Description : 0.15 to 80 MHz, 80% AM, 1 kHz modulated	
	Basic standard: IEC 61000-4-6	
vii.	Test Name : Power frequency magnetic field	
	Description : Continuous	
	Short (1 to 3 s)	
	Basic standard: IEC 61000-4-8	
viii.	Test Name : Damped oscillatory waves	
	Description :	
	AC/DC Power supply:	
	Common mode	
	Differential mode	
	Signal terminals:	
	Common mode	
	Differential mode	
	Telecommunication ports:	
	Common mode	
	1 MHz, 400 Hz repetition rate, 2 s burst duration	
	Basic standard: IEC 61000-4-12	
ix.	Test Name : Conducted common mode disturbance	
	Description : Frequency 50 Hz, continuous mode	
	Basic standard: IEC 61000-4-16	

CHAPTER 12

AC/DC DISTRIBUTION BOARD

Sr.No.	Description	Guaranteed Particulars	
		ACDB	DCDB
I.	GENERAL		
	1. Voltage (volts)		
	2. Frequency (Hz)		
	3. Combined variation in voltage & frequency		
	4. Symmetrical short circuit withstand current of switchgear cubicle		
	5. Degree of protection as per IS: 13947		
	a. Breaker / AC & DC distribution cubicles.		
	b. Bus bar chamber.		
	6. Cubicle sheet metal thickness for front, rear, sides and top. (mm)		
	7. Painting shade as per IS:5		
	a. External surface		
	b. Internal surface		
	8. Standard height, width & depth of typical panel.		
	a. Switch fuse cubicle. (mm)		
	b. AC/DC Distribution Board (mm)		
	9. Width of cable alley (mm)		
	10. Earth bus bar size and material. (mm x mm)		
	11. Approximate weight of AC/DC Distribution Board. (Kg)		
	12. Is extension possible in future. (Yes/No)		
	13. Clearance in air		
	a. Between phases (mm)		
	b. Between phase and earth(mm)		

	14. Fault level (kA)		
II.	BUS BAR		
	1. Continuous		
	2. Short time (1 Sec)		
	3. Bare/Painted/Epoxy insulated/Sleeved		
	4. Minimum clearance		
	5. Phase to phase (mm)		
	6. Phase to earth (mm)		
	7. Continuous current rating at ambient temperature (Deg. C)		
	8. Minimum Cross section and material provided for		
	a. Horizontal bus bar (sq. mm)		
	b. Vertical bus bar (sq. mm)		
	9. Short time current rating for 1 sec. (kArms)		
	10. Material of the support insulators.		
	11. Temperature rise over ambient temperature for continuous current rating (Deg. C)		
	12. Whether bus joints are silver faced (Yes / No)		
13. Dynamic current withstand rating (kApeak)			
III.	ONE MINUTE POWER FREQUENCY WITHSTAND VOLTAGE		
	a. Power circuits		
	b. Control circuits		
IV.	MOULDED CASE CIRCUIT BREAKER		
	1. Name of manufacturer and country		
	2. Applicable standard		
	3. Rated voltage (kV)		

	4. Rated current at design ambient temperature (Amps)		
	5. Continuous current at site ambient temperature. (Amps)		
	6. Rated making current (kA)		
	7. Short time current rating (kA, sec)		
	8. Temperature rise of main contacts when carrying continuous current (Deg. C) above ambient temperature		
	9. Number of operations circuit breaker can make without inspection replacement of contacts or other parts at 100% rated breaking current.		
	10. a) Number of auxiliary contacts provided and their rating. (Amps)		
	b) Total operating time (ms)		
	c) Whether trip free or fixed trip type		
	11. Operating mechanism (for ACB only.)		
	a. Motor rating (V, A, Watts)		
	b. Time for fully charging the closing spring (Sec)		
	c. Emergency manual charging facility provided (Yes/ No)		
	d. Limits of voltage for satisfactory operation of following devices, as percentage of normal voltage.		
	i) Motor (%)		
	ii) Closing Coil (%)		
	12. Air break switches		
	a. Type, make		
	b. Rated current (Amps)		
	c. Applicable standard		
	d. Rated making and breaking capacity (kA)		
	13. Fuses		
	a. Make		
	b. Type		

	c. Rupturing capacity (kA)		
	d. Peak cut-off current (kA)		
	e. Whether mounted on insulated carrier (Yes/ No)		
	14. Rated operating Duty		
V.	CURRENT TRANSFORMERS		
	1. Manufacturer's Name		
	2. Applicable standard		
	3. Ratio		
	4. Rated output		
	5. Accuracy class		
	6. Instrument Security Factor (ISF).		
	7. Insulation level (kV rms)		
	8. Nominal rated voltage (kV)		
	9. Short time thermal rating for 1 sec. (kA rms)		
	10. Type		
	11. Secondary circuit		
	12. Voltage class and Frequency		
	13. Accuracy		
	i. Accuracy class metering CT		
	ii. Accuracy class protection CT		
14. Short time current rating			
15. one minute power frequency withstand voltage			
VI.	VOLTAGE TRANSFORMERS		
	1. Manufacturer's Name		
	2. Applicable standard		
	3. Type		
	4. Rated voltage		
	a. Primary		
	b. Secondary		
5. Accuracy class and VA burden			

	a. Metering		
	b. Protection		
	6. Method of connection		
	a. Primary		
	b. Secondary		
	7. Rated voltage factor		
	8. Class of insulation		
	9. One minute power frequency withstand voltage		
	10. Rated primary voltage (volts)		
	11. Rated Secondary voltage (volts)		
	12. Accuracy class		
	13. Insulation level (kV rms)		
	14. Rated Burden (VA)		
	15. Over voltage factor		
VII.	RELAY		
	1. One minute power frequency withstand voltage		
	2. Make		
	3. Type		
	4. Application		
	5. Operating principle		
	6. Coil burden (VA)		
	7. Setting range (%)		
	8. Number of contacts (Nos.)		
	9. Contact rating (V, A, AC/DC)		
	10. Contacts - (self reset or hand reset)		
	11. Operation indicator provided (Yes/No)		
	12. Time of operation (ms)		

VIII.	CUBICLE COLOUR FINISH		
	a. Interior		
	b. Exterior		
IX.	ACCESSORIES		
	a. Plug point with switch fuse.		
	b. Space heater with thermostat		
	c. Name plate on front of rear		
	d. Danger plate		
X.	CONTACTORS		
	1. Make		
	2. Type and applicable standard		
	3. No. of poles (Nos.)		
	4. Rated voltage of main and auxiliary contacts. (volts)		
	5. Limits of operation		
	a. Supply voltage variation (+/-%)		
	b. Supply frequency variation for closing. (+/-%)		
	c. Drop out voltage (volts)		
	6. Rated breaking capacity (kA)		
	7. Rated making capacity (kA)		
	8. Rated thermal current (kA)		
	9. Rated voltage of coils (volts)		
	XI.	AUXILIARY CONTACTOR	
1. Make			
2. Type			
3. Coil voltage (volts)			
4. Coil burden (VA)			
5. No. of contacts and their rating (V, A, AC/DC)			
	CONTROL / SELECTOR SWITCH		

	1. Make		
	2. Type		
	3. Type of handle		
	4. Number of contacts (Nos.)		
	5. Rating of contacts (V, A, AC/DC)		
	6. No. of positions (Nos.)		
	7. Contact material and plating		
XIII.	PUSH BUTTONS		
	1. Make		
	2. Contact type		
	3. Number of contacts (NO+ NC)		
	4. Contact rating		
XIV.	SPACE HEATERS		
	1. Make		
	2. Type		
	3. Rated Voltage		
	4. Thermostat setting range		
	5. Heater output		
XV.	WIRING AND TERMINAL BLOCKS		
	1. Voltage grade of wires (Volts)		
	2. Minimum size of conductor for		
	a. Power wiring (sq. mm)		
	b. Control wiring (sq. mm)		
	3. Type of control terminal block on		
	a. Fixed portion and draw out portion		
	b. Switchgear and breaker		
	4. Make and type of terminal blocks		
	5. Current rating of terminal blocks (Amp)		
	6. Insulation of wires		
7. Conductor material			

XVI.	INDICATING LAMPS			
	1. Make			
	2. Type			
	3. Voltage (volts)			
	4. Series resistor value and rating(Ohms, Amp)			
XVII.	INDICATING INSTRUMENTS			
	1. Voltmeter			
	a. Make			
	b. Type			
	c. Accuracy class			
	d. Voltage coil rating (volts)			
	e. Voltage coil burden (VA)			
	f. Case size (mm x mm)			
	2. Ammeter			
	a. Make			
	b. Type			
	c. Accuracy class			
	d. Current coil rating (Amp)			
	e. Current coil burden (VA)			
	f. Case size (mm x mm)			
	VIII.	ENCLOSURES		
1. Whether all the drawings as indicated in the specification enclosed. (Yes/No)				
2. Whether characteristics of various types of relays for MCCB enclosed. (Yes/No)				
3. Whether calculations furnished in support of adequacy of bus bar size (AC bus/DC bus) for specified current rating. (Yes/No)				

XIX.	Miniature circuit breaker		
	1. Manufacturer's name and country of manufacture.		
	2. Type		
	3. Rated voltage (volts)		
	4. No. of poles (Nos.)		
	5. Frequency (Hz)		
	6. Current rating (Amp)		
	a) Continuous at 50 Deg. C ambient temperature (Amp)		
	b) 1 sec. (kA rms)		
	7. Breaking capacity		
	8. Terminal suitable for cable size (sq. mm)		
	9. Upto what fault current discrimination between incomer fuse & MCB will be obtained? (kA)		
	10. Standards to which Miniature Circuit Breaker conforms		

CHAPTER 13

DC BATTERY & BATTERY CHARGER

DC BATTERY:

Sr.No.	Description	Guaranteed Particulars	
		For Station Battery	For Communication
1.	Manufacturer's Name and Country		
2.	Applicable standard		
3.	Cell designation		
4.	Type		
5.	Ambient temperature		
	i. Max.		
	ii. Min.		
	iii. No. of cells		
	iv. Rated voltage		
6.	Capacity of the one hour discharge rate to end voltage V/cell at 27° C		
7.	Float voltage		
8.	Optimum float voltage		
9.	Boost voltage		
10.	Ampere-hour efficiency		
11.	Watt-hour efficiency		
12.	Self-discharge		
13.	Life		
14.	Plates:		
	i. Type of positive plate		
	ii. Type of negative plate		
	iii. Number of plates per cell (Nos.)		
15.	a) Thickness, type and material of separators (mm)		
	b) Type of vent plug		
16.	a) Type of container		
	b) Material of container		
17.	Open Circuit Voltage of each cell when completely discharged at 27 Deg. C		
	i. At 10-hour discharge rate (Volts)		
	ii. At one-hour discharge rate (Volts)		

18.	a) Trickle charging voltage range (Volts)		
	b) Trickle charging current (Amps)		
19.	Recommended Trickle charging voltage per cell and maximum variation. (Volts, %)		
20.	Voltage per cell at the end of trickle charging. (Volts)		
21.	Boost charging voltage range (Volts)		
22.	Recommended boost charging rate at starting and finishing		
23.	Voltage per cell at the end of boost charging and time taken for boost charging. (Volts, Hr)		
24.	Capacity of battery at		
	i. Ten hour discharge rate to 1.14 V per cell at 27 Deg. C (AH)		
	ii. One hour discharge rate to 1.14 V per cell at 27 Deg. C (AH)		
25.	Internal resistance of each cell.		
	i. Fully charged (Ohms)		
	ii. Fully discharged (Ohms)		
26.	Quantity and specific gravity of electrolyte for cell required for first filling at 27 Deg. C (Litres)		
27.	Specific gravity of electrolyte of fully charged cell at 27 Deg. C		
28.	Maximum electrolyte temperature that cell shall withstand continuously without affecting the service life of cell. (Deg. C)		
29.	Average life of cell in years. (Years)		
30.	Overall dimension of each cell (mm x mm x mm)		
31.	Distance between the centres of cell when erected. (mm)		
32.	Weight of cell complete with electrolyte. (Kg)		
33.	Size and material of connectors with method of connection cells. (mm)		
34.	Recommended period of storage before first charging. (hr)		
35.	Size of cable recommended for		

	connections of battery-to-battery charger, DC distribution board. (sq. mm)		
36.	Insulator material for rack and cells.		
37.	Battery racks		
	i. Type of material		
	ii. Whether anti-acid coating provided (Yes/No)		
	iii. Net weight (Kg)		
38.	Short circuit current at battery terminals. (Amps)		
39.	Recommended maximum rating of fuse for protection of battery. (Amps)		
40.	Time for which the battery can withstand short circuit at terminals (Sec)		
41.	Recommended interval at which battery should be discharged at 10 hour discharge rate and boost charged.		
42.	AH efficiency (%)		
43.	WH efficiency (%)		
44.	Equalizer charging current and frequency of equalizing charge recommended (Amp, Hz)		
45.	During initial charging		
	i. Recommended starting rate of charge		
	ii. Recommended finishing rate of charge		
	iii. Voltage of cell at the end of charge at finishing rate (volts)		
46.	Enclosures		
	i. Whether all the drawings and technical literature of Battery enclosed (Yes/No)		
	ii. Whether type test reports enclosed (Yes/No)		

BATTERY CHARGER

Sr.No.	Description	Guaranteed Particulars
		Float-cum-Boost Charger
1.	Manufacturer's Name and Country.	
2.	Charger rated output current (Amp)	
3.	Charger rated output voltage (Volts)	
4.	Rectifier assembly	
	a. Type of semi conductor material.	
	b. Rated direct current (Amp)	
	c. Rated direct voltage (Volts)	
	d. Continuous rating (Amp)	
	e. Rated input voltage (Volts)	
	f. Type of connection of rectifier elements (Full wave half/full controlled bridge)	
	g. Maximum temperature rise over ambient of 50 Deg. C outside (Deg. C)	
	h. Overload capacity. (%)	
	i. Applicable standard.	
5.	Type	
6.	A.C. Input	
	a. Supply	
	b. Frequency	
	c. Input voltage variation	
	d. Frequency variation	
	e. Combined voltage & frequency variation	
	f. System Earthing	
7.	D.C. Output	
	a. Continuous D.C. load	
	b. Output voltage range	
	c. For D.C. load variation from 0 to 100% output Voltage stable within	
	d. Continuous Current settings	

	e. Ripple content	
8.	AC input /DC output	
9.	Load limiter current setting range for float charger (Amp, %)	
10.	Automatic voltage regulator (Float/Boost charger).	
	a. Type	
	b. Percentage stabilization of the output DC voltage. (%)	
	c. Voltage setting range. (Volts, %)	
	d. Response time. (ms)	
11.	Manual voltage regulator (Float/Boost charger).	
	a. Type	
	b. Voltage setting range.	
12.	a) Boost charging current setting range (Amp, %)	
	b) Boost charging voltage limit setting range. (Volts, %)	
13.	Rectifier transformer	
	a. Type	
	b. Rated kVA and % impedance (kVA, %)	
	c. Turns ratio	
	d. Class of insulation.	
	e. One minute power frequency withstand voltage. (kV rms)	
	f. Over load capacity (%)	
	g. Applicable standard	
	h. Whether short circuit test has been conducted. (Yes/No)	
14.	Instruments	
	a. Type	
	b. DC voltmeter range (Volts)	
	c. DC Ammeter range (Amp)	
	d. Accuracy class as per IS	

	e. Dial size (mm x mm)	
15.	Contactor	
	a. Type	
	b. Rated voltage (Volts)	
	c. Rated current (Amp)	
	d. No. of Power contacts	
	e. Number, type and rating of auxiliary contacts (V, A, AC/DC)	
	f. Operating coil voltage (Volts)	
	g. Dropout voltage (Volts)	
16.	Thermal over load relay	
	a. Tripping current range (Amp)	
	b. Whether single phasing protection provided (Yes/No)	
	c. Applicable standard	
17.	Air break switches.	
	a. Type	
	b. Rated voltage (Volts)	
	c. Rated current (Amp)	
	d. Type and material of contacts	
	e. Applicable Standards	
	f. Maximum through fault current withstand (kA)	
	g. Rated making and breaking capacity (kA)	
18.	Fuses	
	a. Type	
	b. Rupturing capacity (kA)	
19.	Blocking diode	
	a. Continuous rating (Amp)	
	b. Peak inverse voltage (Volts)	

20.	Ripple content in DC output	
21.	Guaranteed efficiency at rated load (%)	
22.	Whether chargers provided with following features	
	a. Automatic voltage regulators (Yes/No)	
	b. Automatic current regulators (Yes/No)	
	c. Soft start feature (Yes/No)	
	d. Smoothing resistor/capacitor filter circuit (Yes/No)	
	e. Selector switch for automatic and manual mode of operation (Yes/No)	
	f. Load linking circuitry (Yes/No)	
	g. Necessary RC network for protection of rectifier elements. (Yes/No)	
23.	Enclosure :	
	a. Whether all the drawings and technical literature for chargers enclosed (Yes/No)	
	b. Whether type test reports enclosed. (Yes/No)	

CHAPTER – 14
POWER AND CONTROL CABLES

Sr. no.	Description	Guaranteed Particulars
A.	POWER CABLE	
1.	Name of the manufacturer and country.	
2.	Applicable standard	
3.	Cable type designation	
4.	Voltage rating (volts)	
5.	Conductor	
a.	Material of conductor and flexibility class as per IS:8130	
b.	Size of conductor (sq. mm)	
c.	Is conductor stranded (Yes/No)	
d.	Stranded conductor	
	i) Number of strands in each core	
	ii) Size of strand (sq. mm)	
	iii) Maximum DC resistance at 20 deg C (Ohms) / Km	
6.	Number of cores	
7.	Insulation	
a.	Insulation material and type designation	
b.	Minimum thickness of insulation (mm)	
c.	Tolerance on the measured value of thickness (%)	
d.	Minimum volume resistivity at 27 deg. C, 70 deg. C and 90 deg. C (Ohm-cm)	
8.	Sheath	
a.	Material for inner sheath, type of sheathing (extruded or wrapped) and type designation as per IS:5831.	
b.	Material for outer sheath, type of sheathing (extruded or wrapped) and type designation as per IS:5831.	

c.	Thickness of inner sheath and tolerance on measured value. (mm, %)	
d.	Thickness of outer sheath and tolerance on measured values. (mm, %)	
9.	Armour	
a.	Material	
b.	Shape	
c.	Dimension (mm)	
10.	a) Overall diameter of cable (mm)	
	b) Tolerance on diameter (%)	
11.	a) Minimum tensile strength of insulation (kg/sq. cm)	
	b) Minimum elongation at break. (%)	
12.	a) Minimum tensile strength of sheath.(kg/sq. cm)	
	b) Minimum elongation at break (%)	
13.	a) Tensile strength of the armour (kg/sq. cm)	
	b) Elongation after break (%)	
14.	High voltage test and duration (PVC cables)	
a.	At room temperature (kV, mins.)	
b.	Under water (kV, mins.)	
15.	XLPE cable	
a.	High voltage test (kV, mins.)	
b.	Short circuit current rating (kA, Secs)	
c.	Short circuit current rating for armour (kA, Secs)	
16.	a) Current carrying capacity in air and corresponding assumptions/conditions of installation (Amp)	
	b) Current carrying capacity under following conditions:	
	i) Ambient temperature of 50 Deg. C (Amp)	
	ii) Cable laid in covered cable trenches (Amp)	
	iii) 3 to 4 cable trays / racks in trench . (Amp)	
	iv) 5 to 6 cables per tray and touching each other. (Amp)	

17.	Insulation resistance at 27 Deg. C (Ohm/km)	
18.	Capacitive reactance per Km. (Ohm/km)	
19.	Inductive reactance per Km. (Ohm/km)	
20.	Minimum bending radius. (mm)	
21.	Short circuit current rating for 1 sec. for PVC cable. (kA)	
22.	Conductor temperature rise during	
a.	Normal operation (Deg. C)	
b.	Short circuit (Deg. C)	
23.	Weight of cable per Km (Kg/km)	
24.	a) Standard length of cable per drum (m)	
	b) Tolerance on length of cable per drum (%)	
25.	Net weight of drum length of cable (approx.) (Kg)	
26.	Method of core identification for	
a.	Cable upto five cores	
b.	Cable with more than five cores	
27.	Please indicate writing YES or NO whether the following tests have been carried out.	
	i) Ageing test (Yes/No)	
	ii) Loss of mass test (Yes/No)	
	iii) Cold impact test (Yes/No)	
	iv) Heat shock test (Yes/No)	
	v) LV & Tertiary winding (Yes/No)	
	vi) Oxygen index test and temperature index test as per ASTM D-2863. (Yes/No)	
	vii) Fire retardant test (Yes/No)	
28.	Whether technical literature enclosed (Yes/No)	
29.	Whether tables giving rating factors for variation in standard conditions of installation enclosed (Yes/No)	
30.	Whether relevant drawings enclosed (Yes/No)	

B.	CONTROL CABLE	
1.	Name of the manufacturer and country.	
2.	Applicable standard	
3.	Cable type designation	
4.	Voltage rating (volts)	
5.	Conductor	
a.	Material of conductor and flexibility class as per IS:8130	
b.	Size of conductor (sq. mm)	
c.	Is conductor stranded (Yes/No)	
d.	Stranded conductor	
	i) Number of strands in each core	
	ii) Size of strand (sq. mm)	
	iii) Maximum DC resistance at 20 deg C (Ohms) / Km	
6.	Number of cores	
7.	Insulation	
a.	Insulation material and type designation	
b.	Minimum thickness of insulation (mm)	
c.	Tolerance on the measured value of thickness (%)	
d.	Minimum volume resistivity at 27 deg. C, 70 deg. C and 90 deg. C (Ohm-cm)	
8.	Sheath	
a.	Material for inner sheath, type of sheathing (extruded or wrapped) and type designation as per IS:5831.	
b.	Material for outer sheath, type of sheathing (extruded or wrapped) and type designation as per IS:5831.	
c.	Thickness of inner sheath and tolerance on measured value. (mm, %)	
d.	Thickness of outer sheath and tolerance on measured values. (mm, %)	
9.	Armour	
a.	Material	

b.	Shape	
c.	Dimension (mm)	
10.	a) Overall diameter of cable (mm)	
	b) Tolerance on diameter (%)	
11.	a) Minimum tensile strength of insulation (kg/sq. cm)	
	b) Minimum elongation at break. (%)	
12.	a) Minimum tensile strength of sheath.(kg/sq. cm)	
	b) Minimum elongation at break (%)	
13.	a) Tensile strength of the armour (kg/sq. cm)	
	b) Elongation after break (%)	
14.	High voltage test and duration (PVC cables)	
a.	At room temperature (kV, mins.)	
b.	Under water (kV, mins.)	
15.	XLPE cable	
a.	High voltage test (kV, mins.)	
b.	Short circuit current rating (kA, Secs)	
c.	Short circuit current rating for armour (kA, Secs)	
16.	a) Current carrying capacity in air and corresponding assumptions/conditions of installation (Amp)	
	b) Current carrying capacity under following conditions:	
	i) Ambient temperature of 50 Deg. C (Amp)	
	ii) Cable laid in covered cable trenches (Amp)	
	iii) 3 to 4 cable trays / racks in trench . (Amp)	
	iv) 5 to 6 cables per tray and touching each other. (Amp)	
17.	Insulation resistance at 27 Deg. C (Ohm/km)	
18.	Capacitive reactance per Km. (Ohm/km)	
19.	Inductive reactance per Km. (Ohm/km)	
20.	Minimum bending radius. (mm)	
21.	Short circuit current rating for 1 sec. for PVC	

	cable. (kA)	
22.	Conductor temperature rise during	
a.	Normal operation (Deg. C)	
b.	Short circuit (Deg. C)	
23.	Weight of cable per Km (Kg/km)	
24.	a) Standard length of cable per drum (m)	
	b) Tolerance on length of cable per drum (%)	
25.	Net weight of drum length of cable (Kg)	
26.	Method of core identification for	
a.	Cable upto five cores	
b.	Cable with more than five cores	
27.	Please indicate writing YES or NO whether the following tests have been carried out.	
	i) Ageing test (Yes/No)	
	ii) Loss of mass test (Yes/No)	
	iii) Cold bend test (Yes/No)	
	iv) Heat shock test (Yes/No)	
	v) Thermal stability as per IEC-540 (Yes/No)	
	vi) Rodent and termite proof test (Yes/No)	
28.	Enclosures	
a.	Whether tables giving rating factors for variation in standard conditions of installation enclosed (Yes/No)	
b.	Whether relevant drawings enclosed (Yes/No)	

CHAPTER 15

LIGHTING SYSTEM

Sr.No.	Description	Guaranteed Particulars
A.	General	
1.	Supply voltage (volts)	
2.	Frequency (Hz)	
3.	Variation of voltage	
4.	Variation of frequency	
5.	Combined voltage & frequency variation	
6.	Type of internal lighting wires	
7.	Conduit	
8.	Earthing wire	
	i. Material	
	ii. Size	
	iii. Light Points	
	iv. Power Points	
9.	Temperature rise	
B.	Lighting fixtures & Accessories	
1.	Manufacturer's name	
a.	Fixtures	
b.	Accessories	
2.	Country of manufacturer for	
a.	Fixtures	
b.	Accessories	
3.	Applicable standards for	
a.	Fixtures	
b.	Accessories	
4.	Manufacturer's type and catalogue no. for	
5.	Nominal working voltage (Volts)	
6.	Maximum permissible supply voltage variation for satisfactory operation of	
a.	Fixtures	

b.	Accessories	
7.	Average life expectancy of	
a.	Ballast (hours)	
b.	Capacitors (hours)	
c.	Lamps (hours)	
8.	Lamp output at the design temperature	
a.	After 100 burning hours (Lumens)	
b.	After 1000 burning hours (Lumens)	
9.	Lamp output at the end of the expected life period (Lumens)	
10.	Average light output of the fitting as a percentage of lamp output.	
a.	Downwards (%)	
b.	Upwards (%)	
11.	Beam angle for flood lights in	
a.	Horizontal plane (Degrees)	
b.	Vertical plane (Degrees)	
12.	a) Cable/conduit entry size (mm)	
	b) Size and type of cable (sq. mm)	
13.	Earthing terminal	
a.	Material	
b.	Suitable for earthing conductor of size (mm x mm)	
14.	Weights of fixtures (Kg)	
15.	Reference catalogue No.	
C.	Receptacles and Switches	
1.	Manufacturer's name and country of manufacture.	
2.	Manufacturer's type designation.	
3.	Voltage grade (Volts)	
4.	Current rating at specified ambient temperature of 50 Degrees C	
5.	Applicable standards	
6.	Whether descriptive pamphlet is enclosed?	

	(Yes/No)	
D.	Lighting control switches	
1.	Manufacturer's name and country of manufacture.	
2.	Manufacturer's type designation.	
3.	Voltage (Volts)	
4.	Current rating at specified ambient temperature of 50 Deg. C	
5.	Applicable standards	
6.	Whether descriptive pamphlet is enclosed? (Yes/No)	
E.	Conduits & Accessories	
1.	Manufacturer's type designation.	
2.	Applicable standards	
F.	Junction Boxes	
1.	Manufacturer's type designation.	
2.	Terminals	
a.	Make	
b.	Current rating (Amp)	
c.	Voltage rating (Volts)	
d.	Stud type (Yes/No)	
e.	Complete with insulated barriers (Yes/No)	
3.	Whether descriptive pamphlet is enclosed? (Yes/No)	
G.	Boxes	
1.	Manufacturer's name and country of manufacture.	
2.	Manufacturer's type designation.	
3.	Material specification	
4.	Type of enclosure	

5.	Whether descriptive pamphlet is enclosed (Yes/No)	
H.	Lighting Panels	
	(a) General	
1.	Manufacturer's name and country of manufacture.	
2.	Indoor/outdoor application	
3.	Design ambient air temperature (Deg. C)	
4.	Thickness of sheet steel (mm)	
5.	Degree of protection provided (as per IS: 13947 or equivalent)	
6.	Bill of material for various equipment giving make, type rating etc. enclosed. (Yes/No)	
7.	Colour of finish paint	
i.	Outside	
ii.	Inside	
8.	Bus bars	
i.	Material	
ii.	Temperature rise at rated current over specified ambient	
iii.	Continuous current rating at 50 deg. C ambient temperature	
iv.	Whether suitable for one second current rating of 20 kA (AC) or 5 kA (DC) as applicable (Yes/No)	
v.	Cross section	
vi.	Application standard	
9.	Control wiring	
i.	Material of conductor	
ii.	Size of conductor/dia of wire (mm)	
10.	Conductor – (Solid / Stranded.)	
11.	Terminal blocks	
i.	Make	
ii.	Current Rating	

	(a) Power terminal (Amps)	
	(b) Other terminal (Amps)	
	(b) Air Break Switches	
1.	Manufacturer's name and country of manufacture.	
2.	Manufacturer's type description	
3.	Applicable standard	
4.	Rated voltage & frequency (Volts, Hz)	
5.	Rated current (Amps)	
6.	Rated breaking current (Amps)	
7.	Maximum through fault current withstand, derating factor for use under site ambient conditions (Amps)	
8.	Temperature rise of contacts when carrying continuous rated current under site conditions. (Deg. C)	
	(c) Fuses	
1.	Manufacturer's name and country of manufacture.	
2.	Manufacturer's type description	
3.	Applicable standard	
4.	Rated voltage (Volts)	
5.	Rated current (Amp)	
6.	Whether fuse is mounted in an insulated carrier (Yes/No)	
7.	Whether fuse carrier has an aperture for fuse failure indication. (Yes/No)	
8.	Category of duty (IS:2208)	
9.	Rupturing capacities (Prospective current) (kA)	
10.	Maximum let through current for 1 sec. (kA)	
11.	Whether time/current characteristics are enclosed? (Yes/No)	
	(d) Miniature circuit breaker	
1.	Manufacturer's name and country of	

	manufacture.	
2.	Type	
3.	Rated voltage (Volts)	
4.	No. of poles (Nos.)	
5.	Frequency (Hz)	
6.	Current rating (Amp)	
	a) Continuous at 50 Deg. C ambient temperature (Amp)	
	b) 1 sec. (kA rms)	
7.	Breaking capacity	
8.	Total interrupting time (Cycle)	
9.	Type of overload (terminal/magnetic)	
10.	Terminal suitable for cable size (sq. mm)	
11.	Upto what fault current discrimination between incomer fuse & MCB will be obtained? (kA)	
12.	Standards to which Miniature Circuit Breaker conforms	
	(e) Contactors (For each type DC/AC)	
1.	Manufacturer's name and country of manufacture.	
2.	Rated voltage & permissible variation (Volts,%)	
3.	Rated burden (VA)	
4.	Rated current (thermal) of main contacts (Amp)	
5.	No. & type of Aux. Contacts (if any)	
6.	Rated voltage of coil (Volts)	
7.	Pick up voltage (Volts)	
8.	Rated duty class	
9.	Drop off voltage (Volts)	
10.	Applicable standard	
	(f) Emergency portable lighting fixture	
1.	Manufacturer's name	

2.	Country of manufacture	
3.	Applicable standards	
4.	Manufacturer's type & catalogue no.	
5.	Nominal working voltage (Volts)	
6.	Rated duration for providing useful luminous output (hours)	
7.	Lamp wattage (Watts)	
8.	Battery capacity (AH)	
9.	Battery voltage (Volts)	
10.	Bulb voltage (Volts)	
11.	Whether rectifier circuits are solid state (Yes/No)	
12.	Type of charging device used	
13.	Time interval required for charging (hours)	
14.	Whether tropicalised (Yes/No)	
15.	Weight of unit without batteries (Kg)	
16.	Weight of battery (Kg)	
17.	Make of battery	
18.	Expected life of fixture (hours)	
19.	Whether descriptive pamphlets are enclosed? (Yes/No)	
	(g) Street Lighting Poles	
1.	Manufacturer's name and country of manufacture.	
2.	Applicable standard	
3.	Whether sketch and descriptive pamphlet is enclosed? (Yes/No)	
	(h) Lighting Wires	
1.	Manufacturer's name and country of manufacture.	
2.	Standard applicable	
3.	Rated voltage (Volts)	
4.	Continuous current rating when laid in conduit in ambient condition (Amp)	

5.	Conductor	
i.	Material	
ii.	Nominal cross sectional area (sq. mm)	
iii.	Number & diameter of wires (Nos. / mm)	
6.	Insulation	
i.	Composition of insulation	
ii.	Thickness of insulation (mm)	
iii.	Tolerance on thickness of insulation (%)	
iv.	Specific insulation resistance at 60°C	
7.	Colour scheme for identification of wires	
8.	Whether descriptive pamphlet is enclosed? (Yes/No)	
	(i) Ladders	
1.	Manufacturer's name and country of manufacture.	
2.	Manufacturer's type designation	
3.	Applicable standard	
4.	Whether drawing and descriptive pamphlet is enclosed. (Yes/No)	
	(j) Painting	
1.	Paints (for each type)	
i.	Manufacturer's name and country of manufacture.	
ii.	Manufacturer's type designation/brand name	
iii.	Shade.	
2.	Number of coats provided for	
i.	Lighting poles & other fabricated steel structures (Nos.)	
ii.	Junction boxes (Nos.)	
3.	Applicable standards	
	(k) Ceiling fan and regulator	
1.	Ceiling fan	
i.	Manufacturer's name and country of manufacture.	
ii.	Manufacturer's type designation	

iii.	Applicable standard	
iv.	Material of the winding	
v.	Class of insulation	
vi.	Temperature rise above ambient (Deg. C)	
vii.	Maximum and minimum speed (with regulator) (RPM)	
viii.	Rated voltage (volts)	
ix.	Rated frequency (Hz)	
x.	Power factor	
xi.	Air delivery at test voltage (m ³ / min/W)	
xii.	Service value at rated voltage (m ³ / min/W)	
xiii.	Number of blades	
xiv.	Whether descriptive pamphlet is enclosed? (Yes/No)	
2.	Fan Regulator	
i.	Manufacturer's name and country of manufacture.	
ii.	Manufacturer's type designation/brand name	
iii.	Applicable standard (Watts)	
iv.	Type of regulator (Yes/No)	

CHAPTER 16:

CIVIL WORKS

NOT APPLICABLE

CHAPTER-17

SUBSTATION GALVANIZED STEEL STRUCTURES

Sl. No.	Description	Unit	Specific Requirements	Guaranteed Technical Particulars		
				220 kV	132 kV	33 kV
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Substation Steel Structures					
	Guaranteed Weight of Steel Structures designed, fabricated, galvanized etc complete as per technical specifications					
1.1	Gantry Towers and Lightning/Lighting Mast (For Each Type of Structure)		Conforming to Technical Specifications			
1.1.1	Gantry Tower Type- A (Beam only on one Side of tower)	MT				
1.1.2	Gantry Tower Type- B (Beam on two Side of tower)	MT				
1.2	Lightning/Lighting Masts (For Each)	MT	Conforming to Technical Specifications			
1.3	Gantry Beams(For Each)	MT	-do-			
1.4	Circuit Breaker (For Each)	MT	-do-			
1.5	Three pole isolator					
1.5.1	Isolator without Earth Switch(For Each)	MT				
1.5.2	Isolator with Earth Switch(For Each)	MT				
1.5.3	Isolator with Double Earth Switch(For Each)	MT				
1.6	Single Pole Isolator		Conforming to Technical Specifications			
1.6.1	Single Pole Isolator with Earth switch (For Each)	MT				
1.6.2	Single Pole Isolator without earth switch (For Each)	MT				

Sl. No.	Description	Unit	Specific Requirements	Guaranteed Technical Particulars		
				220 kV	132 kV	33 kV
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.7	Current Transformer (For Each)	MT	Conforming to Technical Specifications			
1.8	CVT/Potential Transformer (For Each)	MT	-do-			
1.9	BPI/PI (For Each)	MT	-do-			
1.10	Lightening/Surge Arrestor (For Each)	MT	-do-			
1.11	Neutral Current Transformer (For Each)	MT	-do-			
2.0	Maximum Stress employed in design					
2.1	Tension in net sectional area	N/mm ²	As per IS:802(Part-I/Sec-2)			
2.2	Compression on gross sectional area at maximum slenderness ratio	N/mm ²	-do-			
2.3	Shearing stress on steel bolts	N/mm ²	-Do-			
2.4	Bearing stress on steel bolts	N/mm ²	-Do-			
3.0	Maximum Slenderness Ratio					
3.1	Main leg members of columns, Masts, Beams, Equipment Supporting Structures		As per IS:802(Part-I/Sec-2)			
3.2	Lattice members having calculated stress		-do-			
3.3	Redundant members having nominal stress		-do-			
3.4	Members under tensions only		-do-			
3.5	Strut formula used		-do-			
3.6	Standards according to which properties of sections have been adopted					
4.0	Structural Steel					

Sl. No.	Description	Unit	Specific Requirements	Guaranteed Technical Particulars		
				220 kV	132 kV	33 kV
(1)	(2)	(3)	(4)	(5)	(6)	(7)
4.1	Grade of Structural Steel proposed to be used for Steel Sections & Plates		As per IS:2062			
4.2	Standard/Code of Practice to which quality of steel for the sections and plates would conform and technical properties of the type of steel offered.		-do-			
5.0	Galvanizing of Steel Structures					
5.1	Standard/Code of Practice to which galvanizing shall conform to		As per IS:4579			
5.2	Zinc Coating on Galvanized Structural Members	gm/m ²	As per Technical Specification			
5.3	Zinc Coating on Galvanized Bolts, Nuts & Washers	gm/m ²	-do-			
5.4	Quality/Purity of zinc used for galvanizing	(%)	As per Technical Specification			
6.0	Fabrication of Structures					
6.1	Minimum sheared edge distance for 16 mm Diameter bolts	mm	As per Technical Specification			
6.2	Minimum rolled edge distance for 16 mm diameter bolts	mm	As per Technical Specification			
6.3	Sizes of bolts proposed to be used	mm	16 mm (Only one size)			
6.4	Hole Size for bolt	mm	Not more than 1.5 mm bigger than bolt diameter			
6.5	Bolt gauge distances in flanges of angles		As per Technical Specification			
6.7	Minimum Size of Foundation bolts	mm	Not less than 20 mm			
6.8	Minimum nos. of foundation bolts per leg	nos.	Not less than two nos. per leg.			

Sl. No.	Description	Unit	Specific Requirements	Guaranteed Technical Particulars		
				220 kV	132 kV	33 kV
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	of structure					
6.9	Minimum thickness of Base Plate	mm	Not less than 12 mm			
6.10	Minimum thickness of Gusset Plate	mm	As per technical specifications but not less than 6mm			
6.11	Standard/ Code of Practice to which bolts and nuts would conform to and property class		As per IS:12427 and Property Class 5.6			
6.12	Name of manufacturer of bolts and nuts		Reputed Manufacturer who has supplied bolts and nuts atleast in three Substation/ Transmission Line Projects in last three years			
6.13	Minimum Size of Leg Members of Columns, Masts, Beams, Equipment Supporting Structures		Not smaller than angle of size 65x65x5 mm			
6.14	Minimum Size of Bracing Members		Not smaller than angle size 45 x 45 x 4 mm			
6.15	Type of connection of Gantry Towers and Lightning/Lighting Masts with foundation		Through Base Plate and Anchor/Foundation Bolts			
6.17	Type of connection of equipment supporting structure with foundation		Through Base Plate and Anchor/Foundation Bolts			
6.18	Arrangement for fixing Anchor bolts in foundations during construction for ensuring correct position, alignment and inclination		Through Templates			

Notes:-

1. 'N.A.' may be written against the item which is not applicable.
2. The price for Galvanized Steel Structures in Price Schedule shall be quoted based on guaranteed weight for each type of structure in the above GTP and unit rate per metric ton for galvanized steel structures.
3. The unit rate per metric ton for galvanized steel structures shall be quoted in related Price Schedule separately.
4. The payment for galvanized steel structures shall be made based on guaranteed weight or actual weight as per approved fabrication drawings, whichever is minimum, and unit rate per metric ton for galvanized steel structures.
5. The quantity in Price Schedule has been given in numbers for each type of structure for the convenience of evaluation of bids but payment for galvanized steel structures shall be made as per Note No.4 above. This may be noted by all Bidders.

CHAPTER – 16

MISCELLANEOUS ITEMS FOR SUB-STATIONS

Sr.no.	Description	Guaranteed Particulars		
A.	ALUMINIUM TUBE FOR BUS BAR	220 kV bus bar	132 kV bus bar	33 kV bus bar
1.	Material			
2.	Diameter (mm)			
3.	Maximum Span (mm)			
4.	Type			
5.	Overall Diameter (mm)			
6.	Cross Sectional Area (sq.mm)			
7.	Stranding (nos./mm)			
8.	Mass (Kg/km)			
9.	Ultimate Strength (Kg)			
10.	Rated DC resistance at 20°C (Ω /km)			
B.	POWER CONNECTORS & CLAMPS			
1.	For connecting ACSR Moose conductor			
2.	For connecting equipment terminals made of copper			
3.	For connecting shield wire			
4.	Bolts, nuts & plain washers			
5.	Spring washers for item 'a' to 'c'			
C.	SUSPENSION, TENSION INSULATORS AND HARDWARES	220 kV bus bar	132 kV bus bar	33 kV bus bar
1.	Type			
2.	Size of Disc (sq.mm)			
3.	Rated Voltage (kV)			
4.	No. of Disc. Unit per string			
	a. Suspension (S/S)			
	b. Tension (S/T)			
5.	Minimum failing load			
	a. Suspension (kN)			
	b. Tension (kN)			

6.	Creepage Distance of insulator (mm)			
7.	Power Frequency (wet) withstand voltage (kv)			
8.	Power Frequency (puncture) withstand voltage of single disk (kv)			
9.	Impulse voltage withstand voltage of the disk (kv)			
D.	BUS POST INSULATORS	220 kV	132kV	33kV
1.	Nominal system voltage (kV)			
2.	Highest system voltage (kV)			
3.	Total creepage distance minimum (mm)			
4.	Cantilever strength (KN) Upright/horizontal			
5.	Tensile strength (KN)			
6.	Compression strength (KN)			
7.	Impulse withstand voltage (kV)			
8.	Power Frequency Dry flashover voltage (kV)			
E.	EARTHWIRE			
1.	Material			
2.	Size (mm)			
3.	Ultimate Tensile Strength (Kg)			
4.	Overall diameter (mm)			
5.	Modulus of Elasticity (MPA)			
6.	Co-efficient of linear expansion (degree C)			
7.	Weight (kg/km)			
8.	Cross sectional Area (sq.mm)			
F.	MARSHALLING KIOSKS			
1.	Type			
2.	No. of terminals			
3.	Thickness of sheet steel (mm)			
4.	Conductor for internal wiring and size (sq. mm)			
5.	Incoming supplies (V, A, sq. mm)			
6.	Outgoing supplies (V, A, sq. mm)			

7.	Terminal blocks			
8.	Degree of protection			
9.	Painting			
10.	Other provision			
G.	CABLE TRAYS, TRAY COVERS & ACCESSORIES			
1.	Manufacturer's Name & Address			
2.	Manufacturer's type designation			
3.	Material specification			
4.	Thickness of sheet steel for cable trays and fittings like elbows tees, crosses etc. (mm)			
5.	Maximum permissible loading for 2.5 m long tray simply supported at the ends (Kg or kN)			
6.	Corresponding deflection at centre for the loading (mm, mm)			
7.	Whether hot dip galvanized (Yes/No)			
8.	Weight of zinc coating & minimum thickness of zinc deposit at any spot (gm/sq. m)			
H.	JUNCTION BOXES			
1.	Manufacturer's Name & Address			
2.	Manufacturer's type designation			
3.	Material specification			
4.	Type of enclosure with degree of protection			
5.	Thickness of GI sheet (mm)			
6.	Terminal			
a)	Make			
b)	Current rating (Amp)			
c)	Voltage rating (Volts)			
d)	Stud type			
e)	Complete with insulated barriers (Yes/No)			
f)	Whether suitable for 2 Nos. 2.5 mm copper conductor (Yes/No)			
g)	Whether descriptive pamphlet is enclosed (Yes/No)			

I.	COMPRESSION TYPE CABLE GLAND			
1.	Manufacturer's Name & Address			
2.	Manufacturer's type designation			
3.	Material			
4.	Whether passivated or not (Yes/No)			
J.	CABLE LUGS			
1.	Manufacturer's Name & Address			
2.	Manufacturer's type designation			
3.	Current rating (Amp)			
4.	Material specification			
5.	Tinned (Yes/No)			
6.	Solder less crimping type (Yes/No)			
K.	STRAIGHT THROUGH JOINTS			
1.	Manufacturer's Name & Address			
2.	heat shrinkable type taped type/promoulded type			
3.	Whether bill of materials of the kit furnished (Yes/No)			
4.	Whether straight through joint kit is complete with all accessories (Yes/No)			
L.	CABLE CLAMPS			
1.	Manufacturer's Name & Address			
2.	Material specification, size and type of clamps / cords			
a)	For single core cables (mm)			
b)	For multi core cables (mm)			
c)	For cable in trefoil formation (mm)			

M. FIRE FIGHTING EQUIPMENT

Sr.No.	Description	Guaranteed Particulars
--------	-------------	------------------------

I.	SAND / WATER BUCKETS	
1.	Manufacturer	
2.	Standard to which it conforms	
3.	Capacity (cu.m)	
4.	Number provided	
5.	Provided with hanging arrangement (Yes/No)	
6.	Whether approved by TAC?	
II.	DRY POWDER TYPE EXTINGUISHER	
1.	Manufacturer	
2.	Principle of operation	
3.	Capacity (cu.m)	
4.	Type of extinguisher (Low/High pressure)	
5.	Material of construction	
	a) Body	
	b) Inner shell	
	c) Neck ring	
	d) Cap	
	e) Plunger	
	f) Cartridge holder and sealing device	
	g) Piercer	
	h) Spring	
	i) Syphon tube	
	j) Nozzle and discharge fittings	
	k) Cartridge	
	l) Hose	
6.	Range of throw of jet (m)	
7.	Whether dry powder charge conforms to IS 4308 (Yes/No)	
8.	Max. period of discharging 95% of chemical (Sec)	
9.	Test pressure for extinguisher body (kg/sq. cm)	
10.	Whether handle provided (Yes/No)	
11.	Whether seal provided to indicate that extinguisher has not been used (Yes/No)	
12.	Whether anti-corrosive treatment provided? (Yes/No)	
13.	Whether First charge of chemical supplied? (Yes/No)	
14.	List of accessories provided (Yes/No)	
15.	Painting	
16.	Whether extinguisher is capable of discharging not less than 85% by mass of the actual rated capacity of dry powder at an angle of 45 degree from horizontal	

	(Yes/No)	
17.	List of Test certificate provided (Yes/No)	
18.	Standard to which it conforms	
19.	Whether approved by TAC? (Yes/No)	
20.	Whether each extinguisher has the marking as per IS 2171 (Yes/No)	
21.	Whether approved by the chief inspector of explosives Govt, of India (Yes/No)	
22.	Whether illustrative leaflets attached (Yes/No)	
III.	PORTABLE CARBON DIOXIDE EXTINGUISHER	
1.	Manufacturer	
2.	Capacity (cu.m)	
3.	Number provided (Nos.)	
4.	Material of construction:	
	a) Brass tube	
	b) Siphon or discharge tube	
	c) Wheel of operating head	
	d) Body	
	e) Discharge valve or operating head	
	f) Hose	
	g) Discharge horn	
	h) Carrying handle	
5.	Type of valve provided	
6.	Standard to which it conforms	
7.	Provided with handling arrangement (Yes/No)	
8.	Whether seal to indicate that extinguisher has not been used provided? (Yes/No)	
9.	Whether safety release provided? (Yes/No)	
10.	Whether supplied with first charge of extinguisher agent? (Yes/No)	
11.	Whether each extinguisher has the marking as per IS 2878 (Yes/No)	
12.	Whether approved by TAC? (Yes/No)	
13.	Whether approved by the chief inspector of explosive Govt. of India (Yes/No)	
14.	Whether illustrative leaflets attached (Yes/No)	
15.	List of Test certificate provided (Yes/No)	
16.	Standard to which CO2 extinguisher conforms (Yes/No)	

N. AIR CONDITIONING SYSTEM

Sr.No.	Description	Unit	Guaranteed Particulars
	SPLIT TYPE ROOM AIR CONDITIONERS		
1.	General		
a.	Make		
b.	Model and Number		
c.	Overall dimensions (L x W x H)	(mm x mm x mm)	
d.	Weight	(Kg)	
e.	Material and thickness of casing	(mm)	
f.	Cooling capacity at given ambient conditions	(TR)	
g.	Power consumption	(kW)	
h.	Power supply feeder capacity	(kW)	
i.	Initial fill of refrigerant	(Kg)	
2.	Compressor		
a.	Model		
b.	No. of compressor	(Nos.)	
c.	Type of compressor		
d.	Capacity of each compressor	(TR)	
e.	Compressor motor rating	(kW)	
3.	Condenser		
a.	Face area	(m ²)	
b.	Air quantity	(m ³ /hr)	
c.	Fan type		
d.	Fan diameter	(mm)	
e.	Fan motor rating	(kW)	
f.	No. of rows of coil	(Nos.)	
g.	No. of tubes	(Nos.)	
4.	Evaporator		
a.	Air quantity	(m ³ /hr)	
b.	Fan type		
c.	Fan width	(mm)	
d.	Fan diameter	(mm)	
e.	Fan speed	(RPM)	
f.	No. of rows of coil	(Nos.)	
g.	No. of tubes	(Nos.)	
h.	Face area	(m ²)	
i.	Fan Motor rating	(kW)	
5.	Filter		
a.	Type		

b.	Face area	(m2)	
c.	Thickness	(mm)	
d.	Width	(mm)	
e.	Height	(mm)	

CHAPTER 19
ERECTION, TESTING AND COMMISSIONING OF ELECTRICAL EQUIPMENT

NOT APPLICABLE

CHAPTER 20

400 kVA STATION TRANSFORMER

Sr. no.	Description	Guaranteed Particulars	
1.	Manufacturer's name		
2.	Place of manufacture		
3.	Type designation & model number		
4.	Rated KVA of the Transformer		
5.	Type of installation		
6.	Frequency		
7.	Cooling medium		
8.	Rated Voltage		
	High voltage side		
	Low voltage side		
9.	Highest Continuous System Voltage :		
	High voltage (HV)		
	Low Voltage (LV)		
10.	Method of system earthing:		
	High voltage (HV)		
	Low Voltage (IV)		
11.	Range of tapping		
12.	Impedance at rated MVA Base on Principal tap		
13.	Type of insulation & insulation level for winding:	33 kV	0.4 kV
a.	Type of insulation:		
b.	One minute power frequency withstand test voltage (kV RMS)		
c.	Lightening Impulse withstand test voltage (kVp):		
14.	Winding connection		
15.	Material of winding		
16.	Current density (A/sq.mm)		

17.	Vector group:	
18.	Type of cooling	
19.	Maximum Flux Density (Bm) in core & yoke at normal voltage & frequency	
20.	Short circuit withstand capacity	
21.	Max. Temperature Rise for various types of cooling over an ambient of 40 deg C a) Temperature rise of top oil (Measured by Thermometer) b) Temperature rise of winding (Measured by resistance)	
	Note: The allowable temp rise during testing shall be reduced by 10K for every 250m above 1000m as per IS 2026 part II.	
22.	Noise Level at Rated Voltage & Frequency	
23.	Standard to which Transformer Oil confirm	
24.	Vector group notation	
25.	Cooling	
26.	No load loss at rated voltage (kW)	
27.	No load loss at 110% rated voltage (kW)	
28.	Load loss at rated voltage and power (kW)	
29.	Net weight (kg)	
30.	Particulars	
31.	Weight of oil (kg)	
32.	Total weight (kg)	
33.	Overall dimensions (mm)	
34.	Transport dimensions (mm)	
35.	Noise level (dB(A))	
36.	Off-load Tap Changer Manufacturer's name	
37.	Type designation & model number for Off-load TC	
38.	Rated current for Off-load TC (A)	
39.	Off-load TC step	

40.	Number of tap steps	
-----	---------------------	--

CHAPTER – 21
100 KVA, 415 V DIESEL GENERATOR SETS

Sr.No.	Description	Guaranteed Particulars
A.	GENERAL	
1.	Bidder's Name and Address	
2.	Manufactures Name, type, model	
B.	ALTERNATOR	
1.	Type	
2.	Manufacturer's name	
3.	Rated kW capacity (kW)	
4.	Rated kVA capacity (kVA)	
5.	Type of insulation	
6.	Rated terminal voltage (Volts)	
7.	Rated power factor	
8.	Rated stator current (Amp)	
9.	Rated speed (RPM)	
10.	Rated frequency (Hz)	
11.	Excitation current and voltage at rated power output and power factor (Amp, Volts)	
12.	Alternator net continuous output at site conditions, after deducting power requirement of auxiliaries	
13.	Power factor	
14.	Overload capacity for one (1) hour in twelve consecutive hours of operation	
15.	Rated Frequency (Hz)	
16.	Number of phases	
17.	Winding connections	
18.	Design max ambient temperature	
19.	Type of insulation a. Armature winding	

	b. Field winding c. Connections d. Core connections e. Type of enclosure	
20.	Permissible voltage variation for satisfactory operation at rated KVA	
21.	Permissible frequency variation	
22.	Permissible combined voltage and frequency variation (Absolute sum)	
23.	Method of Neutral grounding	
24.	Efficiency at rated power factor at	
a.	Full load (%)	
b.	3/4 load (%)	
c.	1/2 load (%)	
25.	Efficiencies and power factor at the following values of full load	
a.	110% (% , pf)	
b.	100% (% , pf)	
c.	75% (% , pf)	
d.	50% (% , pf)	
e.	25% (% , pf)	
26.	Inherent voltage regulation (%)	
27.	Are damper windings fitted (Yes/No)	
28.	Percentage impedance (Ohm,%)	
29.	Generator performance	
	Full load losses (kW)	
30.	Exciter	
a.	Type of excitation system	
b.	Continuous capacity	
c.	Short time capacity	
d.	Continuous voltage (Volts)	
e.	Short time voltage (Volts)	
f.	Applicable standard	
31.	Automatic voltage Regulator	
a.	Manufacturer's name & address	
b.	Type	
c.	Time constant	
d.	Sensitivity from no load to full load (%)	
e.	Setting provided	
f.	Characteristic curve for AVR furnished (Yes/No)	

g.	Applicable standard	
h.	Class of insulation	
i.	Applicable standards	
32.	Method of lubrication	
33.	Method of cooling	
34.	Maximum temperature rise of stator core over ambient temperature (Deg. C)	
35.	Electrical auxiliary loads connected to generator terminals with rating (kW)	
36.	Alternator parameters	
C.	ENGINE	
1.	Rating (kVA)	
2.	Revolutions per minute (RPM)	
3.	Number and arrangement of cylinders, cylinder box and stroke (mm)	
4.	Method of starting (Sec)	
5.	Time required for starting from cold conditions	
6.	Auxiliary power consumption (kW)	
7.	i. Type of Governor	
	ii. Relevant standard	
	iii. Confirm portions of mechanical over speed tripping at 110%	
8.	Guaranteed limits of governing	
a.	Permanent variation	
	i) Full load thrown off	
	ii) Full load put on	
b.	Temporary variation	
	i) Full load thrown off	
	ii) Full load put on	
c.	Fuel injection	
	i) at full load	
	ii) at no load	
d.	Fly wheel details	
	i) Diameter (mm)	
	ii) Width of rim (mm)	
	iii) Weight (Kg)	
	iv) Thickness of rim (mm)	

9.	Specification of fuel oil	
10.	Specification of lube oil	
11.	Guaranteed fuel consumption	
a.	At full load (ml/kWh)	
b.	At 3/4 load (ml/kWh)	
c.	At 1/2 load (ml/kWh)	
d.	At 1/4 load (ml/kWh)	
e.	Specific fuel consumption (ml/kWh)	
f.	Compression ratio	
g.	Compression pressure (kg/sq. mm)	
h.	Maximum cylinder pressure (kg/sq. mm)	
12.	Lubricating oil consumption (ml/kWh)	
13.	Capacity of fuel tank (litres)	
14.	Mechanical efficiency (%)	
15.	Thermal efficiency (%)	
16.	Safety protection provided (Yes/No)	
17.	Method of aspiration	
18.	Method of cooling of engine and lubrication oil	
19.	Amount of water required for cooling system (litres)	
20.	Total weight (Kg)	
21.	Space requirement including clearance (m x m x m)	
22.	Air-Filter-Cum-Silencer	
a.	Rated capacity	
b.	Clear area (mm)	
c.	Maximum particle size removed (mm)	
23.	i. Type of flexible coupling provided & length (m)	
	ii. Shaft sealing arrangement	
24.	Pressure Gauges	
a.	Type	
b.	Manufacturer's name	
c.	Least count (kg/sq. mm)	
d.	Range (kg/sq. mm)	
e.	Accuracy (%)	
f.	Location	
g.	Dial size (mm x mm)	
h.	Number supplied (Nos.)	
25.	Level indicator	
a.	Type	
b.	Manufacturer's name	
c.	Range	

d.	Location	
e.	Number supplied (Nos.)	
26.	Tachometer	
a.	Type	
b.	Manufacturer's name	
c.	Reduction ratio	
d.	Range	
e.	Accuracy (%)	
27.	Any hand barring gear provided (Yes/No)	
28.	Permissible voltage range (Volts, %)	
D.	CURRENT TRANSFORMERS	
1.	Type	
2.	Specification & standards	
3.	Number of phases	
4.	Secondary CT	
5.	Rated Burden	
6.	Accuracy Class	
7.	Rated continuous thermal Current at specified ambient temperature	
8.	Rated short time thermal current	
9.	Rated dynamic current	
10.	Class of insulation	
11.	One (1) minute power frequency withstand voltage i) Between all terminals connected together and all parts to be earthed ii) Between contacts terminal with contacts closed and all remaining terminals connected together	
E.	RELAYS	
1.	Make	
2.	Type	

3.	Coil rating	
4.	Setting range	
5.	Burden	
6.	Reset ratio	
7.	Characteristic of time vs current enclosed	
8.	Descriptive pamphlet enclosed	
9.	Applicable standard	
10.	Specifications and standards	
11.	Current coil rated current	
12.	Potential coil rated voltage	
13.	Operating time class	
14.	Control supply	
15.	Class of insulation	
16.	One (I) minute power frequency tests voltage	
	i) Between all terminals connected together and all parts to be earthed	
	ii) Between contacts terminal with contacts closed and all remaining terminals connected together	
	iii) Between circuits to be connected in use	
	iv) Between contacts in open position	
F.	INDICATING INSTRUMENTS	
1.	Type	
2.	Specifications and standards	
3.	Accuracy	
4.	Size	
5.	Finish	
6.	1 (One) minute power frequency test voltage	

G.	STORAGE TANK	
1.	Type and shape	
2.	Capacity (litres)	
3.	Number supplied (Nos.)	
4.	Material of construction	
5.	Overall dimensions (mm x mm x mm)	
6.	Overall internal dimensions (mm x mm x mm)	
7.	Plate thickness (mm)	
8.	Design pressure and temperature (kg/sq. mm, Deg. C)	
9.	Type of welding and joints	
10.	Weight of completely fabricated tank including all supports and fittings (Kg)	
11.	Whether hand pump and accessories supplied. (Yes/No)	
H.	ENGINE ALTERNATOR SET	
12.	Starting time (Sec)	
13.	Tertiary winding (Sec)	
14.	No. of starting impulses (Sec)	
15.	Time for picking up the full load (Sec)	
I.	CONTROL PANEL / BOARD	
1.	Manufacturer's name and address	
2.	Sheet steel thickness (mm)	
3.	Method of vermin proofing and making dust proof	
4.	Outline dimensions (LxWxH) (mm x mm x mm)	
5.	Weight (Kg)	
6.	Type of mounting	
7.	Cable termination details	
8.	Door with locking arrangement provided (Yes/No)	
9.	Colour shade as per IS:5	
10.	Degree of protection	
11.	Make, type, technical specification and catalogues for each type of component to be mounted in control panel enclosed (Yes/No)	
12.	Current Transformers	
a.	Type and make	

b.	Rated transformation ratio	
c.	Rated output (VA)	
d.	Class of accuracy	
e.	Accuracy Limit Factor	
f.	Applicable standard	
g.	Instrument Security Factor	
h.	Short time thermal current rating (Amp, Sec)	
i.	Rated continuous thermal current (Amp)	
13.	Wiring	
a.	Voltage grade (Volts)	
b.	Insulation	
c.	Conductor material	
d.	Size of conductor (sq. mm)	
e.	No. of conductors (Nos.)	
f.	Maximum current rating (Amp)	
g.	Colour code used	
h.	Type of terminals	
i.	Size of terminals (sq. mm)	
j.	Applicable standards	
14.	Indicating Instruments	
a.	Make and type	
b.	Size (mm x mm)	
c.	Scale size (Degrees)	
d.	Accuracy class	
e.	VA burden	
	i) Current coil (VA)	
	ii) Voltage coil (VA)	
f.	Relevant catalogue enclosed (Yes/No)	
g.	Angle of deflection (Degrees)	
h.	Scale length (mm)	
i.	Current coil rating (Amp)	
j.	Voltage coil rating (Volts)	

CHAPTER – 22
CCTV SYSTEM

NOT APPLICABLE

CHAPTER- 23

DIGITAL TELEPHONE EXCHANGE (PBX)

Sr.No.	Description	Guaranteed Particulars
1.	Manufacturer	
2.	Type	
3.	Place of manufacture	
4.	System specification	
	a) Transmission procedure	
	b) Optical code	
	c) Multiplex rate	
	d) Optical signal communication role	
	e) Channel sampling rate	
5.	Number of channel, voice or data.	
	a) Frequency band width	
	b) Audio frequency terminator	
	c) Signaling interface	
	d) Impedance in ohm	
	e) Balanced return loss in dB	
6.	Digital interface	
	a) Bit rate (synchronous operation)	
	b) Encoding	
	b) Pulse shape	
	c) Impedance	
	d) Return loss in dB	
7.	Digital signal nominal bit rate kb/s	
8.	Application code	
9.	Operating wavelength range nm	
	a) Transmitter at reference point S	
	b) Source type	
10.	Spectral characteristics	
11.	Maximum RMS width (s) (nm)	
12.	Maximum -20 dB width (nm)	
13.	Minimum side mode suppression ratio	
14.	Mean launched power	
15.	Minimum extraction ratio dB	
16.	Front access Shall be provided for both electrical & optical interfaces.	
17.	For optimum performance each element in SDH network Shall be timed from a single primary reference clock source and this primary reference clock satisfy the ITU-T	

	Rec G.811	
18.	The synchronization interface shall be specified in ITU-T Rec G.703 #10	

Package-KC2

Koshi Corridor 220/132/33 kV Substations (Basantapur-Baneshwar-Tumlingtar- Inaruwa Substations)

Part II-Section VI: Employer's Requirements

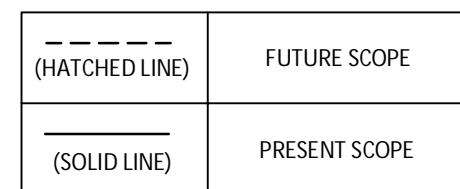
Section-6

Drawings


LIST OF DRAWINGS

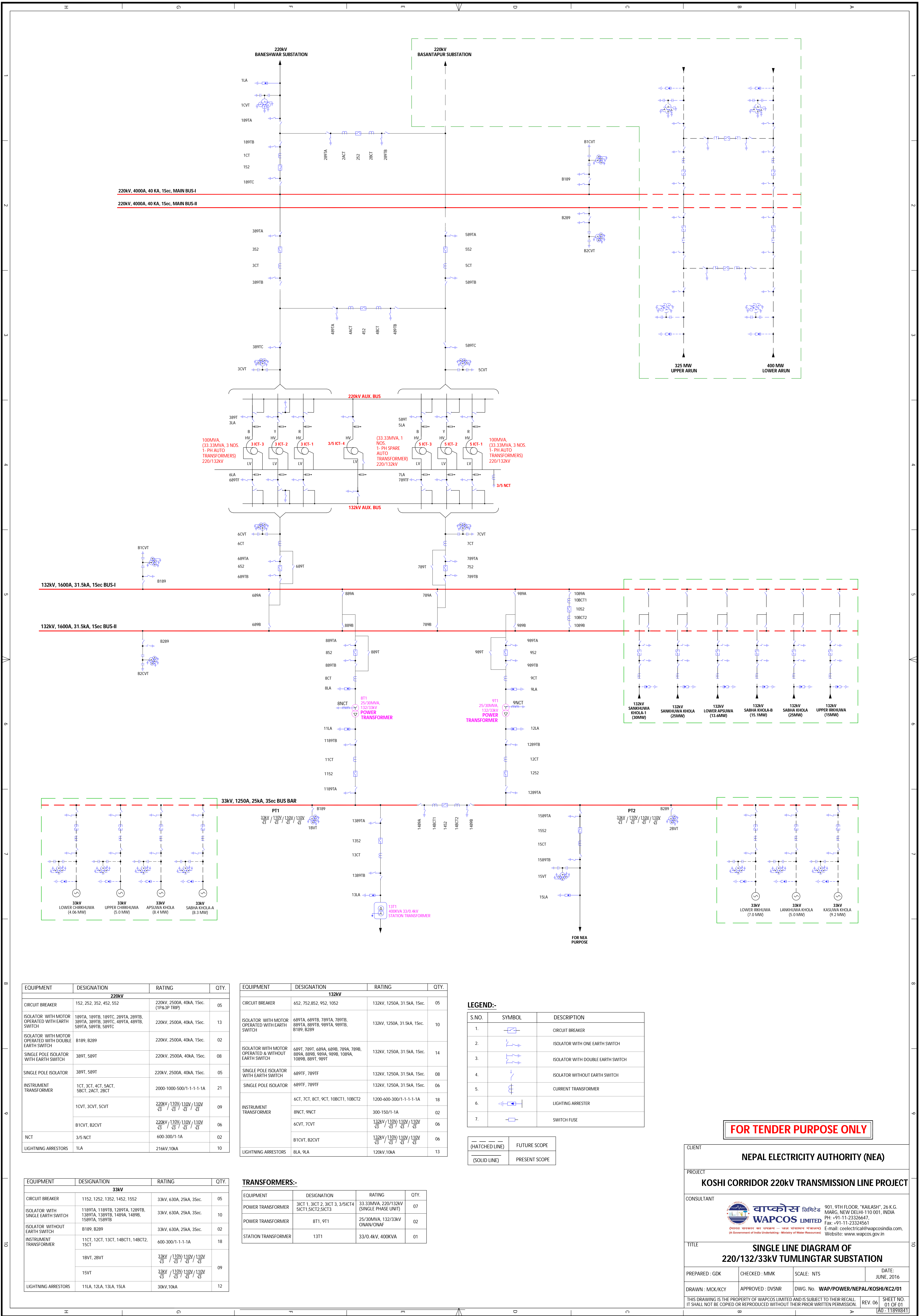
SL NO	DRAWING NAME	DRAWING NUMBER
1)	PROPOSED SCHEME OF TRANSMISSION AND SUBSTATION NETWORK	WAP/POWER/NEPAL/KOSHI/01
2)	SINGLE LINE DIAGRAM OF 220/132/33 kV TUMLINGTAR SUBSTATION	WAP/POWER/NEPAL/KOSHI/KC2/01
3)	SINGLE LINE DIAGRAM OF 220/33 kV BANESHWAR SUBSTATION	WAP/POWER/NEPAL/KOSHI/KC2/02
4)	SINGLE LINE DIAGRAM OF 220/132/33 kV BASANTAPUR SUBSTATION	WAP/POWER/NEPAL/KOSHI/KC2/03
5)	PLOT & LAYOUT PLAN OF 220/132/33 kV SUBSTATION AT TUMLINGTAR	WAP/POWER/NEPAL/KOSHI/KC2/04
6)	PLOT & LAYOUT PLAN OF 220/33 kV SUBSTATION AT BANESHWAR	WAP/POWER/NEPAL/KOSHI/KC2/05
7)	PLOT & LAYOUT PLAN OF 220/132/33 kV SUBSTATION AT BASANTAPUR	WAP/POWER/NEPAL/KOSHI/KC2/06
8)	TYPICAL DETAILS OF CABLE TRENCH WITH CABLE TRAY	WAP/POWER/NEPAL/KOSHI/KC2/C1
9)	UNDERGROUND WATER TANK DETAILS	WAP/POWER/NEPAL/KOSHI/KC2/C2
10)	TYPICAL DETAILS FOR STONE MASONARY BREAST WALL AND TYPICAL SECTION OF RCC RETAINING WALL	WAP/POWER/NEPAL/KOSHI/KC2/C3
11)	TYPICAL SECTION FOR STONE MASONARY DRAIN	WAP/POWER/NEPAL/KOSHI/KC2/C4
12)	DETAILS OF ROAD CUM RAIL TRACK	WAP/POWER/NEPAL/KOSHI/KC2/C5
13)	PLAN AND SECTION FOR 36 kV VCB CIRCUIT BREAKER	WAP/POWER/NEPAL/KOSHI/KC2/C6
14)	PLAN AND SECTION FOR 36 kV ISOLATOR	WAP/POWER/NEPAL/KOSHI/KC2/C7
15)	PLAN AND SECTION FOR 36 kV (3 POLE) VCB CIRCUIT BREAKER	WAP/POWER/NEPAL/KOSHI/KC2/C8
16)	PLAN AND SECTION FOR 245kV AND	WAP/POWER/NEPAL/KOSHI/KC2/C9

	145kV (3 POLE)ISOLATOR	
17)	FOUNDATION PLAN FOR 245 kV SF-6 CIRCUIT BREAKER	WAP/POWER/NEPAL/KOSHI/KC2/C10
18)	FOUNDATION PLAN AND SECTION FOR 145 kV& 36 kV GANTRY FOUNDATION	WAP/POWER/NEPAL/KOSHI/KC2/C11
19)	FOUNDATION PLAN AND SECTION FOR 245kV GANTRY COLUMN AND LIGHTNING MAST	WAP/POWER/NEPAL/KOSHI/KC2/C12
20)	FOUNDATION PLAN AND SECTION FOR 145 kV (SINGLE POLE)ISOLATOR	WAP/POWER/NEPAL/KOSHI/KC2/C13
21)	TYPICAL LAYOUT OF R.C.C. RETAINING WALL	WAP/POWER/NEPAL/KOSHI/KC2/C14
22)	TYPICAL LAYOUT FENCE FOR SWITCHYARD	WAP/POWER/NEPAL/KOSHI/KC2/C15
23)	A TYPICAL SECTIONAL ELEVATION FOR 100MVA TRANSFORMER FOUNDATION	WAP/POWER/NEPAL/KOSHI/KC2/C16
24)	TYPICAL FOUNDATION PLAN FOR TRANSFORMER	WAP/POWER/NEPAL/KOSHI/KC2/C17
25)	TYPICAL PLAN AND ELEVATION FOR OIL COLLECTION PIT	WAP/POWER/NEPAL/KOSHI/KC2/C18
26)	TYPICAL DETAILS OF DG SET ROOM	WAP/POWER/NEPAL/KOSHI/KC2/C19
27)	CONTROL ROOM BUILDING LAYOUT FOR TUMLIGTAR SUB-STATION	WAP/POWER/NEPAL/KOSHI/KC2/CRB-01
28)	CONTROL ROOM BUILDING LAYOUT FOR BANESHWAR SUB-STATION	WAP/POWER/NEPAL/KOSHI/KC2/CRB-02
29)	CONTROL ROOM BUILDING LAYOUT FOR BASANTPUR SUB-STATION	WAP/POWER/NEPAL/KOSHI/KC2/CRB-03



SL. No.	NAME OF SUBSTATION	AVAILABLE POWER GENERATION (MW)	LOCAL POWER REQUIREMENT (MW)	POWER TO BE TRANSFERRED THROUGH LINE (MW)	EXPECTED YEAR OF COMMISSIONING
01	CHANGE 132/33kV	706.1	4.25	CHANGE TO BASANTAPUR 701.85	2025 TO 2035
02	BASANTAPUR 220/132/33kV	311.1	4.25	BASANTAPUR TO INARUWA 306.85	2025 TO 2035
03	TUMLINGTAR 132/33kV	905.6	4.25	TUMLINGTAR TO BANESHWAR TO BASANTAPUR 901.35	2025 TO 2035
04	BANESHWAR 132/33kV	52.22	4.25	BANESHWAR TO BASANTAPUR 47.97	2025 TO 2035
	TOTAL	1975.02	17.00	1958.02	

CLIENT			
<h1 style="text-align: center;">NEPAL ELECTRICITY AUTHORITY (NEA)</h1>			
PROJECT			
<h2 style="text-align: center;">KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT</h2>			
CONSULTANT			
 <div style="display: inline-block; vertical-align: middle;"> वाप्कोस लिमिटेड WAPCOS LIMITED <small>(भारत सरकार का उपक्रम — जल संसाधन मंत्रालय) (A Government of India Undertaking - Ministry of Water Resources)</small> </div>		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
TITLE			
<h2 style="text-align: center;">PROPOSED SCHEME OF TRANSMISSION AND SUBSTATION NETWORK</h2>			
PREPARED : BR/GD	CHECKED : MMK	SCALE: NTS	DATE: JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/01	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01
			REV. - 06
8	1	0	10
			A2 - 594X42



EQUIPMENT	DESIGNATION	RATING	QTY.
220kV			
CIRCUIT BREAKER	152, 252, 352, 452, 552	220kV, 2500A, 40kA, 1Sec. (1P&3P TRIP)	05
ISOLATOR WITH MOTOR OPERATED WITH EARTH SWITCH	189TA, 189TB, 189TC, 289TA, 289TB, 389TA, 389TB, 389TC, 489TA, 489TB, 589TA, 589TB, 589TC	220kV, 2500A, 40kA, 1Sec.	13
ISOLATOR WITH MOTOR OPERATED WITH DOUBLE EARTH SWITCH	B189, B289	220kV, 2500A, 40kA, 1Sec.	02
SINGLE POLE ISOLATOR WITH EARTH SWITCH	389T, 589T	220kV, 2500A, 40kA, 1Sec.	08
SINGLE POLE ISOLATOR	389T, 589T	220kV, 2500A, 40kA, 1Sec.	05
INSTRUMENT TRANSFORMER	1CT, 3CT, 4CT, 5ACT, 5BCT, 2ACT, 2BCT	2000-1000-500/1-1-1-1-1A	21
	1CVT, 3CVT, 5CVT	$\frac{220kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}} / \frac{110V}{\sqrt{3}}$	09
	B1CVT, B2CVT	$\frac{220kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}} / \frac{110V}{\sqrt{3}}$	06
NCT	3/5 NCT	600-300/1-1A	02
LIGHTNING ARRESTORS	1LA	216kV, 10kA	10

EQUIPMENT	DESIGNATION	RATING	QTY.
33kV			
CIRCUIT BREAKER	1152, 1252, 1352, 1452, 1552	33kV, 630A, 25kA, 3Sec.	05
ISOLATOR WITH SINGLE EARTH SWITCH	1189TA, 1189TB, 1289TA, 1289TB, 1389TA, 1389TB, 1489A, 1489B, 1589TA, 1589TB	33kV, 630A, 25kA, 3Sec.	10
ISOLATOR WITHOUT EARTH SWITCH	B189, B289	33kV, 630A, 25kA, 3Sec.	02
INSTRUMENT TRANSFORMER	11CT, 12CT, 13CT, 14BCT1, 14BCT2, 15CT	600-300/1-1-1-1A	18
	1BVT, 2BVT	$\frac{33kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}} / \frac{110V}{\sqrt{3}}$	09
	15VT	$\frac{33kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}} / \frac{110V}{\sqrt{3}}$	09
LIGHTNING ARRESTORS	11LA, 12LA, 13LA, 15LA	30kV, 10kA	12

EQUIPMENT	DESIGNATION	RATING	QTY.
132kV			
CIRCUIT BREAKER	652, 752, 852, 952, 1052	132kV, 1250A, 31.5kA, 1Sec.	05
ISOLATOR WITH MOTOR OPERATED WITH EARTH SWITCH	689TA, 689TB, 789TA, 789TB, 889TA, 889TB, 989TA, 989TB, B189, B289	132kV, 1250A, 31.5kA, 1Sec.	10
ISOLATOR WITH MOTOR OPERATED & WITHOUT EARTH SWITCH	689T, 789T, 889A, 889B, 789A, 789B, 889A, 889B, 989A, 989B, 1089A, 1089B, 889T, 989T	132kV, 1250A, 31.5kA, 1Sec.	14
SINGLE POLE ISOLATOR WITH EARTH SWITCH	689TF, 789TF	132kV, 1250A, 31.5kA, 1Sec.	08
SINGLE POLE ISOLATOR	689TF, 789TF	132kV, 1250A, 31.5kA, 1Sec.	06
INSTRUMENT TRANSFORMER	6CT, 7CT, 8CT, 9CT, 10BCT1, 10BCT2	1200-600-300/1-1-1-1-1A	18
	8NCT, 9NCT	300-150/1-1A	02
	6CVT, 7CVT	$\frac{132kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}} / \frac{110V}{\sqrt{3}}$	06
	B1CVT, B2CVT	$\frac{132kV}{\sqrt{3}} / \frac{110V}{\sqrt{3}} / \frac{110V}{\sqrt{3}}$	06
LIGHTNING ARRESTORS	8LA, 9LA	120kV, 10kA	13

TRANSFORMERS:-			
EQUIPMENT	DESIGNATION	RATING	QTY.
POWER TRANSFORMER	3ICT 1, 3ICT 2, 3ICT 3, 3/5ICT 4, 5ICT 1, 5ICT 2, 5ICT 3	33.33MVA, 220/132kV (SINGLE PHASE UNIT)	07
POWER TRANSFORMER	8T1, 9T1	25/30MVA, 132/33kV ONAN/ONAF	02
STATION TRANSFORMER	13T1	33/0.4kV, 400KVA	01

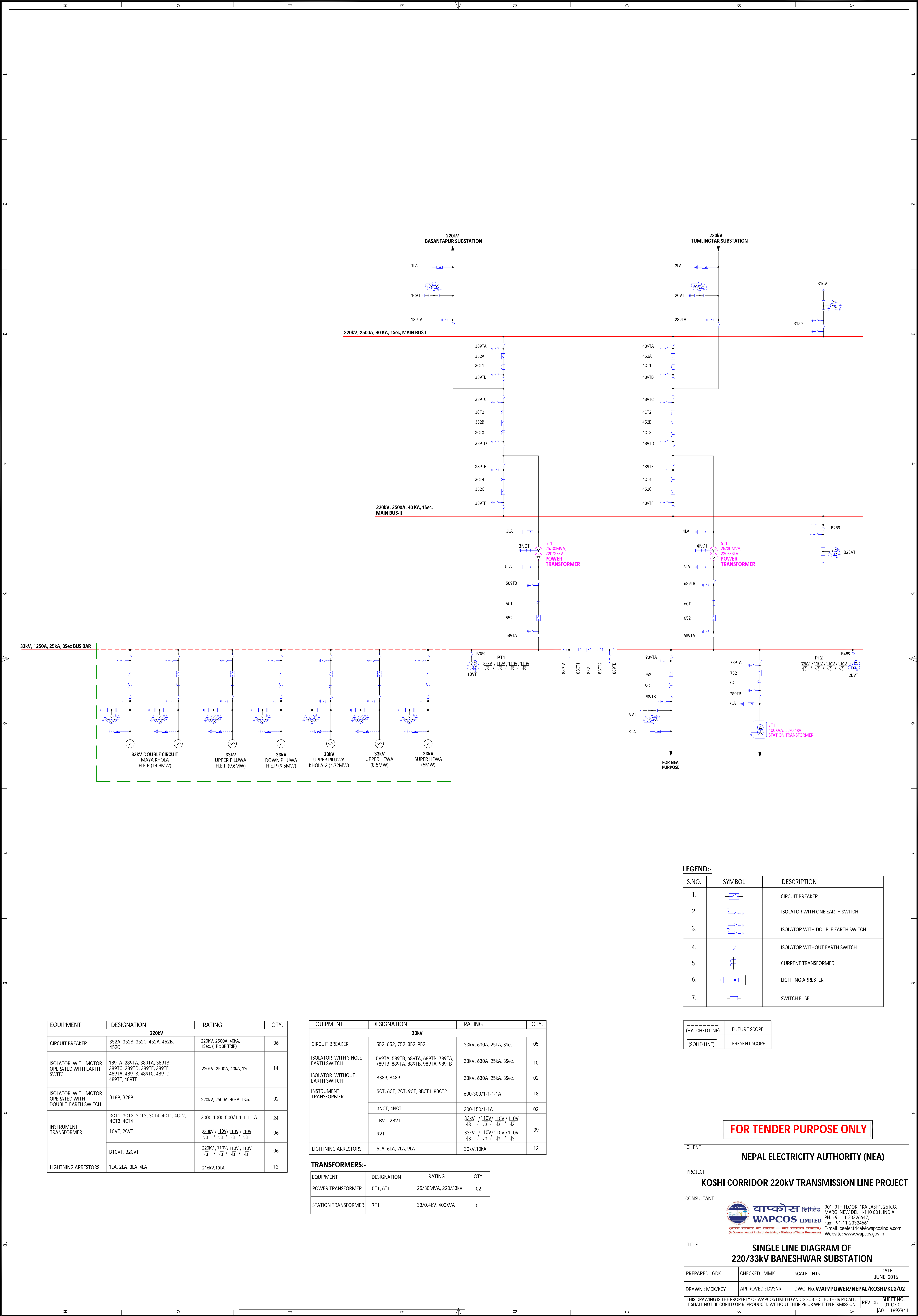
LEGEND:-

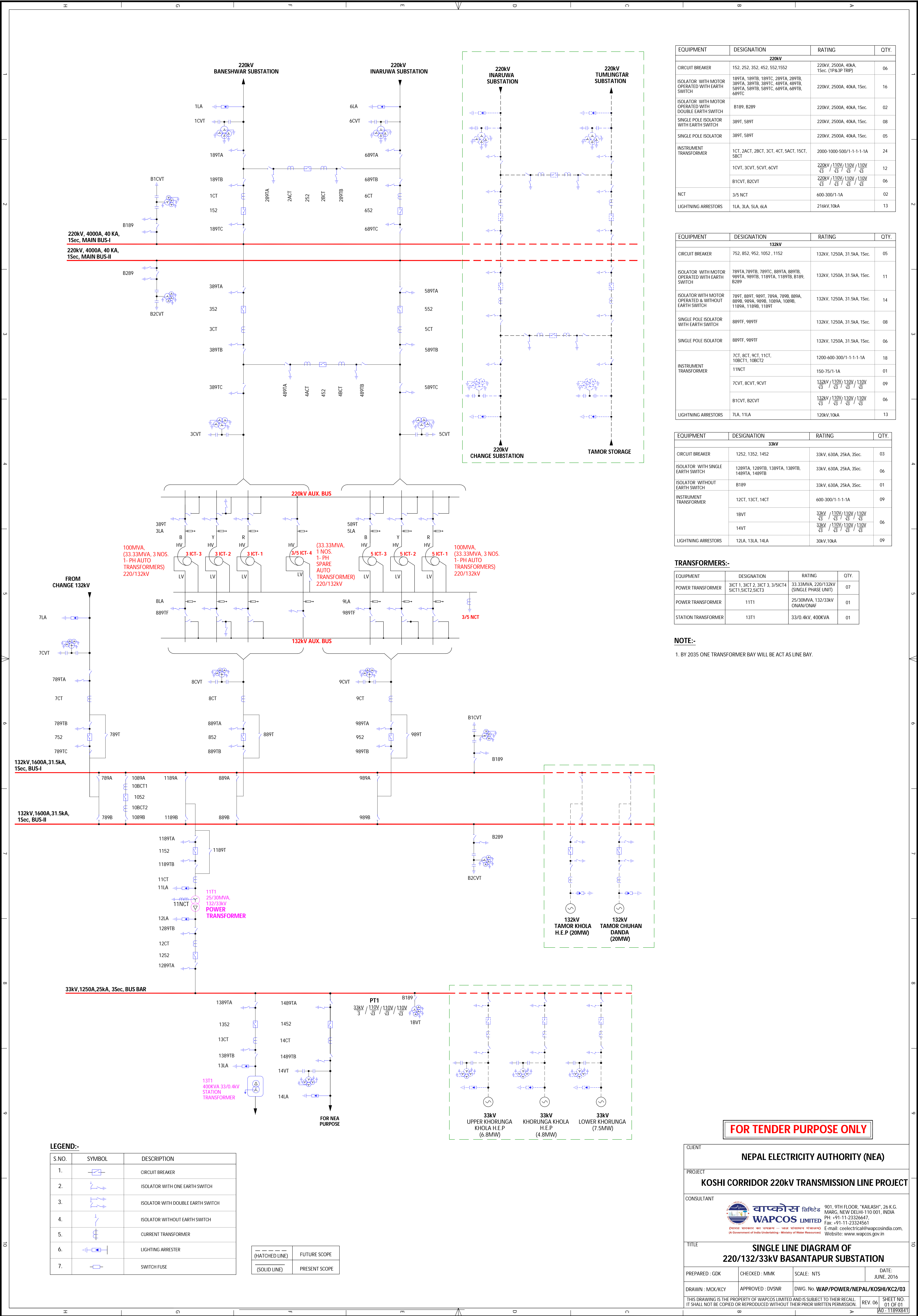
S.NO.	SYMBOL	DESCRIPTION
1.		CIRCUIT BREAKER
2.		ISOLATOR WITH ONE EARTH SWITCH
3.		ISOLATOR WITH DOUBLE EARTH SWITCH
4.		ISOLATOR WITHOUT EARTH SWITCH
5.		CURRENT TRANSFORMER
6.		LIGHTING ARRESTER
7.		SWITCH FUSE

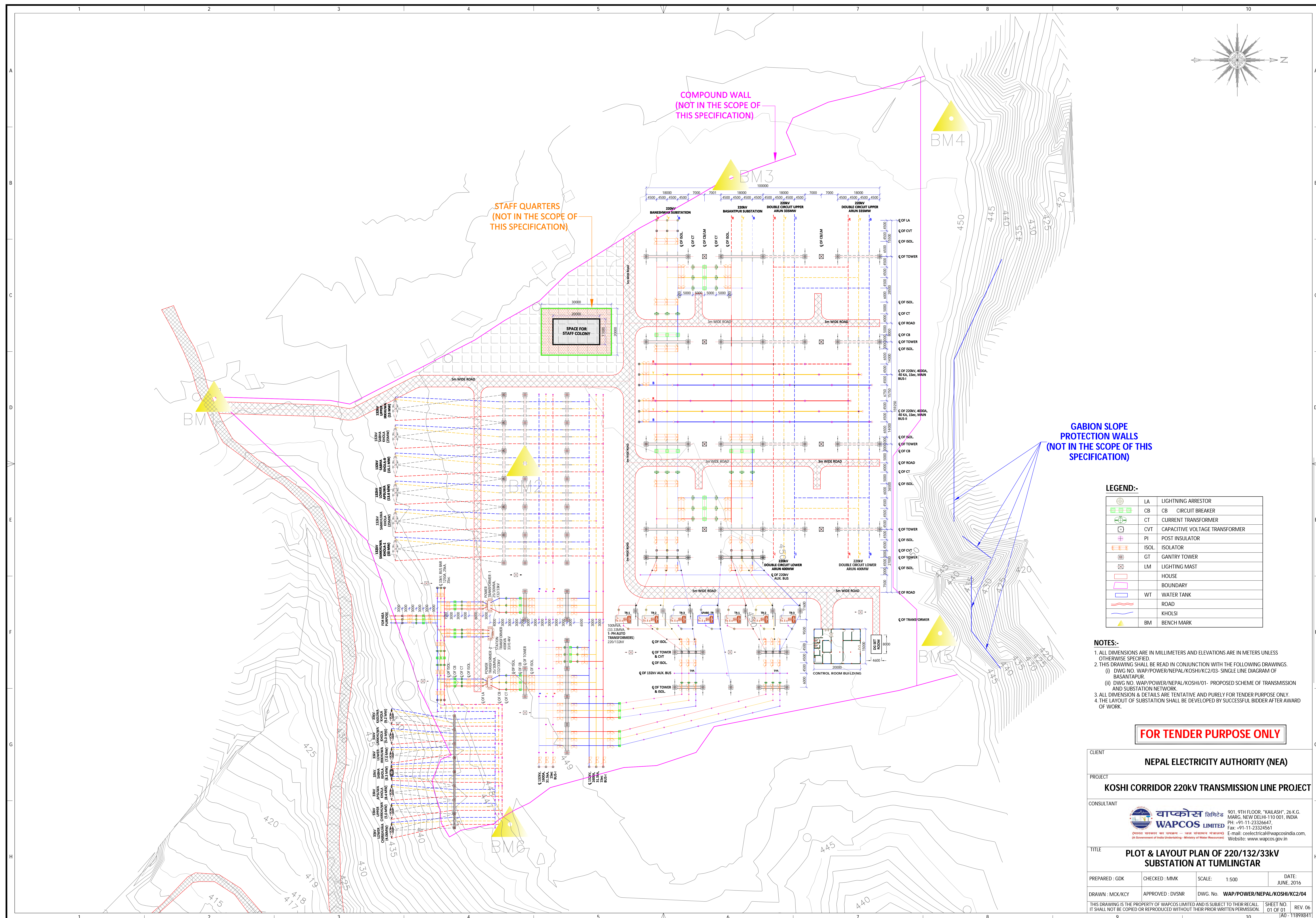
(HATCHED LINE)	FUTURE SCOPE
(SOLID LINE)	PRESENT SCOPE

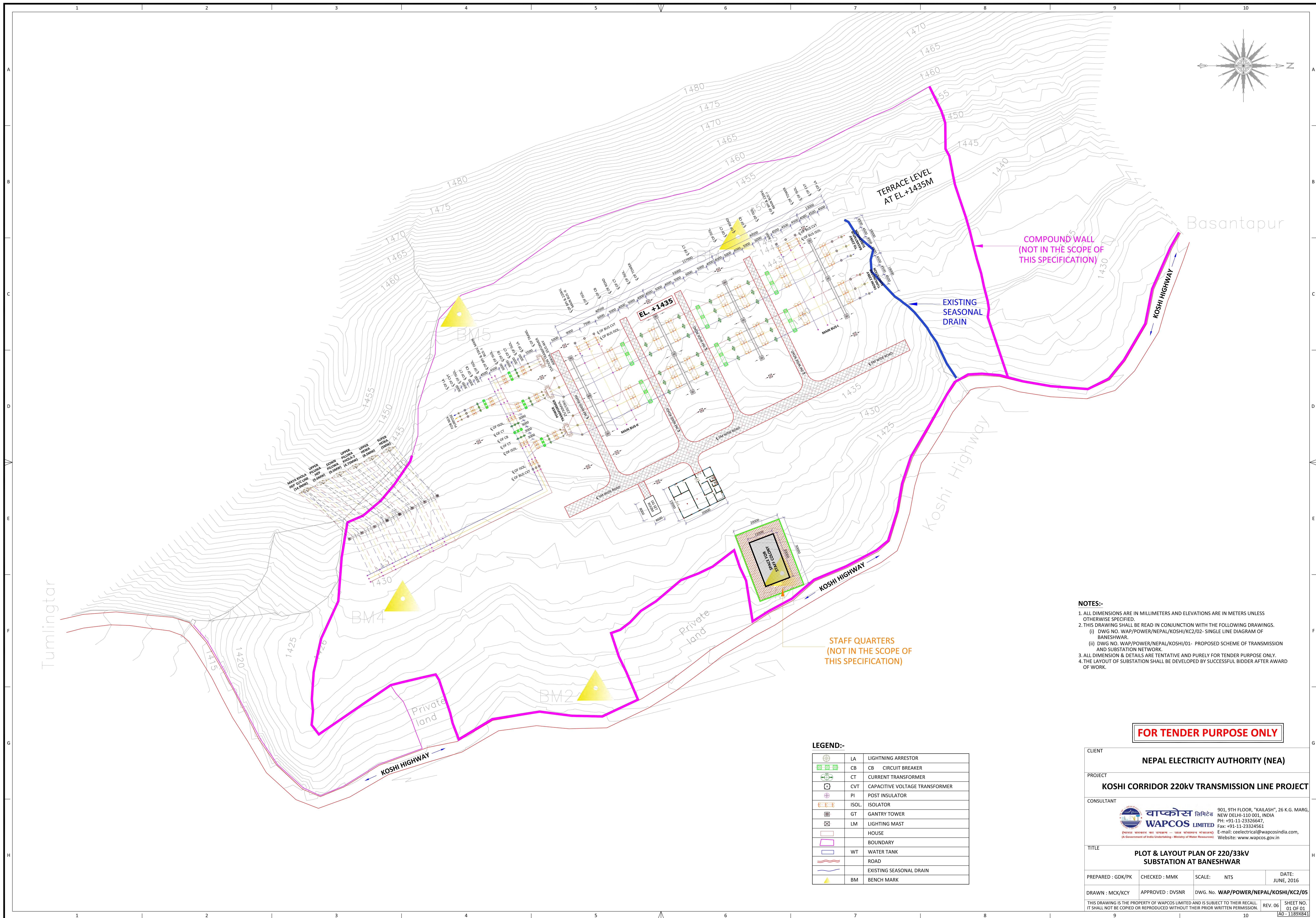
FOR TENDER PURPOSE ONLY

CLIENT	NEPAL ELECTRICITY AUTHORITY (NEA)		
PROJECT	KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT		
CONSULTANT	WAPCOS LIMITED (एनपीएस एन एनपीएस - एनपीएस एन एनपीएस) (A Government of India Undertaking - Ministry of Water Resources) 901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: celectrical@wapcosindia.com, Website: www.wapcos.gov.in		
TITLE	SINGLE LINE DIAGRAM OF 220/132/33kV TUMLINGTAR SUBSTATION		
PREPARED : GDK	CHECKED : MMK	SCALE : NTS	DATE: JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVS/NR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/01	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			REV. 06 SHEET NO. 01 OF 01 (A0-11892641)





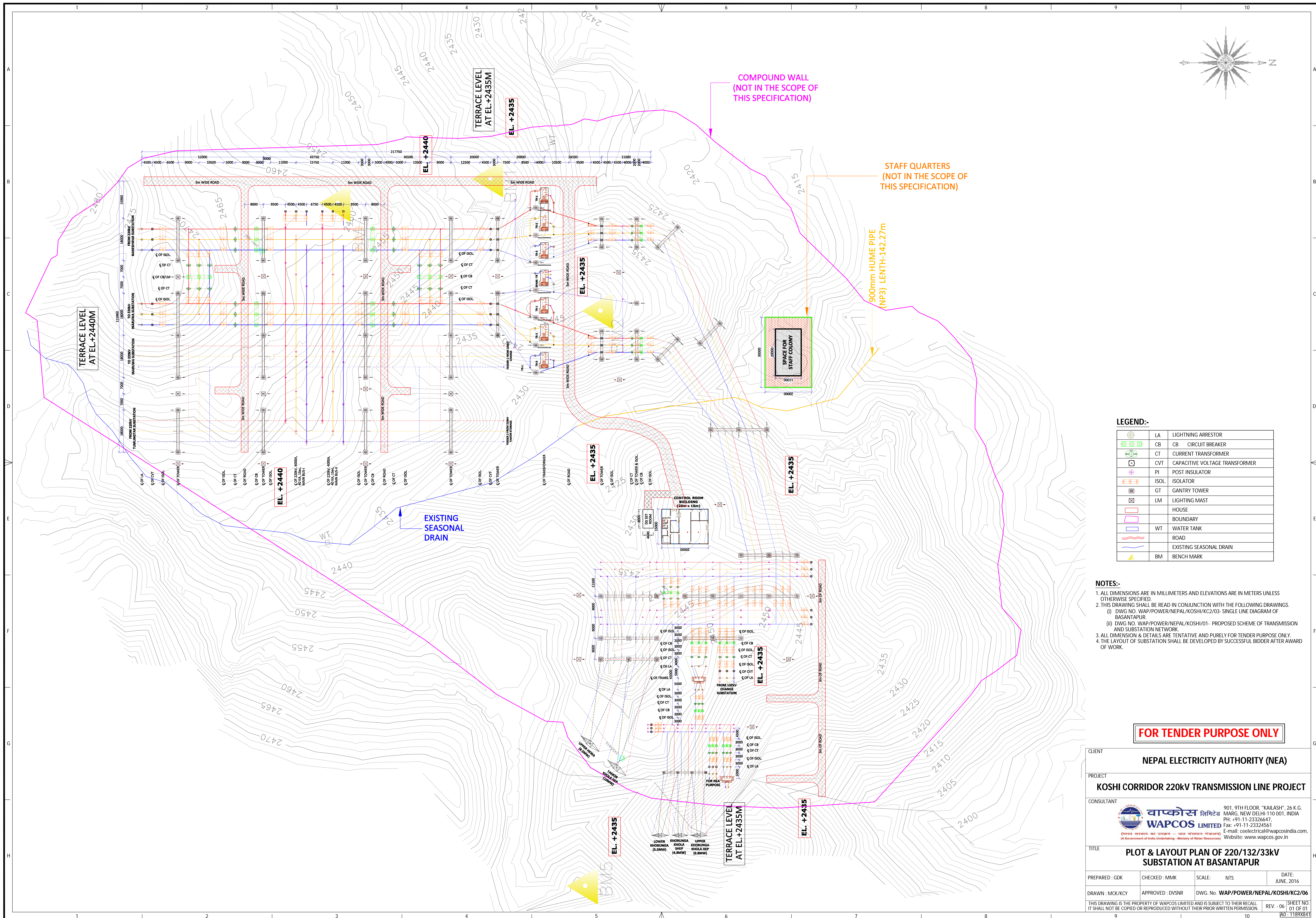




- NOTES:-**
1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
 2. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE FOLLOWING DRAWINGS.
(i) DWG NO. WAP/POWER/NEPAL/KOSHI/KC2/02- SINGLE LINE DIAGRAM OF BANESHWAR.
(ii) DWG NO. WAP/POWER/NEPAL/KOSHI/01- PROPOSED SCHEME OF TRANSMISSION AND SUBSTATION NETWORK.
 3. ALL DIMENSION & DETAILS ARE TENTATIVE AND PURELY FOR TENDER PURPOSE ONLY.
 4. THE LAYOUT OF SUBSTATION SHALL BE DEVELOPED BY SUCCESSFUL BIDDER AFTER AWARD OF WORK.

LEGEND:-		
	LA	LIGHTNING ARRESTOR
	CB	CIRCUIT BREAKER
	CT	CURRENT TRANSFORMER
	CVT	CAPACITIVE VOLTAGE TRANSFORMER
	PI	POST INSULATOR
	ISOL	ISOLATOR
	GT	GANTRY TOWER
	LM	LIGHTING MAST
		HOUSE
		BOUNDARY
	WT	WATER TANK
		ROAD
		EXISTING SEASONAL DRAIN
	BM	BENCH MARK


FOR TENDER PURPOSE ONLY			
CLIENT NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT KOSHI CORRIDOR 220KV TRANSMISSION LINE PROJECT			
CONSULTANT वापकोस लिमिटेड WAPCOS LIMITED 901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: celectrical@wapcosindia.com, Website: www.wapcos.gov.in			
TITLE PLOT & LAYOUT PLAN OF 220/33kV SUBSTATION AT BANESHWAR			
PREPARED : GDK/PK	CHECKED : MMK	SCALE : NTS	DATE : JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/05	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			REV. 06 SHEET NO. 01 OF 01 [A0-1189X841]

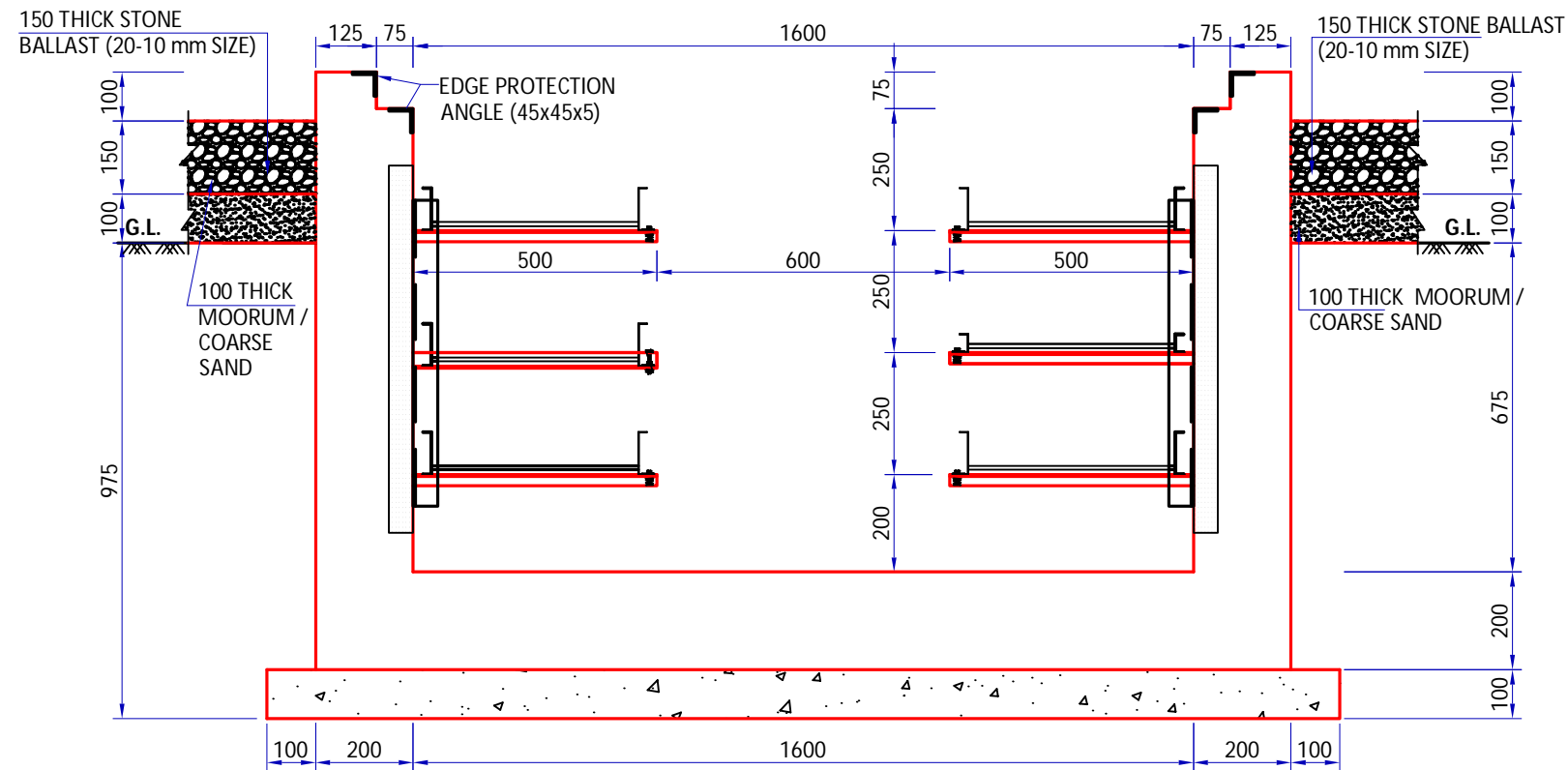


LEGEND:-		
	LA	LIGHTNING ARRESTOR
	CB	CIRCUIT BREAKER
	CT	CURRENT TRANSFORMER
	CVT	CAPACITIVE VOLTAGE TRANSFORMER
	PI	POST INSULATOR
	ISOL	ISOLATOR
	GT	GANTRY TOWER
	LM	LIGHTING MAST
		HOUSE
		BOUNDARY
	WT	WATER TANK
		ROAD
		EXISTING SEASONAL DRAIN
	BM	BENCH MARK

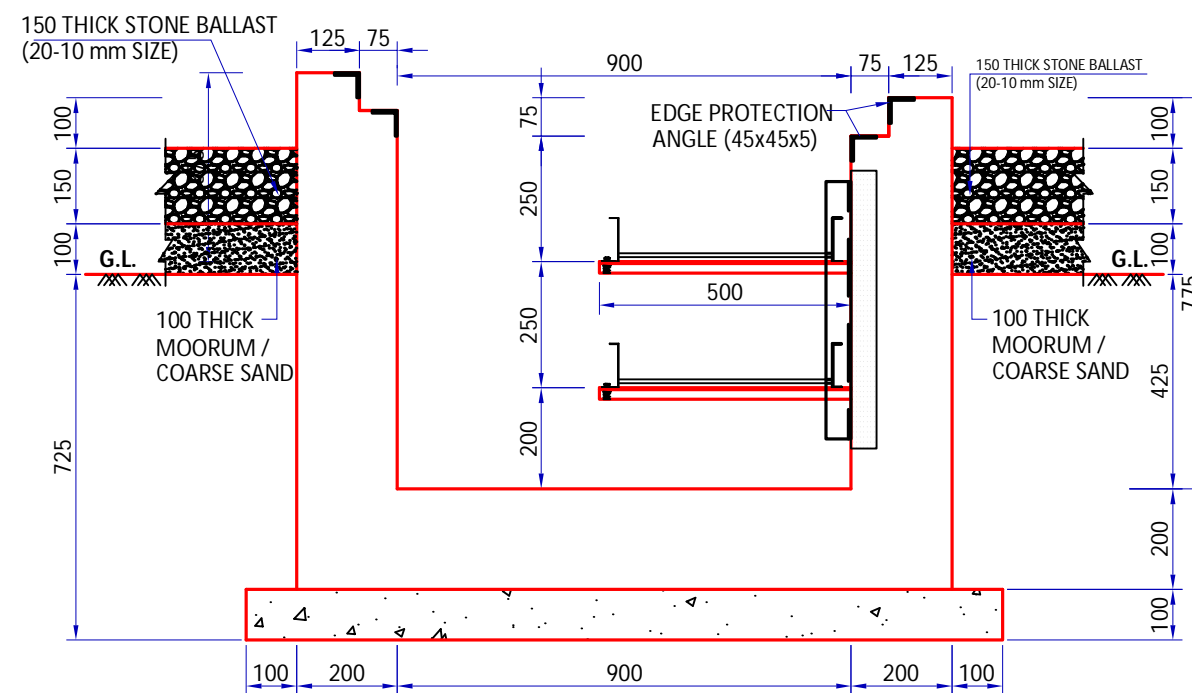
- NOTES:-**
1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
 2. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE FOLLOWING DRAWINGS.
(i) DWG NO. WAP/POWER/NEPAL/KOSHI/KC2/03- SINGLE LINE DIAGRAM OF BASANTAPUR.
(ii) DWG NO. WAP/POWER/NEPAL/KOSHI/01- PROPOSED SCHEME OF TRANSMISSION AND SUBSTATION NETWORK.
 3. ALL DIMENSION & DETAILS ARE TENTATIVE AND PURELY FOR TENDER PURPOSE ONLY.
 4. THE LAYOUT OF SUBSTATION SHALL BE DEVELOPED BY SUCCESSFUL BIDDER AFTER AWARD OF WORK.

FOR TENDER PURPOSE ONLY

CLIENT	NEPAL ELECTRICITY AUTHORITY (NEA)		
PROJECT	KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT		
CONSULTANT	<div>WAPCOS LIMITED (A Government of India Undertaking - Ministry of Water Resources)</div> <div>901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326477, E-mail: celectrical@wapcosindia.com, Website: www.wapcos.gov.in</div>		
TITLE	PLOT & LAYOUT PLAN OF 220/132/33kV SUBSTATION AT BASANTAPUR		
PREPARED : GDK	CHECKED : MMK	SCALE: NTS	DATE: JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/06	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			REV. - 06 SHEET NO. 01 OF 01 A0 - 1189X841




**TYPICAL DETAILS OF CABLE TRENCH
WITH CABLE TRAY ON BOTH SIDES**



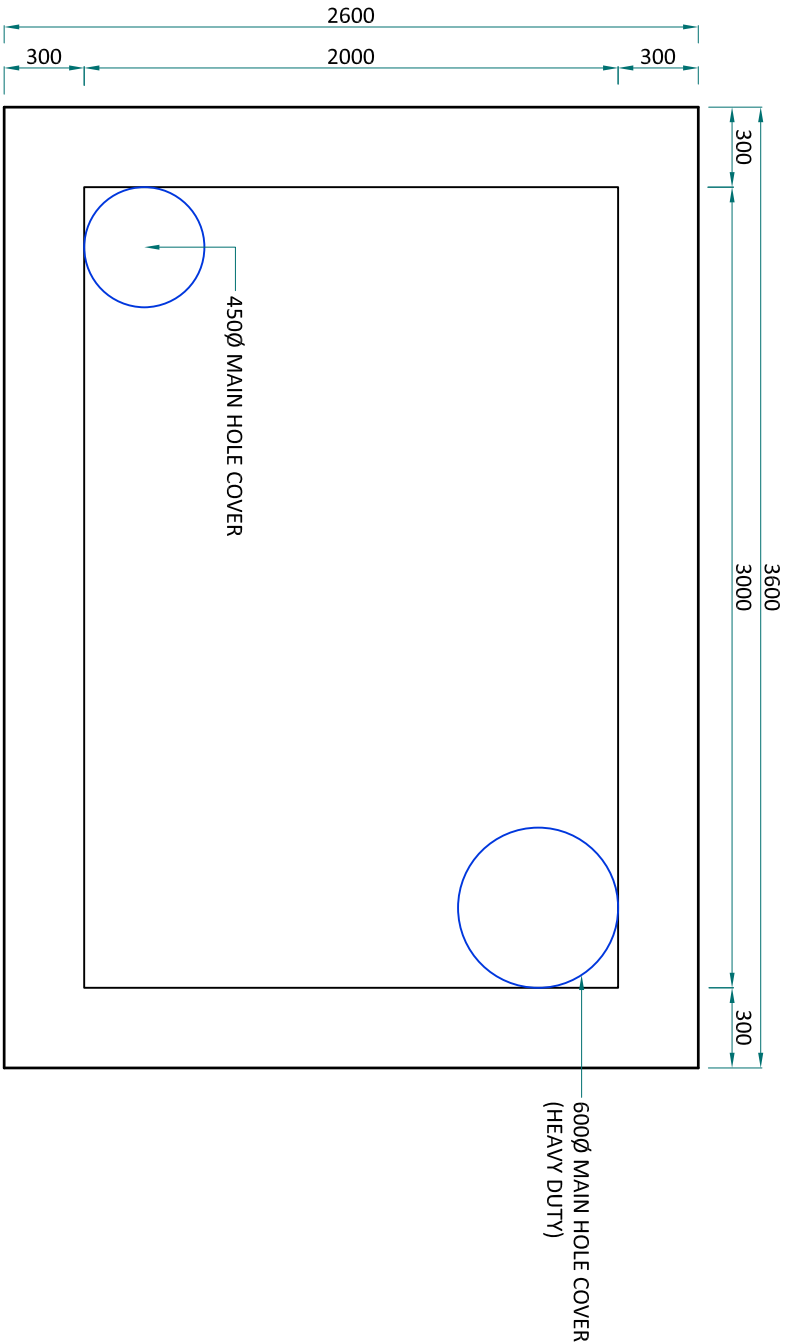
**TYPICAL DETAILS OF CABLE TRENCH
WITH CABLE TRAY ON ONE SIDE**

FOR BID PURPOSE ONLY

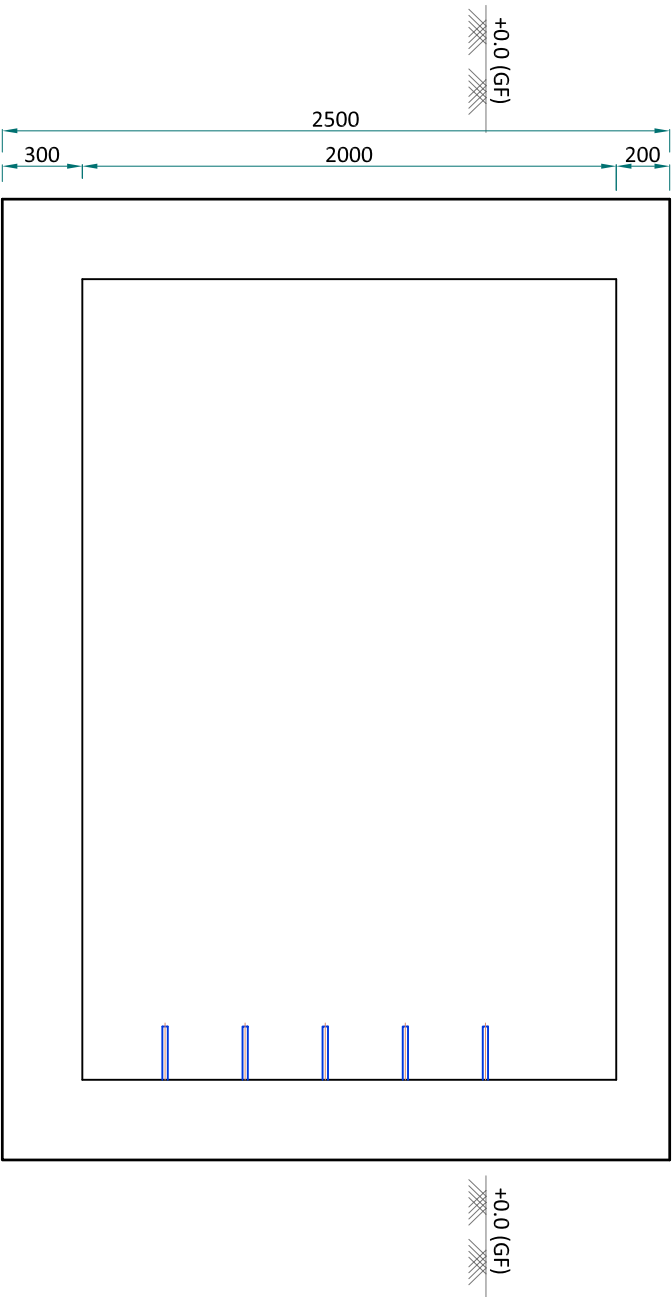
CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220 kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 <div> <div>वापकोस लिमिटेड</div> <div>WAPCOS LIMITED</div> <div>901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA</div> <div>PH: +91-11-23326647, Fax: +91-11-23324561</div> <div>E-mail: celectrical@wapcosindia.com, Website: www.wapcos.gov.in</div> </div>			
TITLE			
TYPICAL DETAILS OF CABLE TRENCH WITH CABLE TRAY			
PREPARED : VK	CHECKED : AKJ	SCALE: NTS	DATE: JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/C1	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01

A3 - 420X297

- NOTE :
- ALL DIMENSIONS ARE IN MILLIMETERS.
 - ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.




(PLAN)
UNDER GROUND WATER TANK FOR POTABLE WATER

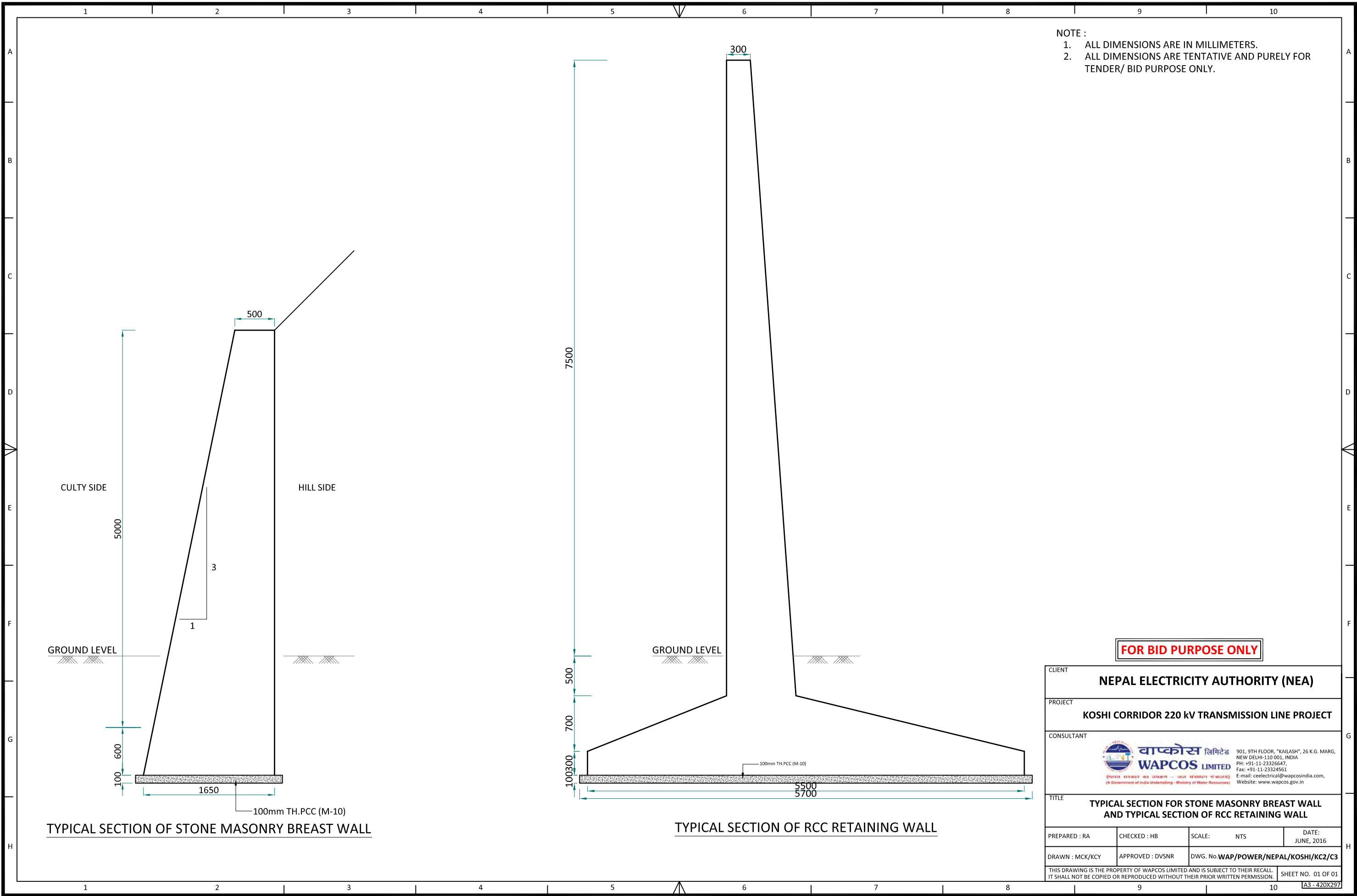


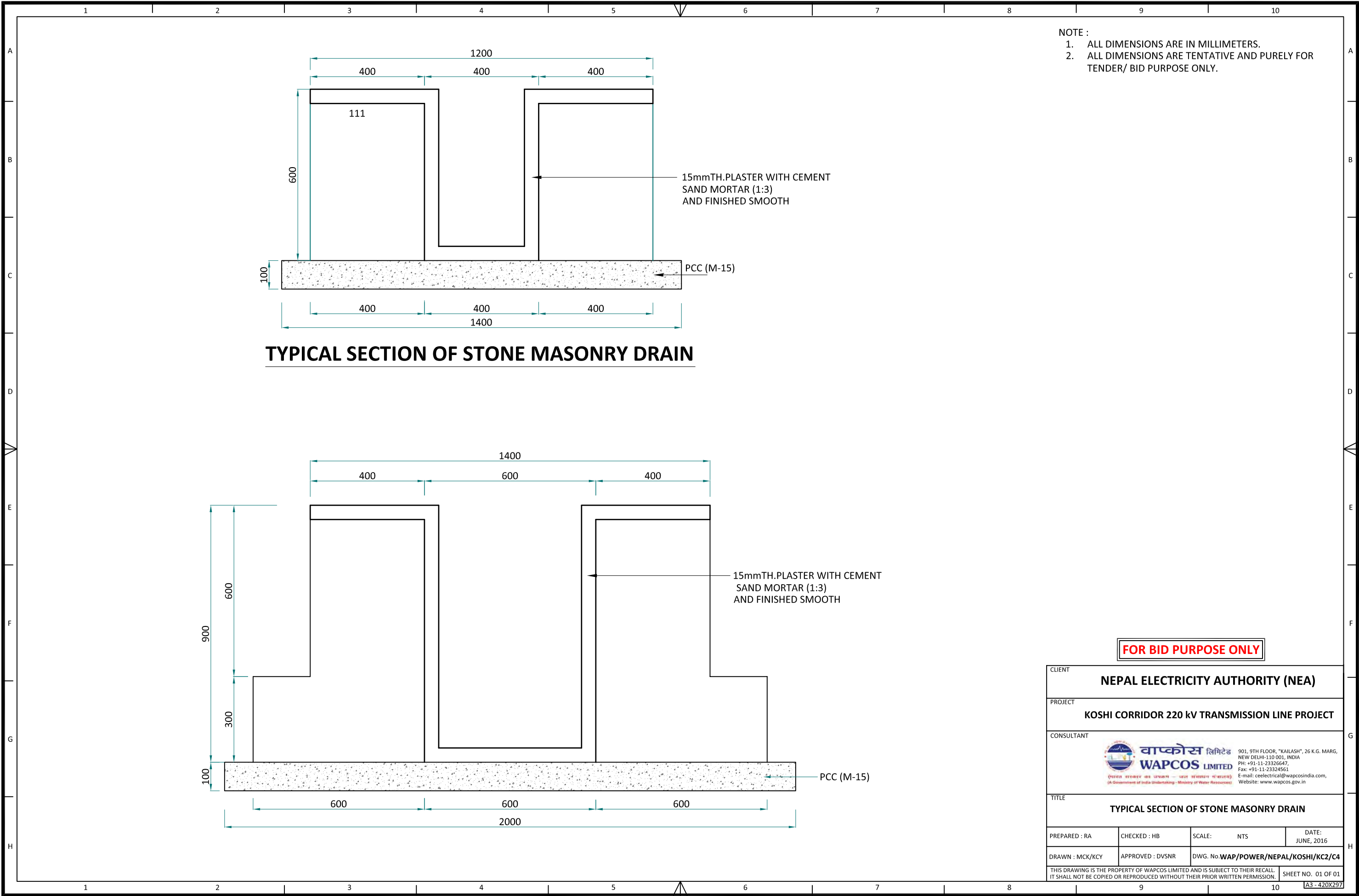
ELEVATION
UNDER GROUND WATER TANK FOR POTABLE WATER

FOR BID PURPOSE ONLY


CLIENT	NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT	KOSHI CORRIDOR 220 KV TRANSMISSION LINE PROJECT			
CONSULTANT	<div><div><div><div><div><div></div><div>वाय्कोस लिमिटेड</div></div></div><div><div>WAPCOS LIMITED</div><div>(Public Enterprise of Nepal)</div><div>(A Government of India Undertaking - Ministry of New Education)</div></div></div><div><div>901, 9TH FLOOR, "KALASHI", 26 K.G. MARG, NEW DELHI-110 001, INDIA</div><div>Ph: +91-11-23336647</div><div>Email: sales@wapcosltd.com, Website: www.wapcos.gov.in</div></div></div></div>			
TITLE	UNDERGROUND WATER TANKS DETAIL			
PREPARED : RA	CHECKED : HB	SCALE: NTS	DATE: JUNE, 2016	
DRAWN : MCK/KCY	APPROVED : DVS/NR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/C2	SHEET NO. 01 OF 01	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR REGAL IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.				

AS-4202927



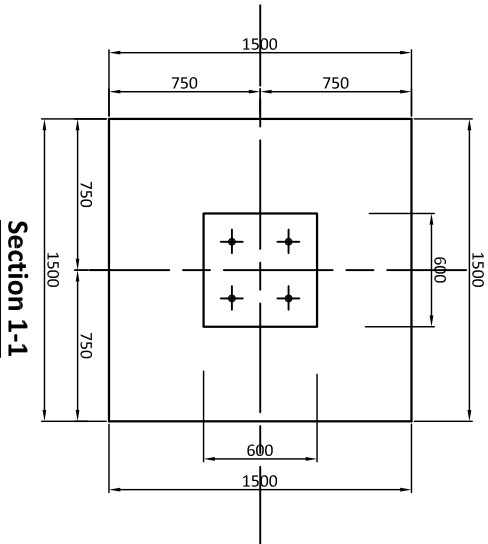
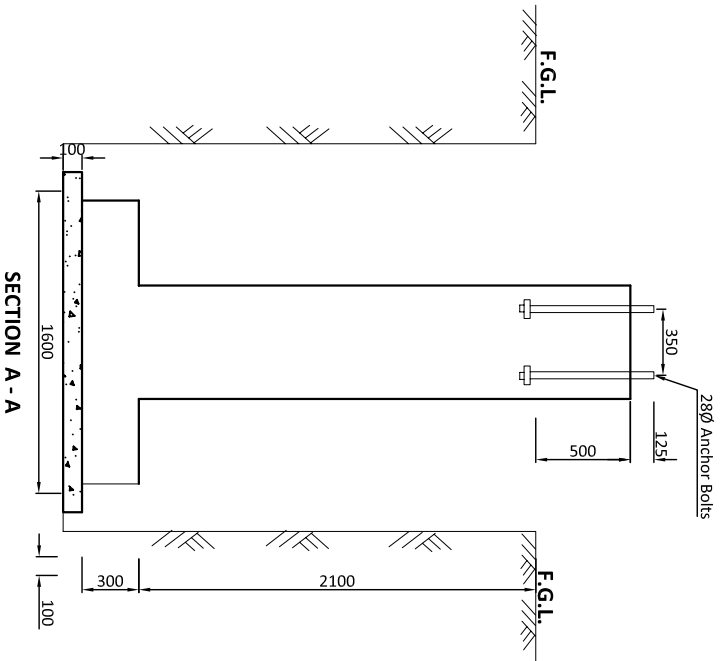


FOR BID PURPOSE ONLY

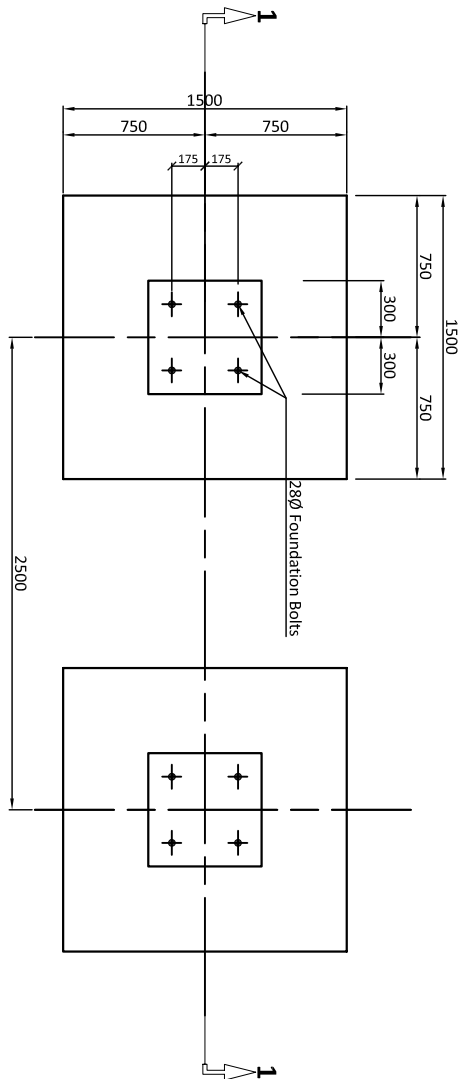
CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220 kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 वाष्कोस लिमिटेड WAPCOS LIMITED (भारत सरकार का अधिकांश — जल संधारण मंत्रालय) (A Government of India Undertaking - Ministry of Water Resources)		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
TITLE			
TYPICAL SECTION OF STONE MASONRY DRAIN			
PREPARED : RA	CHECKED : HB	SCALE: NTS	DATE: JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No.WAP/POWER/NEPAL/KOSHI/KC2/C4	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01

A3 - 420X297

- NOTE :
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.



Foundation Plan for 245 KV (Single Pole) Isolater



FOR BID PURPOSE ONLY

CLIENT	NEPAL ELECTRICITY AUTHORITY (NEA)		
PROJECT	KOSHI CORRIDOR 220KV TRANSMISSION LINE PROJECT		
CONSULTANT	<div><div><div><div>WAPCOS LIMITED</div><div>एन सी ई सी लिमिटेड</div></div></div><div><div>901, 9TH FLOOR, "KALASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA</div><div>PH: +91-11-23326647,</div><div>FAX: +91-11-23324561</div><div>E-mail: ce@electrical@wapcosindia.com,</div><div>Website: www.wapcos.gov.in</div></div></div>		

TITLE			
PLAN AND SECTION FOR 36 KV ISOLATOR			


PREPARED : VK	CHECKED : ANJ	SCALE: NTS	DATE: JUNE, 2016
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KCZ/C-7	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR REGAL IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01

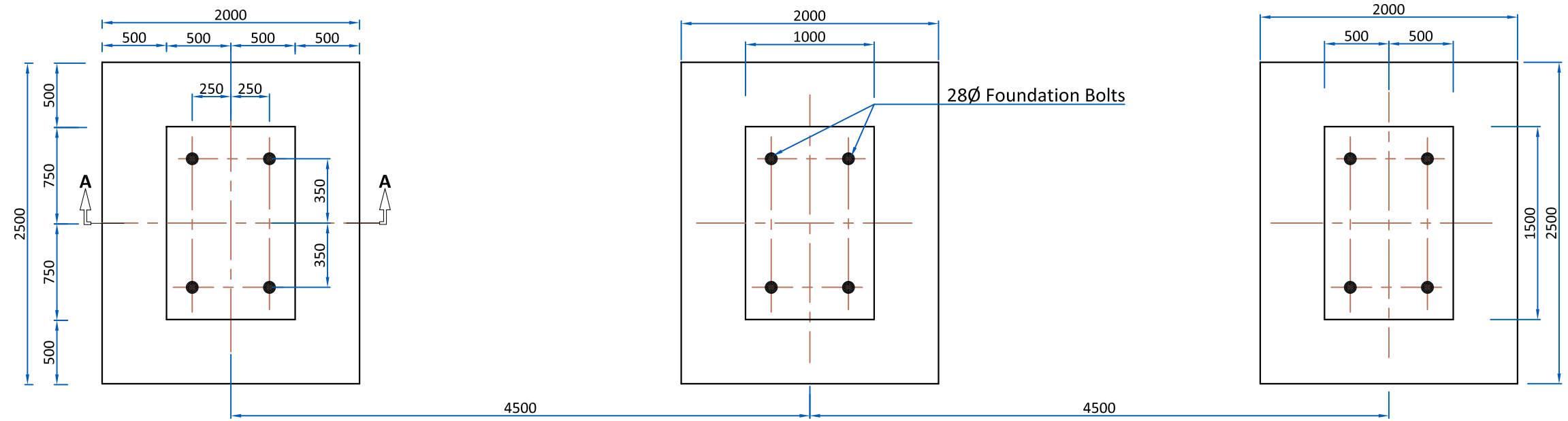
LA-4202927



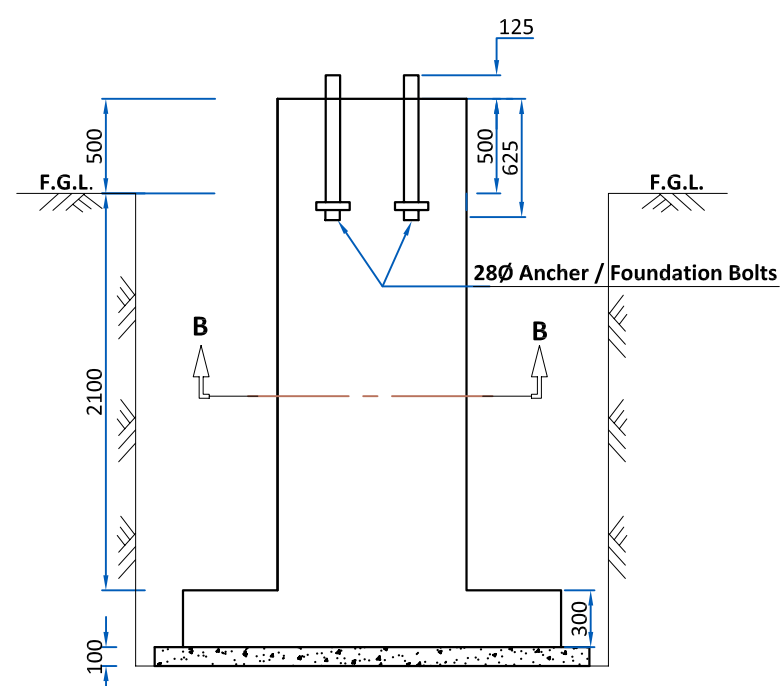
NOTE :

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

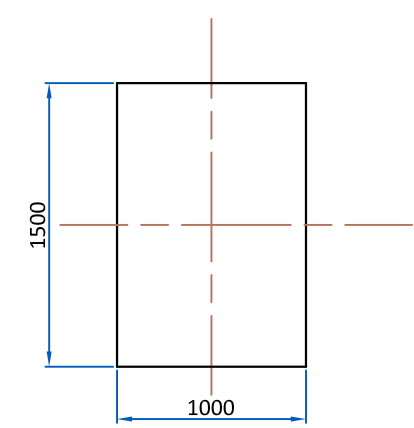
CIENT	NEPAL ELECTRICITY AUTHORITY (NEA)					
PROJECT	KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT					
CONSULTANT	 वाप्कोस लिमिटेड WAPCOS LIMITED <small>(एनएसई एक्सचेंजमा सूचीकृत) (श्रीलंका पर्यटन विभाग) (An Government of India Undertaking Ministry of Water Resources)</small>		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: celectrical@wapcosindia.com Website: www.wapcos.gov.in			
TITLE	PLAN AND SECTION FOR 36 kV (3-Pole) ISOLATOR VCB CIRCUIT BREAKER					
PREPARED : VK	CHECKED : AKJ	SCALE :		NTS	DATE: JUNE, 2016	
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No.		WAP/POWER/NEPAL/KOSHI/KC2/C		
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.					SHEET NO. 01 OF 02	



Foundation Plan For 220 kV SF6 Circuit Breaker




SECTION A - A

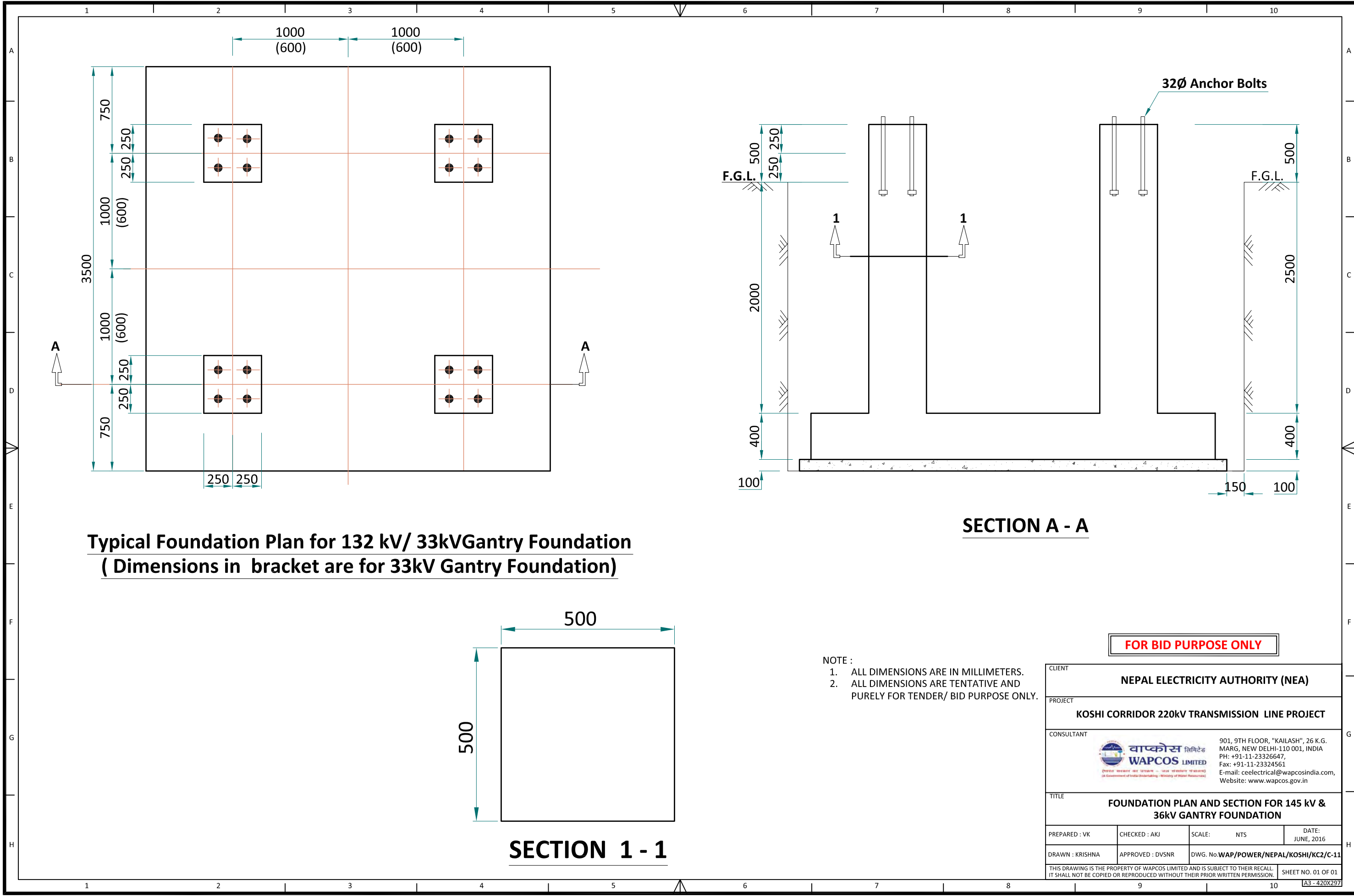


SECTION B- B

- NOTE :
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

FOR BID PURPOSE ONLY

CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 वापकोस लिमिटेड WAPCOS LIMITED <small>(PUNJ LLOYD LIMITED - NEW DELHI - INDIA) (A Government of India Undertaking: Ministry of Power Resources)</small>	901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in		
TITLE			
FOUNDATION PLAN FOR 245kV SF-6 CIRCUIT BREAKER			
PREPARED : VK	CHECKED : AKJ	SCALE: NTS	DATE: JUNE, 2016
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/C-10	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01



Typical Foundation Plan for 132 kV/ 33kVGantry Foundation
(Dimensions in bracket are for 33kV Gantry Foundation)

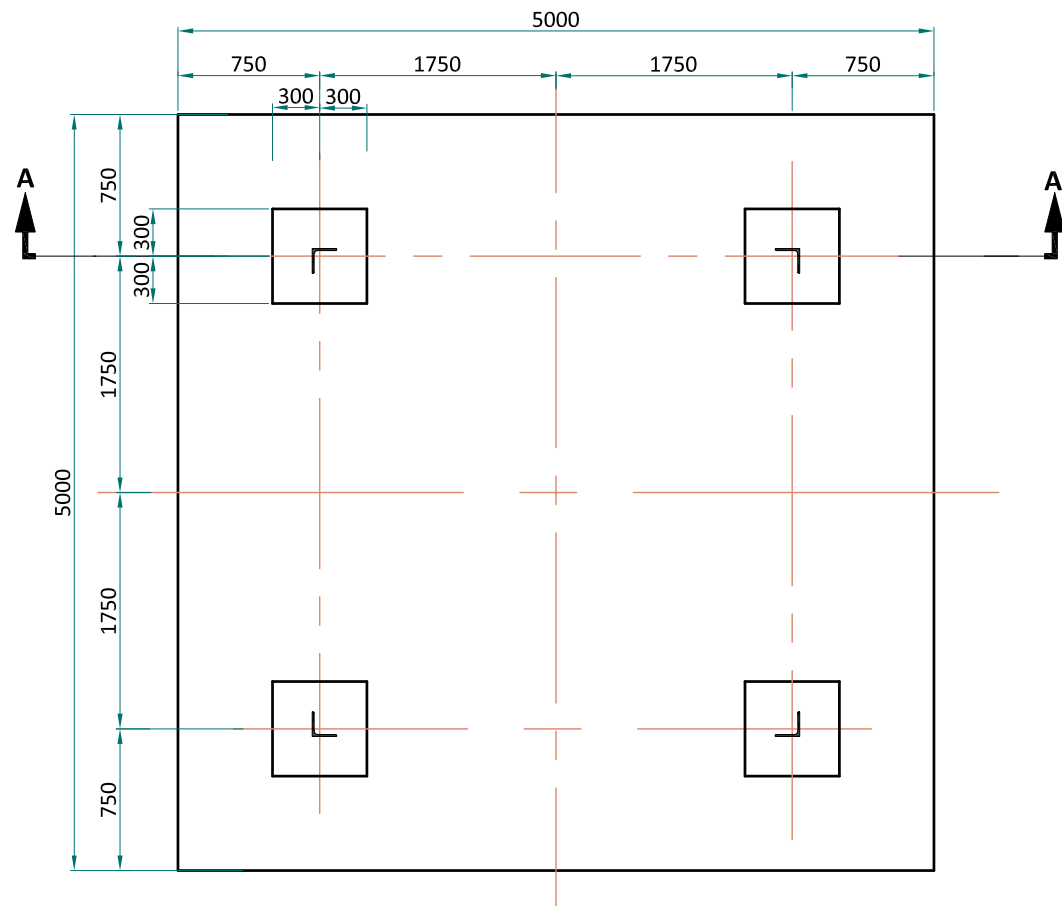
SECTION A - A

SECTION 1 - 1

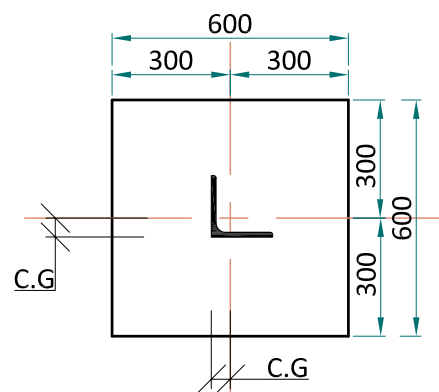
- NOTE :
- 1. ALL DIMENSIONS ARE IN MILLIMETERS.
 - 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

FOR BID PURPOSE ONLY

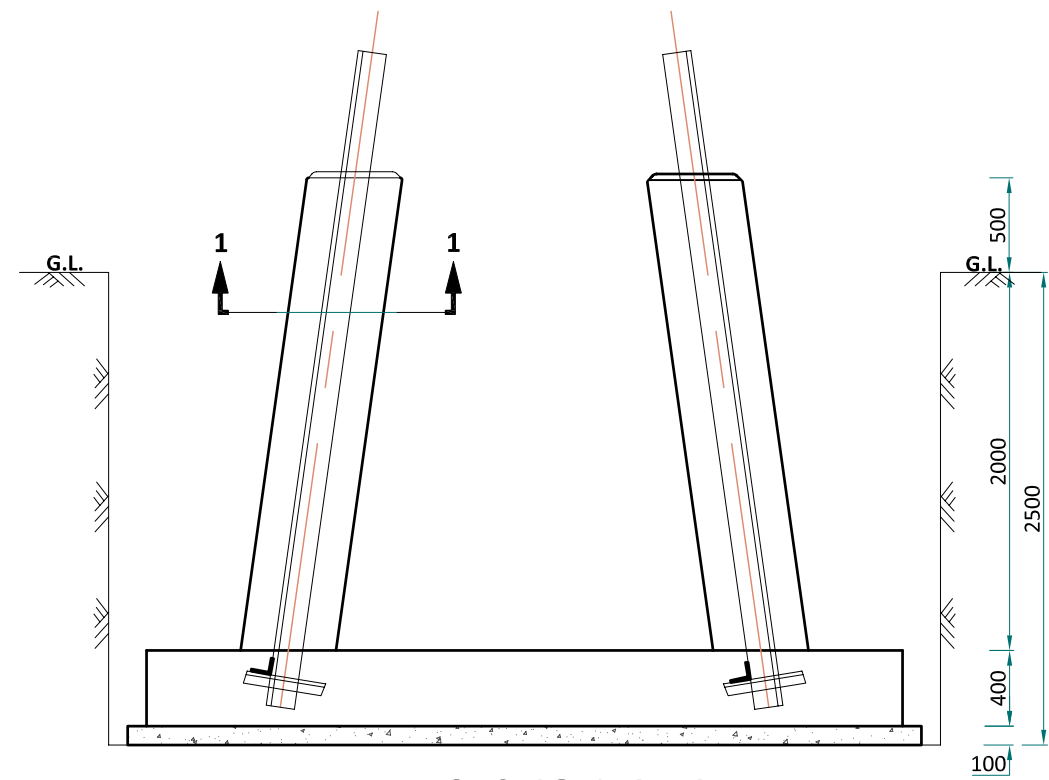
CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 वाष्कोस लिमिटेड WAPCOS LIMITED <small>(एकता सरकार जीव सहायता) - (एकता सरकार जीव सहायता) (A Government of India Undertaking - Ministry of Water Resources)</small>		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
TITLE			
FOUNDATION PLAN AND SECTION FOR 145 kV & 36kV GANTRY FOUNDATION			
PREPARED : VK	CHECKED : AKJ	SCALE: NTS	DATE: JUNE, 2016
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No.WAP/POWER/NEPAL/KOSHI/KC2/C-11	SHEET NO. 01 OF 01
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			A3 - 420X297



**Typical Foundation Plan for 220 kV Gantry,
Column and Lightning / Lightning mast Foundation**




SECTION 2 - 2



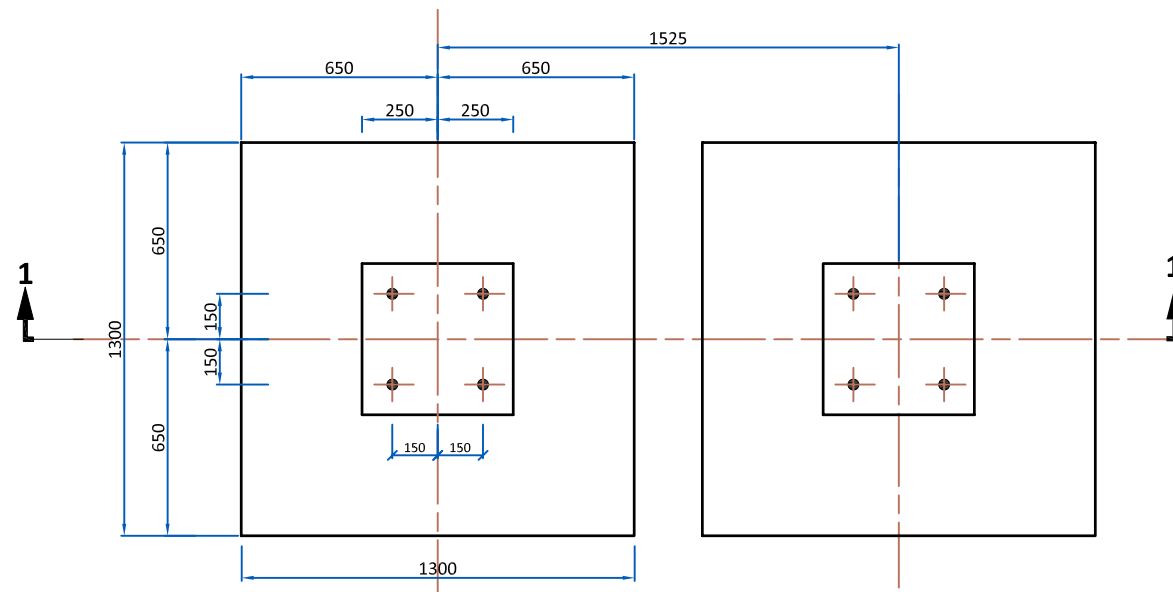
SECTION A - A

- NOTE :
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

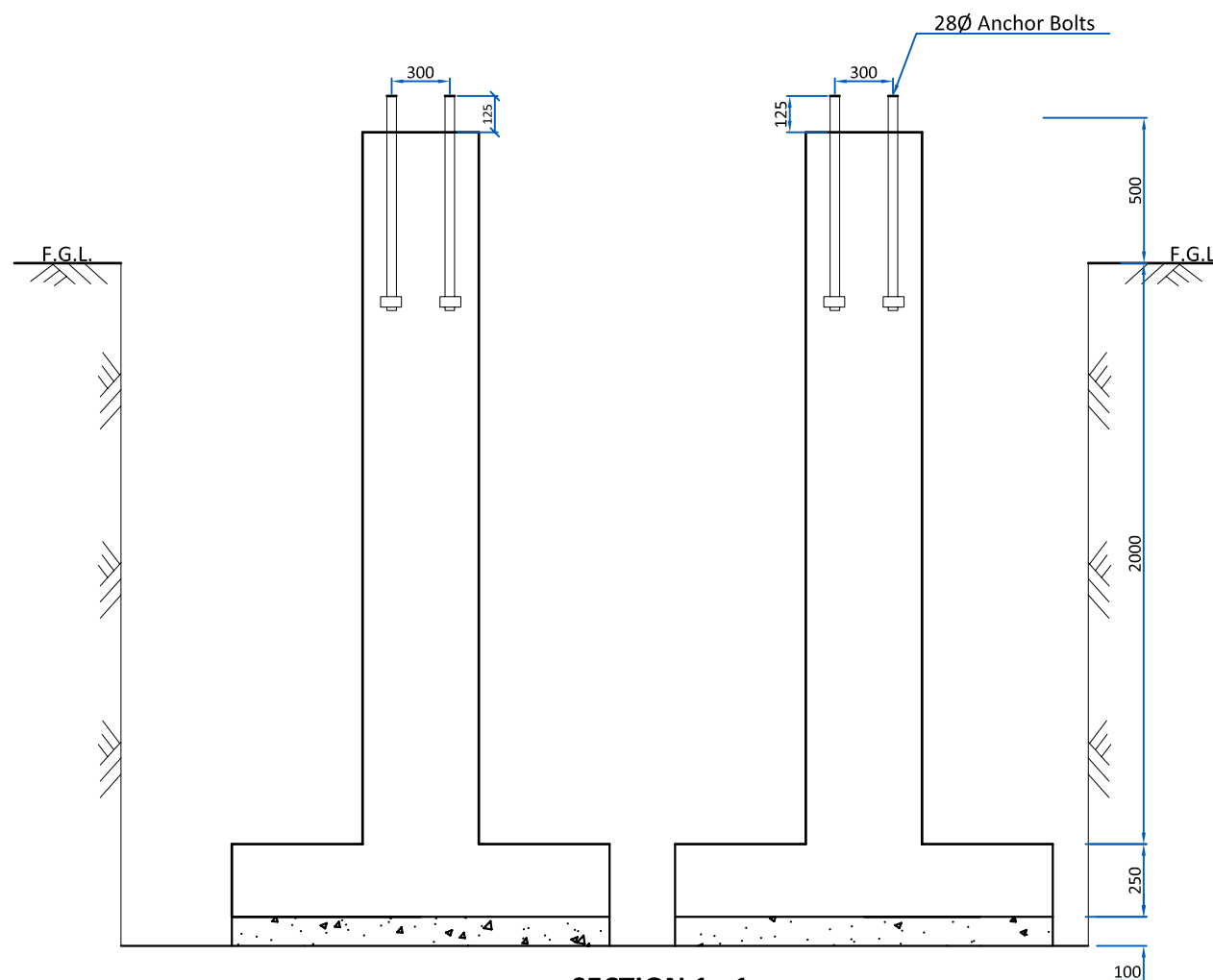
FOR BID PURPOSE ONLY

CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 वाप्कोस लिमिटेड WAPCOS LIMITED <small>(एनएसई एनएसईसी एनएसईसी - एनएसईसी एनएसईसी) (A Government of India Undertaking - Ministry of Water Resources)</small>	901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in		
TITLE			
FOUNDATION PLAN & SECTION 245 KV GANTRY COLUMN AND LIGHTNING MUST			
PREPARED : VK	CHECKED : AKJ	SCALE: NTS	DATE: DECEMBER, 2015
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No.WAP/POWER/NEPAL/KOSHI/KC2/C-12	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01

A3 - 420X297




Foundation Plan for 145KVA (Single Pole) Isolator



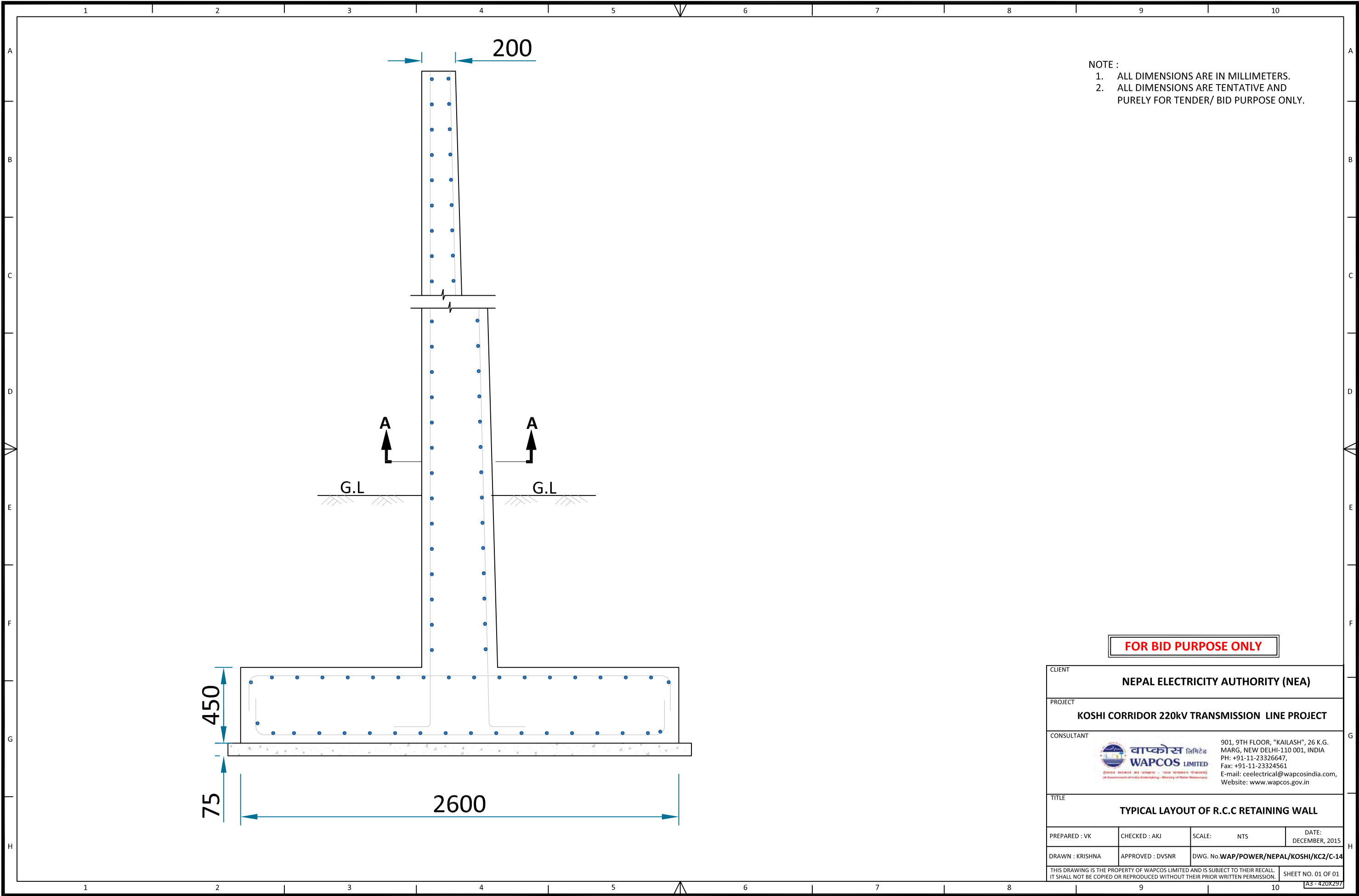
SECTION 1 - 1

- NOTE :
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

FOR BID PURPOSE ONLY


CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 वाप्कोस लिमिटेड WAPCOS LIMITED <small>(एनएसई-लिस्टेड कंपनी) (एनएसई-लिस्टेड कंपनी) (A Government of India Undertaking - Ministry of Water Resources)</small>	901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in		
TITLE			
FOUNDATION PLAN AND SECTION FOR 145 KVA (SINGLE POLE) ISOLATOR			
PREPARED : VK	CHECKED : AKJ	SCALE: NTS	DATE: JUNE, 2016
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/C-13	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01
[3 - 170797]			

A3 - 420X297

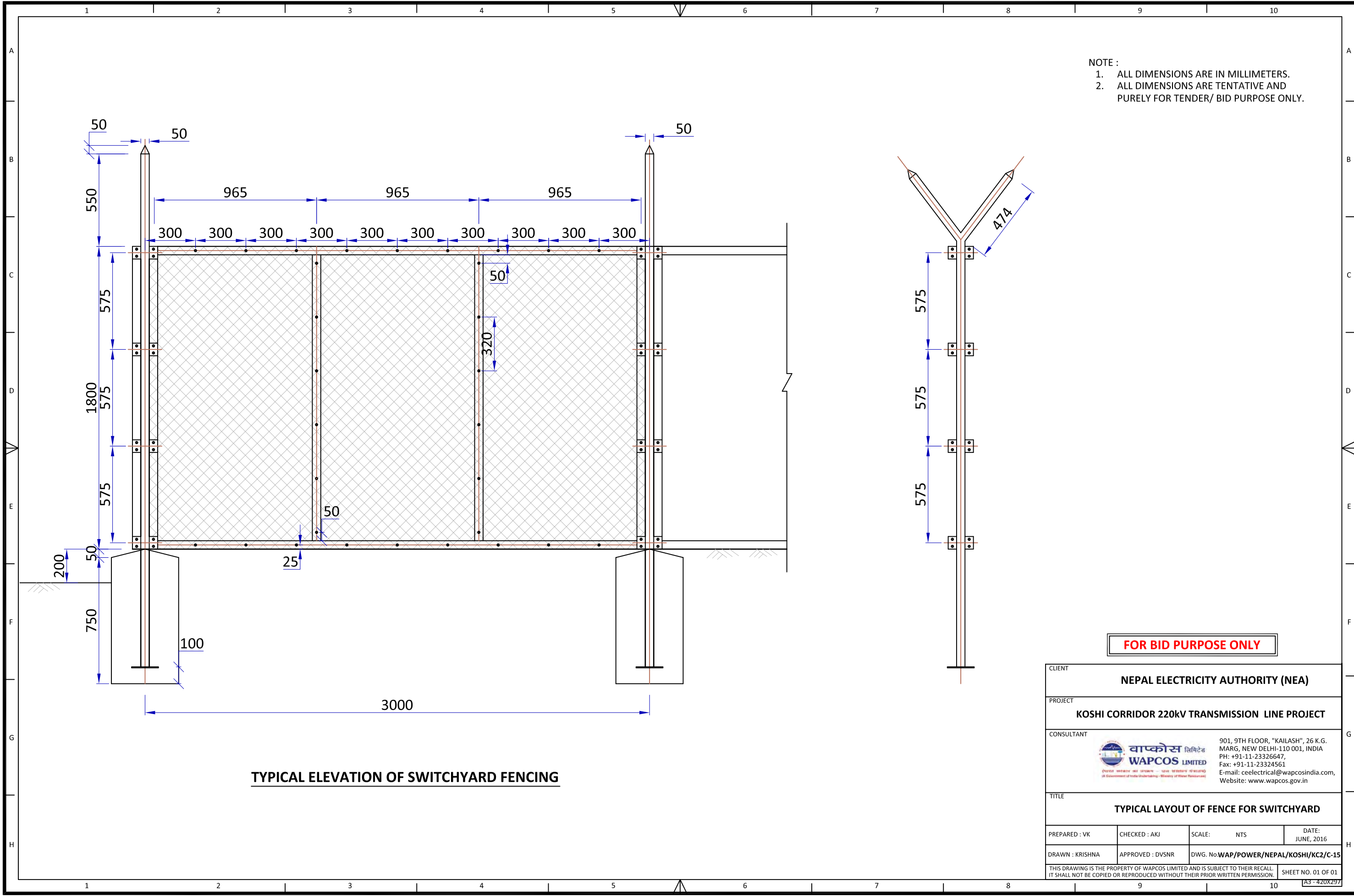


- NOTE :
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

FOR BID PURPOSE ONLY


CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 <div>वाष्कोस लिमिटेड WAPCOS LIMITED (एक निर्यातक इकाई) (एक निर्यातक इकाई) (A Government of India Undertaking - Ministry of Water Resources)</div>		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
TITLE			
TYPICAL LAYOUT OF R.C.C RETAINING WALL			
PREPARED : VK	CHECKED : AKJ	SCALE: NTS	DATE: DECEMBER, 2015
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KC2/C-14	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01

A3-420X297

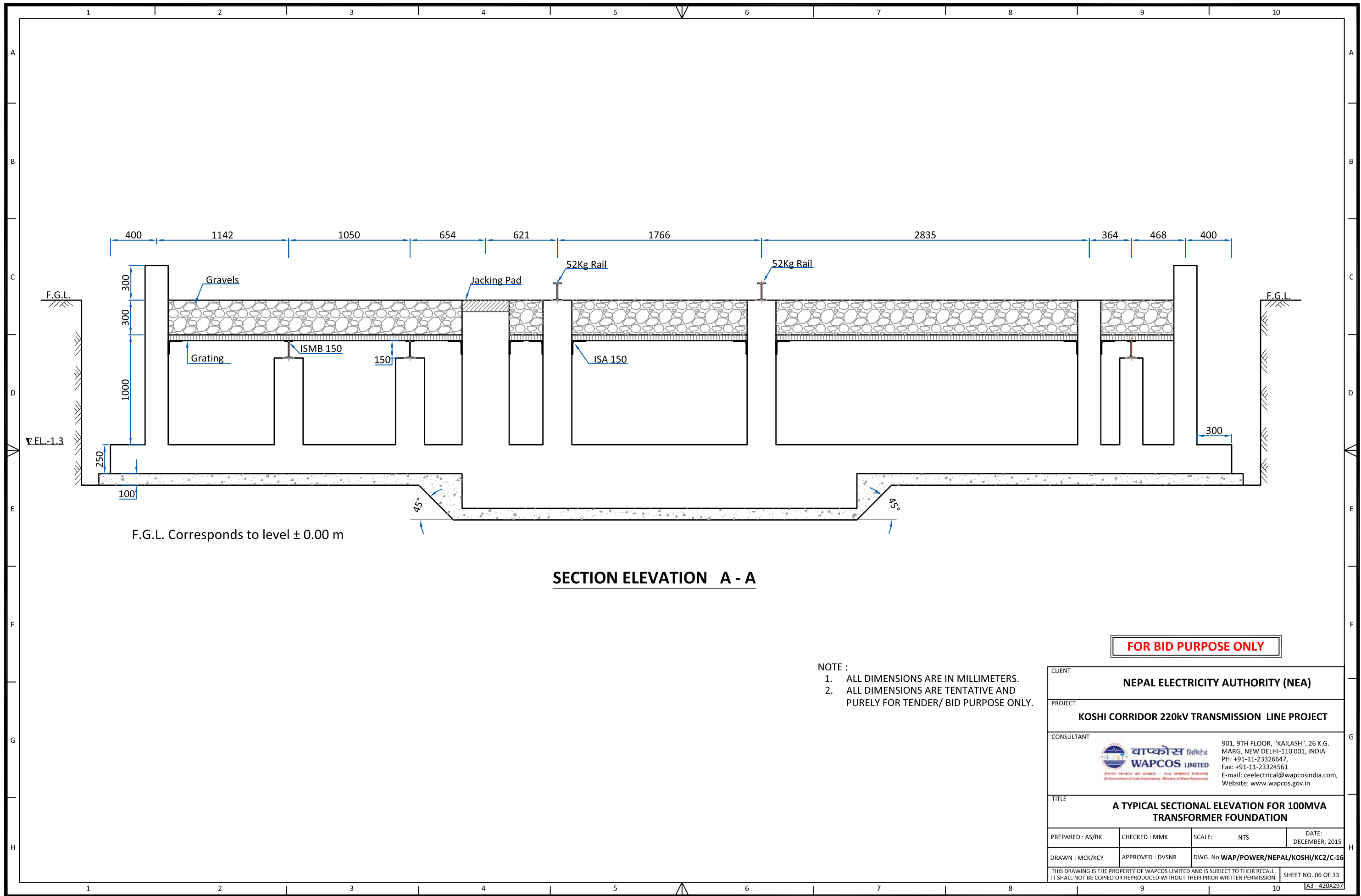


- NOTE :
- 1. ALL DIMENSIONS ARE IN MILLIMETERS.
 - 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

FOR BID PURPOSE ONLY

CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
 वाष्कोस लिमिटेड WAPCOS LIMITED <small>(एक भारतीय उद्यम — एक भारतीय संसाधन) (A Government of India Undertaking — Ministry of Water Resources)</small>			
TITLE			
TYPICAL LAYOUT OF FENCE FOR SWITCHYARD			
PREPARED : VK	CHECKED : AKJ	SCALE: NTS	DATE: JUNE, 2016
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/C-15	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01


A3-420X297



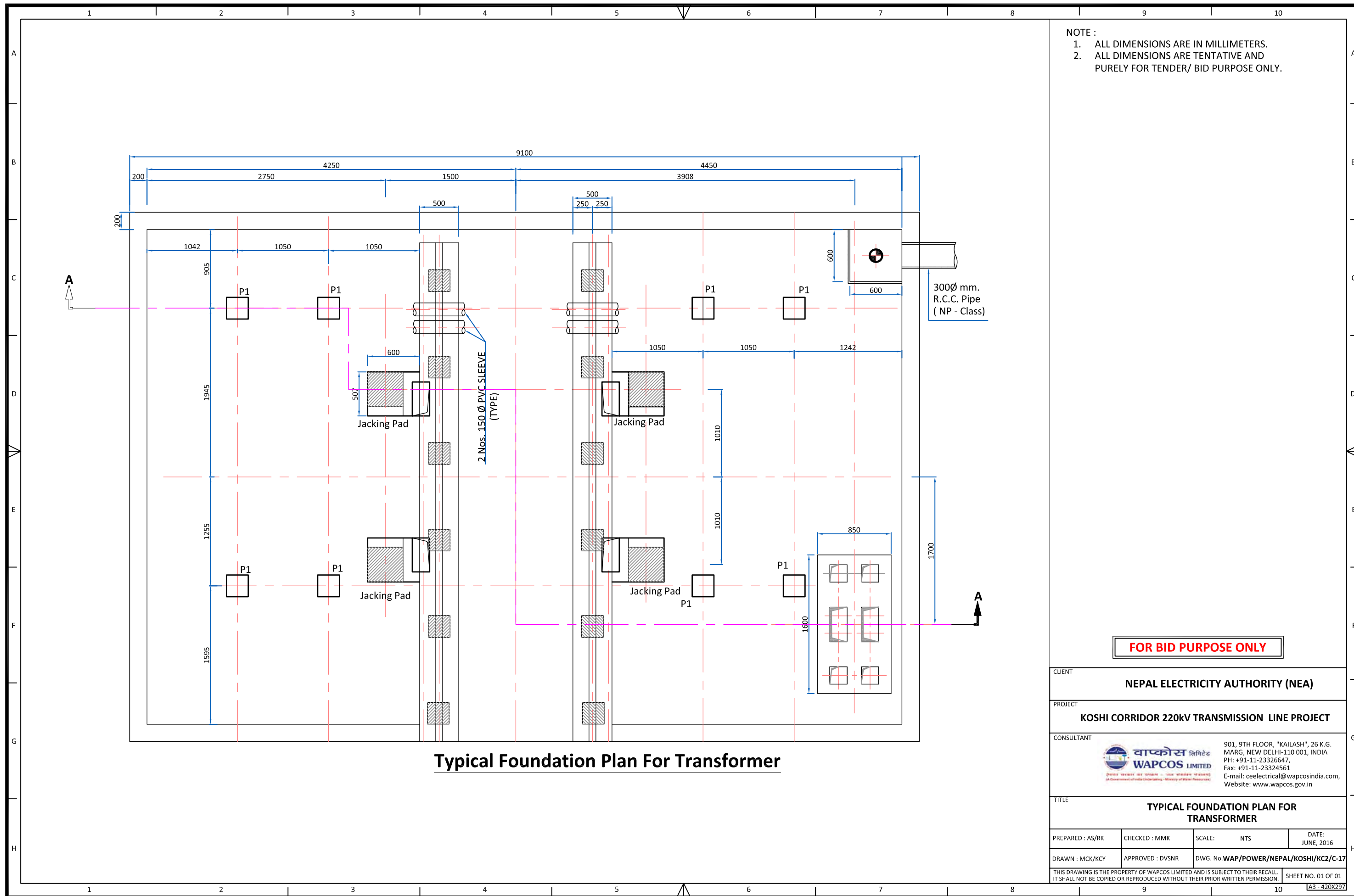
SECTION ELEVATION A - A

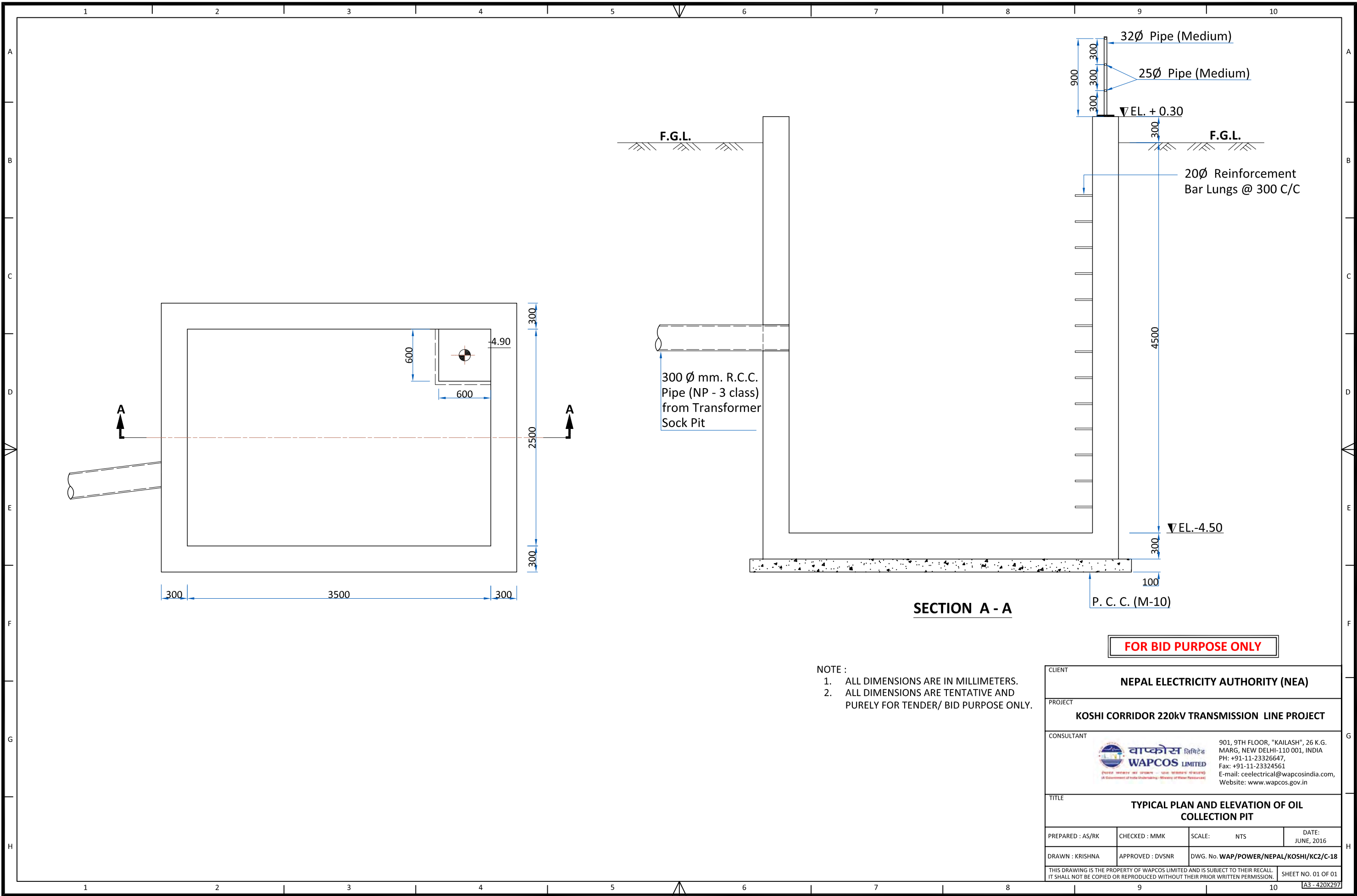
- NOTE :
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

FOR BID PURPOSE ONLY

CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 <div>वाष्कोस लिमिटेड WAPCOS LIMITED (एनपीएल सरकारका खास सल्लाहकार — भारत सरकारको खास सल्लाहकार) (A Government of India Undertaking - Ministry of Water Resources)</div>		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
TITLE			
A TYPICAL SECTIONAL ELEVATION FOR 100MVA TRANSFORMER FOUNDATION			
PREPARED : AS/RK	CHECKED : MMK	SCALE: NTS	DATE: DECEMBER, 2015
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KC2/C-16	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 06 OF 33

A3 - 420X297






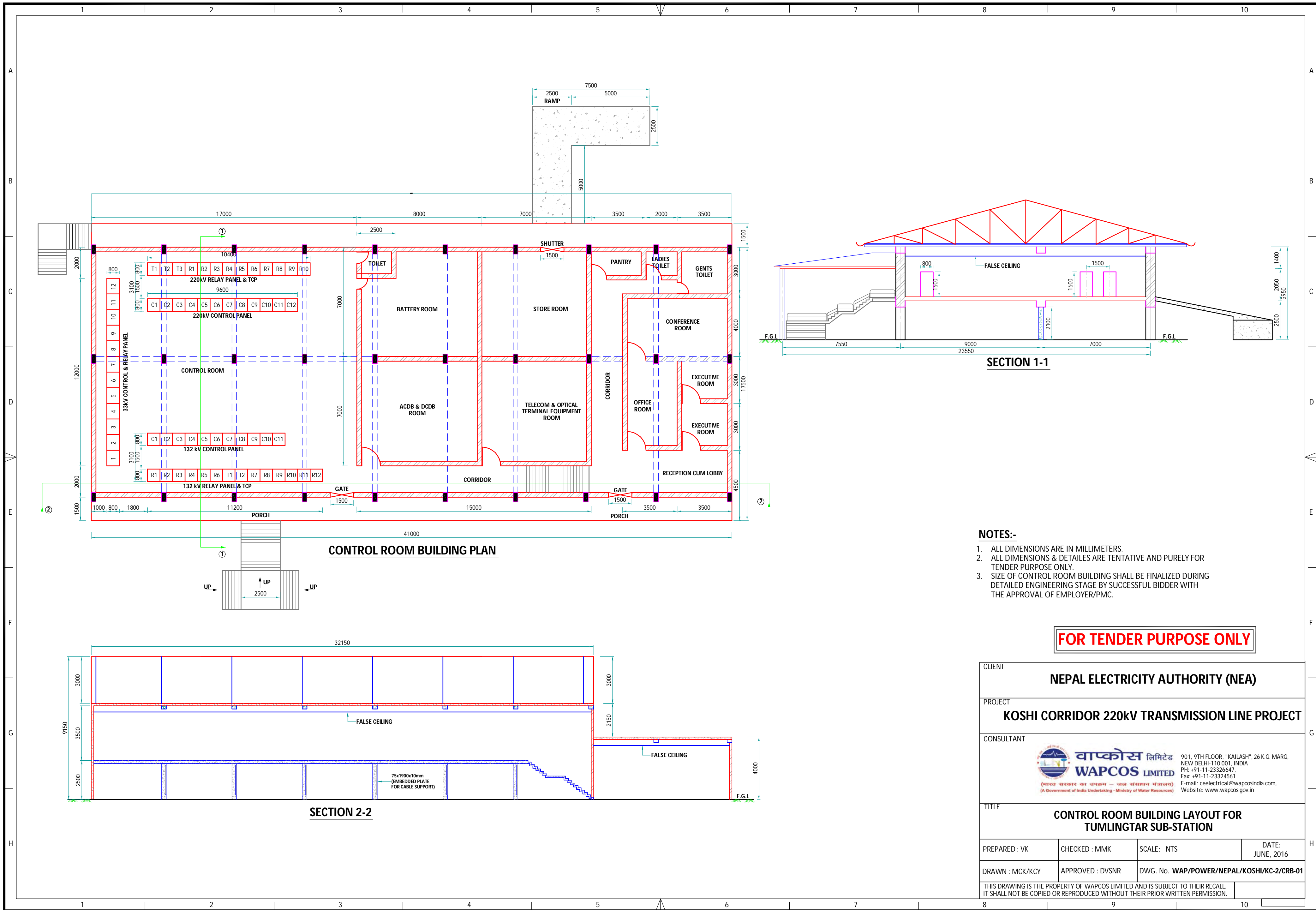
SECTION A - A

FOR BID PURPOSE ONLY

- NOTE :
- 1. ALL DIMENSIONS ARE IN MILLIMETERS.
 - 2. ALL DIMENSIONS ARE TENTATIVE AND PURELY FOR TENDER/ BID PURPOSE ONLY.

CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220KV TRANSMISSION LINE PROJECT			
CONSULTANT			
 वाष्कोस लिमिटेड WAPCOS LIMITED <small>(पूँजन सञ्चालन तथा उपग्रहण — जल सञ्चालन विभाग) (A Government of India Undertaking - Ministry of Water Resources)</small>		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
TITLE			
TYPICAL PLAN AND ELEVATION OF OIL COLLECTION PIT			
PREPARED : AS/RK	CHECKED : MMK	SCALE: NTS	DATE: JUNE, 2016
DRAWN : KRISHNA	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC2/C-18	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			SHEET NO. 01 OF 01

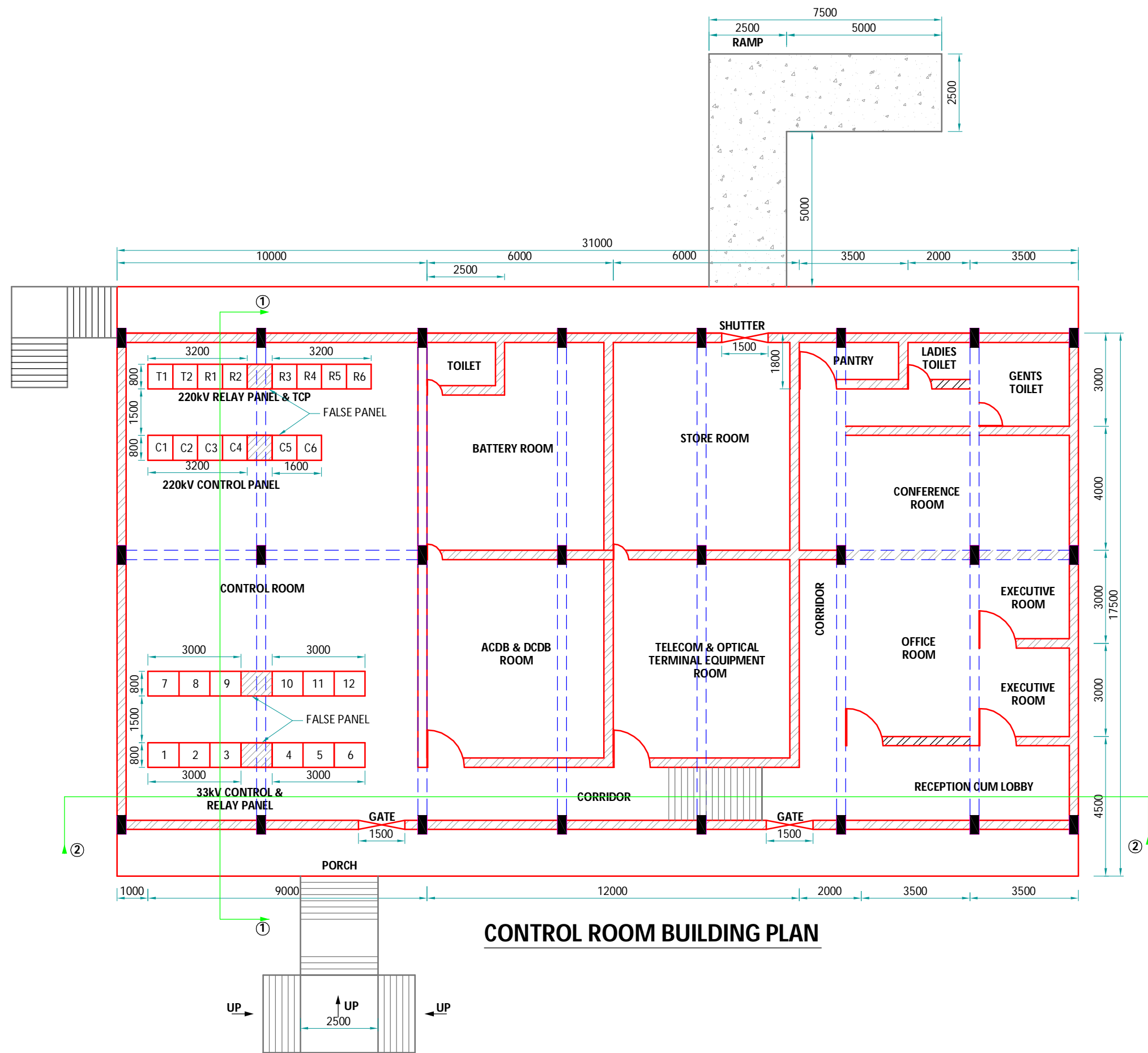
A3 - 420X297



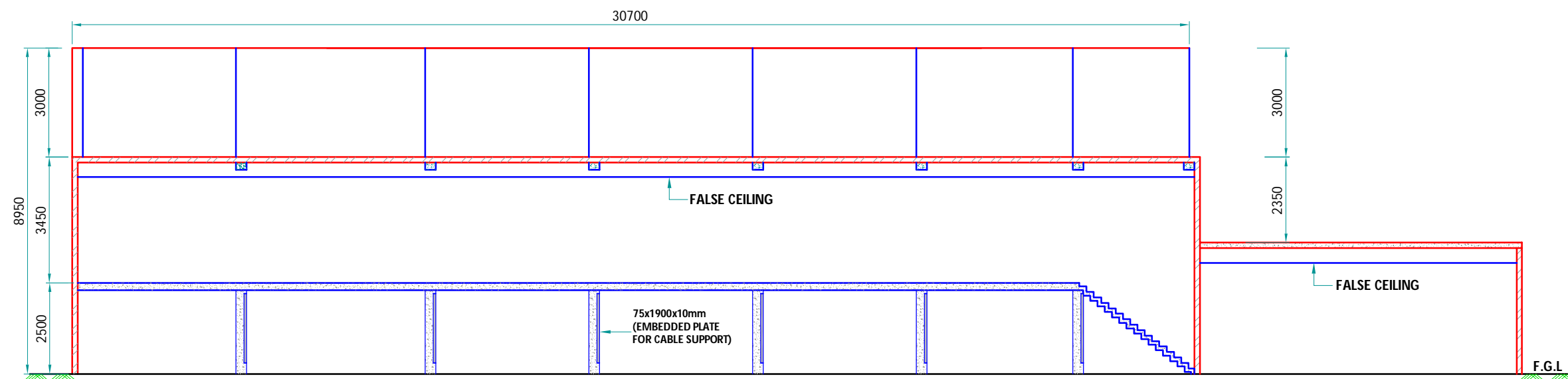
- NOTES:-**
- 1. ALL DIMENSIONS ARE IN MILLIMETERS.
 - 2. ALL DIMENSIONS & DETAILS ARE TENTATIVE AND PURELY FOR TENDER PURPOSE ONLY.
 - 3. SIZE OF CONTROL ROOM BUILDING SHALL BE FINALIZED DURING DETAILED ENGINEERING STAGE BY SUCCESSFUL BIDDER WITH THE APPROVAL OF EMPLOYER/PMC.

FOR TENDER PURPOSE ONLY

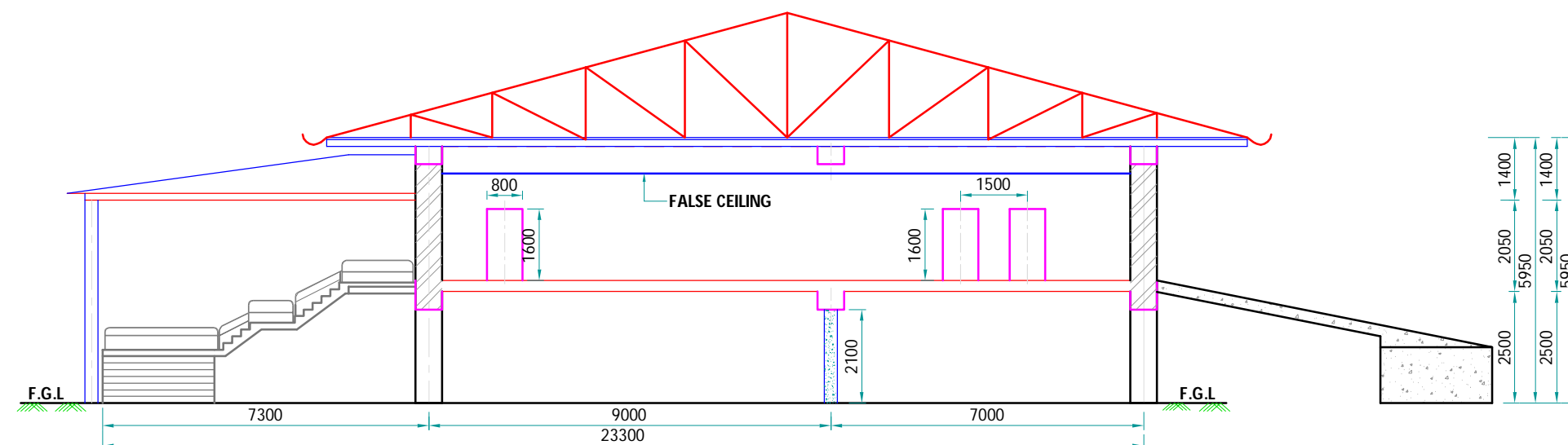
CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 <div>वाष्कोस लिमिटेड WAPCOS LIMITED (भारत सरकार का उपक्रम — जल संसाधन मंत्रालय) (A Government of India Undertaking - Ministry of Water Resources)</div>		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
TITLE			
CONTROL ROOM BUILDING LAYOUT FOR TUMLINGTAR SUB-STATION			
PREPARED : VK	CHECKED : MMK	SCALE: NTS	DATE: JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC-2/CRB-01	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			



CONTROL ROOM BUILDING PLAN



SECTION 2-2




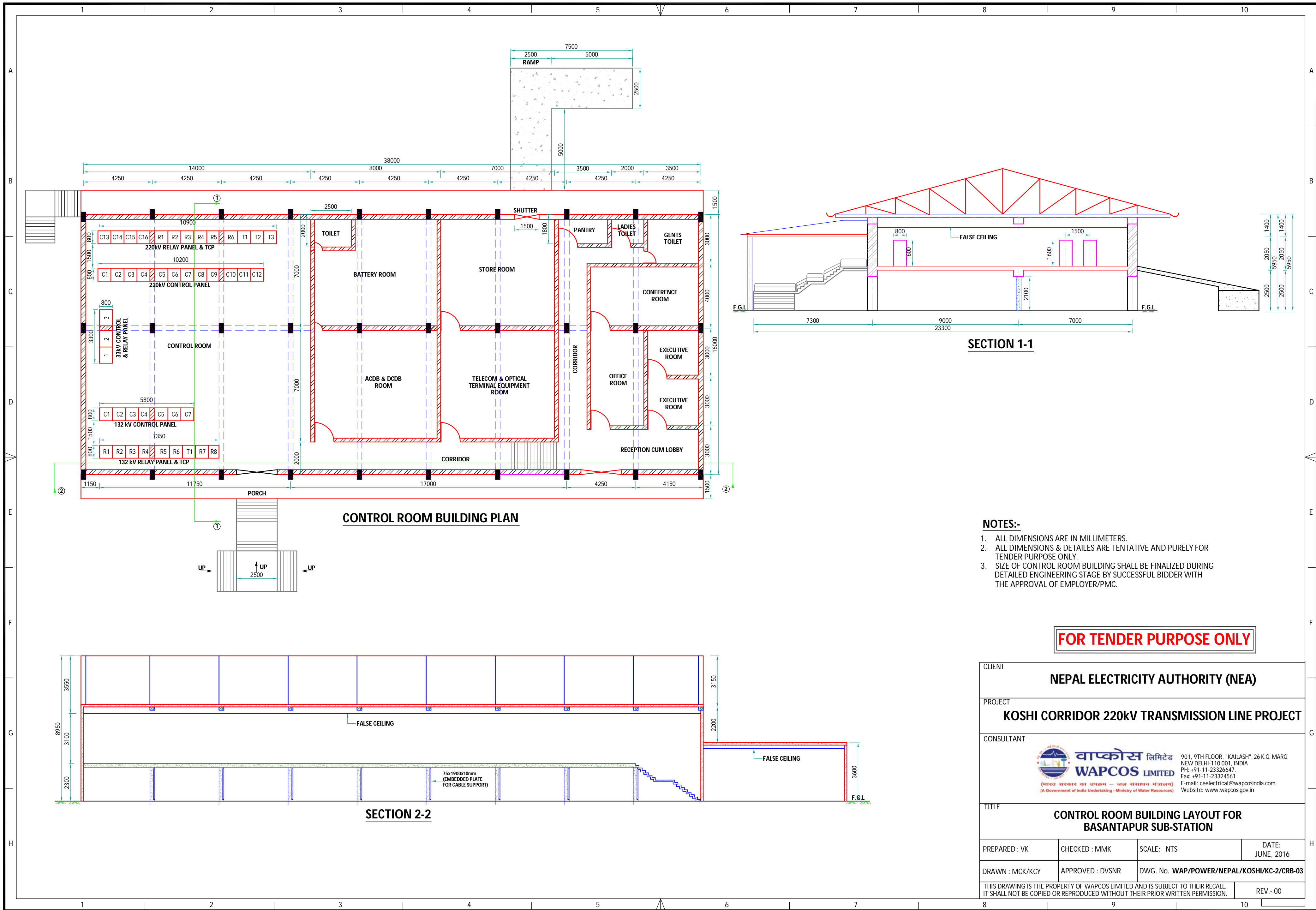
SECTION 1-1

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. ALL DIMENSIONS & DETAILS ARE TENTATIVE AND PURELY FOR TENDER PURPOSE ONLY.
3. SIZE OF CONTROL ROOM BUILDING SHALL BE FINALIZED DURING DETAILED ENGINEERING STAGE BY SUCCESSFUL BIDDER WITH THE APPROVAL OF EMPLOYER/PMC.


FOR TENDER PURPOSE ONLY

CLIENT			
NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT			
KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT			
 वाष्कोस लिमिटेड WAPCOS LIMITED <small>(भारत सरकार का उपक्रम — जल संचालन विभाग) (A Government of India Undertaking - Ministry of Water Resources)</small>		901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in	
TITLE			
CONTROL ROOM BUILDING LAYOUT FOR BANESHWAR SUB-STATION			
PREPARED : VK	CHECKED : MMK	SCALE : NTS	DATE: JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC-2/CRB-02	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			



- NOTES:-**
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. ALL DIMENSIONS & DETAILS ARE TENTATIVE AND PURELY FOR TENDER PURPOSE ONLY.
 3. SIZE OF CONTROL ROOM BUILDING SHALL BE FINALIZED DURING DETAILED ENGINEERING STAGE BY SUCCESSFUL BIDDER WITH THE APPROVAL OF EMPLOYER/PMC.

FOR TENDER PURPOSE ONLY

CLIENT NEPAL ELECTRICITY AUTHORITY (NEA)			
PROJECT KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT			
CONSULTANT  वाष्कोस लिमिटेड WAPCOS LIMITED <small>(भारत सरकार का उपक्रम - जल संचालन विभाग) (A Government of India Undertaking - Ministry of Water Resources)</small> 901, 9TH FLOOR, "KAILASH", 26 K.G. MARG, NEW DELHI-110 001, INDIA PH: +91-11-23326647, Fax: +91-11-23324561 E-mail: ceelectrical@wapcosindia.com, Website: www.wapcos.gov.in			
TITLE CONTROL ROOM BUILDING LAYOUT FOR BASANTAPUR SUB-STATION			
PREPARED : VK	CHECKED : MMK	SCALE : NTS	DATE: JUNE, 2016
DRAWN : MCK/KCY	APPROVED : DVSNR	DWG. No. WAP/POWER/NEPAL/KOSHI/KC-2/CRB-03	
THIS DRAWING IS THE PROPERTY OF WAPCOS LIMITED AND IS SUBJECT TO THEIR RECALL. IT SHALL NOT BE COPIED OR REPRODUCED WITHOUT THEIR PRIOR WRITTEN PERMISSION.			REV. - 00